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RESEARCH REPORT

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How do people quit smoking using e-cigarettes? A mixed-methods exploration of participant smoking pathways following receiving an opportunistic e-cigarette-based smoking cessation intervention

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Abstract

Background and Aims: Pathways of transitioning from tobacco smoking to vaping after receiving an e-cigarette-based smoking cessation intervention have been minimally explored. Study aims: 1) identify pathways between intervention delivery and final follow-up; 2) describe baseline and post-intervention statistical data in relation to smoking/vaping behaviour of the different pathway groups; 3) explore qualitative participant perspectives contextualising pathway groups.

Design: Embedded mixed-methods analysis of data collected for the Cessation of Smoking Trial in the Emergency Department (COSTED) randomised controlled trial.

Setting: Recruitment from 6 Emergency Departments (5 in England and 1 in Scotland) between January and August 2022.

Participants: 366 adult smokers who were randomised to receive the COSTED intervention and provided data at 6-month follow-up. Qualitative subsample of 24 participants interviewed after follow-up.

Interventions: Brief smoking cessation advice, provision of an e-cigarette starter kit and referral to the local Stop Smoking Service.

Measurements: Descriptive statistical reporting of identified pathways and smoking/vaping behaviour at baseline and 6-month follow-up. Semi-structured phone/video interviews analysed thematically.

Findings: 13.4% (n = 49) of participants quit smoking within 1 month of receiving the intervention, 19.1% (n = 70) quit between 1 and 6 months, 24.9% (n = 91) reduced cigarettes per day (CPD) by at least 50%, and 42.6% did not experience a significant smoking reduction. Approximately a third of participants who quit reported not vaping at follow-up. Reporting dual use was associated with a reduction in CPD. Appoximately a third reported experimenting with a different device to the one provided as part of the intervention. Quitters reported themes of satisfaction with vaping, changes in environment facilitating quitting and motivation to quit.

Conclusions: Dual use of cigarettes and e-cigarettes can result in a reduction of smoking and may prelude quitting smoking. Sustained e-cigarette use is not always necessary for quitting success. Success depends on personal context as well satisfaction with vaping.

KEYWORDS
e-cigarette, intervention, mixed methods, pathways, qualitative, smoking cessation, vaping

INTRODUCTION

There is high certainty evidence that e-cigarette (EC) based smoking cessation interventions are effective in trial settings [1]. Meta-analysis of EC trial data shows that 70% of participants who had quit by 6 months, were vaping at 6 months [2]. Yet there is very little published exploration of how cessation was achieved (or not) in the intervening period after being given an EC as part of an intervention. It is important to explore processes of change and participant pathways occurring in the time-period between intervention and final follow-up, because it provides insight into why and how the intervention is effective for some participants and not others, therefore, informing future implementation.

A naturalistic trial in the United States (US) where participants were sent an EC starter kit found that most intervention participants were dual using by 6 month follow up, although 14% had quit with approximately a third taking longer than 4 weeks [3]. Longitudinal qualitative research has also shown different routes to quitting, with some people switching straight away, whereas others have prolonged dual use [4]. Participants who were abstinent from tobacco discussed being motivated and confident to quit and were comfortable vaping, whereas those who relapsed to smoking only or dual use discussed vaping's inability to replicate and replace smoking. Survey research has consistently shown that those who manage to quit smoking via vaping tend to report higher satisfaction with vaping, whereas those who continue smoking tend to hold negative attitudes toward vaping and have more concerns about EC safety [5–10]. The available research provides an indication of reasons for pathways between initiating EC use and the various outcomes (continuing to smoke tobacco, dual using ECs and tobacco, exclusively using an EC or smoking neither an EC or tobacco), but there is limited research to date exploring pathways in the context of a trial where participants were opportunistically provided with an EC.

The COSTED RCT included an opportunistic smoking cessation intervention targeting people who smoke attending the emergency department (ED). The intervention was manualised [11] and consisted of (1) one-time brief stop smoking advice delivered by a dedicated smoking cessation advisor relating the importance of switching away from tobacco to the presenting condition and personal motivation to quit; (2) demonstration and provision of an EC starter kit including a 'pod device' ('DotPro', manufactured by an independent vaping company) and 11 pods with a choice of three flavours with the expectation that participants would purchase ongoing supplies; 3) a referral to the local National Health Service (NHS) Stop Smoking Service (SSS) [12]. The intervention was found to be effective with a biochemically verified quit rate of 7.2% in the intervention group compared to 4.1% in the control group (absolute difference = 3.3%, 95% CI = 0.3–6.3; $P = 0.032$). Self-reported 7-day abstinence at 6 months was 23.3% in the intervention group and 12.9% in the control group (absolute difference 10.6%, 95% CI = 5.86–15.41; $P < 0.001$) [13]. The process evaluation found the intervention to be feasible for implementation in the ED environment and broadly acceptable to staff and participants [14]. This article aimed to explore participant experiences following COSTED intervention delivery by meeting the objectives outlined below:

1. Identify COSTED participant smoking pathways between intervention delivery and final follow-up.
2. Describe baseline and post-intervention statistical data in relation to smoking/vaping behaviour of the different pathway groups.
3. Explore qualitative participant perspectives contextualising pathway group.

METHODOLOGY

The mixed-methods data drawn on to meet the objectives were collected as part of the COSTED trial [13]. The trial was approved by the United Kingdom (UK) National Research Ethics Committee-Oxford B (reference 21/SC/0288). The analyses were pre-specified in the COSTED Exploratory Statistical Analysis Plan (available on request).

