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Vaping and socioeconomic inequalities in smoking cessation and relapse: a longitudinal analysis of the UK Household Longitudinal Study

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► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/tc-2022-057728).

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Received 31 August 2022
Accepted 21 March 2023

ABSTRACT

Background Smoking is a key cause of socioeconomic health inequalities. Vaping is considered less harmful than smoking and has become a popular smoking cessation aid, and therefore has potential to reduce inequalities in smoking.

Methods We used longitudinal data from 25 102 participants in waves 8–10 (2016 to early 2020) of the UK Household Longitudinal Study to examine how vaping affects socioeconomic inequalities in smoking cessation and relapse. Marginal structural models were used to investigate whether vaping mediates or moderates associations between educational attainment and smoking cessation and relapse over time. Multiple imputation and weights were used to adjust for missing data.

Results Respondents without degrees were less likely to stop smoking than those with a degree (OR: 0.65; 95% CI 0.54–0.77), and more likely to relapse (OR: 1.74; 95% CI 1.37–2.22), but this inequality in smoking cessation was not present among regular vapers (OR: 0.99; 95% CI 0.54–1.82). Sensitivity analyses suggested that this finding did not hold when comparing those with or without any qualifications. Inequalities in smoking relapse did not clearly differ by vaping status.

Conclusions Vaping may be especially helpful as a cessation aid for smokers without degree level education and therefore may help reduce inequalities in smoking. Nevertheless, other supports or aids may be needed to reach the most disadvantaged (ie, those with no qualifications) and to help people avoid relapse after cessation, though we did not find clear evidence suggesting that vaping would increase inequalities in relapse.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Socioeconomic inequalities in smoking cessation have narrowed in recent years since e-cigarettes have become more widely available as a cessation aid.
⇒ It is not clear whether this was as a result of increased vaping or other due to other confounding factors.
⇒ Existing research on vaping and socioeconomic inequalities in smoking cessation has been limited to using cross-sectional data.

WHAT THIS STUDY ADDS

⇒ Using longitudinal data, over 2 years of follow-up, our study suggests that vaping may reduce socioeconomic inequalities in smoking cessation, as smoking cessation is less strongly associated with having degree level education among regular vapers.
⇒ However, sensitivity analyses suggested that this finding did not hold when comparing those with or without any qualifications.
⇒ We did not find clear evidence to suggest that vaping would adversely affect inequalities in smoking relapse.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Vaping regulations should consider that it may have a net positive impact on inequalities in smoking cessation, without adversely impacting on inequalities in smoking relapse.
⇒ However, other aids may still be needed for the most disadvantaged and to help people avoid smoking relapse.

INTRODUCTION

Smoking is a leading cause of ill health and contributes substantially to socioeconomic health inequalities.[1–4] E-cigarettes (ie, vaping products) offer an alternative nicotine delivery method to smoking. They are currently the most popular smoking cessation aid in England, used by around 6% of adults.[1] While the long-term health consequences remain unknown, vaping is now widely considered to be markedly less harmful than smoking.[5 6] Some research suggests that vaping may be associated with increased rates of smoking cessation,[1 7–9] and may be a more effective cessation aid than nicotine replacement therapy.[10] However, recent meta-analysis suggests that while e-cigarette provision as a therapeutic intervention was associated with increased smoking cessation in randomised controlled trials, e-cigarette use as a consumer product was not associated with smoking cessation in observational studies.[11] Moreover, current evidence suggests that, among ex-smokers, vaping may increase smoking relapse risks.[12 13] The frequency of e-cigarette use and the type of device used is also consequential, as some research suggests that those vaping less frequently and/or using less advanced devices are less likely to quit smoking/more likely to relapse.[9 14]

One important aspect of e-cigarette usage relates to its impacts on socioeconomic inequalities. Smoking cessation has tended to be less likely for smokers in a more disadvantaged socioeconomic position (SEP), with disadvantaged smokers being less likely to quit/more likely to relapse, but not less likely to want to quit.[15–19] Theoretically, e-cigarettes

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To cite: Hardie I, Green MJ. *Tob Control* Epub ahead of print: [*please include* Day Month Year]. doi:10.1136/tc-2022-057728

may potentially reduce this socioeconomic inequality if they can make smoking cessation more accessible for disadvantaged smokers, but conversely may widen inequalities if vaping exposes disadvantaged ex-smokers to increased relapse risk.[20 21] Importantly, inequalities in smoking cessation have narrowed recently since e-cigarettes have become more widely available,[22] though it is not clear whether this occurred because of increased vaping or other confounding factors.

Current evidence on the impact of vaping on socioeconomic inequalities in smoking cessation/relapse is fairly limited. One review suggests e-cigarette ‘awareness’, ‘ever use’ and ‘current use’ are patterned by a range of sociodemographic factors, but that overall there is a lack of a clear pattern in these outcomes with regard to SEP, particularly in high-quality studies.[23] US data suggest that socioeconomic inequalities in smoking cessation remained unchanged from 2014 to 2019 and that attempts to quit via vaping were higher among those in higher SEP groups.[24] Conversely, data from England suggest that e-cigarette use increased for all SEP groups from 2014 to 2019 but was highest among those from lower SEP groups.[21] Finally, UK cross-sectional research suggests that socioeconomic inequalities in smoking cessation were weaker among those who vaped.[20] This highlights that, while more research is needed, e-cigarettes may potentially narrow health inequalities by helping disadvantaged smokers to quit, and suggests that vaping may have contributed to the recent reduction in inequalities in smoking cessation in the UK.[22]

The interplay between vaping and smoking can be complex, involving, for example, patterns of dual use (with or without intentions to quit smoking), switching fully from smoking to vaping or using vaping as a ‘stepping stone’ to stop smoking and eventually cease nicotine use.[1 25–27] However, since smoking is considered far more harmful than vaping,[5 6] inequalities in smoking are of more critical public health importance. With the potential both for inequalities in vaping behaviour and for effects of vaping on cessation and relapse rates it may be helpful to frame the issue in terms of whether vaping mediates or moderates inequalities in smoking cessation/relapse. Importantly, ‘mediation’ could include ‘suppression’ effects,[28] where, for example, vaping might be more common among disadvantaged smokers and might help them quit, thus leading to narrower inequalities in cessation than would be present without access to e-cigarettes. Even without inequalities in vaping, it is possible that vaping could impact inequalities in smoking if it moderates associations between SEP and cessation/relapse.[29]

The aim of this study is to assess whether vaping mediates or moderates socioeconomic inequalities in smoking cessation/relapse. Specifically, the following research questions (RQ) are addressed over 2 years of follow-up:

RQ1: Among current smokers:

a. Is SEP associated with vaping?
b. Is vaping associated with smoking cessation?
c. Is SEP associated with smoking cessation?
d. Does vaping mediate or moderate associations between SEP and smoking cessation?

RQ2: Among ex-smokers:

a. Is SEP associated with vaping?
b. Is vaping associated with smoking relapse?
c. Is SEP associated with smoking relapse?
d. Does vaping mediate or moderate associations between SEP and smoking relapse?

METHODS

Data and sample

Analyses used longitudinal data from waves 8–10 of the UK Household Longitudinal Study (UKHLS), a nationally representative household panel study based on a clustered-stratified probability sample of ~40 000 UK households.[30] UKHLS data collection began in 2009–2011, and individuals from the same households are interviewed annually face-to-face or online. Our analysis primarily used wave 8 (2016–2018), wave 9 (2017–2019) and wave 10 (2018–2020) data, although some information from earlier waves was used where applicable (see below). Waves 8–10 were selected as they included more detailed categorisations of vaping status than previous waves, and are the most recent waves which were unaffected by the COVID-19 pandemic. Details of UKHLS response rates are available online.[31]

Using smoking status at wave 8 as a baseline, smoking cessation/relapse was then measured over the following 2 years (waves 9–10). UKHLS respondents were included in our analysis if they met the following inclusion criteria: (1) were interviewed at wave 8, (2) had a valid, non-missing wave 8 weight and (3) had data on smoking status at wave 9 or 10. This gave a final primary sample of 25 102 individuals (see online supplemental appendix A for details of sample size/exclusions/missing data). All analyses were conducted using Stata/MP V.17.0. Wave 8 weights were applied to adjust for survey design/non-response, and we applied additional weighting using baseline variables for having smoking data at waves 9 and 10. Item non-response was dealt with via multiple imputation, using chained equations,[32] with 50 imputations added (see online supplemental appendix A for details of missingness across variables).

