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Shoesmith, Emily Kate, Huddlestone, Lisa Jane, Lorencatto, Fabiana et al. (2021) Supporting smoking cessation and preventing relapse following a stay in a smokefree setting: a meta-analysis and investigation of effective behaviour change techniques. Addiction. pp. 2978-2994. ISSN: 1360-0443

https://doi.org/10.1111/add.15452

ADDICTION
SSA SOCIETY FOR THE STUDY OF ADDICTION
REVIEW
doi:10.1111/add.15452

Supporting smoking cessation and preventing relapse following a stay in a smoke-free setting: a meta-analysis and investigation of effective behaviour change techniques

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ABSTRACT

Background and Aims Admission to a smoke-free setting presents a unique opportunity to encourage smokers to quit. However, risk of relapse post-discharge is high, and little is known about effective strategies to support smoking cessation following discharge. We aimed to identify interventions that maintain abstinence following a smoke-free stay and determine their effectiveness, as well as the probable effectiveness of behaviour change techniques (BCTs) used in these interventions. **Methods** Systematic review and meta-analyses of studies of adult smokers aged ≥ 18 years who were temporarily or fully abstinent from smoking to comply with institutional smoke-free policies. Institutions included prison, inpatient mental health, substance misuse or acute hospital settings. A Mantel–Haenszel random-effects meta-analysis of randomized controlled trials (RCTs) was conducted using biochemically verified abstinence (7-day point prevalence or continuous abstinence). BCTs were defined as 'promising' in terms of probable effectiveness (if BCT was present in two or more long-term effective interventions) and feasibility (if BCT was also delivered in ≥ 25% of all interventions). **Results** Thirty-seven studies (intervention n = 9041, control n = 6195) were included: 23 RCTs (intervention n = 6593, control n = 5801); three non-randomized trials (intervention n = 845, control n = 394) and 11 cohort studies (n = 1603). Meta-analysis of biochemically verified abstinence at longest follow-up (4 weeks–18 months) found an overall effect in favour of intervention [risk ratio (RR) = 1.27, 95% confidence interval (CI) = 1.08–1.49, I^2 = 42%]. Nine BCTs (including 'pharmacological support', 'goal-setting (behaviour)' and 'social support') were characterized as 'promising' in terms of probable effectiveness and feasibility. **Conclusions** A systematic review and meta-analyses indicate that behavioural and pharmacological support is effective in maintaining smoking abstinence following a stay in a smoke-free institution. Several behaviour change techniques may help to maintain smoking abstinence up to 18 months post-discharge.

Keywords Smoking cessation, smoking, smoke-free policy, relapse, systematic review, tobacco, meta-analyses.

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Submitted 8 October 2020; initial review completed 16 December 2020; final version accepted 10 February 2021

INTRODUCTION

Smoking remains a leading cause of mortality and morbidity world-wide [1]. Smoking prevalence in the general population in England has steadily declined, but recent data indicate that prevalence remains approximately 50% higher among people with mental health conditions in the United Kingdom [2]. Smokers with mental health conditions are more likely to experience greater dependence on smoking, and the long-term quit rates among this population are lower [2–5]. However, people with mental health conditions are just as motivated to quit as those in the general population [2,6], but are less likely to receive the required support compared to smokers without mental health conditions [3].

Smoking prevalence can reach 80% in inpatient, substance misuse and prison settings, widening inequalities in morbidity and mortality [7]. Efforts to address this

inequality have been made, including the implementation of smoke-free policies in many health and care residential settings, and delivery of smoking abstinence and cessation support for smokers during their stay [8]. These settings often act as an individual's residence for the duration of their stay, and thus can provide a unique opportunity of abstinence to initiate long-term change to reduce morbidity and mortality [7].

Evidence suggests individuals can successfully remain abstinent during their smoke-free inpatient stay when behavioural and/or pharmacological support is offered [7]. However, where a smoke-free stay resulted in temporary smoking abstinence or cessation, the risk of relapse post-discharge is high [9,10]. Relapse to smoking post-discharge often occurs quickly, and the vast majority of smokers appear to return to smoking on the same day of discharge [11,12]. Therefore, it is vital to provide support post-discharge to prevent relapse; however, little is known about effective strategies to prevent return to previous smoking behaviours following discharge from a range of settings [7].

Traditionally, systematic reviews and meta-analyses aim to investigate the effectiveness of interventions, and whether or not they 'work' for the intended population [7,13]. However, reviews of non-pharmacological, behavioural interventions for smoking cessation often find wide variation in effect sizes [14]. Behaviour change interventions (including smoking cessation behavioural support) can be designed and delivered in various ways. These interventions are also typically complex, comprising multiple, interacting component behaviour change techniques (BCTs) [15,16], defined as 'active components of an intervention designed to change behaviour' [17]. Examples of well-known BCTs include setting goals, action planning and providing feedback on behaviour. To understand what influences the effectiveness of interventions and further identify what makes one intervention more effective than another, it is useful to investigate which component BCTs are likely to be associated with effectiveness.

Taxonomies of BCTs have been developed to enable the clear specification of intervention content [18]. The behaviour change technique taxonomy version 1 (BCTTv1) [19] contains 93 discrete BCTs, each with a consistent label and definition (divided into 16 clusters), and is intended to be applicable across behavioural domains. The BCTTv1 has been increasingly applied in systematic reviews to specify or describe the content of behavioural interventions using a common language and explore the association with outcomes of specific intervention components [7,20,21]. Although a previous systematic review on maintaining smoking abstinence after a smoke-free stay conducted by Brose *et al*. [7] applied the BCTTv1 to specify the content of interventions, it did not link BCTs to outcomes in order to identify potentially effective or 'promising' BCTs. Rather, the authors identified BCTs that were most prevalent within the included interventions, delivered in mental health settings, substance abuse centres or prisons. The evidence base was relatively small, and included 10 quantitative studies with a limited range of interventions. This is an area of emerging research, with a range of recent quantitative and qualitative studies investigating the subject in a variety of relevant settings, including acute hospitals, which had not been part of the previous review [7].

Effective health-care interventions require an understanding of the broader context of the problem (e.g. the social and environmental context, and non-contextual influences on behaviour such as knowledge, consequences and motivation) [22]. The theoretical domains framework (TDF) is an integrative theoretical model that synthesizes main behaviour change constructs across key theories into 14 domains, such as 'knowledge' or 'goals' [23]. It has been used to inform the development of behaviour change interventions [24], including smoking cessation support [25]. The application of the TDF can help to highlight in which domains the factors associated with the success or failure to smoking cessation lie, and help to identify BCTs that might effectively target these. Additionally, understanding the experiences, needs and perceptions of participants and staff is important to ensuring future interventions and policy align with the preferences of the intended population for smoking cessation.