Sample

Between January and August 2022, 1010 adult daily smokers (who vaped less than daily or not at all) were recruited from five EDs in England and one in Scotland (35 were accompanying people assigned to the same groups as the patients they accompanied were randomised into). A total of 505 people received the COSTED intervention. Participants were followed up at 1-, 3- and 6-months after recruitment. Only intervention participants who responded at 6 months follow-up were included in the analysis for this study, resulting in a quantitative sample of 366 participants. The qualitative component comprised 24 participants who took part in interviews as part of the process evaluation. The interviews were undertaken by P.B., E.W. and C.N., between October 2022 and March 2023. Interview participants were purposefully selected for the process evaluation so that they

represented demographic characteristics of the main study sample, were proportionally representative of number of participants recruited in each site and included representation from people who had quit, reduced or maintained cigarettes per day (CPD).

Procedure

Written consent to participate and baseline data were collected face-to-face in the ED by local site research teams on study recruitment and follow-up data were collected remotely via text at 1 and 3 months and texted/emailed survey link at 6 months (please refer to the protocol for detailed trial methodology [12]). Participants gave separate written consent for recorded interviews, which took place over phone/video call, median 8 weeks post follow-up. The interview guide was developed in consultation with patient and public involvement (PPI) representatives. The interviews explored not only participant perspectives on the acceptability and feasibility of the intervention components, but also vaping and smoking behaviour and motivations in the time-period between receiving the intervention and participating in the interview.

Analysis

Data were analysed using Stata 18 by A.C. and S.S. Descriptive statistics were presented for baseline variables (gender; age; ethnicity; index of multiple deprivation [15] [IMD]; Fagerstrom Test of Nicotine Dependence [FTND] [16]; Motivation to Stop Smoking Scale [MTSS] [17]; and EC use within 3 months before baseline yes/no [Y/N]) and 6 month follow-up variables (vaping frequency; purchased new EC over trial period Y/N; type of EC purchased; use of nicotine replacement therapy [NRT] over trial period Y/N; accessed stop smoking support Y/N; smoker in household Y/N; and change in MTSS scores). Descriptive statistics were organised by the four following participant smoking pathways identified as occurring between intervention delivery and final follow-up: 'rapid quitters', participants who quit smoking within 1 month of being recruited into the study; 'delayed quitters', participants who quit at some point after the first month since recruitment; 'tobacco reducers', participants who had a reduction in CPD by at least 50% since recruitment; 'tobacco non-reducers', participants who did not reduce their CPD by at least 50% since recruitment. These pathways warranted exploration and were chosen because of similar pathways being previously identified in the literature [4,5,18] (e.g. people who quit quickly vs those who took longer, people who reduced smoking) combined with thematic analysis undertaken as part of the process evaluation identifying potential differing characteristics and narratives of participants with these different smoking outcomes. E.W., P.B., I.P., A.C. and S.S. met to review the variables collected at 6 months with the objective of using them to define the four pathways and identify participants in each pathway group for analysis. The final pathway definitions agreed via consensus are reported in Table 1.

TABLE 1 Definitions of identified smoking pathway groups.

Group name	Definition	Data coded from 6-month follow-up[a]
Rapid quitters	Participants who quit smoking within 1 month of being recruited into the study	Participants reported being smoke free at 6 months and had not smoked in the last 7 days at 1 month, 3 months and 6 months
Delayed quitters	Participants who quit at some point after the first month since recruitment	Participants reported being smoke free at 6 months and had not smoked in the last 7 days at 6 months and had reported smoking at 1 or 3 months or did not reply at 1 or 3 months
Tobacco reducers	Participants who had a reduction in CPD by at least 50% since recruitment	Participants reported being smoke free at 6 months but having smoked in the last 7 days or smoking at 6 months having reduced their CPD by at least 50%
Tobacco non-reducers	Participants who did not reduce their CPD by at least 50% since recruitment	Participants reported not being smoke free and <50% reduction in CPD at 6 month follow-up or did not provide a figure for CPD at follow-up

Abbreviation: CPD, cigarettes per day.
[a]If participants did not provide data at 1 or 3 months a conservative approach was taken to assume smoking at those timepoints. Likewise, if participants did not provide CPD at 6 months, a conservative approach was undertaken to assume no reduction in smoking.

Interviews were transcribed verbatim and anonymised. Qualitative analysis involved writing detailed case summaries for each interview participant using structured theme headings following a detailed read-through of each interview transcript and amalgamating inductive thematic coding [19] already undertaken for the process evaluation using NVivo qualitative analysis software. The case summary deductive headings were developed so that they mapped onto the quantitative variables related to baseline factors (smoking history; vaping history; and motivation) and post-intervention factors (smoking behaviour; vaping behaviour; NRT; healthcare professional support; other support; and current motivation) allowing for participant centred explanations of survey data. The case summaries were grouped according to their pathway group and an interpretive analytical write up of themes was undertaken by E.W., triangulating with the quantitative data. The write up was shared with C.N. and P.B., who were familiar with the qualitative data set, and a consensus of theme validity was reached.

RESULTS

The characteristics of the quantitative sample and qualitative subsample are reported in Table 2.

Objective 1: Identify COSTED participant smoking pathways between intervention delivery and final follow-up

Pathways are reported in Table 3. Over half (n = 210, 57.3%) of intervention group participants (who provided data at 6 months) had quit or reduced smoking by 6-month follow-up. Most people who quit were delayed quitters and had quit after 1 month of receiving the intervention (n = 70, 19.1%).

