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## Pregnant women's use of e-cigarettes in the UK: a cross-sectional survey

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**Objective** To estimate prevalence of vaping in pregnancy. Compare characteristics and attitudes between exclusive smokers and vapers, and between exclusive vapers and dual users (smoke and vape).

**Design** Cross-sectional survey.

**Setting** Hospitals across England and Scotland.

**Population** Pregnant women attending antenatal clinics in 2017.

**Methods** Women at 8–24 weeks' gestation completed screening questions about their smoking and vaping. Current or recent ex-smokers and/or vapers completed a full detailed survey about vaping and smoking.

**Main outcome measures** The prevalence of vaping, characteristics and attitudes of women who vape and/or smoke.

**Results** Of 3360 pregnant women who completed screening questions, 515 (15.3%, 95% CI 14.1–16.6) were exclusive smokers, 44 (1.3%, 95% CI 1.0–1.8) exclusive vapers and 118 (3.5%, 95% CI 2.9–4.2) dual users. In total, 867 (25.8%) women completed the full

survey; compared with smokers ( $n = 434$ ), vapers ( $n = 140$ ) were more likely to hold higher educational qualifications (odds ratio [OR] 1.51, 95% CI 1.01–2.25). Compared with exclusive vapers ( $n = 33$ ), dual users ( $n = 107$ ) were younger (OR 0.91 95% CI 0.85–0.98) and less likely to hold high qualifications (OR 0.43, 95% CI 0.20–0.96). Compared with smokers, dual users were more likely to be planning to quit smoking (OR 2.27, 95% CI 1.24–4.18). Compared with smokers, vapers were more likely to think vaping was safer than smoking (78.6% versus 36.4%).

**Conclusions** One in 20 pregnant women report vaping, and most also smoke. Dual users are more motivated towards stopping smoking than smokers. Where women have tried but cannot stop smoking, clinicians could encourage them to consider vaping for smoking cessation.

**Keywords** E-cigarettes, pregnancy, prevalence, smoking, vaping.

**Tweetable extract** One in 20 women report vaping during pregnancy but of those that do vape, most also smoke, despite having intentions to quit.

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### Introduction

Smoking when pregnant affects the health of women and their fetus.<sup>1–4</sup> Global prevalence of smoking in pregnancy is around 2% but varies between countries and regions.<sup>5</sup> In England around 11% of women self-report smoking at the time of delivery, with higher rates among women below the age of 20 years and those in routine or manual

occupations.<sup>6,7</sup> Most women who quit during pregnancy, relapse within the first 6 months after birth.<sup>8–10</sup>

The prevalence of vaping outside of pregnancy is 5–7%<sup>11</sup> and has remained stable in recent years.<sup>12–15</sup> The most frequently reported reason for vaping is to help quit smoking, and ex-smokers often report vaping to prevent relapse.<sup>16</sup> In non-pregnant smokers, a large trial found electronic cigarettes (ECs) to be more effective for cessation than nicotine

replacement therapy (NRT).<sup>17</sup> ECs are not risk-free; however, compared with smoking, ECs are likely to be less harmful<sup>18</sup>; long-term vapers who do not smoke have lower levels of carcinogens and toxins.<sup>19</sup>

There is limited information about the nature or extent of EC use in pregnancy<sup>20–24</sup> and few studies have addressed the safety. ECs often contain nicotine and the effects of using nicotine, particularly in higher doses, is unclear in the human pregnancy.<sup>25</sup> Some studies indicate an association between ECs and adverse infant outcomes<sup>26,27</sup> and dual use (smoking and vaping) is not associated with lower nicotine intake.<sup>28</sup> However, others have shown associations between exclusive vaping (non-smokers) and higher birth-weight compared with women who smoke during pregnancy.<sup>29</sup> In addition, ECs do not expose users to toxic products of combustion, which are associated with adverse effects on the fetus.<sup>30</sup> A large trial in pregnancy is currently assessing the effectiveness of ECs.<sup>31</sup> UK advice for health professional, is in favour of using ECs in pregnancy in order to avoid smoking.<sup>32</sup> Understanding who vapes during pregnancy, how they vape and attitudes towards vaping will help health professionals target and support pregnant smokers to use ECs, who might otherwise continue to smoke, and assist vapers who continue to smoke to stop smoking.

We aimed to estimate the prevalence of vaping in pregnancy and compare characteristics, smoking behaviour and attitudes of pregnant women who smoke exclusively (and do not vape) with pregnant women who vape. For women who reported currently vaping in pregnancy, we compared the characteristics of exclusive vapers with dual users.