The present review updates and complements the existing knowledge base [2] by examining pharmacological or behavioural interventions delivered during the stay and/or post-discharge following a stay in a smoke-free setting, including mental health and substance abuse settings, prisons and acute hospital settings. Qualitative studies were included to explore stakeholders' experiences with interventions. Therefore, research aims were to determine:

1 What interventions (behavioural and/or pharmacological) have been provided to maintain smoking abstinence following a stay at a smoke-free setting, and which BCTs have been delivered within these interventions.
2 The effectiveness of interventions to maintain smoking abstinence following a stay at a smoke-free setting, and which component BCTs are identified as 'promising'; the factors associated with/predictors of success or failure of post-discharge smoking cessation or relapse prevention interventions.
3 Participant and/or staff experiences, needs or perceptions related to supporting smoking cessation or relapse prevention following a stay at a smoke-free setting.
4 The quality of included studies and potential publication bias.

METHODS

We report methodology in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines [26], following a pre-registered International Prospective Register of Systematic Reviews (PROSPERO) protocol [CRD42020170275].

Search strategy

MEDLINE, EMBASE, PsycINFO, CINAHL and Web of Science were searched up to February 2020. The search strategy published by Brose *et al.* [7] was adapted to include additional terms relating to relevant settings (e.g. acute hospitals), relevant study types (qualitative studies) and outcomes (e.g. perceptions, experiences, factors associated with/predictors of success or failure of smoking cessation interventions). Searches were limited to studies in English involving adults. All the studies included in the review conducted by Brose *et al.* [7] were included in the current review. The full search strategy is presented in Supporting information, Table S1. Endnote X9 was used to record publications at all stages of the selection process (Fig. 1). Titles and abstracts were screened independently by two authors (E.S. and L.H.) to ensure consensus. If there was a disagreement, studies were included in the full-text review. Full-text screening of included articles was undertaken independently by two authors (E.S. and L.H.), with disagreements settled by a third author (E.R.).

Inclusion criteria

Studies were identified for inclusion based on the population, intervention, comparator and outcome (PICO) method for eligibility. Randomized controlled trials (RCTs) (including feasibility and pilot trials), observational cohort studies and surveys or qualitative studies were considered.

Population

Studies including adult smokers ≥ 18 years of age who were temporarily or fully abstinent from smoking to comply with institutional smoke-free policies (those in mental health services, treatment for substance abuse, prisoners/offenders, or acute hospital wards) and were followed-up post-discharge were included. Biochemical validation of abstinence was not a requirement for study inclusion.

Intervention

Intervention comprised studies that described or evaluated behavioural and/or pharmacological interventions to

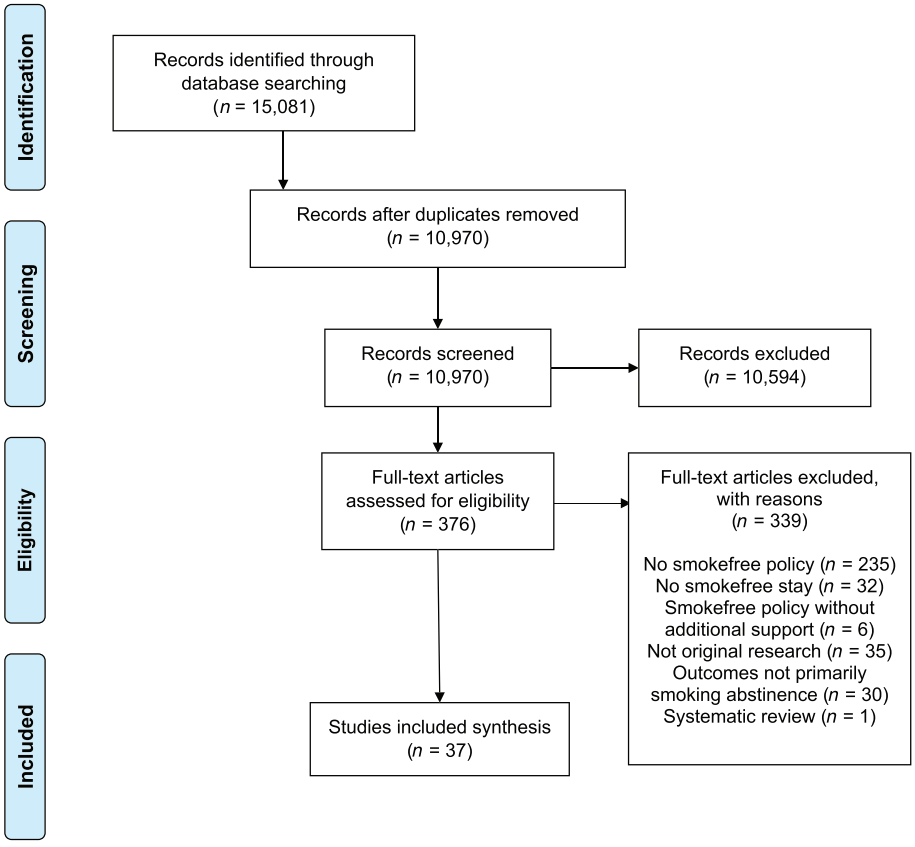

Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) diagram of paper selection process

support smoking cessation during the stay, post-discharge or a combination of both.

Comparator

A control comparator was not necessary for inclusion in this review. Studies with or without the following controls were considered: no treatment control groups, placebo, waiting-list control, normal practice or any other intervention described by the authors as a comparator.

Outcomes

Outcomes included RCTs (including randomized feasibility studies and pilot trials) and cohort studies that reported smoking abstinence, either via self-report and/or validated by biochemical verification at any time-point post-discharge. Qualitative studies were included if they reported participant and/or staff experiences, needs or perceptions relating to supporting smoking cessation following a stay at a smoke-free setting.

Exclusion criteria

Studies were excluded if: (1) settings did not have a smoke-free policy; (2) smoke-free policies and/or smoking cessation interventions were described or evaluated, but did not include a stay in a smoke-free setting; (3) settings had a smoke-free policy but did not implement any intervention to support smoking cessation; or (4) they were systematic reviews or not original research.

Outcome measures

i Biochemically verified smoking abstinence at longest follow-up.
ii Modifiable factors associated with/predictors of success or failure of smoking cessation interventions (e.g. participant motivation, participant fear of failure).
iii Participant/staff experiences, needs or perceptions related to supporting smoking cessation (e.g. experiences, needs or perceptions of receipt or delivery of an intervention).