TABLE 2 Profile of pathways study sample.

	Sample (n = 366)	Interview subsample (n = 24)
Male, No. (%)	221 (60.4)	14 (58.3)
Age (y), mean (SD)	41.7 (13.44)	42.6 (13.62)
IMD, mean (SD)[a]	4.4 (2.6)	5.1 (2.8)
Ethnicity, White British, No. (%)	269 (73.5)	17 (70.8)

[a]Index of Multiple Deprivation 2019 [15]—measures relative deprivation in small areas; indices of deprivation decile range from 1 to 10, with 1 being the most deprived and 10 being the least deprived.

TABLE 3 Proportion of sample by smoking pathway group.

Pathway group	Sample (n = 366)	Interview subsample (n = 24)
Rapid quitters	49 (13.4%)	5 (20.8%)
Delayed quitters	70 (19.1%)	2 (8.4%)
Tobacco reducers	91 (24.9%)	12 (50%)
Tobacco non-reducers	156 (42.6%)	5 (20.8%)

Objective 2: Describe statistical data in relation to smoking/vaping behaviour of the different pathway groups and Objective 3: Explore qualitative participant perspectives contextualising pathway group

Participant perspectives (objective 3) provide context to the descriptive statistics for each pathway group (objective 2) and are, therefore, discussed together in the Results section. For ease of interpretation, baseline and post-intervention factors are discussed in turn.

Baseline factors and participant perspectives

Table 4 shows the baseline descriptive statistics for each group. Rapid quitters were older on average than the other groups (mean age = 44.5) and had the lowest proportion of injury related presenting conditions (n = 11, 22.5%). Interview data suggested that having complex or multiple health conditions prompted participants to seriously consider the impacts of smoking. Rapid quitters also had the smallest proportion of people who had used an EC within 3 months before baseline (n = 11, 22.5%). Prior concerns raised by the interview participants about ECs included safety, cost, dependence and perceived complexity of vaping, and those with EC experience described vaping intolerances and dissatisfaction. The intervention being delivered in an NHS setting reassured interview participants about these vaping concerns.

Rapid quitters had the highest average motivation to stop smoking scores (mean = 4.6) and Tobacco non-reducers had the lowest (mean = 3.8). The most common motivations discussed in interviews were that the study presented an opportunity for distraction from discomfort or boredom while waiting in the ED, or that it offered a

TABLE 4 Baseline factors by smoking pathway group.

	Rapid quitters (n = 49)	Delayed quitters (n = 70)	Tobacco reducers (n = 91)	Tobacco non-reducers (n = 156)
Male, No. (%)	32 (65.3)	37 (52.9)	56 (61.5)	96 (61.5)
Age (y), mean (SD)	44.5 (13.9)	40 (13.4)	40.9 (13.1)	41.9 (13.5)
IMD[a], mean (SD)	4.6 (2.5)	4.4 (2.6)	4.1 (2.7)	4.5 (2.6)
White British, No. (%)	35 (71.4)	53 (75.7)	68 (74.7)	113 (72.4)
Motivation to Stop Smoking Scale, mean (SD)[b]	4.6 (1.7)	4.3 (1.4)	4.2 (1.6)	3.8 (1.7)
EC use 3 months before baseline, No. (%)	11 (22.5)	20 (28.6)	32 (35.2)	41 (26.3)
Fagerstrom test for nicotine dependence, mean (SD) [10][c]	4.8 (2.0)	4.7 (2.4)	5.3 (2.1)	4.8 (2.4)
Presenting condition at ED: injury (including laceration), No. (%)	11 (22.5)	29 (41.4)	37 (40.7)	59 (37.8)

Abbreviations: ED, emergency department; IMD, Index of Multiple Deprivation.
[a]IMD 2019 [14]—measures relative deprivation in small areas; indices of deprivation decile range from 1 to 10, with 1 being the most deprived and 10 being the least deprived.
[b]Motivation to Stop Smoking Scale [16], a single item measure scored between 1 and 7, with the higher the score indicating greater motivation.
[c]Fagerstrom Test of Nicotine Dependence [15], a six item measure, scored between 0 and 10, with the higher the total score indicating greater nicotine dependence.

non-committal switching attempt (e.g. 'nothing to lose'). Potential to improve finances was also discussed by some interview participants. Rapid quitters and delayed quitters had slightly lower baseline dependence scores on average compared to tobacco reducers or tobacco non-reducers. Interview participants, particularly from the tobacco reducer and tobacco non-reducer groups, described experiencing significant past or present mental health issues, with smoking perceived as a coping mechanism for stress. These results give some understanding of how baseline factors could have impacted on pathways, but given the similarities and overlap between the pathway groups, it is important to investigate factors intersecting with pathways post-intervention.

Post-intervention factors and participant perspectives

Table 5 shows the post-intervention quantitative factors collected at 6-month follow-up for each pathway group. Table 6 outlines the qualitative themes in each pathway group with case studies to illustrate common themes. The EC provided as part of the intervention at baseline is referred to in the text in the subsections below as the 'study EC'.