Measured variables

Our sample was stratified by baseline (wave 8) smoking status (1=never smoker, 2=ex-smoker, 3=current smoker). Respondents were categorised as current smokers if they self-reported being a smoker at wave 8. Those who self-reported being a smoker in earlier wave(s), or historic daily smoking, were categorised as ex-smokers. Remaining respondents were categorised as never smokers. Outcomes were binary indicators measuring: (1) smoking cessation by wave 9 or 10 among wave 8 smokers (0=no, 1=yes), and (2) smoking relapse by wave 9 or 10 among wave 8 ex-smokers (0=no, 1=yes). Our main exposure variable, SEP, was represented using educational attainment (0=degree, including higher degree/first degree or equivalent/diploma in higher education/teaching or nursing qualification, 1=no degree). Wave 8 self-reported regular (ie, at least weekly) vaping status was defined as a mediator (0=not regular vaper, 1=regular vaper).

Causal relationships between SEP, vaping and smoking cessation/relapse are complex, with various potential confounders at different stages of the causal pathway (see figure 1). Consequently, our analysis included a list of: (1) exposure-outcome (and exposure-mediator) confounders, that is, potential determinants of both exposure (wave 8 SEP), mediator (wave 8 vaping) and outcome (smoking cessation/relapse at wave 9 or 10); and (2) mediator-outcome confounders, that is, potential determinants of both mediator (wave 8 vaping) and outcome (smoking cessation/relapse at wave 9 or 10), some of which may have been caused by the exposure (wave 8 SEP). Since these groups of variables have different roles in the causal pathway they were treated differently in our analysis (see the statistical analysis section).

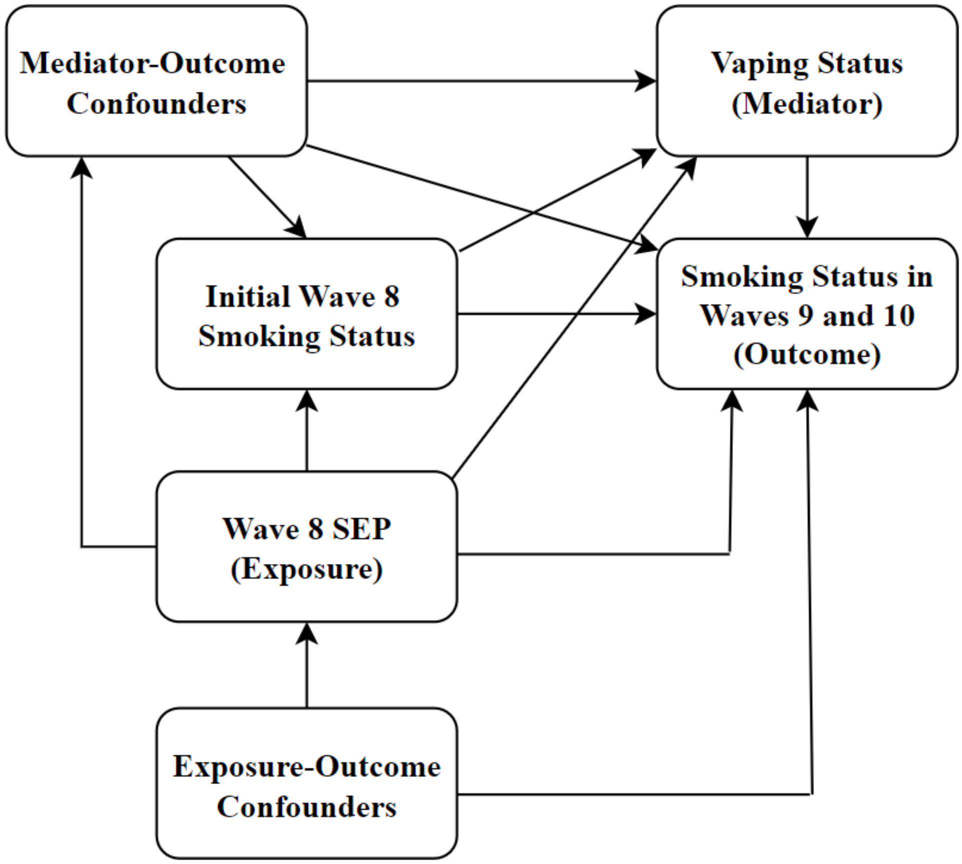

Figure 1 Causal diagram of the relationship between SEP, vaping and smoking cessation/relapse.

Exposure-outcome variables were: sex (0=male, 1=female), age group (1=16–24, 2=25–34, 3=35–44, 4=45–54, 5=55+), UK country (1=England, 2=Wales, 3=Scotland, 4=Northern Ireland), ethnicity (0=white, 1=non-white) and rurality (0=rural, 1=urban). Mediator-outcome variables were: partner status (0=in couple, 1=single), has kids (0=no, 1=yes), housing tenure (0=owner, 1=renter), National Statistics Socio-economic Classification (NSSEC) (1=management/professional, 2=intermediate, 3=routine, 4=not in paid employment), has longstanding illness (0=no, 1=yes), vaping history (0=does not vape at all at wave 7, 1=vapes at all at wave 7), mental health (measured by General Health Questionnaire (GHQ)) (1=GHQ <4, 2=GHQ 4+), poverty status (0=not in poverty, 1=in poverty), age started smoking (0=0–15, 1=16–18, 2=19–25, 3=>25) and smoking history, that is, mean number of cigarettes per day across waves or when last smoked regularly (0=0–10, 1=11–20, 2=>20). With the exception of the vaping and smoking history variables, all exposure-outcome/mediator-outcome variables were measured at wave 8 (or wave 7 if wave 8 data were missing).

Statistical analysis

Our analysis plan was preregistered using Open Science Framework (available: https://osf.io/e3z8q). Our reporting is consistent with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (see online supplemental appendix B). First, we used logistic regression to estimate unadjusted associations between the variables of interest in each RQ. These unadjusted associations may be subject to collider bias,[33 34] because the data are stratified by wave 8 smoking status, which is potentially determined by both (1) the exposure variable and (2) other variables determining cessation/relapse. This is shown in figure 1.

Second, to account for this, we used inverse probability weighted marginal structural models to estimate controlled direct effects (CDE) of SEP on smoking cessation/relapse, controlling for observed confounding, including mediator-outcome confounders that are affected by the exposure.[35] The CDE represents the effect of the exposure, with mediators set to a particular level (eg, setting wave 8 status to either current smoking or ex-smoking, and to either regular vaping or not regular vaping). Weights were calculated within each imputed data set and final results were aggregated across imputed data sets using Rubin's rules.[32] These models aim to remove any imbalance of observed confounders across exposure levels that is not caused by the exposure. CDE estimates account for interactions between the exposure and the mediators and may therefore vary depending on the values mediators are set to.[35] As explained below, some of our CDE estimates treat wave 8 smoking status as the only mediator, so provide estimates with wave 8 smoking set to either current smoking or ex-smoking (to get separate estimates for cessation and relapse). Later estimates include vaping as an additional mediator and compare estimates with vaping set to regular or not regular vaping. We estimate effects across two waves of follow-up using a discrete-time, event history approach, with up to two rows of data for waves 9 and 10; the wave 10 row is censored if cessation/relapse occurs at wave 9. Thus, ORs can be interpreted as the hazard or risk of cessation/relapse in a given year if this has not already occurred.

For part (a) of our RQs (Is SEP associated with vaping?), we created a weight to estimate the CDE of education with wave 8 smoking status set to either current smoking or ex-smoking.