## Methods

### Study design

This paper reports cross-sectional baseline findings from a UK longitudinal cohort study, designed to explore the use of and attitudes towards EC during pregnancy. Anyone over 16 years old and 8–24 weeks pregnant were eligible to answer an initial set of short questions (screening survey) which asked their vaping and smoking status; those who were recent ex-smokers, currently smoked and/or vaped were invited to complete a longer survey (the full survey). Consent was then gained to complete a further two surveys in late pregnancy and postpartum. We report findings from the first survey here. Women were offered a £10 high street shopping voucher for completing the full survey.

### Recruitment of participants

We used purposive non-probability sampling by selecting 17 National Health Service (NHS) hospital recruitment sites with varying smoking in pregnancy rates from a range of geographical locations across the UK (England and

Scotland). We recruited from various antenatal clinics at each hospital (e.g. general and specialist); between June and November 2017 a research midwife/nurse systematically handed out a screening survey to all pregnant women attending selected clinics.

The screening survey contained a question asking women whether they had completed the survey before; if they had, they were then excluded from answering any further questions. Each hospital was asked to recruit approximately 44 women into a longitudinal cohort. Women who completed the full survey, were asked for their contact details and given a unique identifier; a member of the research team cross-matched these details to ensure each woman only completed the full survey once.

Of 4193 pregnant women handed the screening survey, 3360 (80.0%) were eligible to complete the initial screening questions about smoking and vaping; 797 women were ineligible (20.0%) due to gestation (<8 weeks/>24 weeks) or age (<16 years), or because they had completed the survey before (Figure S1).

This work was funded by Cancer Research UK, Tobacco Advisory Group Project and was externally peer-reviewed (Grant number C53479/A22733). A patient public involvement panel (PPI) was involved in the study concept and design. Table S1 shows in more detail how PPI was used in this study. Ethical approval was given by the South West Frenchay Research Ethics Committee. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidance<sup>33</sup> and Transparent Reporting of Evaluations with Nonrandomized Designs (TREND)<sup>34</sup> guidance were used for reporting. Full details of the study are in the protocol<sup>35</sup> and Research Registry database.<sup>36</sup>

### Survey content and measurements

The survey was divided into two parts: the screening survey and the full survey (Appendix S1).

#### Screening survey

Women were asked their gestation (weeks pregnant), age and whether they had completed the survey previously. They were then asked about current smoking and vaping status. For smoking, the categories were: never smoker, ex-smoker (stopped smoking more than 3 months before finding out they were pregnant), recent ex-smoker (stopped smoking in the 3 months before pregnancy or after finding out about pregnancy), and current smoker (smoke occasionally, but not every day; smoke every day, but have cut down; smoke every day, about the same as before pregnancy; smoke every day, more than before pregnancy). For vaping, the categories were: never vaped (never heard of EC and never tried; heard of EC but never tried), ex-vaper (tried, but do not use now), current vaper (currently use ECs, but not every day; use ECs every day).

### Full survey

In the full survey, participants were asked questions about their views and experiences of using ECs, including a combination of original questions and ones derived from previous studies (shown by citations). This included questions about future intentions to use ECs in pregnancy and the postpartum<sup>37</sup> (answers on a 5-point Likert scale, ranging from very likely to very unlikely). Attitudes towards and acceptability of the use of ECs during pregnancy including views on safety of use during pregnancy and vaping safety compared with smoking and NRT<sup>38</sup> (answers on a 7-point Likert scale, ranging from strongly disagree to strongly agree).

Participants were also asked questions about their current smoking behaviour and beliefs: when they last smoked (in the last 24 h, 1–6 days ago, 7–30 days ago, 1–2 months ago, 2–3 months ago, more than 3 months ago), nicotine dependence, which was categorised according to the Heaviness of Smoking Index (HSI)<sup>39,40</sup> (time to first smoking in the morning and number of cigarettes per day), and attitudes to stopping smoking in pregnancy, including when they tried to stop smoking during pregnancy (yes/no/stopped smoking before I became pregnant) and whether they were planning to quit (yes, within next 2 weeks/yes, within the next 30 days/yes, within the next 3 months/no). Cigarettes smoked per day (CPD) were categorised as either '0–10' or '≥11' to distinguish between heavy and light smokers<sup>41</sup>; we included zero, as some women smoked occasionally but not every day.

Demographic questions asked about educational attainment, age participant left education and ethnicity.

### Measurements

The main outcome measure was smoking and vaping status collected from the screening survey questions, and was defined as follows.

'Exclusive smokers': pregnant women who reported they currently smoked cigarettes (daily or occasionally) and were not currently using an EC.