Rapid quitters

At 6-month follow-up, 58.1% (n = 25) of rapid quitters had vaped in the last 7 days. Rapid quitter interviewees who remained regularly vaping described how they needed to vape to avoid relapse, although they expressed a desire to quit vaping in the future. Rapid quitter interviewees credited their quitting success, in part, to finding the study EC very satisfying and easy to use. Approximately a third of rapid quitters had experimented with different devices during the trial period (*n* = 17, 34.7%). Rapid quitter interviewees discussed how difficulties accessing study EC consumables, rather than dissatisfaction with the device, had prompted them to purchase a new EC. Alongside finding the EC satisfying, rapid quitter interviewees described using successful distraction and tobacco avoidance strategies and over a quarter (*n* = 12, 27.3%) of rapid quitters had used NRT during the trial period. Interestingly, 21.9% (*n* = 9)

TABLE 5 Six-month follow-up self-reported post-intervention factors by smoking pathway group.

	Rapid quitters	Delayed quitters	Tobacco reducers	Tobacco non-reducers
Used EC in last 7 days, No. (%)	25 (58.1), *n* = 43	40 (64.5), *n* = 62	46 (53.4), *n* = 86	48 (34.0), *n* = 141
Frequency of vaping over last 6 months, No. (%)	*n* = 43	*n* = 61	*n* = 86	*n* = 109
No	7 (16.3)	12 (19.7)	11 (12.8)	18 (12.8)
Once a month	2 (4.7)	1 (1.6)	5 (5.8)	32 (22.7)
On 2–4 days a month	2 (4.7)	2 (3.3)	10 (11.6)	20 (14.2)
On 2–3 days a week	4 (9.3)	6 (9.8)	14 (16.3)	30 (21.3)
On 5–6 days a week	3 (7)	4 (6.6)	8 (9.3)	9 (6.4)
Daily	25 (58.1)	36 (59.0)	38 (44.2)	32 (22.7)
Purchased different EC during trial period, No. (%)	17 (34.7)	25 (35.7)	25 (27.5)	26 (16.7)
Type of EC purchased, No. (%)	*n* = 17	*n* = 25	*n* = 25	*n* = 26
Disposable	6 (35.3)	16 (64)	9 (36)	12 (46.2)
Refillable	1 (5.9)	2 (8)	6 (24)	3 (11.5)
Pod	6 (35.3)	1 (4)	4 (16)	3 (11.5)
Unknown	4 (23.5)	6 (24)	6 (24)	8 (30.8)
No. quit attempts, median (IQR)	–	–	1 (0–4)	2 (1–4)
MTSS score at 6 months, mean (SD)[a]	–	–	4.5 (1.64)	4.0 (1.55)
Change in MTSS scores: (outcome – baseline) positive value indicate higher at outcome, negative values higher at baseline	–	–	0.40 (2.05)	0.30 (1.78)
Smoking cessation support accessed in last 6 months, No. (%)[a]	11 (25.6), *n* = 43	5 (8.3), *n* = 62	21 (24.1), *n* = 86	16 (11.4), *n* = 140
NRT use in the last 6 months, No. (%)	12 (27.3), *n* = 44	10 (16.1), *n* = 62	20 (22.7), *n* = 88	32 (22.4), *n* = 143
Smoker in household, No. (%) (collected at baseline)	20 (40.8)	33 (47.1)	39 (42.9)	72 (46.1)

Abbreviations: EC, e-cigarettes; GP, general practitioner; IQR, interquartile range; MTSS, Motivation to Stop Smoking Scale; NHS, National Health Services; NRT, nicotine replacement therapy.

[a]MTSS [17], a single item measure scored between 1 and 7, with the higher the score indicating greater motivation.

[b]Smoking cessation support included contacting an NHS stop smoking service, GP or nurse, or a stop smoking helpline.

TABLE 6 Main qualitative themes and illustrative case study for each smoking pathway group.