Table 1 Sociodemographic patterning of sample by wave 8 smoking and vaping status

	Unweighted n (weighted %)					
		Smoking status			Vaping status	
Covariates	Total	Never smokers	Ex-smokers	Current smokers	Non-regular vapers	Regular vapers
	25 102 (100)	13 511 (53.7)	7724 (30.1)	3867 (16.1)		
Smoking status						
Never smoker					13 489 (55.9)	22 (2.5)
Ex-smoker					7134 (28.8)	590 (62.3)
Current smoker					3513 (15.3)	354 (35.2)
Vaping status						
Non-regular vaper	24 136 (96.0)	13 489 (99.8)	7134 (91.6)	3513 (91.2)		
Regular vaper	966 (4.0)	22 (0.2)	590 (8.4)	354 (8.8)		
Degree						
No degree	15 743 (63.8)	7603 (57.3)	5090 (66.6)	3049 (80.4)	15 036 (63.3)	706 (75.0)
Has degree	9359 (36.2)	5907 (42.7)	2634 (33.4)	818 (19.6)	9100 (36.7)	259 (25.0)
Sex						
Male	11 035 (47.8)	5394 (45.3)	3800 (51.1)	1841 (49.7)	10 544 (47.5)	491 (54.1)
Female	14 067 (52.2)	8117 (54.7)	3924 (48.9)	2026 (50.3)	13 592 (52.5)	475 (45.9)
Age						
16–24	1601 (12.8)	1062 (16.4)	153 (4.2)	386 (17.1)	1543 (13.0)	58 (9.7)
25–34	2682 (13.1)	1520 (13.6)	561 (9.3)	601 (18.4)	2524 (12.7)	158 (20.9)
35–44	4028 (14.9)	2235 (14.8)	1083 (14.3)	710 (16.5)	3821 (14.7)	207 (19.6)
45–54	5037 (17.9)	2780 (17.7)	1427 (17.7)	830 (18.7)	4804 (17.7)	233 (21.9)
55+	11 754 (41.3)	5914 (37.5)	4500 (54.6)	1340 (29.3)	11 444 (41.9)	310 (27.9)
Ethnicity						
White	22 087 (92.0)	11 468 (89.3)	7230 (95.6)	3389 (94.2)	21 199 (91.9)	888 (95.3)
Non-white	3015 (8.0)	2043 (10.7)	494 (4.4)	478 (5.8)	2937 (8.1)	78 (4.7)
NSSEC						
Management/professional	6426 (24.7)	4066 (29.4)	1748 (22.2)	612 (13.8)	6207 (24.8)	219 (21.5)
Intermediate	3516 (13.7)	2016 (15.0)	985 (12.1)	515 (12.1)	3348 (13.6)	168 (15.8)
Routine	4569 (20.3)	2206 (18.6)	1257 (17.9)	1106 (30.4)	4313 (20.0)	256 (28.6)
Not in paid employment	10 591 (41.3)	5223 (36.9)	3734 (47.8)	1634 (43.7)	10 268 (41.6)	323 (34.0)
Single in household						
No	16 834 (59.7)	9248 (59.1)	5499 (67.5)	2087 (46.8)	16 218 (59.7)	616 (57.8)
Yes	8268 (40.3)	4263 (40.9)	2225 (32.5)	1780 (53.2)	7918 (40.3)	350 (42.2)
Kids in household						
No	18 681 (76.2)	9899 (76.8)	5975 (76.7)	2807 (72.9)	18 012 (76.4)	669 (69.8)
Yes	6421 (23.8)	3612 (23.2)	1749 (23.3)	1060 (27.1)	6124 (23.6)	297 (30.2)
Tenure						
Owner	18 960 (67.9)	11 057 (75.0)	5940 (69.4)	1963 (41.5)	18 381 (68.7)	579 (49.1)
Renter	6142 (32.1)	2454 (25.0)	1784 (30.6)	1904 (58.5)	5755 (31.3)	387 (50.9)
Rural/urban						
Rural	6678 (24.2)	3624 (24.4)	2224 (25.8)	830 (20.5)	6477 (24.4)	201 (19.8)
Urban	18 424 (75.8)	9887 (75.6)	5500 (74.2)	3037 (79.5)	17 659 (75.6)	765 (80.2)
Has long-standing illness						
No	15 596 (63.1)	9028 (68.3)	4293 (55.5)	2275 (59.8)	15 013 (63.3)	583 (59.4)
Yes	9506 (36.9)	4483 (31.7)	3432 (44.5)	1592 (40.2)	9123 (36.7)	383 (40.6)
In poverty						
No	21 951 (87.2)	11 953 (88.7)	6845 (88.0)	3153 (80.6)	21 105 (87.3)	846 (85.7)
Yes	3151 (12.8)	1558 (11.3)	879 (12.0)	714 (19.4)	3031 (12.7)	120 (14.3)
GHQ						
<4 (less distressed)	20 519 (80.7)	11 278 (83.0)	6356 (80.8)	2885 (73.1)	19 759 (80.9)	760 (77.4)
4+ (more distressed)	4583 (19.3)	2233 (17.0)	1368 (19.2)	981 (26.9)	4377 (19.1)	206 (22.6)
Wave 7 e-cigarettes ever use						
No	23 331 (92.6)	13 423 (99.3)	7085 (91.0)	2823 (73.1)	23 033 (95.2)	298 (31.4)
Yes	1771 (7.4)	88 (0.7)	639 (9.0)	1044 (26.9)	1103 (4.8)	668 (68.6)

Continued

Table 1 Continued

	Unweighted n (weighted %)					
		Smoking status			Vaping status	
Covariates	Total	Never smokers	Ex-smokers	Current smokers	Non-regular vapers	Regular vapers
Current/ex-smoker mean number of cigarettes per day across waves						
<11	5535 (47.9)		3393 (44.2)	2142 (54.8)	5130 (48.5)	405 (41.7)
11–20	4539 (39.2)		3074 (39.7)	1465 (38.2)	4142 (38.8)	398 (43.3)
>20	1517 (12.9)		1257 (16.1)	260 (7.0)	1376 (12.7)	141 (15.0)
Current/ex-smoker age started smoking						
<16	4552 (41.6)		2782 (37.3)	1770 (49.6)	4131 (41.1)	420 (46.6)
16–19	5010 (42.7)		3495 (45.0)	1515 (38.4)	4627 (43.0)	383 (39.4)
19–25	1568 (12.3)		1127 (13.8)	441 (9.4)	1455 (12.3)	113 (11.5)
>25	461 (3.5)		320 (3.9)	141 (2.7)	433 (3.6)	28 (2.6)

Multiple imputed data with 50 imputations added. Weighting uses UK Household Longitudinal Study (UKHLS) wave 8 sampling weight.
GHQ, General Health Questionnaire; NSSEC, National Statistics Socio-economic Classification.

This adjusts for (exposure-outcome) confounders of education, vaping and smoking through follow-up, and for (mediator-outcome) confounders of wave 8 smoking status, vaping and smoking through follow-up. A similar set of weights were then used for part (b) of our RQs (Is vaping associated with smoking cessation/relapse?), but with vaping treated as the exposure rather than education, and cessation/relapse as the outcome. For part (c) of our RQs (Is SEP associated with smoking cessation/relapse?) the same weights as part (a) were used to estimate the CDE of education on smoking cessation/relapse. Finally, for part (d) of our RQs (Does vaping mediate or moderate associations between SEP and smoking cessation/relapse?), the same inverse probability weights used for parts (a) and (b) were used, but with an additional step of weighting to account for regular vaping as the mediator. We produced separate CDE estimates for effects of education on cessation/relapse with vaping status set to either regular or not regular vaping. For full details of the process of creating the weights and running the modelling for each RQ, see online supplemental appendix C.

Finally, we conducted additional sensitivity analyses. First, vaping status was recoded to indicate any vaping (0=non-vaper, 1=infrequent/regular vaper). Next, we used two binary classifications of NSSEC as our main SEP measure (0=management/professional, 1=not management/professional; and 0=in paid employment, 1=not in paid employment), with education reclassified as an exposure-outcome confounder. This assesses whether there is evidence for any additional effect of a more proximal SEP measure, over and above the effect of the education measure used in the main analyses. Lastly, analyses were repeated with education recoded to indicate possession of any qualifications (0=has qualifications, including degree or any school-level qualifications, 1=no qualifications).

RESULTS

Descriptive statistics

Descriptive statistics showing sociodemographic patterning of our sample by wave 8 smoking and vaping status are provided in table 1. Overall, 16.1% were smokers and 30.1%

Table 2 Estimated effects of SEP on regular vaping among current smokers and ex-smokers

	Unadjusted association between having no degree and regular vaping	Controlled direct effect of having no degree on regular vaping
	OR (95% CI)	OR (95% CI)
Wave 8 regular vaping (current smokers)		
(Reference: Degree)		
No degree	1.28 (0.93–1.76)	1.24 (0.87–1.78)
Wave 8 regular vaping (ex-smokers)		
(Reference: Degree)		
No degree	1.27 (1.02–1.60)	1.66 (1.33–2.07)

Regular vaping is defined as vaping at least weekly. The unadjusted association uses UK Household Longitudinal Study (UKHLS) wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.
SEP, socioeconomic position.