'Vapers': pregnant women who currently used an EC (daily or occasionally); vapers were sub-divided into 'exclusive vapers' who currently used an EC but did not currently smoke, and 'dual users' who currently used an EC (daily or occasionally) and also currently smoked cigarettes (daily or occasionally).

We excluded recent ex-smokers who were not using ECs from our comparisons in our analysis as there is already strong evidence to show that pregnant women who quit smoking are systematically different from those who continue.<sup>42,43</sup>

Multiple choice and Likert type scales were collapsed into smaller categories due to low use of some of the response options. Questions that used yes/no responses

were not recategorised. Continuous data were not normally distributed and were summarised into medians/interquartile ranges.

### Sample size

The sample size calculation was based on the precision of estimates of prevalence of vaping and smoking for the longitudinal cohort study. We determined a priori that a sample size of 600 women would ensure adequate precision, using a Wilson score 95% confidence interval for small proportions and assuming the prevalence is around 5%, to provide 95% confidence limits of 3.5–7%, with greater precision for estimates of prevalence for the baseline screening survey. The actual precision for those that completed the screening survey is apparent from the 95% confidence intervals presented.

### Data analysis

We used screening survey responses to estimate the prevalence of vaping and smoking for all pregnant women with 95% confidence intervals. We used estimates of the proportions, in the following categories: exclusive smokers, exclusive vapers and dual users. We then compared prevalence of vaping and smoking status (smokers/non-smokers/exclusive vapers, dual users) by age group, gestation when recruited into the study and region using Chi-square tests.

For those who were eligible and completed the full survey, we described maternal characteristics, smoking and vaping behaviour, and attitudes towards ECs among all participants. Then we used these latter independent variables to conduct Chi-square tests to determine differences between all women who vaped (both exclusive and dual users) and those who were exclusive smokers, and any differences between exclusive vapers and dual users. We used the Mann-Whitney U-test to compare age between the groups. We compared current smoking behaviour between dual users and exclusive smokers using Chi-square tests. Logistic regression was used to obtain the odds ratio (OR) for any significant findings.

Missing data are described but were excluded from significance tests. We did not use multiple imputation, as for most variables less than 5% of responses were missing. The *P*-values were deemed significant if they were less than 0.05. Analysis was carried using STATA-SE version 15 (StataCorp LLC, College Station, TX, USA).

## Results

In all, 3360 women completed a screening survey; 2336 (69.5%) of the women had never smoked, had stopped smoking >3 months ago and/or were not current vapers, and therefore were not eligible to complete the full survey (Figure S1). A total of 1024 (30.5%) reported they were a

smoker, recent ex-smoker and/or vaped; 867 (25.8%) completed the full survey.

A total of 515 women (15.3%, 95% CI 14.1–16.6) who completed the screening survey were exclusive smokers, 162 (4.8%, 95% CI 4.1–5.6) were currently vaping; 44 (1.3%, 95% CI 1.0–1.8) were exclusive vapers and 118 (3.5%, 95% CI 2.9–4.2) were dual users (Table 1). Women were predominantly between the ages 25 and 34 years (57.6%), from the North of England (27.1%) and in their second trimester of pregnancy (50.6%). There were statistical differences between vaping and smoking status by age group and region in which the participant was recruited ( $P \leq 0.001$ ) but not with gestation at recruitment.

Table S2 provides a detailed breakdown of self-reported smoking and vaping of everyone who completed the screening questions; one woman (0.03%) who had never smoked reported being a current vaper.

Table 2 shows the characteristics of the 867 women who completed the full survey (i.e. those who were current or recent ex-smokers, and/or vapers). There were 434 (50.1%, 95% CI, 46.7–53.4) exclusive smokers and 140 (16.1%, 95% CI, 13.8–18.8) current vapers (dual and exclusive); of the vapers, 33 (23.6%) were exclusive vapers and 107 (76.4%) were dual users. Educational level was a significant predictor of EC use; having an educational attainment of A-level or above compared with GCSE or less increased the odds of using an EC by 51% (OR 1.51, 95% CI 1.01–2.25).

When comparing pregnant women who are exclusive vapers with dual users, dual users were significantly

younger (OR 0.91, 95% CI 0.85–0.98), less likely to hold a higher level of qualification (OR 0.43, 95% CI 0.20–0.96), less likely to have stayed in education above the age of 16 years (OR 0.34, 95% CI 0.15–0.78), more likely to report their pregnancy was unplanned (OR 3.74, 95% CI 1.65–8.50) and more likely to have smoked in previous pregnancies (OR 4.04, 95% CI 1.59–10.29) (Table 2).