Pathway group	Key themes	Case study
Rapid quitters (*n* = 5)	• High vape satisfaction • High motivation (often related to health) and confidence • Smoking cessation strategies • Strong support system • Changes in life circumstance supportive of quitting • Experimentation because of inaccessibility to pods	Case study 1: 'Lucy', age 61, 20 CPD to 0 CPD Lucy attended ED because of a severe allergic reaction, but also had other health conditions. She had tried a Cigalike EC many years ago and had not found it to be effective, causing her to be a little hesitant about using the study EC. Despite this, she tried the EC soon after discharge and to her surprise switched over straight away, stating her success with the vape being because of its usability; 'It was small, it's discreet. It's clean, it was easy to use'. She also credited her quit being because of improved mood and other healthier lifestyle changes as a result of an abusive relationship ending; she thought the intervention 'had come at the right time'. Lucy had quit by the time SSS contacted her so was ineligible for their support. Lucy had bought a similar pod device, but only because she had not been able to get replacement pods for the study EC. She had seen improvement to her health and at the time of interview she was vaping less than daily; 'I think gradually I do it less. There's not that sense of [gasps], I need a cigarette. You do not get that sense of [gasps], I need to vape'.
Delayed quitters (*n* = 2)	• 'Delayed trying' or 'gradual quit' (dual use) • High vape satisfaction • Smoking cessation strategies • Exposure to other smokers • Experimentation because of inaccessibility to pods, curiosity, and convenience	Case study 2: 'Jade', age 20, 25 CPD to 0 CPD Jade attended ED because of acute abdominal issues and admits that 'I really wasn't thinking about quitting at that time' but felt that she had nothing to lose by trying the study EC. Jade had tried various ECs in the past and was impressed by how the study EC compared; 'I got on perfectly fine with it, it's a great vape'. She managed to reduce to 3 CPD within 2 weeks, crediting this as being not only because of the EC, but also that recovering from her medical condition meant that she did not have as many smoking urges and was less exposed to other smokers socially. Jade turned down SSS when they contacted her because she did not want to use NRT. Unfortunately, Jade had a change in personal circumstances, which meant that she became homeless for a period and increased to 10 CPD;'I became homeless, I stayed smoking because I was so depressed'. She dual used for a period of ~5 months and then quit completely. She credits her success with moving to disposable ECs, which she found satisfying, using distraction and tobacco avoidance strategies and receiving support from family members.
Tobacco reducers (*n* = 12)	• Smoking to cope with stress and mental health • Smoking as part of routine • Dual use – 'gradual reduction' or 'relapse to reduction' • Not vaping – reduction because of NRT/life circumstance changes • Mixed vape satisfaction • Exposure to other smokers • Low perceived motivation	Case study 3: 'Abdul', age 31, reduced from 12 CPD to 6 CPD Abdul attended ED because of a significant mental health crisis. He had viewed smoking as essential to managing his mental health and was previously sceptical of vaping. He was not looking to quit, but the intervention reassured him about vaping and he thought he would try it to help with his finances. He quit straight after leaving hospital, liking vaping's convenience and replication of smoking. He does not recall SSS contacting him, but said that he would not have taken up support because of his poor mental health at the time. He stopped smoking for 4 months, but he struggled to find replacement pods, went through a period of work stress and started watching anti-vaping TikTok videos, triggering a relapse to 6 CPD. Despite the relapse, he commented that 'the desire to smoke as much as I did previously has diminished drastically'. He is currently dual using and is finding it hard to give up smoking at work. However, his mental health has improved and he believes that he will try and quit again in the future, crediting the study as giving him confidence; 'maybe there is a chance for me'.
Tobacco non-reducers (*n* = 5)	• Smoking because of boredom and stress • Three routes—'cessation of vaping upon initiation', 'relapse' and 'dual use for substitution' • Vaping dissatisfaction • Low motivation • Exposure to other smokers	Case study 4: 'Veronica', age 52, 15 CPD to 15 CPD Veronica attended ED because of a serious work injury to her leg. She had tried ECs in the past, but she had found they made her cough, and she was also concerned about EC safety. The study reassured her and she decided to take part primarily to help with the research. She tried the EC when she got home, but stopped vaping shortly after initiation; 'I did try it a few times, but I did not like it'. She turned down SSS support when they contacted her because she 'wasn't in the right headspace'. Veronica continues to smoke at the same level, primarily to help relieve the boredom of being off work waiting for an operation for her leg injury; 'being stuck in house, I've had nothing else to do'. She also reports finding it hard to cut down as she smokes with her partner who works

TABLE 6 (Continued)

Pathway group	Key themes	Case study
		from home. Veronica currently lacks motivation, but wants to stop as she knows it would be the best thing to do to improve the success of her operation. She is unsure about whether vaping is for her, and still hold some concerns; 'the perception I feel, is that they are on them all the time'.

Abbreviations: CPD, cigarettes per day; ED, emergency department; SSS, Stop Smoking Service.

rapid quitters had not used a vape, or had vaped monthly or less, over the trial period, indicating that the study EC had not been a major part of their quit attempt. This was the case for one rapid quitter interviewee who quit almost immediately following a lung cancer diagnosis with the assistance of NRT, although he credited the brief advice given as part of the intervention as contributing to the quit:

> 'I remember talking to the [COSTED] lady about stopping smoking and then obviously, 7 hours later, I got the diagnosis. The whole thing sort of combined into my consciousness. It made me think now is definitely the time to stop. [It] gave me that impetus […] I have not had a cigarette since the [diagnosis date]. I went on the nicotine lozenges.'
>
> (Male, 63)

A quarter of rapid quitters (n = 11, 25.6%) had accessed some form of stop smoking support within the last 6 months. Interviewees in this group stated that support was not needed because of quitting so quickly. Rapid quitters reported the lowest proportion of smokers in household (40.8%) and interviewees described being well supported by their family/friends. Changes in life circumstances supportive of quitting were also discussed (e.g. change of job, less stress). Rapid quitter interviewees commented that they remained highly motivated not to smoke and none reported a relapse. Developing an aversion to smoke was mentioned by interviewees, as was witnessing an improvement to health. Case study 1 presented in Table 6 provides an example of a rapid quitter, illustrating common themes of satisfaction with vaping, life circumstances supportive of quitting and strong quitting motivation.

Delayed quitters

Delayed quitters had the highest proportion of people who had vaped in the last 7 days at 6 month follow-up (n = 40, 64.5%). Interview data revealed two routes to delayed quitting; 'gradual quit' and 'delayed trying'. 'Gradual quit' refers to participants who dual used for a period while cutting down; this period of reduction did not necessarily occur linearly and could involve relapse, with smoking prompted by personal stress and/or smoking opportunity (see case study 2, Table 6). 'Delayed trying' refers to participants who put off trying the device for a lengthy period because of disinterest, but were then prompted to try it out of curiosity or not being able to access tobacco, leading to a full switch shortly after EC initiation (similar to instant quitters):

> 'My work tends to be quite stressful so I carried on smoking [for 3 months after being give the EC]. On the day of the Queen's funeral, I had run out of cigarettes the day before and obviously all the shops were closed. I turned my house upside down trying to find any of them […] I came across the bag, and I tried that off cold turkey and I went straight to the e-cigs, and I have not smoked a cigarette since that day.'
>
> (Male, 28)

Delayed quitter interviewees were surprised at the effectiveness of the study EC to satisfy cravings. Like the rapid quitters, a third of delayed quitters (n = 25, 35.7%) had purchased a different device during the trial period. Disposables were the most popular purchased device and delayed quitter interviewees cited a desire for experimentation and convenience as reasons for purchasing disposables.