Table 3 Estimated effects of regular vaping on smoking cessation/relapse

	Unadjusted association between wave 8 regular vaping and smoking cessation/relapse	Controlled direct effect of wave 8 regular vaping on smoking cessation/relapse
	OR (95% CI)	OR (95% CI)
Smoking cessation		
(Reference: Not regular vaper)		
Regular vaper	1.28 (1.03–1.59)	1.13 (0.82–1.55)
Smoking relapse		
(Reference: Not regular vaper)		
Regular vaper	2.75 (2.02–3.73)	2.97 (2.10–4.22)

Regular vaping is defined as vaping at least weekly. The unadjusted association uses UK Household Longitudinal Study (UKHLS) wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

ex-smokers. Smoking was disproportionately prevalent among people without degrees, as well as among those who were single, renting, younger, in urban areas, in poverty, or with a long-standing illness or higher GHQ scores. Regular vaping was rare overall (4.0% of sample), but was more prevalent among smokers (8.8%) and ex-smokers (8.4%). Vaping was also disproportionately prevalent among those without degrees and those who were male, aged 25–34, white, renting, in urban areas or with kids in their household. In addition to table 1, online supplemental appendix D table S2 also provides descriptive statistics showing how smoking cessation/relapse outcomes vary by SEP and vaping status.

Effects of SEP on regular vaping

Table 2 shows the estimated effects of education on vaping among wave 8 current smokers and ex-smokers. Both unadjusted and adjusted CDE estimates are provided. Among current smokers, having no degree was associated with regular vaping, but CIs overlapped the null in both the unadjusted (OR: 1.28; 95% CI 0.93–1.76) and adjusted (OR: 1.24; 95% CI 0.87–1.78) models. Among ex-smokers, having no degree was associated with increased odds of regular vaping in both unadjusted (OR: 1.27; 95% CI 1.02–1.60) and adjusted (OR: 1.66; 95% CI 1.33–2.07) models.

Effects of regular vaping on smoking cessation/relapse

Table 3 shows the estimated effects of regular vaping on smoking cessation/relapse, again providing both unadjusted and adjusted CDE estimates. Regular vaping was associated with increased odds of smoking cessation among wave 8 current smokers (OR: 1.28; 95% CI 1.03–1.59), but this was attenuated after adjusting for observed confounding (OR: 1.13; 95% CI 0.82–1.55). Among wave 8 ex-smokers, regular vaping was associated with increased odds of smoking relapse in both unadjusted (OR: 2.75; 95% CI 2.02, 3.73) and adjusted (OR: 2.97; 95% CI 2.10–4.22) models.

Effects of SEP, and its interaction with regular vaping, on smoking cessation/relapse

Table 4 shows the relationship between SEP and smoking cessation/relapse with unadjusted associations, CDE estimates adjusting for confounding but not for vaping and CDE estimates dependent on regular vaping status. If vaping mediates inequalities in smoking cessation/relapse, then the estimates dependent on regular vaping status (columns 3 and 4) would be reduced relative to associations not conditioned on vaping (column 2). If vaping moderates inequalities in smoking cessation/relapse, then the estimates dependent on regular vaping status will differ from each other. Among wave 8 current smokers, having no degree was associated with reduced odds of smoking cessation. This was consistent across unadjusted (OR: 0.62; 95% CI 0.52–0.73) and confounder-adjusted models (OR: 0.65; 95% CI 0.54–0.77). A similar relationship was present among those who were not regular vapers (OR: 0.62; 95% CI 0.50–0.76), but the association disappeared for regular vapers (OR: 0.99; 95% CI 0.54–1.82).

Among wave 8 ex-smokers, having no degree was associated with raised risk of relapse in unadjusted (OR=1.34; 95% CI 1.04–1.72) and confounder-adjusted (OR: 1.74; 95% CI 1.37–2.22) models. After regular vaping was included, the association remained present among regular vapers (OR: 2.13; 95% CI 1.05–4.29) and those who were not regular vapers (OR: 1.55; 95% CI 1.09–2.18).

Sensitivity analysis

Findings from sensitivity analyses in which vaping status was recoded to include infrequent vapers were broadly consistent with the main analysis (see online supplemental appendix E). Analyses using NSSEC suggested little remaining socioeconomic inequality in cessation/relapse after adjusting for educational attainment (see online supplemental appendices F and G). Nevertheless, despite wide CIs, both analyses showed cessation as being less likely in disadvantaged occupations, with a similar association for those who did not regularly vape, while for regular vapers the association had reversed in direction. One other difference worth noting is that respondents not in employment had lower odds of vaping among both current smokers and ex-smokers than those in employment.

Recoding our education measure to indicate no qualifications produced notably different findings (see online supplemental appendix H). Respondents with no qualifications were less likely to be regular vapers (unadjusted OR: 0.69; 95% CI 0.54–0.87; CDE OR: 0.86; 95% CI 0.67–1.11) than those with qualifications. Moreover, while smoking cessation was less likely among those with no qualifications this association was present among regular vapers (OR: 0.30; 95% CI 0.14–0.65) and those who were not regular vapers (OR: 0.75; 95% CI 0.56–0.99). Together with our main analyses, this suggests a non-linear relationship, whereby vaping may help reduce socioeconomic inequalities in smoking cessation at the middle/upper end of

Table 4 Estimated effects of SEP on smoking cessation/relapse with and without interaction by regular vaping status

	Unadjusted association between having no degree and smoking cessation/relapse	Controlled direct effect of having no degree on smoking cessation/relapse	Controlled direct effect of having no degree on smoking cessation/ relapse among non-regular vapers	Controlled direct effect of having no degree on smoking cessation/ relapse among regular vapers
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Smoking cessation				
(Reference: Degree)				
No degree	0.62 (0.52–0.73)	0.65 (0.54–0.77)	0.62 (0.50–0.76)	0.99 (0.54–1.82)
Smoking relapse				
(Reference: Degree)				
No degree	1.34 (1.04–1.72)	1.74 (1.37–2.22)	1.55 (1.09–2.18)	2.13 (1.05–4.29)

Regular vaping is defined as vaping at least weekly. The unadjusted association uses UK Household Longitudinal Study (UKHLS) wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.
SEP, socioeconomic position.

the educational distribution (ie, between those with/without degrees), but is unlikely to help reduce inequalities at the lower end of the educational distribution (ie, between those with/without any qualifications).

DISCUSSION

This study has examined the impact of vaping on socioeconomic inequalities in smoking cessation/relapse using UKHLS data spanning 2016 to early 2020. Our findings suggest that smokers with lower educational attainment were less likely to stop smoking, but this inequality was not present among smokers who vaped regularly. However, vaping only appeared to alleviate inequalities when comparing those at the top of the educational distribution (those with degrees) to those in the middle/bottom (those without degrees). It did not appear to alleviate inequalities at the lower end of the distribution, between those with no qualifications and those who did have some. With regard to smoking relapse, our findings suggest that ex-smokers with less education were more likely to relapse, SEP was associated with vaping among ex-smokers and vaping was associated with relapse. These relationships did not appear strong enough for our final analysis to show clear evidence of mediation or moderation of inequalities in relapse by vaping status.

Importantly, if e-cigarettes can be particularly useful in helping disadvantaged groups to quit smoking, then this could lead to long-term reductions in health inequalities. Overall, data from England suggest that socioeconomic inequalities in cessation have narrowed recently.[22] Our findings suggest that increased vaping among those of lower SEP (ie, without degrees) is likely to have contributed positively to this, as smoking cessation is less strongly associated with having degree level education among regular vapers. We confirm previous cross-sectional research where inequalities were found to be weaker among adult vapers,[20] but our study extends this finding with longitudinal data. We also demonstrate that the impact of vaping on inequalities is focused around the upper/middle end of the educational distribution, but does little to help those who are most disadvantaged, or to address inequalities in relapse among ex-smokers.

Our study has some limitations. First, while we adjust for many relevant confounders, causal interpretation is based on assumptions of no unmeasured confounding. Since our analysis was stratified by wave 8 smoking status, this includes unmeasured confounding of smoking at wave 8 and through follow-up in waves 9 and 10 (ie, any unmeasured determinant of continued smoking). One obvious candidate for an unmeasured confounder is residual differences in smoking history, which we did adjust for, but the measures were crude (being based on limited data from earlier surveys) and may not fully reflect smoking history differences between smoking/vaping categories. It is plausible that bias arising from this, for example, may have contributed to the observed association between vaping and greater risk of smoking relapse. An additional limitation is that our smoking cessation measure is based on self-reported smoking status between waves, and we do not know how long respondents had quit for. Finally, UKHLS data do not distinguish between different device types or different motivations for vaping.