Data extraction

Using a pre-defined table, relevant data were extracted from all studies by two authors (E.S. and L.H.). Published descriptions of the content of smoking cessation interventions were coded using the BCTTv1 [18]. BCTs were coded for the intervention as a whole, and also separated for those delivered during the smoke-free stay and those delivered post-discharge/release. As current guidance for reporting of trials and their interventions recommends that both experimental and comparator interventions are reported in similar detail [27–29], BCTs were also coded in the control or comparator arm (e.g. standard care/other interventions) for studies with a comparator. All articles were coded independently by two researchers (E.S. and L.H.), and included the involvement of a behaviour change expert with experience in using the BCTTv1 and delivering training in its application (F.L.). A + and ++ system was not applied to coding, as this system is often used in initial training for use of the BCTTv1, but not always during coding analyses. Instead, the researchers were cautious to not infer a presence of a BCT, basing the coding on reported content in intervention descriptions only, and any instances of uncertainty were discussed as a team.

Modifiable and non-modifiable factors associated with success or failure of smoking cessation interventions (as identified by the study authors) were extracted. Non-modifiable factors were common covariates (e.g. participant demographics and nicotine dependence). Modifiable factors (e.g. plans to not smoke, desire to quit) were coded to the TDF. All articles were coded independently by one author and subsequently coded by a second author, with disagreements resolved through discussion with a third author.

Quality assessment

Version 11 of the mixed methods appraisal tool (MMAT) [30] was used to assess each study. The MMAT was developed for complex systematic reviews, permitting quality appraisal for a range of methodological studies. The tool's validity and reliability have been established [31]. Two authors independently assessed and rated the studies and compared scores. Disagreements were resolved through discussion.

Data synthesis

For RCTs, a Mantel–Haenszel meta-analysis was conducted using RevMan version 5.4 [32]. Heterogeneity between study outcomes was assessed using the I^2 statistic, suitable for smaller meta-analyses [33]. Due to the likelihood of significant heterogeneity, a random-effects model was used. *Post-hoc* subgroup analyses to separate studies by those with a follow-up length of fewer than 6 months and those with a follow-up length of more than 6 months were also conducted. For all meta-analyses, participants lost to follow-up were treated as non-abstinent, except those who were reported as deceased [34]. Publication bias was assessed using funnel plots. Where visual inspection indicated potential funnel plot asymmetry, Egger's regression intercept, used to quantify publication bias [35], was used to investigate this.

BCTs were defined as 'promising' in terms of probable effectiveness if the technique was present in at least two long-term effective interventions [36], defined as those

reporting statistically significant ($P < 0.05$, where reported) differences in smoking abstinence between intervention and control groups at a 6-month follow-up point or later (either biochemically validated or by self-report). Subsequently, the BCTs defined as 'promising' in terms of probable effectiveness were defined as 'promising' in terms of feasibility if they were also delivered in ≥ 25% interventions. By using this approach, BCTs were considered in terms of their overall frequency and allowed identification of techniques that were most likely to be feasible, acceptable and fit for purpose [20].

For modifiable factors associated with/predictors of success or failure, deductive analysis guided by the domains of the TDF was conducted by coding extracted factors to the domains they were judged to best represent. Data regarding the perceptions, needs or experiences of participants and staff were summarized in a narrative synthesis.

Additional information (treatment manuals or treatment protocols) was requested from the authors of all included studies. Detailed intervention descriptions were provided by six authors, and information was also obtained from the supplementary information provided by Brose *et al.* [7]. For authors who could not be contacted, or where additional information was not available from Brose *et al.* [7], studies were coded based on published descriptions of intervention content.

RESULTS

Quality assessment

Research questions were clearly stated in all the studies, and methods that were appropriate to answer the research questions were used. The majority provided sufficient information to allow MMAT assessment, and were considered as being of high quality. Those lacking the required information included eight RCTs where it was not possible to ascertain whether the outcome assessors were blinded to the intervention, and one which provided insufficient information in relation to the rate of attrition. Full details of the studies assessed are provided in Supporting information, Table S2.

Description of studies

The search identified 15 081 records; 37 studies (intervention $n = 9041$, control $n = 6195$) were included in the review (Fig. 1). Twenty-three studies [10,37–58] were RCTs (intervention $n = 6593$, control $n = 5801$). Three studies [59–61] were trials, but adopted a non-randomized design (intervention $n = 845$, control $n = 394$). In one study, patients decided which group they wanted to participate in [61], but the remaining studies did not provide further information regarding how participants were allocated to each group [59,60]. Eleven studies [9,62–71] used a cohort design ($n = 1603$). No qualitative studies were eligible for inclusion, primarily due to participants not staying in a smoke-free setting or settings not reporting a smoke-free policy. Therefore, for the fourth research question, information regarding participant experiences, needs or perceptions were obtained from data provided in other study designs where available.

The origin of studies varied (see Supporting information, Table S3), with the majority being conducted in the United States ($n = 25$). The remaining studies were conducted in Australia ($n = 5$), Brazil (n = 2) and the United Kingdom, Tunisia, France, Canada and Greece ($n = 1$, respectively). Most studies were conducted in acute hospitals ($n = 20$), followed by mental health inpatient settings ($n = 9$), substance abuse treatment settings (n = 5) and prisons ($n = 3$).

Of studies reporting average length of stay ($n = 20$), the longest stay was in prison settings, reporting an average of 1.5 and 1.2 years [10,70]. For non-prison settings, the longest average length of stay was 90 days in a substance abuse setting [68,69]. Study follow-up periods ranged from 3 weeks [70,71] to 18 months [49].

Intervention characteristics

Interventions varied in frequency, content and mode of delivery (see Supporting information, Table S3). For studies in acute hospital settings ($n = 20$), the majority of interventions was delivered by hospital staff or smoking cessation practitioners. Five studies [39,41,43,47,48] involved researchers in intervention delivery. For studies in mental health or substance abuse settings ($n = 14$), the majority of the interventions were delivered by mental health or substance use professionals, with the exception of three studies [49,54,67] in which the interventions were delivered by researchers. Three interventions delivered in prisons [10,70,71] were facilitated by researchers.

Post-discharge interventions were included in the majority of the trials ($n = 23$), with the exception of three [38,39,45] and five cohort studies [9,61,63,66,67]. Telephone calls were used in 14 studies [10,41,42,48,50–52,54–56,58,60,61,67], ranging from one to 14 calls at time-points between 1 day and 9 months post-discharge. Three studies delivered a computer-assisted intervention 3 and 6 months post-discharge [43,47,49], and one intervention supported patients via text message during the first 8–15 days post-discharge [41].