Table 3 describes smoking and vaping behaviour including intention to quit for all those who completed the full survey and compares exclusive smokers and vapers. Compared with exclusive smokers, dual users were more likely to be planning to quit smoking (OR 2.27, 95% CI 1.24–4.18) and to report not smoking in the previous 24 h (OR 7.93, 95% CI 4.86–12.93). Over half of women who were exclusive vapers (57.6%) had stopped smoking before pregnancy, and 74.8% of dual users and 70.3% of exclusive smokers had tried to stop smoking after becoming pregnant.

Table 4 describes attitudes to EC use in pregnancy among all those who completed the full survey and compares exclusive smokers with vapers (exclusive and dual). Vapers were more likely to think using an EC was safer than smoking (78.6 versus 36.4%). There was no significant difference in their perception of the harms of nicotine in pregnancy, with most vapers (70%) and smokers (76%) agreeing with the statement '*nicotine is harmful to my unborn baby*'. There were no significant differences between dual and exclusive vapers in their attitudes towards ECs or how acceptable they found them (data not shown).

**Table 1.** Prevalence of vaping and smoking among pregnant women

Total		Completed screening questions <i>n</i> = 3360 (%)*	Exclusive vapers <i>n</i> = 44 (1.3%)**	Exclusive smokers <i>n</i> = 515 (15.3%)**	Dual users <i>n</i> = 118 (3.5%)**	<i>P</i> -value: comparisons between categories****
Age (years)	16–24	794 (23.6)	3 (6.8)	203 (39.4)	45 (38.1)	<0.001
	25–34	1936 (57.6)	35 (79.6)	250 (48.5)	55 (46.6)	
	35≥	604 (17.9)	6 (13.6)	62 (12.0)	16 (13.6)	
	Missing***	26 (0.8)	0	0	2 (1.7)	
NHS sites by region	South	728 (21.7)	6 (0.8)	95 (13.0)	13 (1.8)	<0.001
	London	546 (16.3)	3 (0.5)	54 (9.9)	11 (2.0)	
	Midlands	859 (25.6)	22 (2.6)	194 (22.3)	39 (4.5)	
	North	909 (27.1)	10 (1.1)	138 (15.2)	38 (4.2)	
	Scotland	318 (9.5)	3 (0.9)	34 (10.7)	17 (5.3)	
Gestation at recruitment	1st trimester	1543 (45.9)	23 (52.3)	219 (42.5)	55 (46.6)	0.18
	2nd trimester	1699 (50.6)	20 (45.5)	287 (55.7)	58 (49.2)	
	Unknown/Missing***	118 (3.5)	1 (2.3)	9 (1.8)	5 (4.2)	

\*Percentages presented in columns for those who completed the screening questions in the survey.

\*\*Percentages presented by rows for the breakdown by vaping and smoking status.

\*\*\*Missing excluded from chi-square analysis.

\*\*\*\**P*-value to determine statistical differences between vaping and smoking status (smokers/non-smokers/exclusive vapers, dual users) by age group, gestation when recruited into the study and region using Chi-square tests.

**Table 2.** Socio-demographic characteristics; comparisons between pregnant vapers and exclusive smokers, and between exclusive vapers and dual users