Despite these limitations, our findings have some important implications. While inequalities in smoking cessation have previously been intractable, our findings highlight that vaping may help alleviate inequalities between those with/without degrees. This suggests that e-cigarette policy/regulations should consider that vaping may be especially helpful as a cessation aid for smokers without degree level education and therefore may help reduce inequalities in smoking. Concerns remain because the long-term health consequences of vaping are unknown and some fear potential 'gateway effects' between vaping and smoking uptake. However, vaping is now widely considered to be substantially less harmful than smoking,[5 6] and latest evidence suggests 'gateway effects' are unlikely.[36] Our findings did not show that vaping helped with inequalities between those with/without any qualifications, or with inequalities in smoking relapse, although there was not clear evidence of an adverse impact on inequalities in relapse either. Therefore, other cessation aids may be more useful to those most disadvantaged (ie, with no qualifications), and may be needed for avoiding relapse. Nonetheless, a reduction in inequalities in smoking cessation is significant and likely means that vaping can have a net positive impact on inequalities in smoking.

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Acknowledgements The data set used for this analysis, the UK Household Longitudinal Study (UKHLS) aka Understanding Society, is an initiative funded by the Economic and Social Research Council and various government departments, with scientific leadership by the Institute for Social and Economic Research, University of Essex, and survey delivery by NatCen Social Research and Kantar Public. The research data are distributed by the UK Data Service (SN 6614).

Contributors IH: data curation, formal analysis, writing—original draft, guarantor. MJG: conceptualisation, methodology, writing—review and editing.

Funding This work was supported by the Medical Research Council (grant number: MC_UU_00022/2) and the Scottish Government Chief Scientist Office (grant number: SPHSU17).

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. The data set used for this article's analysis, the UK Household Longitudinal Study (UKHLS), is secondary data accessed via the UK Data Service. The College of Medical, Veterinary and Life Sciences (MVLS) Ethics Committee at the University of Glasgow states that research using secondary data accessed through the UK Data Service does not require MVLS committee ethical approval because the UK Data Service's own governance process you go through before they release their data to you is suitable. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available. UK Household Longitudinal Study (UKHLS) data are held by the UK Data Service. Researchers who would like to access UKHLS need to register with the UK Data Service before being allowed to apply to access and download data sets (https://www.understandingsociety.ac.uk/documentation/access-data).

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SUPPORTING INFORMATION APPENDIX A

Figure S1. Flowchart showing sample size and missing data at each stage of inclusion criteria

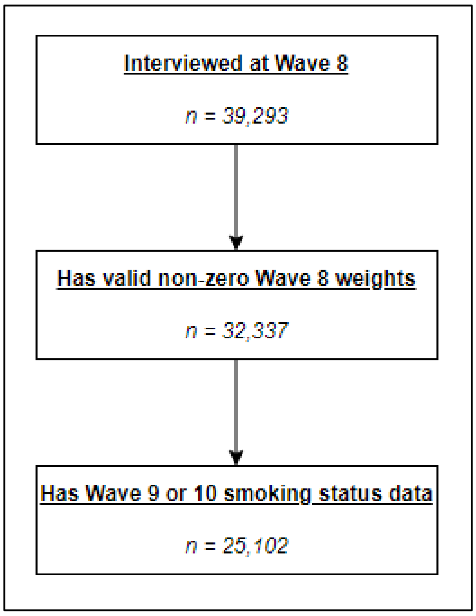

Table S1. Missingness Across Covariates in Final Primary Sample

	Missing N (Weighted % of Observations)			
Covariate	**Total**	**Never Smokers**	**Ex-Smokers**	**Current Smokers**
Degree	3,656 (10.8%)	1,867 (10.1%)	1,224 (12.6%)	565 (9.7%)
GHQ	871 (2.8%)	505 (3.0%)	222 (2.34%)	144 (3.0%)
Vaping History: wave 7 E-Cigs Ever Use	579 (2.9%)	285 (2.9%)	100 (1.5%)	194 (5.5%)
Smoking History: current/ex-smoker mean # cigarettes per day across waves	1,243 (5.3%)	0	1,168 (15.1%)	75 (2.0%)
Smoking History: current/ex-smoker age started smoking	824 (3.0%)	0	175 (2.6%)	649 (13.9%)

*Note: all other covariates (sex, age, ethnicity, NSSEC, single in household, kids in household, tenure, rural/urban, longstanding illness and poverty) had full data in primary sample.

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SUPPORTING INFORMATION APPENDIX B

STROBE Checklist of items that should be included in reports of observational studies

	Item	Recomendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(a) Cohort study—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants (b) Cohort study—For matched studies, give matching criteria and number of exposed and unexposed Case-control study—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at

Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) Cohort study—If applicable, explain how loss to follow-up was addressed Case-control study—If applicable, explain how matching of cases and controls was addressed Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses
Results		
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Cohort study—Summarise follow-up time (eg, average and total amount)
Outcome data	15	Cohort study—Report numbers of outcome events or summary measures over time Case-control study—Report numbers in each exposure category, or summary measures of exposure Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

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Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

SUPPORTING INFORMATION APPENDIX C

FULL DETAILS OF STATISTICAL ANALYSIS BY RESEARCH QUESTION

Research Questions part (a): Is SEP associated with vaping?

The primary sample with multiple imputations was used to create a stabilised inverse probability weight for the exposure (E) using our set of exposure-outcome confounders (x). This was based on the following two logistic regression models: (1) SEP as outcome, with no predictors (i.e. estimating: P(E)), and (2) SEP as outcome, with all exposure-outcome confounders as predictors (i.e. estimating: P(E|x)). This was used to calculate the predicted probabilities of each respondents' observed exposure level (P*(E) and P*(E|x), where P*=P if the exposure=1 and P*=1-P if the exposure=0). Then, the exposure weight was calculated as P*(E)/P*(E|x).

Next, we created an inverse probability weight for w8 smoking status (M), conditioned on both exposure-outcome confounders (x), and mediator outcome confounders (z), using the following two logistic regression models: (1) wave 8 smoking status as outcome, predicted only by SEP (i.e. estimating: P(M|E)), and (2) wave 8 smoking status as outcome, predicted by SEP, and all exposure-outcome and mediator-outcome confounders (i.e. estimating: P(M|E, x, z)). This was conducted in two stages, with the first stage being conducted for ever vs. never smokers and the second stage for ever vs. current smokers. The vaping and smoking history variables were only included in the second stage as they were either highly correlated or deterministically-related to smoking status. This was used to calculate predicted probabilities (P*) of each respondents' observed wave 8 smoking status, and the wave 8 smoking status weight is calculated as P*(M|E)/P*(M|E, x, z). This was multiplied together with the exposure weight (and the sampling/non-response weights) and represents respondents' wave 9 analysis weight. Finally, a further weight was created for having smoking data at wave 10 (C), conditional on wave 9 smoking status (Y9). This was based on the following models: (1) Smoking data at wave 10 as outcome, predicted only by SEP, w8 smoking status and w9 smoking status (i.e. estimating: P(C|E, M, Y9)), and (2) Smoking data at wave 10 as outcome, predicted by SEP, w8 smoking status, w9 smoking status and all confounders (i.e. estimating: P(C|E, M, Y9, x, z)). An inverse probability weight was created using P* as above, and this is multiplied together with the wave 9 analysis weight to create a wave 10 analysis weight.

Logistic regression models were then used, with this final analysis weight applied, to examine the relationship between education and vaping, with wave 8 smoking status set to either current or ex-smoking. The odds ratio from these models can be interpreted as the CDE of education on vaping.

Research Questions part (b): Is vaping associated with smoking cessation?

In a similar process to research question 1, we created two inverse probability weights based on the following two logistic regression models: (1) wave 8 smoking status as outcome, predicted only by regular vaping status, and (2) wave 8 smoking status as outcome, predicted by regular vaping status and all exposure-outcome and mediator-outcome confounders. These weights were then multiplied together and used in logistic regression models, which estimate the CDE of regular vaping on smoking cessation/relapse.

Research Questions part (c): Is SEP associated with smoking cessation/relapse?

The same weights as research question 1 were used to estimate the CDE of education on smoking cessation/relapse.

Research Questions part (d): Does vaping mediate or moderate the associations between SEP and smoking cessation/relapse?

The same inverse probability weights used for research questions 1 and 2 were used, but with an additional step of weighting for regular vaping as the mediator. These weights were multiplied together and used in logistic regression models with smoking cessation/relapse as the outcome and SEP, wave 8 regular vaping, and the interaction between the two included as predictors. This estimates the CDE of education on smoking cessation/relapse with vaping status set to either regular vaping or not regular vaping.