Trials used varying controls, including usual care [44,49,54]; enhanced treatment as usual [47]; brief cessation interventions [39]; and a health-related, non-smoking cessation intervention matched for frequency and duration [10].

Biochemically verified smoking abstinence

Four trials [40,42,55,58] were excluded from the meta-analysis; Chui *et al.* [40] did not report biochemically verified abstinence; Cummins *et al.* [42] reported a 30-day abstinence rate validated by cotinine analysis, but did not report the results separately for the control group versus the three intervention arms. Two trials reported biochemically verified abstinence in participant subgroups, as opposed to intervention/control arm [55,58].

The meta-analysis of smoking abstinence at longest respective follow-up (4 weeks to 18 months) found an overall effect in favour of intervention [risk ratio (RR) = 1.27, 95% confidence interval (CI) = 1.08–1.49] (Fig. 2). Overall, 14.0% participants in the intervention groups achieved abstinence compared with 11.7% in the control groups. However, substantial heterogeneity was indicated for the meta-analysis.

To explore heterogeneity, subgroup analyses were conducted to separate studies by those with a follow-up length of fewer than 6 months (Fig. 3a) and those with a follow-up length of more than 6 months (Fig. 3b).

The subgroup analysis of smoking abstinence in studies with a follow-up length of fewer than 6 months found an overall effect in favour of intervention (RR = 1.30, 95% CI = 1.00–1.68) (Fig. 3a), but still indicated substantial heterogeneity. Those with a follow-up length of more than 6 months found an overall effect in favour of intervention (RR = 1.23, 95% CI = 1.02–1.48) (Fig. 3b), and indicated less heterogeneity. There was no difference in the risk ratios for those with a follow-up length of fewer than 6 months and those with a follow-up length of more than 6 months, based on the overlapping CIs.

Subgroup analyses to separate studies by those that included post-discharge support and those that did not were considered. However, due to the number imbalance (20 RCTs offered post-discharge support, whereas three did not), the subgroup analysis was not conducted. A funnel plot suggested the possibility of publication bias (Supporting information, Fig. S1). Egger's regression intercept was significant, but no evidence of asymmetry was seen when the trim-and-fill method was used (Supporting information, Fig. S2).

Three cohort studies aimed to use biochemically verified abstinence. One study found all participants reported smoking at the 3-month follow-up [9], and two did not report findings of verified abstinence [62,67]. Ten cohort studies reported self-reported abstinence [9,63–71]. Figure 4 presents abstinence rates (either self-reported or biochemically verified in all intervention and control groups) by longest follow-up length. Where studies had the same follow-up length, the average value was calculated for abstinence rates.

Behaviour change techniques

Inter-rater coding reliability was high, with an average agreement of 91% per intervention (range = 60–100%). Supporting information, Table S3 presents BCTs identified in each intervention arm in all studies. A total of 59 of the 93 BCTs from the BCTTv1 were identified within interventions at least once across all studies (Supporting information, Table S4). For control interventions (n = 27), only four BCTs were identified at least once (Supporting information, Table S5).

Focusing upon long-term effective interventions [39,43,48,49,51,59,61] only, five of the six interventions offered educational materials and counselling during the stay, in addition to pharmacological support and/or further behavioural support post-discharge. A total of 37 of the 93 BCTs were identified in at least one study. The number of BCTs identified ranged from five to 36, with an average of

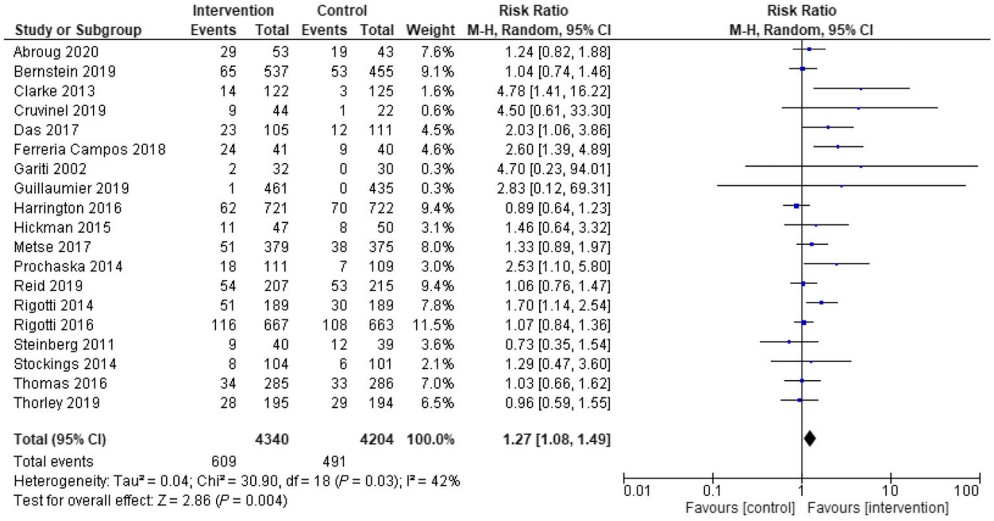

Figure 2 Comparison of biochemically verified abstinence at longest follow-up in randomized controlled trials (RCTs)