	Total	Completed the full survey <i>n</i> = 867	Vapers (exclusive and dual) <i>n</i> = 140	Exclusive smokers <i>n</i> = 434	<i>P</i> -value Comparisons between vapers & exclusive smokers	Exclusive vapers <i>n</i> = 33/140 (23.5%)	Dual users <i>n</i> = 107/140 (76.4%)	<i>P</i> -value: comparisons between exclusive vapers & dual users
Age	Median [IQR]	26 (22–31)	26 (23–31)	26 (22–31)	0.18	28 (26–33)	26 (22–29)	0.007
	Missing*	3	2	0		2	0	
Highest educational level	GCSEs, similar or none**	502 (57.9%)	84 (60.0%)	296 (68.2%)	0.04	15 (45.5.0%)	69 (64.5%)	0.04
	A levels/degree, similar or above**	348 (40.1)	54 (38.6%)	126 (29.0%)		18 (54.6%)	636 (33.6%)	
	Missing*	17 (2.0%)	2 (1.4%)	12 (2.8%)		0 (0%)	2 (1.9%)	
Age left education	≤16	415 (47.9%)	73 (52.1%)	251 (57.8%)	0.61	11 (33.3%)	62 (57.9%)	0.03
	≥17	408 (47.1%)	58 (41.4%)	161 (37.1%)		20 (60.6%)	38 (35.5%)	
	Still in education	25 (2.9%)	5 (3.6%)	10 (2.3%)		1 (3.0%)	4 (3.7%)	
	Missing*	19 (2.2%)	4 (2.9%)	12 (2.8%)		1 (3.0%)	3 (2.8%)	
Ethnicity	White British	759 (87.5%)	131 (93.6%)	382 (88.2%)	0.53	31 (93.9%)	100 (93.5.2%)	0.76
	Other	63 (11.1%)	7 (5.0%)	45 (10.4%)		2 (6.1%)	5 (4.7%)	
	Missing*	12 (1.4%)	2 (1.4%)	7 (1.6%)		0 (0%)	2 (1.9%)	
Gestation at recruitment	1st trimester	399 (46.0%)	72 (51.4)	188 (43.3)	0.06	21 (63.6)	51 (47.7)	0.91
	2nd trimester	460 (53.1)	65 (46.4)	243 (56.0)		11 (33.3)	54 (50.5)	
	Don't know/missing	8 (0.9)	3 (2.1)	3 (0.7)		1 (3.0)	2 (1.9)	
Previous pregnancy	Yes	561 (64.7%)	100 (71.4%)	306 (70.5%)	0.50	27 (81.8%)	73 (68.2%)	0.27
	No	288 (33.2%)	34 (24.3%)	121 (27.9%)		6 (18.2%)	28 (26.2%)	
	Missing*	18 (2.1%)	6 (4.3%)	7 (1.6%)		0 (0%)	6 (5.6%)	
If yes – smoked in previous pregnancy	Yes	345 (61.5%)	72 (72.0%)	232 (75.8%)	0.32	13 (48.2%)	59 (80.8%)	0.007
	No	197 (35.1%)	26 (26.0%)	59 (19.3%)		14 (51.9%)	12 (16.4%)	
	Don't remember	12 (2.1%)	2 (2.0%)	8 (2.6%)		0 (0%)	2 (2.7%)	
	Missing*	7 (1.3%)	0(0%)	7 (2.3%)		0(0%)	0 (0%)	
Planned pregnancy	Yes	292 (33.7%)	43 (30.7%)	121 (27.9%)	0.53	18 (54.6%)	25 (23.4%)	0.001
	No	548 (63.2%)	93 (66.4%)	299 (68.9%)		15 (45.4%)	78 (72.9%)	
	Missing*	27 (3.1%)	4 (2.9%)	14 (3.2%)		(0%)	4 (3.7%)	

\*Missing data excluded from chi-square analysis.  $\neq$  *P*-values are for comparisons between exclusive smokers (who do not vape) and dual users.

\*\*GCSE: General Certificate of Secondary Education, compulsory exams in the UK taken at age 15–16. A levels: General Certificate of Education Advanced Level certificate, non-compulsory exams, taken in the UK, after compulsory education ends. To note: The remaining 293/867 women who completed the full survey were recent ex-smokers who were not using e-cigarettes and are not included in table.

## Discussion

### Main findings

This is the first UK study to report vaping prevalence, user characteristics and attitudes towards vaping during pregnancy. Just under 5% of all pregnant women reported currently vaping, the majority of whom continued to smoke. Among smokers and ex-smokers, just over 16% reported vaping in pregnancy, mostly as dual users. Dual users were more likely to report wanting to quit smoking and less likely to have smoked in the previous 24 h compared with exclusive smokers. There were significant differences between dual users and exclusive vapers; dual users were

younger, less educated, less likely to have a planned pregnancy and more likely to have smoked in a previous pregnancy. Over half of exclusive vapers had stopped smoking before becoming pregnant.

### Strength and limitations

Strengths include the prospective recording of data during pregnancy, rather than retrospective data collection post-partum, reducing recall error and bias. The selection of hospital recruitment sites was non-random, as we only used hospitals that had research nurses/midwives available to recruit, although the majority of hospitals in England have this service available.<sup>44</sup> Efforts were made to ensure a



**Table 3.** Smoking and vaping behaviour; comparisons between pregnant vapers and exclusive smokers, and between exclusive vapers and dual users