A total of 21.3% (n = 13) delayed quitters had used a vape monthly or less, or not at all, in the last 6 months, indicating that they did not seriously try the study EC. A lower percentage of delayed quitters compared to rapid quitters had accessed stop smoking support in the last 6 months (n = 5, 8.3%) and used NRT (n = 10, 16.1%). Delayed quitters were the most likely to report a smoker in the household (n = 33, 47.1%) of all the groups. Delayed quitter interviewees discussed family members smoking and had encouraged them to switch to vaping. Alongside being satisfied with vaping, delayed quitter interviewees (like rapid quitter interviewees) had developed distraction and tobacco avoidance quitting strategies. Long-term health was not given as an intrinsic motivation, with delayed quitter interviewees describing convenience and financial savings of vaping as motivations.

Tobacco reducers

Just over half (n = 46, 53.4%) of tobacco reducers had vaped in the last 7 days at 6-month follow-up, indicating that sustained regular dual use was common for these participants. Interviews revealed two routes to dual use for this group: 'relapse to reduction' or 'gradual reduction'. Tobacco reducer interviewees who had experienced

'relapse to reduction' had managed to quit completely for a time but had relapsed, primarily because of stress (see case study 3, Table 6). At follow-up, tobacco reducers reported a median of one serious quit attempt in the past 6 months (interquartile range [IQR] = 0–4), indicating relapse was typical. Tobacco reducer interviewees who experienced a 'gradual reduction' followed a similar pathway to the delayed quitter interviewees who had experienced a 'gradual quit', but tobacco reducer interviewees were not able to relinquish the last few remaining cigarettes, perceiving them as necessary to deal with stress or an essential part of their routine:

> 'I started to use [study EC], but I did not really like the flavours of it very much. And so, I got a reusable vape and I've drastically cut down the amount that I'm smoking now […] When you are on a 24 hour shift and it's stressful sometimes, it's just nice to have a cigarette […] I'm hoping I'll be able to reduce it even more over-time. I'm hoping to be able to cut it out. But I think that's a very long-term goal.'
>
> (Female, 22)

Tobacco reducer interviewees reported mixed views of the study EC, with most appreciating its design and usability, but some finding the inhaled vapour from the device harsh on their throat. Interestingly, tobacco reducers included the lowest proportion of people who had purchased a different device in the last 6 months (*n* = 25, 27.5%). Disposable vapes were the most popular to experiment with. Tobacco reducer interviewees discussed using disposable vapes because of convenience, peer influence and a desire to experiment with flavours. A total of 19.3% (*n* = 16) of tobacco reducers had vaped monthly or less, or not at all, in the last 6 months, indicating that some participants reduced their smoking without becoming regular dual users. Tobacco reducers interviewees who had followed this route discussed dissatisfaction with vaping and vaping intolerances. They credited their reduction in smoking to NRT and/or a change in life circumstances reducing desire or opportunity to smoke:

> 'I was in hospital already for that heart problem. You've got somebody there that's standing in front of you telling you there's an option of giving up and here's a vape. Yeah, it was perfect for me […] [I tried it] about a week later and to tell you truth, I did not like the vape. I did not like it. I did not like the taste of it, I did not like it at all […] I think I started using the patches back in October. I had my heart replacement in September. You've got to try something.'
>
> (Female, 48)

A quarter of tobacco reducers had accessed stop smoking support in the last 6 months (*n* = 21, 24.1%) and a fifth had used NRT (22.7%). Tobacco reducer interviewees stated that they did not access support because they were not ready to quit or they wanted to try by themselves. Almost half lived with another smoker (*n* = 39, 42.9%) and this was discussed in the interviews as a barrier to quitting, as was being exposed to people who smoked either socially or at work. Most tobacco reducer interviewees discussed feeling supported by friends/family with examples of joint quit attempts and friends organically migrating to vaping. Like the quitter groups, some tobacco reducers experienced positive impacts of reducing on health or finances. However, motivation to stop smoking at follow-up had only slightly increased (+0.4) for tobacco reducers since baseline, despite the reduction in smoking. Smoking to cope with mental health problems was a common theme for the tobacco reducer interviewees. Most interviewees described struggling with certain smoking triggers or routines and held a belief about needing more 'willpower' to quit. Quitting smoking was discussed as a long-term goal.

Tobacco non-reducers

A total of 35.5% (*n* = 50) tobacco non-reducers had used an EC monthly or less, or not at all, in the last 6 months, indicating that they did not seriously try the study EC. At 6 month follow-up, tobacco non-reducers had the lowest proportion of participants compared to the other groups who had vaped in the last 7 days (n = 48, 34%). In the interviews, three routes were identified: 'cessation of vaping on initiation' where participants described stopping vaping shortly after EC initiation because they found the study EC tasted unpleasant or did not satisfy their cravings (see case study 4, Table 6); 'relapse' where participants quit for a short period and then relapsed because of stress or low motivation; and 'dual use for tobacco substitution' where participants used an EC instead of smoking in places where they could not smoke (perhaps resulting in a slight reduction in number of cigarettes smoked):

> 'I used it quite a lot at work instead of smoking. I start work at five o'clock in the morning so there's not shops open to buy cigarettes anyway. It saved me money for when I was at work.'
>
> (Female, 28)

The three routes were not necessarily mutually exclusive. Only 16.7% (*n* = 26) of Tobacco non-reducers purchased an alternative vape during the trial period and of those that did purchase a different device, disposable vapes were the most popular.