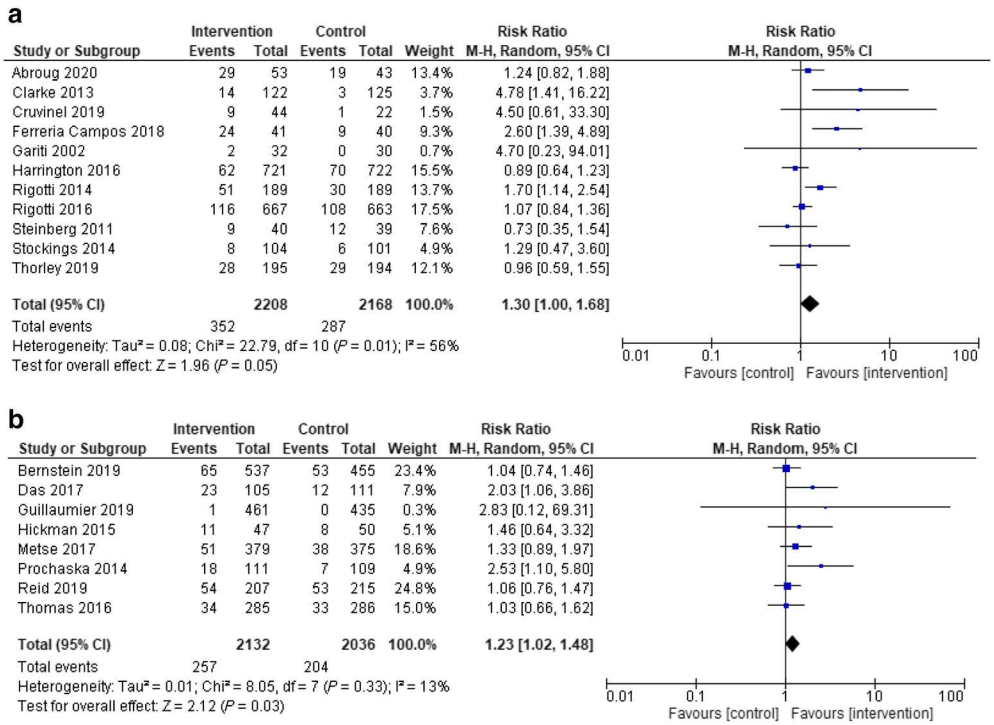

Figure 3 (a) Comparison of biochemically verified abstinence in randomized controlled trials (RCTs) with a follow-up length of below 6 months (range = 4 weeks–6 months). (b) Comparison of biochemically verified abstinence in RCTs with a follow-up length of above 6 months (range = 6.5 months–18 months)

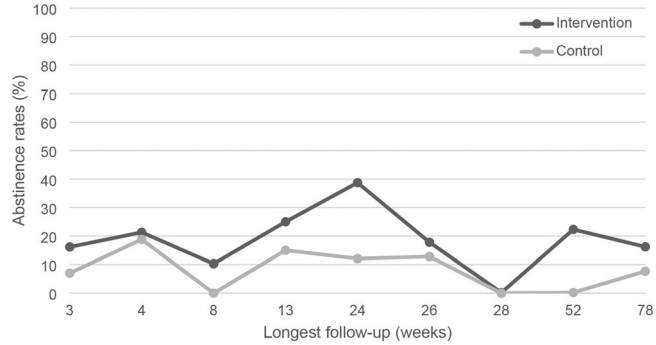

Figure 4 Abstinence rates (%) in all intervention and control arms (via self-report or biochemical validation), by longest follow-up length

10.7 BCTs per intervention. Table 1 presents the frequency of BCTs in all long-term effective interventions ($n = 7$). The most frequent BCTs were: 'goal-setting (behaviour)' ($n = 6$); 'pharmacological support' ($n = 6$); 'information about health consequences' ($n = 5$) and 'action planning' ($n = 5$). Similarly, the most frequent BCTs in control groups were: 'pharmacological support' ($n = 14$) and 'information about health consequences' ($n = 7$). Two control groups delivered 'social support (unspecified)' and one delivered 'problem-solving'.

Twelve BCTs were characterized as 'promising', or most likely to enhance effectiveness of interventions to maintain smoking abstinence (Table 1). Of those, nine were also delivered in ≥ 25% of all interventions, indicating their promise in terms of feasibility (Table 1).

Factors associated with/predictors of success or failure of post-discharge smoking interventions

Forty-two factors associated with/predictors of success and 17 factors associated with/predictors of failure were identified by study authors. Of those 59 predictors, 37 were non-modifiable (e.g. age, ethnicity, nicotine dependence, mental health diagnosis). Six were modifiable, but related to a behaviour, rather than an influence on a behaviour (e.g. the use of pharmacotherapy or behavioural support). These were not coded to the TDF, as only modifiable influences on a behaviour (e.g. barriers/enablers) were coded, rather than demographic factors or supporting behaviours.

The remaining 16 predictors were modifiable (e.g. plans to not smoke post-release or desire to quit), but four were

Table 1 Behaviour change techniques (BCTs) identified as 'promising' in terms of probable effectiveness and feasibility.

BCT label	*Definition (Michie* et al.*, 2013)*	*Example of BCT delivered*	*BCTs in long-term effective trials n (%); max n = 7*	*BCTs in all interventions n (%); max n = 37*
Pharmacological support	Provide, or encourage the use of or adherence to, drugs to facilitate behaviour change	Patients were offered NRT during hospitalization and were offered a 10-week course of NRT available at discharge (Das *et al.*, 2017)	6[a] (85.7)	31[b] (83.8)
Goal-setting (behaviour)	Set or agree on a goal defined in terms of the behaviour to be achieved	For smokers considering tobacco abstinence after hospital discharge, the counsellor conducted a standard assessment and helped the smoker to create a quit plan (Rigotti *et al.*, 2014)	6[a] (85.7)	27[b] (73.0)
Information about health consequences	Provide information (e.g. written, verbal, visual) about health consequences of performing the behaviour	Physician informed patients about the potential health risks of tobacco use and benefits of quitting (Politis *et al.*, 2018)	5[a] (71.4)	23[b] (62.2)
Action planning	Prompt detailed planning of performance of the behaviour	Participants repeated the computer intervention post-discharge, which recommended next steps towards smoking and maintaining abstinence (Das *et al.*, 2017)	5[a] (71.4)	22[b] (59.5)
Problem-solving	Analyse (or prompt the person to analyse) factors influencing the behaviour and generate or select strategies that include overcoming barriers and/or increasing facilitators	The counselling sessions provided stage-tailored strategies for managing temptations (Das *et al.*, 2017)	4[a] (57.1)	22[b] (59.5)
Instruction on how to perform the behaviour	Advise or agree on how to perform the behaviour (includes 'skills training')	At discharge, all participants received a pack of NRT and instructions for use (Metse *et al.*, 2017)	4[a] (57.1)	20[b] (51.4)
Social support (emotional)	Advise on, arrange or provide emotional social support for performance of the behaviour	Automated interactive voice response telephone calls provided support messages that prompted smokers to quit, and triaged smokers to a return telephone call from a live counsellor for additional support. The automated telephone script encouraged participants to request a call-back from a counsellor if they had low confidence in their ability to stay quit (Rigotti *et al.*, 2014)	4[a] (42.9)	19[b] (51.4)
Social support (practical)	Advise on, arrange or provide practical help for performance of the behaviour	Patients could request a call from a counsellor if they needed a medication refill, had problems with a medication or had stopped using medication (Rigotti *et al.*, 2014)	4[a] (42.9)	15[b] (40.5)
Social support (unspecified)	Advise on, arrange or provide social support or non-contingent praise or reward for performance of the behaviour. It includes encouragement and counselling, but only when it is directed at the behaviour	An initial motivational interview used the 5As method: ask about tobacco use, advise to quit, assess willingness to quit, assist towards a successful quit attempt and arrange follow-up (Politis *et al.*, 2018)	3[a] (42.9)	15[b] (40.5)
Feedback on behaviour	Monitor and provide informative or evaluative feedback on performance of the behaviour	Participants repeated the computer intervention post-hospitalization which stored their previous entries, providing ipsative feedback on how they changed over time (Das *et al.*, 2017)	2[a] (28.6)	8 (21.6)