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SUPPORTING INFORMATION APPENDIX D

Table S2. Patterning of Smoking Cessation Outcomes (Among Wave 8 Current Smokers) and Smoking Relapse Outcomes (Among Wave 8 Ex-Smokers) by Vaping Status and Socioeconomic Position (Measured by Having Degree Level Education)

	Unweighted N (Weighted Row %)							
	Smoking Cessation (Among Wave 8 Current Smokers, N = 3,867)				**Smoking Relapse** (Among Wave 8 Ex-Smokers, N = 7,724)			
	By Wave 9		**By Wave 10**		**By Wave 9**		**By Wave 10**	
	No	Yes	No	Yes	No	Yes	No	Yes
Vaping Status								
Not-Reg Vaper	2,930 (82.5%)	583 (17.5%)	2,822 (80.1%)	691 (19.9%)	6,856 (94.7%)	278 (5.3%)	6,790 (93.2%)	344 (6.8%)
Reg Vaper	268 (79.7%)	86 (20.3%)	258 (75.4%)	96 (24.6%)	522 (87.7%)	68 (12.3%)	503 (85.3%)	87 (14.7%)
Degree								
No Degree	2,575 (84.4%)	474 (15.6%)	2,492 (81.5%)	558 (18.5%)	4,858 (93.3%)	233 (6.7%)	4,787 (91.4%)	304 (8.6%)
Has Degree	623 (74.1%)	195 (25.9%)	587 (72.6%)	230 (27.4%)	2,521 (95.6%)	112 (4.4%)	2,505 (94.7%)	128 (5.3%)

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SUPPORTING INFORMATION APPENDIX E

Sensitivity analysis: vaping variable categorised as 0 = non-vaper, 1 = infrequent or regular vaper

Table S2. Estimates of Effects of SEP on Smoking Cessation/Relapse, With and Without Interaction by Vaping Status

	Unadjusted Association between Having No Degree and Smoking Cessation/Relapse	**Controlled Direct Effect of Having No Degree on Smoking Cessation/Relapse**	**Controlled Direct Effect of Having No Degree on Smoking Cessation/Relapse Among Non-Vapers**	**Controlled Direct Effect of Having No Degree on Smoking Cessation/Relapse Among Vapers**
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Smoking Cessation				
[Reference: Has Degree]				
No Degree	0.62 [0.52-0.73]	0.65 [0.54-0.77]	0.58 [0.48-0.72]	1.23 [0.70-2.14]
Smoking Relapse				
[Reference: Has Degree]				
No Degree	1.35 [1.06-1.75]	1.77 [1.38-2.25]	1.57 [1.10-2.25]	1.73 [0.93-3.21]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Vaping is defined as using or sometimes using e-cigarettes. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

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Table S3. Estimates of Effects of SEP on Vaping Among Current Smokers and Ex-Smokers

	Unadjusted Association between Having No Degree and Vaping	**Controlled Direct Effect of Having No Degree on Vaping**
	OR [95% CI]	OR [95% CI]
Wave 8 Vaping (Ex-Smokers)		
[Reference: Has Degree]		
No Degree	1.27 [1.03, 1.58]	1.67 [1.35, 2.06]
Wave 8 Vaping (Current Smokers)		
[Reference: Has Degree]		
No Degree	1.05 [0.82, 1.35]	1.03 [0.79, 1.37]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Vaping is defined as using or sometimes using e-cigarettes. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Table S4. Estimates of Effects of Vaping on Smoking Cessation/Relapse

	Unadjusted Association between Wave 8 Vaping and Smoking Cessation/Relapse	**Controlled Direct Effect of Wave 8 Vaping on Smoking Cessation/Relapse**
	OR [95% CI]	OR [95% CI]
Smoking Cessation		
[Reference: Not Vaper]		
Vaper	1.12 [0.94-1.35]	0.98 [0.76-1.27]
Smoking Relapse		
[Reference: Not Vaper]		
Vaper	3.10 [2.32-4.13]	3.27 [2.37-4.50]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Vaping is defined as using or sometimes using e-cigarettes. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

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SUPPORTING INFORMATION APPENDIX F

Sensitivity analysis: SEP based on NSSEC, categorised as 0 = management/professional, 1 = not management/professional

Table S5. Estimates of Effects of SEP on Smoking Cessation/Relapse, With and Without Interaction by Vaping Status

	Unadjusted Association between NSSEC and Smoking Cessation/Relapse	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse**	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse Among Non-Regular Vapers**	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse Among Regular Vapers**
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Smoking Cessation				
[Reference: Management/Professional]				
Not Management/Professional	0.75 [0.63-0.89]	0.95 [0.76-1.18]	0.93 [0.71-1.23]	2.02 [0.80-5.13]
Smoking Relapse				
[Reference: Management/Professional]				
Not Management/Professional	0.96 [0.74-1.25]	1.25 [0.95-1.66]	1.15 [0.75-1.78]	2.06 [0.87-4.90]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Table S6. Estimates of Effects of SEP on Regular Vaping Among Current Smokers and Ex-Smokers

	Unadjusted Association between NSSEC and Vaping	**Controlled Direct Effect of NSSEC on Vaping**
	OR [95% CI]	OR [95% CI]
Wave 8 Regular Vaping (Ex-Smokers)		
[Reference: Management/Professional]		
Not Management/Professional	0.83 [0.66-1.04]	1.09 [0.85-1.39]
Wave 8 Regular Vaping (Current Smokers)		
[Reference: Management/Professional]		
Not Management/Professional	1.09 [0.77-1.54]	1.01 [0.65-1.57]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

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SUPPORTING INFORMATION APPENDIX G

Sensitivity analysis: SEP based on NSSEC, categorised as 0 = in paid employment, 1 = not in paid employment

Table S7. Estimates of Effects of SEP on Smoking Cessation/Relapse, With and Without Interaction by Vaping Status

	Unadjusted Association between NSSEC and Smoking Cessation/Relapse	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse**	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse Among Non-Regular Vapers**	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse Among Regular Vapers**
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Smoking Cessation				
[Reference: in Paid Employment]				
Not in Paid Employment	0.80 [0.69-0.93]	0.86 [0.73-1.01]	0.88 [0.72-1.08]	1.62 [0.89-2.92]
Smoking Relapse				
[Reference: in Paid Employment]				
Not in Paid Employment	0.61 [0.49-0.77]	1.02 [0.81-1.30]	1.06 [0.74-1.53]	0.90 [0.41-2.03]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Hardie I, Green MJ. *Tob Control* 2023;0:1–8. doi: 10.1136/tc-2022-057728

Table S8. Estimates of Effects of SEP on Regular Vaping Among Current Smokers and Ex-Smokers

	Unadjusted Association between NSSEC and Vaping	**Controlled Direct Effect of NSSEC on Vaping**
	OR [95% CI]	OR [95% CI]
Wave 8 Regular Vaping (Ex-Smokers)		
[Reference: in Paid Employment]		
Not in Paid Employment	0.46 [0.37-0.57]	0.67 [0.53-0.86]
Wave 8 Regular Vaping (Current Smokers)		
[Reference: in Paid Employment]		
Not in Paid Employment	0.87 [0.66-1.14]	0.70 [0.51-0.96]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Hardie I, Green MJ. *Tob Control* 2023;0:1–8. doi: 10.1136/tc-2022-057728

SUPPORTING INFORMATION APPENDIX H

Sensitivity analysis: no qualifications used instead of no degree as the educational attainment SEP measure)

Table S9. Estimates of Effects of SEP on Regular Vaping Among Current Smokers and Ex-Smokers

	Unadjusted Association between Having No Qualifications and Regular Vaping	**Controlled Direct Effect of Having No Qualifications on Regular Vaping**
	OR [95% CI]	OR [95% CI]
Wave 8 Regular Vaping (Ex-Smokers)		
[Reference: Has Qualifications]		
No Qualifications	0.69 [0.54-0.87]	0.86 [0.67-1.11]
Wave 8 Regular Vaping (Current Smokers)		
[Reference: Has Qualifications]		
No Qualifications	1.17 [0.88-1.55]	1.03 [0.74-1.40]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Table S10. Estimates of Effects of SEP on Smoking Cessation/Relapse, With and Without Interaction by Regular Vaping Status