A total of 11.4% (*n* = 16) of tobacco non-reducers had accessed stop smoking support in the last 6 months, but almost a quarter (*n* = 18, 22.4%) had used NRT in the last month. None of the tobacco non-reducers interviewed had engaged with stop smoking support or used NRT, stating that it 'wasn't the right time' to proactively quit. They stated that they wanted to quit eventually, with some discussing planning to access support in the future. Tobacco non-reducers were more likely to report living with a smoker (*n* = 72, 46.1%). Tobacco non-reducer interviewees did not mention support from family and friends. Average motivation to stop smoking had only increased very slightly since baseline (+0.3) for tobacco non-reducers and

interviewees discussed a current lack of intrinsic motivation as a barrier to quitting, with stress cited as the main reason for continuing to smoke:

> 'I used the kit for a few days. The problem I have is I live on my own and I work from home. So therefore, there's a lot of isolation which also brings on all the anxiety attacks. I was fighting that […] [Smoking's] a bit of a crutch, it's like having a drink. It will not solve the problem but it will help at the time.'
>
> (Male, 62)

Despite the lack of motivation, tobacco non-reducers reported a median of 2 (IQR = 1–4) serious quit attempts in the past 6 months. Boredom, stress and opportunities to smoke were discussed by interviewees as preventing quitting success.

DISCUSSION

This study triangulated mixed methods process evaluation data to explore different pathways from intervention to outcome, following participating in an opportunistically delivered EC smoking cessation trial delivered in ED. Some quitters stopped smoking soon after intervention delivery, but more commonly, quitters took longer than 1 month to stop smoking. Some quitters switched almost immediately after initiating EC use, whereas others relapsed before quitting or gradually cut down, experiencing a period of dual use. This contradicts the commonly held notion that quitters must abruptly stop smoking completely, rather than cut down, to successfully quit in the long-term, (which supports findings of tobacco harm reduction interventions [3,20,21]). Instead, dual use may be a slower pathway to cessation for some people, rather than a negative outcome. A different approach than traditional smoking cessation support may need to be adopted for quitting with ECs, incorporating support and advice on how to switch (as was provided by the COSTED intervention). SSS could promote engagement and encourage sustained motivation to quit rather the focussing on short-term outcomes.

The mixed methods evidence presented suggests that those who were older, more motivated by health concerns and less experienced with ECs might be particularly receptive to a hospital-based EC intervention. Vaping naivety may be linked to rapid quitting success because people would not have had the previous opportunity to test whether vaping could work for them, or they may have only tried older, less effective devices. Many participants who quit in this trial, however, did not necessarily have significant health needs or a lack of prior vaping experience and were not particularly distinguishable from the participants who did not quit in terms of baseline factors, indicating that other factors following intervention delivery contribute to different outcomes.

Approximately a fifth of participants who quit or reduced smoking had used an EC monthly or less, or not at all, during the trial period. Our qualitative data suggests that the quit or reduction for these participants was instead in part because of a change in circumstances reducing opportunities or the desire to smoke. In addition, the brief advice given in the ED as part of the intervention had brought awareness to their smoking, had built quitting confidence and, in some cases, prompted the seeking of additional stop smoking support. Other participants, who found success with ECs, reduced their vaping frequency over the trial period. This finding, that not everyone who is given an EC and quits smoking will become a long-term regular vaper, has important implications for initiatives such as Swap to Stop [22] where large numbers of people will be encouraged to use vaping to support a smoking quit attempt. Nevertheless, just under two thirds of the quitters were still vaping at follow-up (similar to vaping rates shown in other EC trials) [2], and a higher proportion of quitters reported vaping daily compared to other groups, indicating that sustained EC use can be beneficial for relapse prevention.

Although the trial intervention was overall effective for smoking cessation [13], following EC initiation most participants relapsed to smoking or dual used (in keeping with other observational [23] and trial research [1,3]). Dual use was associated with a reduction of smoking, and although both pathway groups who were still smoking discussed stress and opportunity to smoke as being key drivers for their continued smoking, those who had reduced their smoking discussed more satisfaction with vaping. The small number of dual users who did not reduce CPD may have been vaping to enable nicotine use in places they could not smoke (substitution) rather than attempting to reduce or quit smoking; previous research has indicated that although dual use may perpetuate continued tobacco use, some people with this usage pattern may find themselves unintentionally reducing smoking overtime and eventually quitting [24]. Some of the dual users could, therefore, potentially be on a pathway to stopping smoking completely, like those quitters who had gradually quit following a period of dual use, highlighting the importance of longer-term follow-up in EC trials.

Vape satisfaction is a key factor in quitting success using ECs [4–10], and although the study EC was generally well received by quitters (following a lengthy PPI process to select the most appropriate device [25]), approximately a third of the quitters had purchased a different device over the trial period. This indicates that vape experimentation may aid quitting even when provided with a starter kit, supporting the importance of commercial routes to vaping alongside healthcare options [26]. Disposable vapes were the most popular type of device purchased reflecting wider purchasing patterns [27], with participants discussing buying them because of convenience and a desire to experiment with different flavours. Psychosocial (non-vaping related) factors were also important. Supporting previous research,[4,24,] participants who managed to maintain a quit at follow-up, compared to those that were smoking, perceived themselves to have strong intrinsic motivation, able to use other quitting strategies and be in an environment that was more conducive to quitting. For those who do not manage to quit or reduce following being given an EC, more intensive support targeting psychosocial factors may be useful, alongside further EC experimentation to find a satisfying device.