	Total	Total participants who completed the full survey <i>n</i> = 867	Vapers (exclusive & dual) <i>n</i> = 140 16.1%	Exclusive smokers <i>n</i> = 434 50.1%	<i>P</i> -value Comparisons between vapers & exclusive smokers	Exclusive vapers <i>n</i> = 33	Dual users <i>n</i> = 107	<i>P</i> -value: comparisons between exclusive vapers & dual users
Tried to stop smoking since becoming pregnant	Yes	639 (73.7%)	94 (67.1%)	305 (70.3%)	0.28	14 (42.4%)	80 (74.8%)	<0.001
	No	142 (16.4%)	23 (16.4%)	116 (26.7%)		0 (0%)	23 (21.5%)	
	Stop smoking before pregnancy	61 (7.0%)	19 (13.6%)	0%		19 (57.6%)	0 (0%)	
	Missing*	25 (2.7%)	4 (2.9%)	13 (3%)		0 (0%)	4 (3.7%)	
Likely to try or continue to use EC while still pregnant	Likely	199 (23.0%)	103 (73.6%)	82 (18.9%)	<0.001	24 (72.7%)	79 (73.8%)	0.02
	Neither likely or unlikely	113 (13.0%)	16 (11.4%)	79 (18.2%)		3 (9.1%)	13 (12.2%)	
	Unlikely	432 (49.8%)	8 (5.7%)	188 (43.3%)		5 (15.2%)	3 (2.8%)	
	I don't know	94 (10.8%)	10 (7.1%)	68 (15.7%)		1 (3.0%)	9 (8.4%)	
Likely to try or continue to use EC once baby is born	Missing*	29 (3.3%)	3 (2.1%)	17 (3.9%)	<0.001	0	3 (2.8%)	0.78
	Likely	212 (24.5%)	91 (65.0%)	98 (22.6%)		22 (64.5%)	69 (64.5%)	
	Neither likely or unlikely	138 (15.9%)	26 (18.6%)	79 (18.2%)		6 (18.2%)	20 (19.0%)	
	Unlikely	381 (43.9%)	6 (4.3%)	168 (38.7%)		1 (3.0%)	5 (4.7%)	
Current smokers only	I don't know	107 (12.3%)	13 (9.3%)	70 (16.1%)	NA	4 (12.1%)	9 (8.4%)	<0.001 ≠
	Missing*	29 (3.3%)	4 (2.9%)	19 (4.4%)		0	4 (3.7%)	
	≤24 h	541	--	434		NA	<b>107</b>	
	>24 h	470 (86.9%)	--	390 (89.9%)			80 (74.8%)	
Last smoked	Missing*	59 (10.9%)	--	34 (7.8%)	NA		25 (23.4%)	0.53 ≠
	Low dependence (0–2)	12 (2.2%)	--	10 (2.3%)			2 (1.9%)	
	Moderate/high dependence (3–6)	345 (63.8%)	--	278 (64.1%)			67 (62.7%)	
	Missing*	158 (29.2%)	--	131 (30.2%)			27 (25.2%)	
Heaviness of Smoking Index	0–10	38 (7.0%)	--	25 (5.8%)	NA		13 (12.1%)	0.09 ≠
	≥11	387 (71.5%)	--	306 (71.0%)			81 (75.7%)	
	Missing*	128 (23.7%)	--	110 (25.4%)			18 (16.8%)	
Cigarettes smoked per day	Missing*	26 (4.8%)	--	18 (4.2%)	NA		8 (7.5%)	0.01 ≠
	Yes	362 (66.9%)	--	286 (65.9%)			76 (71.0%)	
	No	128 (23.7%)	--	114 (26.3%)			14 (13.1%)	
Seriously planning to quit smoking	Missing*	52 (9.4%)	--	34 (7.8%)	NA		17 (15.9%)	0.01 ≠

Note: The remaining 293/867 women who completed the full survey were recent ex-smokers who were not using e-cigarettes.

\*Missing data excluded from chi-square analysis. ≠ *P*-values are for comparisons between exclusive smokers (who do not vape) and dual users.

wide range of geographical locations, socio-economic areas and variation in smoking in pregnancy rates. Non-smokers may have been less likely to complete the screening survey as they might consider the topic not relevant and non-English readers would not be included. We did not record how many declined to complete the screening survey; however, in a previous study measuring smoking prevalence in

pregnancy, using very similar methods, the rate of decline was only 4.5%.<sup>42</sup> The socio-demographic profile of the smokers was similar to previous cohort studies measuring smoking in pregnancy; women were predominantly white-British, with low education.<sup>6,42,45</sup> Only women who attended antenatal clinics were surveyed; however, most women in the UK attend these appointments.<sup>46</sup>

**Table 4.** Attitudes towards e-cigarette (EC) use in pregnancy; comparisons between pregnant vapers and exclusive smokers