(***Continues***)

Table 1. (Continued)

BCT label	*Definition (Michie* et al.*, 2013)*	*Example of BCT delivered*	*BCTs in long-term effective trials n (%); max n = 7*	*BCTs in all interventions n (%); max n = 37*
Pros and cons	Advise the person to identify and compare reasons for wanting (pros) and not wanting to (cons) change the behaviour	The counselling provided motivational enhancement and strategies for managing temptations, considering the pros and cons of change (decisional balance) (Das *et al.*, 2017)	2[a] (28.6)	7 (18.9)
Framing/ re-framing	Suggest the deliberate adoption of a perspective or new perspective on behaviour (e.g. its purpose) in order to change cognitions or emotions about performing the behaviour	Counsellors assessed the knowledge and beliefs of the participant, as well as the potential barriers to smoking cessation, explained the mechanisms of nicotine dependence and symptoms of withdrawal, and presented counter-arguments to belief barriers and discussed behavioural self-management strategies to counter triggers (Ferreira Campos *et al.*, 2018)	2[a] (28.6)	6 (16.2)
Information about antecedents	Provide information about antecedents (e.g. social and environmental situations and events, emotions, cognitions) that reliably predict performance of the behaviour	[c]	1 (14.3)	13 (35.1)
Avoidance/ reducing exposure to cues for the behaviour	Advise on how to avoid exposure to specific social and contextual/physical cues for the behaviour, including changing daily or weekly routines.	[c]	1 (14.3)	12 (32.4)
Social reward	Arrange verbal or non-verbal reward if and only if there has been effort and/or progress in performing the behaviour	[c]	1 (14.3)	10 (27.0)
Restructuring the social environment	Change, or advise to change the social environment in order to facilitate performance of the wanted behaviour or create barriers to the unwanted behaviour (other than prompts/cues, rewards and punishments)	[c]	1 (14.3)	10 (27.0)
Focus on past success	Advise to think about or list previous successes in performing the behaviour (or parts of it)	[c]	1 (14.3)	10 (27.0)
Prompts/cues	Introduce or define environmental or social stimulus with the purpose of prompting or cueing the behaviour. The prompt or cue would normally occur at the time or place of performance	[c]	1 (14.3)	10 (27.0)
Restructuring the physical environment	Change, or advise to change the physical environment in order to facilitate performance of the wanted behaviour or create barriers to the unwanted behaviour (other than prompts/cues, rewards and punishments)	[c]	1 (14.3)	9 (24.3)
Self-monitoring of outcomes of behaviour	Establish a method for the person to monitor and record their behaviour(s) as part of a behaviour change strategy	[c]	1 (14.3)	9 (24.3)

(***Continues***)

Table 1. (Continued)

BCT label	*Definition (Michie* et al.*, 2013)*	*Example of BCT delivered*	*BCTs in long-term effective trials n (%); max n = 7*	*BCTs in all interventions n (%); max n = 37*
Behaviour substitution	Prompt substitution of the unwanted behaviour with a wanted or neutral behaviour	[c]	1 (14.3)	7 (18.9)
Behavioural practice/ rehearsal	Prompt practice or rehearsal of the performance of the behaviour one or more times in a context or at a time when the performance may not be necessary, in order to increase habit and skill	[c]	1 (14.3)	6 (16.2)
Self-talk	Prompt positive self-talk (aloud or silently) before and during the behaviour	[c]	1 (14.3)	6 (16.2)
Information about social and environmental consequences	Provide information (e.g. written, verbal, visual) about social and environmental consequences of performing the behaviour	[c]	1 (14.3)	6 (16.2)
Self-reward	Prompt self-praise or self-reward if and only if there has been effort and/or progress in performing the behaviour	[c]	1 (14.3)	5 (13.5)
Reduce negative emotions	Advise on ways of minimizing demands on mental resources to facilitate behaviour change.	[c]	1 (14.3)	5 (13.5)
Body changes	Alter body structure, functioning or support directly to facilitate behaviour change	[c]	1 (14.3)	5 (13.5)
Identity associated with changed behaviour	Advise the person to construct a new self-identity as someone who 'used to engage with the unwanted behaviour'	[c]	1 (14.3)	5 (13.5)
Mental rehearsal of successful performance	Advise to practice imagining performing the behaviour successfully in relevant contexts	[c]	1 (14.3)	5 (13.5)
Imaginary reward	Advise to imagine performing the wanted behaviour in a real-life situation followed by imagining a pleasant consequence	[c]	1 (14.3)	5 (13.5)
Non-specific reward	Arrange delivery of a reward if and only if there has been effort and/or progress in performing the behaviour	[c]	1 (14.3)	5 (13.5)
Incompatible beliefs	Draw attention to discrepancies between current or past behaviour and self-image, in order to create discomfort	Counsellor presented counter-arguments to belief barriers (Ferreira Campos *et al.*, 2018)	1 (14.3)	3 (8.1)
Commitment	Ask the person to affirm or reaffirm statements indicating commitment to change the behaviour	[c]	1 (14.3)	3 (8.1)
Adding objects to the environment	Add objects to the environment in order to facilitate performance of the behaviour	[c]	1 (14.3)	3 (8.1)
Graded tasks	Set easy-to-perform tasks, making them increasingly difficult, but achievable, until the behaviour is performed	[c]	1 (14.3)	2 (5.4)
Social comparison	Draw attention to others' performance to allow comparison with the person's own performance.	[c]	1 (14.3)	2 (5.4)
	Provide information about what other people think about the behaviour. The	[c]	1 (14.3)	2 (5.4)

(***Continues***)

Table 1. (Continued)

BCT label	*Definition (Michie* et al.*, 2013)*	*Example of BCT delivered*	*BCTs in long-term effective trials n (%); max n = 7*	*BCTs in all interventions n (%); max n = 37*
Information about others' approval	information clarifies whether others will like, approve or disapprove of what the person is doing or will do			

[a]Indicates 'promising' BCTs in terms of probable effectiveness; [b]indicates 'promising' BCTs in terms of feasibility; [c]indicates BCTs identified in additional information provided by an author contacted by Brose *et al.* While these BCTs were identified, examples were either not provided by Brose *et al.* or not provided due to a confidentiality and non-disclosure agreement.

not reported in sufficient detail to enable coding and interpretation. For example, Hickman *et al.*, [47] identified thoughts about abstinence desire and success as a significant predictor of abstinence, but reported no further information. This could not be confidently coded based on the level of detail provided. The 12 modifiable factors associated with/predictors of success that could be mapped on to the TDF are presented in Table 2. All the predictors mapped onto the domains 'intentions', 'environmental context and resources' and 'goals' were modifiable enablers that were associated with a successful outcome. Conversely, the predictors that mapped onto the domains 'beliefs about consequences' and 'emotion' were modifiable barriers to smoking cessation.