	Unadjusted Association between Having No Qualifications and Smoking Cessation/Relapse	**Controlled Direct Effect of Having No Qualifications on Smoking Cessation/Relapse**	**Controlled Direct Effect of Having No Qualifications on Smoking Cessation/Relapse Among Non-Regular Vapers**	**Controlled Direct Effect of Having No Qualifications on Smoking Cessation/Relapse Among Regular Vapers**
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Smoking Cessation				
[Reference: Has Qualifications]				
No Qualifications	0.67 [0.57-0.79]	0.74 [0.61-0.89]	0.75 [0.56-0.99]	0.30 [0.14-0.65]
Smoking Relapse				
[Reference: Has Qualifications]				
No Qualifications	0.63 [0.49-0.82]	0.99 [0.76-1.29]	1.14 [0.65-1.98]	2.13 [1.14-3.96]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

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SUPPORTING INFORMATION APPENDIX A

Figure S1. Flowchart showing sample size and missing data at each stage of inclusion criteria

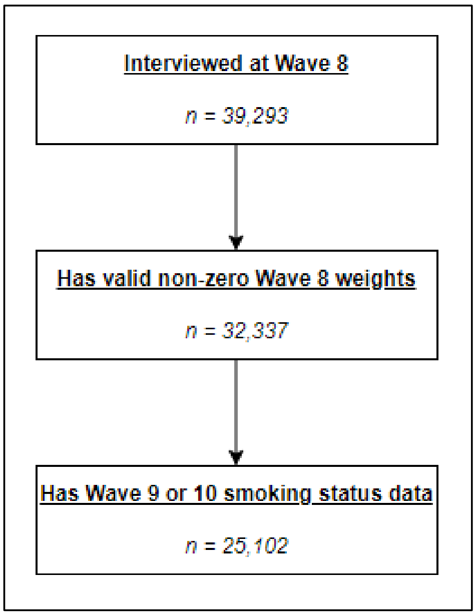

Table S1. Missingness Across Covariates in Final Primary Sample

	Missing N (Weighted % of Observations)			
Covariate	**Total**	**Never Smokers**	**Ex-Smokers**	**Current Smokers**
Degree	3,656 (10.8%)	1,867 (10.1%)	1,224 (12.6%)	565 (9.7%)
GHQ	871 (2.8%)	505 (3.0%)	222 (2.34%)	144 (3.0%)
Vaping History: wave 7 E-Cigs Ever Use	579 (2.9%)	285 (2.9%)	100 (1.5%)	194 (5.5%)
Smoking History: current/ex-smoker mean # cigarettes per day across waves	1,243 (5.3%)	0	1,168 (15.1%)	75 (2.0%)
Smoking History: current/ex-smoker age started smoking	824 (3.0%)	0	175 (2.6%)	649 (13.9%)

*Note: all other covariates (sex, age, ethnicity, NSSEC, single in household, kids in household, tenure, rural/urban, longstanding illness and poverty) had full data in primary sample.

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SUPPORTING INFORMATION APPENDIX B

STROBE Checklist of items that should be included in reports of observational studies

	Item	Recomendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(a) Cohort study—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants (b) Cohort study—For matched studies, give matching criteria and number of exposed and unexposed Case-control study—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at

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Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) Cohort study—If applicable, explain how loss to follow-up was addressed Case-control study—If applicable, explain how matching of cases and controls was addressed Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses
Results		
Participants	13	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Cohort study—Summarise follow-up time (eg, average and total amount)
Outcome data	15	Cohort study—Report numbers of outcome events or summary measures over time Case-control study—Report numbers in each exposure category, or summary measures of exposure Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

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Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

SUPPORTING INFORMATION APPENDIX C

FULL DETAILS OF STATISTICAL ANALYSIS BY RESEARCH QUESTION

Research Questions part (a): Is SEP associated with vaping?

The primary sample with multiple imputations was used to create a stabilised inverse probability weight for the exposure (E) using our set of exposure-outcome confounders (x). This was based on the following two logistic regression models: (1) SEP as outcome, with no predictors (i.e. estimating: P(E)), and (2) SEP as outcome, with all exposure-outcome confounders as predictors (i.e. estimating: P(E|x)). This was used to calculate the predicted probabilities of each respondents' observed exposure level (P*(E) and P*(E|x), where P*=P if the exposure=1 and P*=1-P if the exposure=0). Then, the exposure weight was calculated as P*(E)/P*(E|x).

Next, we created an inverse probability weight for w8 smoking status (M), conditioned on both exposure-outcome confounders (x), and mediator outcome confounders (z), using the following two logistic regression models: (1) wave 8 smoking status as outcome, predicted only by SEP (i.e. estimating: P(M|E)), and (2) wave 8 smoking status as outcome, predicted by SEP, and all exposure-outcome and mediator-outcome confounders (i.e. estimating: P(M|E, x, z)). This was conducted in two stages, with the first stage being conducted for ever vs. never smokers and the second stage for ever vs. current smokers. The vaping and smoking history variables were only included in the second stage as they were either highly correlated or deterministically-related to smoking status. This was used to calculate predicted probabilities (P*) of each respondents' observed wave 8 smoking status, and the wave 8 smoking status weight is calculated as P*(M|E)/P*(M|E, x, z). This was multiplied together with the exposure weight (and the sampling/non-response weights) and represents respondents' wave 9 analysis weight. Finally, a further weight was created for having smoking data at wave 10 (C), conditional on wave 9 smoking status (Y9). This was based on the following models: (1) Smoking data at wave 10 as outcome, predicted only by SEP, w8 smoking status and w9 smoking status (i.e. estimating: P(C|E, M, Y9)), and (2) Smoking data at wave 10 as outcome, predicted by SEP, w8 smoking status, w9 smoking status and all confounders (i.e. estimating: P(C|E, M, Y9, x, z)). An inverse probability weight was created using P* as above, and this is multiplied together with the wave 9 analysis weight to create a wave 10 analysis weight.

Logistic regression models were then used, with this final analysis weight applied, to examine the relationship between education and vaping, with wave 8 smoking status set to either current or ex-smoking. The odds ratio from these models can be interpreted as the CDE of education on vaping.

Research Questions part (b): Is vaping associated with smoking cessation?

In a similar process to research question 1, we created two inverse probability weights based on the following two logistic regression models: (1) wave 8 smoking status as outcome, predicted only by regular vaping status, and (2) wave 8 smoking status as outcome, predicted by regular vaping status and all exposure-outcome and mediator-outcome confounders. These weights were then multiplied together and used in logistic regression models, which estimate the CDE of regular vaping on smoking cessation/relapse.

Research Questions part (c): Is SEP associated with smoking cessation/relapse?

The same weights as research question 1 were used to estimate the CDE of education on smoking cessation/relapse.

Research Questions part (d): Does vaping mediate or moderate the associations between SEP and smoking cessation/relapse?

The same inverse probability weights used for research questions 1 and 2 were used, but with an additional step of weighting for regular vaping as the mediator. These weights were multiplied together and used in logistic regression models with smoking cessation/relapse as the outcome and SEP, wave 8 regular vaping, and the interaction between the two included as predictors. This estimates the CDE of education on smoking cessation/relapse with vaping status set to either regular vaping or not regular vaping.

Hardie I, Green MJ. *Tob Control* 2023;0:1–8. doi: 10.1136/tc-2022-057728

SUPPORTING INFORMATION APPENDIX D

Table S2. Patterning of Smoking Cessation Outcomes (Among Wave 8 Current Smokers) and Smoking Relapse Outcomes (Among Wave 8 Ex-Smokers) by Vaping Status and Socioeconomic Position (Measured by Having Degree Level Education)

	Unweighted N (Weighted Row %)							
	Smoking Cessation (Among Wave 8 Current Smokers, N = 3,867)				**Smoking Relapse** (Among Wave 8 Ex-Smokers, N = 7,724)			
	By Wave 9		**By Wave 10**		**By Wave 9**		**By Wave 10**	
	No	Yes	No	Yes	No	Yes	No	Yes
Vaping Status								
Not-Reg Vaper	2,930 (82.5%)	583 (17.5%)	2,822 (80.1%)	691 (19.9%)	6,856 (94.7%)	278 (5.3%)	6,790 (93.2%)	344 (6.8%)
Reg Vaper	268 (79.7%)	86 (20.3%)	258 (75.4%)	96 (24.6%)	522 (87.7%)	68 (12.3%)	503 (85.3%)	87 (14.7%)
Degree								
No Degree	2,575 (84.4%)	474 (15.6%)	2,492 (81.5%)	558 (18.5%)	4,858 (93.3%)	233 (6.7%)	4,787 (91.4%)	304 (8.6%)
Has Degree	623 (74.1%)	195 (25.9%)	587 (72.6%)	230 (27.4%)	2,521 (95.6%)	112 (4.4%)	2,505 (94.7%)	128 (5.3%)