Total		All participants who completed the full survey, n (%) n = 867	Vapers (exclusive & dual) n = 140 (16.1%)	Exclusive smokers n = 434 (50.1%)	P- value: comparisons between vapers & exclusive smokers
More likely to vape in pregnancy if health professional recommended	Agree	483 (55.7%)	117 (83.6%)	235 (54.2%)	<0.001
	Neither agree or disagree	165 (19.0%)	16 (11.4%)	94 (21.7%)	
	Disagree	208 (24.0%)	6 (4.3%)	99 (22.8%)	
	Missing*	11 (1.3%)	1 (0.7%)	6 (1.4%)	
Vaping in pregnancy harms my baby	Agree	294 (33.9%)	11 (7.9%)	126 (29.0%)	<0.001
	Neither agree or disagree	448 (51.7%)	87 (62.1%)	246 (56.7%)	
	Disagree	114 (13.2%)	41 (29.3%)	56 (12.9%)	
Vaping in pregnancy is as safe as using nicotine patches	Agree	151 (17.4%)	43 (30.7%)	68 (15.7%)	<0.001
	Neither agree or disagree	492 (56.8%)	76 (54.3%)	249 (57.37%)	
	Disagree	214 (24.7%)	19 (13.6%)	113 (26.0%)	
Vaping in pregnancy is much less harmful than tobacco cigarettes	Agree	415 (47.9%)	110 (78.6%)	158 (36.4%)	<0.001
	Neither agree or disagree	304 (35.1%)	24 (17.1%)	189 (43.6%)	
	Disagree	135 (15.6%)	4 (2.9%)	80 (18.4%)	
Nicotine is harmful to my unborn baby	Agree	674 (77.7%)	98 (70.0%)	330 (76.0%)	0.19
	Neither agree or disagree	140 (16.2%)	29 (20.7%)	80 (18.4%)	
	Disagree	42 (4.8%)	11 (7.9%)	19 (4.4%)	
Most important reasons for vaping in pregnancy*	Agree	11 (1.3%)	2 (1.4%)	5 (1.2%)	0.06
	To help quit smoking	392 (45.2%)	65 (46.4%)	184 (42.4%)	
	To help cut down cigarettes	40 (4.6%)	6 (4.3%)	25 (5.8%)	
	Less harmful to others around me compared to tobacco smoke	28 (3.2%)	0 (0%)	12 (2.8%)	
	Healthier than tobacco cigarettes	26 (3.0%)	5 (3.6%)	10 (2.3%)	
	They are cheaper than tobacco cigarettes	13 (1.5%)	1 (0.7%)	6 (1.4%)	
	Other	53 (6.1%)	2 (1.4%)	27 (6.2%)	
Missing*	315 (36.3%)	61 (43.6%)	170 (39.2%)		
Most important reasons for NOT vaping in pregnancy*	They do not get rid of the smoking habit	102 (11.8%)	12 (8.6%)	49 (11.3%)	0.009
	Not enough research	135 (15.6%)	21 (15.0%)	52 (12.0%)	
	Bad stories in press/ social media	81 (9.3%)	9 (6.4%)	59 (13.6%)	
	Worried about side effects	71 (8.2%)	7 (5.0%)	25 (5.8%)	
	Do not get rid of nicotine addiction	52 (6.0%)	15 (10.7%)	17 (3.9%)	
	Other	154 (17.8%)	49 (35.0%)	89 (20.5%)	
	Missing*	272 (31.4%)	49 (35.0%)	143 (33.0%)	

Note: The remaining 293/867 women who completed the full survey were recent ex-smokers who were not using e-cigarettes.

\*Missing data excluded from chi-square analysis \*There were multiple answers to the questions asked about the most important reason to use or not to vape: the five most commonly reported answers are presented in the tables.

Reliance on self-reported smoking and vaping status may lead to under-reporting.<sup>47</sup> The social stigma of smoking is well known and qualitative work suggests there is also a stigma associated with vaping;<sup>37</sup> however, the surveys were anonymous, everyone was asked to complete them, and this could be done quickly and discreetly. We did not report whether women were using other forms of nicotine in pregnancy, such as NRT; however, this is generally

low.<sup>48</sup> Another caution is that the number of vapers, particularly exclusive vapers, is relatively low, and a quarter of reported exclusive vapers from the screening survey did not complete the full survey. Therefore, findings may not be representative of all pregnant vapers and we may have missed small differences between exclusive vapers and dual users. Also, as countries vary in smoking prevalence<sup>5</sup> it is likely vaping prevalence will, too, therefore these results

may not apply to all pregnant populations. Women below the age of 16 years were excluded, therefore we do not report vaping patterns in this age category. Data collected about attitudes and beliefs should be approached with caution, as responses will be limited to the questions asked; further qualitative research is required to establish the validity of responses.