Experiences, needs or perceptions related to smoking cessation support

Two cohort studies collected post-intervention data related to participants' perceptions or experiences of the intervention [62,67]. Bernard *et al.*, [62] reported that, overall, the intervention was perceived positively by participants. All participants were interested in receiving specific advice from health professionals regarding reduction strategies and nicotine replacement therapy (NRT), as well as to facilitate interactions with a peer: 'training partner for support is an advantage for coming in session'. Strong *et al.* [67] reported that the participants' experiences were positive, and the elements most frequently described as being helpful

Table 2 Factors associated with/predictors of success mapped onto the TDF.

Domain label	*Definition of domain (Michie* et al.*, 2014)*	*Frequency (n)*	*Study example*
Intentions	A conscious decision to perform a behaviour or a resolve to act in a certain way	7	The likelihood of successful smoking cessation was associated with a good motivation to quit ($P = 0.009$) (Abroug *et al.*, 2020)
Beliefs about consequences	Acceptance of the truth, reality, or validity about outcomes of a behaviour in a given situation	2	Perceived barriers to smoking cessation, primary among which were concerns about weight gain and urge management (Strong *et al.*, 2012
Environmental context and resources	Any circumstance of a person's situation or environment that discourages or encourages the development of skills and abilities, independence, social competence, and adaptive behaviour	1	Reid *et al.*, (2019) concluded that when support and access to cessation assistance was extended beyond hospital discharge, continuous abstinence was improve
Goals	Mental representations of outcomes or end states that an individual wants to achieve	1	Patients with non-abstinence related goals (83%) were more likely to return to smoking on the day of discharge compared to those who endorsed the goal of complete abstinence (58%, $P = 0.016$) (Prochaska *et al.*, 2006)
Emotion	A complex reaction pattern, involving experiential, behavioural and physiological elements, by which the individual attempts to deal with a personally significant matter or event	1	The perceived benefits of smoking cigarettes were significantly and positively correlated with endorsement of the first cigarette upon post-release as expressing freedom ($P = 0.048$). (Van den Berg *et al.*, 2014)

TDF = Theoretical Domains Framework.

were discussing techniques to quit or stay quit, receiving referrals and having a copy of the change plan worksheet completed by the therapist during the sessions.

Spontaneous comments collected during interviews in one cohort study [65] indicated that post-smoke-free policy patients found the hospital smoking ban acceptable, but many resented the mandatory nature of the nicotine treatment programme. Many participants reported limited support for smoking cessation post-discharge.

Three RCTs evaluated participant perceptions of an intervention that included post-discharge contact via text-messaging and telephone calls [41,57] or e-mail [46]. The majority of participants (80%) reported that the text message content was 'helpful', and 95% found telephone calls to be 'just the right length' [41]. Almost all participants (88%) recalled receiving e-mails, and approximately half stated that they read the e-mails [46]. However, 70 participants added text comments, whereby 40% were negative, for example, 'e-mails incessant' or 'don't use computer' [46]. Thorley *et al.* [57] reported that both home visits and follow-up behavioural support, either face-to-face or via telephone, were accepted by and delivered to $> 70\%$ of participants, and supportive telephone calls, texts and NRT by $> 50\%$. These components were considered helpful by the majority of participants, whereas uptake of referral to a local stop smoking service was very low ($< 2\%$).

One RCT collected data on the physician's perceptions of the E-STOPS intervention [38], an electronic support tool to enhance providers' treatment of adult smokers admitted to an acute hospital. Although a subset of physicians ($n = 21$) perceived the benefit of E-STOPS, they had specific suggestions for improvements (e.g. intervention timing and additional support and training). Furthermore, a few of the subset had concerns about the clinical appropriateness of beginning treatment for tobacco dependence during hospitalization.

DISCUSSION

This review identified 37 studies investigating the maintenance of smoking abstinence or cessation following a stay in a smoke-free setting. There was evidence to suggest behavioural and pharmacological interventions were effective for improving abstinence, and 12 BCTs were identified as 'promising' in terms of probable effectiveness. Generally, studies delivered fewer BCTs post-discharge/release than during the stay, with the exception of eight trials. These aimed to deliver a more complex intervention following discharge [41,42,50–52,54,55,58]. Factors associated with/predictors of success or failure of smoking cessation interventions were identified, building upon a previous review [7]. These findings provide valuable data for policymakers and settings that deliver smoking cessation support, offering guidance about effective support and training needed for delivery of effective services.

Although the BCT analysis provides evidence on which techniques are 'promising', it remains difficult to ascertain any definitive conclusions regarding which techniques are the most effective, as a meta-regression was not conducted. While a meta-regression was considered, this was discounted due mainly to the insufficient reporting of information by study authors [72]. Descriptions of the BCTs used in the published articles were often brief, and while efforts were made to retrieve further information, the full range of BCTs delivered may not have been captured in all studies. The number of BCTs that could be coded varied considerably between studies and was higher when additional information (e.g. intervention manuals) was provided by the study authors; a limitation also cited in previous smoking cessation reviews [7]. Secondly, subgroup analyses conducted in this review indicated less heterogeneity when the studies were separated by trial design, thus heterogeneity was accounted for [72]. Finally, the current BCT analysis approach has been successfully implemented in previous literature, including research relating to smoking cessation [20,36]. Although these previous studies included pregnant or postpartum participants, there was a commonality of potentially effective BCTs (e.g. 'problem-solving', 'information about health consequences' and 'social support'). Similarly, there is a commonality of potentially effective BCTs previously reported for the general population [73] and those with mental health conditions [7], suggesting that the BCTs identified in the current review as 'promising' in terms of probable effectiveness may be applicable to a range of populations.

The domains have been mapped to the BCT taxonomy [74], facilitating comparison between the domains and relevant BCTs. Several enablers of cessation (e.g. motivation and plans to not smoke) were mapped onto the 'intentions' domain. Intentions have previously been reported as important barriers and facilitators to smoking cessation [75], and a number of BCTs relating to goal-setting and action planning, which could potentially help strengthen one's motivation to quit, were identified in this review. Furthermore, one enabler was mapped onto the 'goals' domain. BCTs that target this domain include: 'goal-setting (behaviour)' and 'action planning' [74,76]. These were identified as 'promising' in this review, in terms of probable effectiveness and feasibility. Additionally, they have been previously associated with the effectiveness of behavioural support interventions for smoking cessation [21,36,73]. One enabler relating to support and access to cessation support after discharge was mapped onto the 'environmental context and resources' domain. BCTs that target this domain include 'prompts/cues' and 'avoidance/reducing exposure to cues for the behaviour' [74,76]. While these

BCTs were delivered in a number of interventions identified in this review, they were not characterized as 'promising'. This may, perhaps, explain why some interventions were less effective, as they did not include BCTs to target key enablers to cessation.