Hardie I, Green MJ. *Tob Control* 2023;0:1–8. doi: 10.1136/tc-2022-057728

SUPPORTING INFORMATION APPENDIX E

Sensitivity analysis: vaping variable categorised as 0 = non-vaper, 1 = infrequent or regular vaper

Table S2. Estimates of Effects of SEP on Smoking Cessation/Relapse, With and Without Interaction by Vaping Status

	Unadjusted Association between Having No Degree and Smoking Cessation/Relapse	**Controlled Direct Effect of Having No Degree on Smoking Cessation/Relapse**	**Controlled Direct Effect of Having No Degree on Smoking Cessation/Relapse Among Non-Vapers**	**Controlled Direct Effect of Having No Degree on Smoking Cessation/Relapse Among Vapers**
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Smoking Cessation				
[Reference: Has Degree]				
No Degree	0.62 [0.52-0.73]	0.65 [0.54-0.77]	0.58 [0.48-0.72]	1.23 [0.70-2.14]
Smoking Relapse				
[Reference: Has Degree]				
No Degree	1.35 [1.06-1.75]	1.77 [1.38-2.25]	1.57 [1.10-2.25]	1.73 [0.93-3.21]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Vaping is defined as using or sometimes using e-cigarettes. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Hardie I, Green MJ. *Tob Control* 2023;0:1–8. doi: 10.1136/tc-2022-057728

Table S3. Estimates of Effects of SEP on Vaping Among Current Smokers and Ex-Smokers

	Unadjusted Association between Having No Degree and Vaping	**Controlled Direct Effect of Having No Degree on Vaping**
	OR [95% CI]	OR [95% CI]
Wave 8 Vaping (Ex-Smokers)		
[Reference: Has Degree]		
No Degree	1.27 [1.03, 1.58]	1.67 [1.35, 2.06]
Wave 8 Vaping (Current Smokers)		
[Reference: Has Degree]		
No Degree	1.05 [0.82, 1.35]	1.03 [0.79, 1.37]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Vaping is defined as using or sometimes using e-cigarettes. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Table S4. Estimates of Effects of Vaping on Smoking Cessation/Relapse

	Unadjusted Association between Wave 8 Vaping and Smoking Cessation/Relapse	**Controlled Direct Effect of Wave 8 Vaping on Smoking Cessation/Relapse**
	OR [95% CI]	OR [95% CI]
Smoking Cessation		
[Reference: Not Vaper]		
Vaper	1.12 [0.94-1.35]	0.98 [0.76-1.27]
Smoking Relapse		
[Reference: Not Vaper]		
Vaper	3.10 [2.32-4.13]	3.27 [2.37-4.50]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Vaping is defined as using or sometimes using e-cigarettes. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

SUPPORTING INFORMATION APPENDIX F

Sensitivity analysis: SEP based on NSSEC, categorised as 0 = management/professional, 1 = not management/professional

Table S5. Estimates of Effects of SEP on Smoking Cessation/Relapse, With and Without Interaction by Vaping Status

	Unadjusted Association between NSSEC and Smoking Cessation/Relapse	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse**	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse Among Non-Regular Vapers**	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse Among Regular Vapers**
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Smoking Cessation				
[Reference: Management/Professional]				
Not Management/Professional	0.75 [0.63-0.89]	0.95 [0.76-1.18]	0.93 [0.71-1.23]	2.02 [0.80-5.13]
Smoking Relapse				
[Reference: Management/Professional]				
Not Management/Professional	0.96 [0.74-1.25]	1.25 [0.95-1.66]	1.15 [0.75-1.78]	2.06 [0.87-4.90]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Hardie I, Green MJ. *Tob Control* 2023;0:1–8. doi: 10.1136/tc-2022-057728

Table S6. Estimates of Effects of SEP on Regular Vaping Among Current Smokers and Ex-Smokers

	Unadjusted Association between NSSEC and Vaping	**Controlled Direct Effect of NSSEC on Vaping**
	OR [95% CI]	OR [95% CI]
Wave 8 Regular Vaping (Ex-Smokers)		
[Reference: Management/Professional]		
Not Management/Professional	0.83 [0.66-1.04]	1.09 [0.85-1.39]
Wave 8 Regular Vaping (Current Smokers)		
[Reference: Management/Professional]		
Not Management/Professional	1.09 [0.77-1.54]	1.01 [0.65-1.57]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Hardie I, Green MJ. *Tob Control* 2023;0:1–8. doi: 10.1136/tc-2022-057728

SUPPORTING INFORMATION APPENDIX G

Sensitivity analysis: SEP based on NSSEC, categorised as 0 = in paid employment, 1 = not in paid employment

Table S7. Estimates of Effects of SEP on Smoking Cessation/Relapse, With and Without Interaction by Vaping Status

	Unadjusted Association between NSSEC and Smoking Cessation/Relapse	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse**	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse Among Non-Regular Vapers**	**Controlled Direct Effect of NSSEC on Smoking Cessation/Relapse Among Regular Vapers**
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Smoking Cessation				
[Reference: in Paid Employment]				
Not in Paid Employment	0.80 [0.69-0.93]	0.86 [0.73-1.01]	0.88 [0.72-1.08]	1.62 [0.89-2.92]
Smoking Relapse				
[Reference: in Paid Employment]				
Not in Paid Employment	0.61 [0.49-0.77]	1.02 [0.81-1.30]	1.06 [0.74-1.53]	0.90 [0.41-2.03]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

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Table S8. Estimates of Effects of SEP on Regular Vaping Among Current Smokers and Ex-Smokers

	Unadjusted Association between NSSEC and Vaping	**Controlled Direct Effect of NSSEC on Vaping**
	OR [95% CI]	OR [95% CI]
Wave 8 Regular Vaping (Ex-Smokers)		
[Reference: in Paid Employment]		
Not in Paid Employment	0.46 [0.37-0.57]	0.67 [0.53-0.86]
Wave 8 Regular Vaping (Current Smokers)		
[Reference: in Paid Employment]		
Not in Paid Employment	0.87 [0.66-1.14]	0.70 [0.51-0.96]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

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SUPPORTING INFORMATION APPENDIX H

Sensitivity analysis: no qualifications used instead of no degree as the educational attainment SEP measure)

Table S9. Estimates of Effects of SEP on Regular Vaping Among Current Smokers and Ex-Smokers

	Unadjusted Association between Having No Qualifications and Regular Vaping	**Controlled Direct Effect of Having No Qualifications on Regular Vaping**
	OR [95% CI]	OR [95% CI]
Wave 8 Regular Vaping (Ex-Smokers)		
[Reference: Has Qualifications]		
No Qualifications	0.69 [0.54-0.87]	0.86 [0.67-1.11]
Wave 8 Regular Vaping (Current Smokers)		
[Reference: Has Qualifications]		
No Qualifications	1.17 [0.88-1.55]	1.03 [0.74-1.40]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Table S10. Estimates of Effects of SEP on Smoking Cessation/Relapse, With and Without Interaction by Regular Vaping Status

	Unadjusted Association between Having No Qualifications and Smoking Cessation/Relapse	**Controlled Direct Effect of Having No Qualifications on Smoking Cessation/Relapse**	**Controlled Direct Effect of Having No Qualifications on Smoking Cessation/Relapse Among Non-Regular Vapers**	**Controlled Direct Effect of Having No Qualifications on Smoking Cessation/Relapse Among Regular Vapers**
	OR [95% CI]	OR [95% CI]	OR [95% CI]	OR [95% CI]
Smoking Cessation				
[Reference: Has Qualifications]				
No Qualifications	0.67 [0.57-0.79]	0.74 [0.61-0.89]	0.75 [0.56-0.99]	0.30 [0.14-0.65]
Smoking Relapse				
[Reference: Has Qualifications]				
No Qualifications	0.63 [0.49-0.82]	0.99 [0.76-1.29]	1.14 [0.65-1.98]	2.13 [1.14-3.96]

Notes: OR = odds ratio and 95% CI = 95% confidence interval. Regular vaping is defined as vaping at least weekly. The unadjusted association uses UKHLS wave 8 sampling weights to account for survey design and non-response but does not adjust for any confounders. The controlled direct effect uses inverse probability weighted marginal structural modelling to additionally adjust for exposure-outcome confounders and mediator-outcome confounders.

Hardie I, Green MJ. *Tob Control* 2023;0:1–8. doi: 10.1136/tc-2022-057728