### Interpretation

Previous studies, mostly based in the USA between 2014 and 2017, estimated the prevalence of vaping during pregnancy to be 0.6–15%.<sup>20–23,49</sup> Variations in findings are likely due to different data collection and recall periods, including use before or at differing points during pregnancy. Our findings show that 4.8% of pregnant women are vaping in early pregnancy. Previous UK data from Stop Smoking Services (SSS), a free support service in the UK, found only 2.2% women were vaping in pregnancy (16); however, this figure will not include those who quit smoking before or on discovering they are pregnant. Our findings suggest that one in 20 pregnant women in England and Scotland whom antenatal clinicians encounter is vaping. Among pregnant smokers or ex-smokers, around 16% are vaping, which is far greater than that reported by SSS, as many pregnant smokers do not access these services. Understanding the characteristics of pregnant vapers and reasons women vape is clearly relevant to antenatal care, and clinicians require knowledge and skills to deal appropriately with issues arising from this.

Around three-quarters of vapers were dual users, which concurs with findings showing that both pregnant<sup>20,22</sup> and non-pregnant vapers<sup>15</sup> often continue to smoke. Outside of pregnancy, dual users report that vaping is a way to reduce their smoking below a perceived harm threshold.<sup>50</sup> Reduced levels of carbon monoxide have been identified in non-pregnant dual users who significantly cut down their smoking.<sup>51</sup> However, the greatest reduction in toxicant exposure is seen in EC users who completely stop smoking.<sup>19,28</sup> Understanding how clinicians can support pregnant vapers to stop smoking is required; our finding that, like other women who smoke during pregnancy,<sup>6,42</sup> dual users were younger and less likely to hold higher educational qualifications compared with exclusive vapers could help target behavioural cessation support by addressing social influences, knowledge and intentions in these specific groups.

Over half of exclusive vapers in our study reported stopping smoking before pregnancy. Outside of pregnancy, vaping among long-term ex-smokers is common,<sup>15,17</sup> and in one randomised controlled trial (RCT) 80% of those abstinent after 1 year and assigned to ECs reported still using them.<sup>17</sup> Understanding pregnant women's reasons for continued use would help provide more appropriate support for women who want to quit both vaping and smoking.

A majority of vapers believed ECs were safer than smoking during pregnancy, and this did not differ between dual and exclusive vapers, therefore facilitating beliefs may be important in the uptake of vaping. However, both vapers and smokers were undecided about the harms of using nicotine during pregnancy. Animal studies have shown that nicotine is associated with detrimental neurological and behavioural effects on the fetus.<sup>25,52</sup> The effects of high-dose nicotine alone in human pregnancy is unclear.<sup>25</sup> However, the short-term<sup>53,54</sup> and long-term effects of nicotine exposure through NRT in human pregnancy are not associated with greater risk to the fetus<sup>55</sup> or infant.<sup>56</sup> Perinatal exposure to ECs in animals<sup>23</sup> is potentially detrimental and there are mixed reviews about their safety in human studies,<sup>26–29</sup> but data are very limited. However, similar to NRT, ECs have no products of combustion and this may prevent most tobacco-related harms<sup>30</sup> if successfully used to quit. For women to make informed decisions about using ECs to stop smoking, clinicians and healthcare providers should supply women with the latest evidence.

### Conclusion

Our findings suggest that in England and Scotland, one in 20 women use e-cigarettes in pregnancy, most of whom smoke concurrently. Among women who smoke in pregnancy or did so shortly before conception, around 16% are vaping. Currently, the UK NHS supports pregnant smokers to stop smoking; our findings show that clinicians need to be aware of the frequency with which they are likely to encounter pregnant women who vape. Pregnant dual users are more motivated towards stopping smoking than are women who only smoke. Clinicians may consider encouraging smokers who have unsuccessfully tried stopping, to consider vaping as a step towards stopping smoking; understanding the characteristics of pregnant vapers and reasons for vaping may help with this.

### Disclosure of interests

Dr Hayden McRobbie has in the past 3 years received honoraria for speaking at smoking cessation meetings and attending advisory board meetings that have been organised by Pfizer. He has no relations with the manufacturers of vaping products. The remaining authors have no disclosures of interest to declare. Completed disclosure of interest forms are available to view online as supporting information.

### Contribution to authorship

The study was designed by SC, SL, TC, LB, LS, HM, MU, FN, SO, KB. KB, LP and SC were involved in planning and managing the data collection. SL, SC, KB and AK (medical student) were involved in the statistical analysis. KB wrote the manuscript with support and critical review from all authors.



## Details of ethical approval

Ethical approval was granted by the South West Frenchay Research Ethics Committee on the 16 May 17 (study no. 17/SW/0095).

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## Supporting Information

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

**Figure S1.** Flowchart, consort flow diagram of recruitment.

**Table S1.** Patient Public Involvement (GRIPP2-SF).

**Table S2.** Smoking and vaping among all pregnant women who answered the screening the survey.

**Appendix S1.** Screening and full survey. ■

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