Conversely, barriers to cessation were mapped onto the 'beliefs about consequences' and 'emotion' domains. BCTs that target these domains include 'salience of consequences' and 'social support (emotional)' [74]. Although 'salience of consequences' was not identified as 'promising' in the current review, 'social support (emotional)' was identified as 'promising' in both terms of probable effectiveness and feasibility. Social support has been identified as a key component BCT in smoking cessation interventions [21,73], and is known to be a key facilitator in preventing relapse [77,78]. However, the magnitude of influence that social networks have on smoking behaviour requires complex action [79], and although social support was identified as 'promising', this was due probably to many studies involving support from smoking cessation specialists. A holistic approach may be required, incorporating a number of tailored techniques to involve a wider social network in the cessation process [77].

The current findings advance our understanding of the kind of behavioural and pharmacological support might be effective for smoking cessation following a smoke-free stay. The lack of evidence of a difference in abstinence rates between short- and long-term follow-up should also be noted. This may suggest that interventions that aim to maintain abstinence may function differently to standard cessation interventions as risk of relapse reduces over time and increased numbers of participants will have maintained abstinence during their stay, resulting in more stable effects earlier on [80]. Conversely, it is also possible that the presence of wide CIs may disguise the difference in abstinence rates between short- and long-term follow-up. Even in the absence of difference in the various follow-up periods, this does not provide information about the overall risk of relapse; given that if relapse rates are high but similar between groups, then RRs will remain consistent over time.

Future interventions to maintain abstinence might include BCTs focused on goal planning, pharmacological support and social support to maximize effectiveness. Aligning with the existing evidence base, these BCTs are often suggested to be necessary for treating nicotine dependence or developing a cessation plan [81]. However, even if interventions incorporate the same BCTs, implementation will differ in terms of mode of delivery, frequency, quality and adherence: factors that can all have an impact on the intervention outcomes. Considering all the included studies, it was unclear whether these characteristics related to the effectiveness of identified BCTs. Descriptions of intervention characteristics and fidelity-related issues were restricted; a limitation also noted in previous literature [82]. In addition, there was restricted information relating to participant compliance with smoke-free policies implemented during their stay. As it is well known that compliance can be limited and vary greatly between settings [83,84] this factor should be considered, as it may effect smoking behaviour post-discharge and subsequently have an impact upon intervention outcomes.

For continued smoking abstinence post-discharge/release, many of the studies found evidence for positive effects of education, counselling and pharmacological support, including those delivered remotely. Nearly half of all included studies ($n = 17$) delivered remote support, including computer-generated interventions or support via telephone call or text messaging. It is important to consider that some BCTs, however, may not be easily implemented remotely. For example, it would be possible to implement 'goal setting' remotely by requesting a participant to select a quit date [41], whereas other BCTs such as 'biofeedback' [57] could be challenging to deliver via an on-line platform as it requires biochemical verification. Although there have been emerging technologies and devices that enable participants to conduct biochemical assessments remotely [85,86], the cost of carbon dioxide (CO) monitors prohibits widespread remote application [87]. Previous research has also reported low compliance rates, as only 25% of participants who self-reported abstinence submitted CO readings remotely using a device that required connection to a computer to function [88]. Recently, affordable smartphone-enabled CO monitors have become available, which may offer one low-cost option to biochemically verify smoking status remotely [87], and would be useful to consider in the context of COVID-19-related research restrictions. Additionally, there has been an emergence of smartphone applications (app.) as popular aids for smoking cessation (e.g. the Smoke Free app.) [89]. As internet-based support has been found in some cases to aid cessation [90], smartphone apps can provide this functionality, with the added advantage of being readily accessible [89]. However, future interventions need to consider issues of implementation and acceptability within populations who may be difficult to engage with via on-line methods.

Development and provision of effective interventions to enable cessation or maintenance of abstinence after a smoke-free stay is crucial to address smoking-related inequalities in vulnerable groups of smokers [7]. Behavioural and pharmacological support is effective in maintaining smoking abstinence following a smoke-free stay, but those including BCTs focused upon goal planning, pharmacological support and social support appear to be the most promising. Future research should evaluate interventions in more diverse countries, policy settings and health and care settings to investigate the potential impact of these contextual differences.

Declaration of interests

L.S. is a HEFCE funded member of staff at University College London. He has received honoraria for talks, an unrestricted research grant and travel expenses to attend meetings and workshops from Pfizer and an honorarium to sit on advisory panel from Johnson&Johnson, both pharmaceutical companies that make smoking cessation products. He has acted as paid reviewer for grant awarding bodies and as a paid consultant for health-care companies. Other research has been funded by the government, a community-interested company (National Centre for Smoking Cessation) and charitable sources. He has never received personal fees or research funding of any kind from alcohol, electronic cigarette or tobacco companies. All other authors declare no conflicts of interest.

Acknowledgements

This study is funded by the National Institute for Health Research (NIHR) Programme Grants for Applied Research programme (reference: NIHR200607). The views expressed are those of the authors and not necessarily those of the NIHR or the Department of Health and Social Care.

Author contributions

Emily Shoesmith: Conceptualization; data curation; formal analysis; investigation; methodology; project administration. **Lisa Huddlestone:** Conceptualization; data curation; formal analysis; investigation; methodology; project administration. **Fabiana Lorencatto:** Data curation; formal analysis; methodology; supervision. **Lion Shahab:** Formal analysis; methodology; supervision. **Elena Ratschen:** Conceptualization; funding acquisition; investigation; methodology; project administration; resources; supervision; visualization.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Supplementary Table 1. Search strategies for all databases (adapted from Brose *et al.* (2018)).

Supplementary Table 2. Quality assessment of included studies.

Supplementary Table 3. Study characteristics.

Supplementary Table 4. Frequency of BCTs identified in all interventions, including RCTs, non-randomised designs and observational cohort studies.

Supplementary Table 5. Frequency of BCTs identified in all control interventions, including RCTs, non-randomised designs and observational cohort studies.

Supplementary Figure 1. Funnel plot of studies included in primary meta-analysis.

Supplementary Figure 2. Funnel plot of studies included in primary meta-analysis using the trim and fill method.