Strengths and limitations

A strength of this research is that the trial provided a large quantitative sample across different sites in England and Scotland, allowing for investigation of participant EC pathways rarely explored following opportunistic intervention delivery. There were missing data at 6-month follow-up from 27% of the intervention group sample that were lost to follow up, however, this resulted in smaller pathway group sizes, limiting analysis. Participants providing data at 6 month follow up differed slightly on certain characteristics to those who did not provide data at 6 month follow up (namely, slightly younger on average and a higher proportion of males than other groups) (Supporting Information, Appendix S1). It should be noted, however, this is an exploratory study designed to illuminate possible pathways following intervention delivery and the sample (including interview subsample) did include representation of the full range of characteristics.

The 6-month follow-up questionnaire was primarily designed to test efficacy and effectiveness of the intervention, rather than gather information on participant trajectories. Despite this, the breadth of quantitative data collected allowed for a broad analysis of smoking/vaping behaviour occurring during the trial period. To conduct an in-depth analysis of participant pathways, it would have been useful to collect quantitative data on length of time between being given the study EC and initiation, the total number of days the device was used in the trial period, the frequency the device was used during the day, the type of retailer used to purchase vaping products and information about vaping cessation. Data collected relied on retrospective reporting by participants, which could have impacted on the accuracy of the data. Future research could use Ecological Momentary Assessment (EMA) methods on a subsample of trial intervention participants to explore participant behaviour in 'real time'.

A strength of the study was the use of the qualitative data to contextualise the quantitative findings to provide an in-depth insight into participant pathways. However, qualitative findings are not necessarily generalizable to the wider sample or population. In addition, the primary focus of the interviews was to gather data about feasibility of the intervention as part of the process evaluation rather than reflections on pathways (although this was included in the topic guide), therefore, participants were not purposefully sampled by pathway group, leading to uneven numbers in each group. Despite these limitations, the themes generated are supported by previous qualitative research.

Conclusion

This study offered unique mixed methods exploration of a rarely investigated, but important, aspect of smoking cessation RCTs and participant pathways between intervention delivery and follow-up. The study showed that there were a variety of routes to quitting success, with the intervention working for participants in different ways. For example, an opportunistically delivered EC intervention can provide some people with the confidence to try an EC, find it satisfying and switch straight away, whereas others may have more reservations and dual use for a period or relapse before achieving success. Therefore, those engaging with opportunistic EC interventions may be less receptive to traditional approaches (e.g. setting a quit date), and targets and measured outcomes may need to be adapted to reflect the different routes to quitting. Those with less recent experience with ECs seemed particularly receptive to the intervention, demonstrating the importance of opportunistic approaches in medical settings in reaching people who would not normally engage with SSS or vape shops. The study indicated that some people who receive brief advice and an EC will go on to quit without using the EC, and others will reduce their vaping significantly within a few months, suggesting that sustained nicotine dependence is not an outcome for everyone who is provided with an EC to support quitting. However, it is important to recognise that for some, longer-term EC use may be a desirable outcome because it potentially prevents relapse to smoking. Context is more influential for some participants than others, with exposure to other smokers, perceived stress and personal motivation reported as being as important to quitting success as satisfaction with vaping. Future EC interventions could incorporate a relapse prevention component to support participants within their personal context.

AUTHOR CONTRIBUTIONS

Emma Ward: Data curation (equal); formal analysis (lead); investigation (supporting); methodology (lead); project administration (equal); supervision (equal); visualization (lead); writing—original draft (lead); writing—review and editing (lead). **Pippa Belderson:** Data curation (equal); formal analysis (supporting); investigation (equal); methodology (supporting); project administration (supporting); supervision (supporting); visualization (supporting); writing—original draft (supporting); writing—review and editing (supporting). **Allan Clark:** Data curation (lead); formal analysis (supporting); methodology (supporting); software (lead); visualization (supporting); writing—original draft (supporting); writing—review and editing (supporting). **Susan Stirling:** Data curation (supporting); formal analysis (supporting); methodology (supporting); visualization (supporting); writing—original draft (supporting); writing—review and editing (supporting). **Lucy Clark:** Project administration (lead); resources (lead); supervision (equal); writing—original draft (supporting); writing—review and editing (supporting). **Ian Pope:** Conceptualization (lead); formal analysis (supporting); funding acquisition (lead); methodology (supporting); project administration (lead); supervision (lead); writing—original draft (supporting); writing—review and editing (supporting). **Caitlin Notley:** Conceptualization (lead); formal analysis (supporting); funding acquisition (lead); methodology (supporting); project administration (equal); supervision (lead); writing—original draft (supporting); writing—review and editing (supporting).

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DECLARATION OF INTEREST

We declare no competing interests. The EC and pods used in the trial were DotPro produced by independent vaping company Liberty Flights and were purchased at wholesale price. Liberty Flights had no role in the study design, data collection, data analysis, data interpretation or writing of this manuscript.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

CLINICAL TRIAL REGISTRATION

ClinicalTrials.gov NCT04854616.

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SUPPORTING INFORMATION

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

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