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Purchasing and sourcing of e-cigarettes among youth in Scotland and England following Scotland's implementation of an e-cigarette retail register and prohibition of e-cigarette sales to under-18s

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Abstract

Background. Scotland implemented new e-cigarette regulations in April 2017 prohibiting sales to under-18s, requiring age verification, and requiring retailer registration. This study examined purchasing and sourcing of e-cigarettes among minors aged 16-17, and youth aged 18-19, in the short- (4 months) and longer-term (16 months) after regulations were implemented, compared with England.

Methods. Data were from the July/August 2017 and August/September 2018 cross-sectional online ITC Youth Tobacco and Vaping Surveys of 16- to 19-year-olds in Scotland ($n_{2017/2018}$=434/377) and England ($n_{2017/2018}$=3,791/3,743). Logistic regressions were used to examine differences in past-12-month purchasing, past-12-month sale refusal, and past-30-day sourcing of e-cigarettes between 2017 and 2018, by country and age group.

Results. Among vapers aged 16-17 in Scotland, from 4 to 16 months post-regulations, e-cigarette purchasing increased from 21% to 50% and sale refusal increased from 14% to 16%, but these changes were not significant and did not differ from changes observed in 18-19-year-olds or England (p>.05). Purchasing and sale refusal were most common in vape shops. Purchasing from a vape shop increased among vapers aged 16-17 in Scotland from 4 to 16 months post-regulations (17% to 85%, p=.003) but not among 18-19-year-olds or in England (p>.05). Among past-30-day vapers, social sources were most common.

Conclusions. Youth vapers in Scotland showed no significant changes in overall purchasing, sale refusal, or sourcing of e-cigarettes, from 4 to 16 months post-regulations, and changes did not differ by age group or from England. Findings suggest low compliance with age-of-sale regulations in Scotland and England.

Introduction

Scotland implemented new e-cigarette retail regulations in April 2017 which included: (i) prohibition of the sale of e-cigarette products to under-18s; (ii) e-cigarette retailers must operate an age verification policy; and, (iii) e-cigarette retailers must be registered on the Register of Tobacco and Nicotine Vapour Product Retailers by 1st October 2017 . By contrast, England has prohibited the sale of e-cigarette products to under-18s since 2015 (Department of Health, 2015), although at the time of this study did not require retailers to register the sale of e-cigarette products. Scotland's new e-cigarette retail regulations therefore brought Scotland in line with England in terms of sales to under-18s, and went further by mandating retailer registration.

In the United States (US) and Canada, regulations requiring e-cigarette retailer licensing (Azagba et al., 2019) and prohibiting e-cigarette sales to minors (Nguyen, 2019; Wilhelm et al., 2021) have been associated with a reduction in youth vaping prevalence. Self-reported difficulty in obtaining e-cigarettes also increased overall among Canadian youth after the prohibition of e-cigarette sales to minors, although obtaining e-cigarettes from social sources increased (Nguyen, 2019). There is little research examining the impact of prohibiting e-cigarette sales to under-18s and retailer registration outside the US and Canada. Such evidence is important for countries considering how to regulate e-cigarette sales.

This study aimed to examine youth purchasing, sale refusal, and sourcing of e-cigarette products in the short- (four months) and longer-term (16 months) after Scotland's retail regulations were implemented. England, where no new e-cigarette retail regulations were implemented during the study period, was used as a comparison. We hypothesised that youth in Scotland, compared to England, would show changes in purchasing, sale refusal, and sourcing of e-cigarette products, from four to 16 months post-implementation, and that changes would be greater among youth aged 16-17 (i.e., minors) than youth aged 18-19 (i.e., those of legal purchasing age).

Methods

Sample. Data are from the 2017 (July-August) and 2018 (August-September) England and Scotland arms of the repeat cross-sectional International Tobacco Control (ITC) Policy Evaluation Project Youth Tobacco and Vaping surveys of youth aged 16 to 19. Inclusion of Scotland in 2017 and 2018 was for a pilot project evaluating Scotland's e-cigarette policies. Methods are described online (Hammond et al., 2020; Hammond et al., 2019). A total of N=9,982 respondents completed the surveys, of whom N=8,345 were retained in this study's analytic sample (n=1,637 excluded due to: failing integrity checks, participating in a previous survey wave, providing incomplete/invalid data on variables used for weighting, or selecting 'Don't know' or 'Refused' on planned outcomes).

Pre-registration. Analyses were pre-registered (East et al., 2019); however, due to low cell counts for several outcomes and a lack of pre-implementation data, some outcomes were not modelled. Measure details, including measures that

were pre-registered but not modelled, are in Table 1.

Table 1. All planned outcomes and whether or not they were modelled, with justification

Outcome	Item wording and coding	Modelled
Past 12-month purchasing		
Any	Respondents who had vaped in the past 12 months were asked,*2017 survey:* "Have you bought an e-cigarette/vaping device, cartridge, or e-liquid in the past 12 months? Yes, No", *2018 survey:* "Have you bought any of the following in the past 12 months? (a) E-cigarette/vaping device, (b) Cartridge or pod (for an e-cigarette/vaping device), (c) E-liquid (for an e-cigarette/vaping device)" with response options for each: "Yes, No". Responses for each were combined: Yes (Yes to any item), No (No to all items).[1]	Yes
From a vape shop	Participants who had purchased an e-cigarette product in the past 12 months were asked, "Where have you bought an e-cigarette/vaping device, cartridge, [pod]*, or e-liquid in the past 12 months? (select all that apply)" followed by a list of locations. Those who selected "From a vape shop" were coded as purchasing from a vape shop.	Yes
From a regular shop/chemist	Participants who had purchased an e-cigarette product in the past 12 months were asked, "Where have you bought an e-cigarette/vaping device, cartridge, [pod]*, or e-liquid in the past 12 months? (select all that apply)" followed by a list of locations. Those who selected "From a regular shop (convenience, newsagents, supermarket, etc.)"or "From a chemist" were coded as purchasing from a regular shop/chemist. These two locations were combined because of low numbers of respondents who selected "From a chemist" (n=30); criteria for dealing with outcomes of low sample size were specified in the pre-registration (osf.io/4BA9H/).	Yes
From the internet	Participants who had purchased an e-cigarette product in the past 12 months were asked, "Where have you bought an e-cigarette/vaping device, cartridge, [pod]*, or e-liquid in the past 12 months? (select all that apply)" followed by a list of locations. Those who selected "From the internet" were coded as purchasing from the internet.	No – n=0 for at least one country at one time point and this location was not suitable to group with others because age verification policies differ for internet versus in-shop purchases.

[1] Respondents could also select "Don't know" or "Refused" to these measures, but in doing so were excluded from the analytic sample (n=377).

Outcomes. Six outcomes were assessed: past-12-month purchasing (any, from a vape shop, from a regular shop/chemist [sources grouped due to low cell counts]); any past-12-month sale refusal; and past-30-day source (social source, purchased from a store) of e-cigarettes.

Predictors. Country (Scotland/England), survey year (2017/2018), age group (16-17/18-19).

Covariates. Sex (male/female), student status (yes/other), race/ethnicity (White only/other), smoking status (never/ever/past-30-day), and vaping status (never/ever/past-30-day; for models predicting purchasing and sale refusal).

Analyses. Unadjusted and adjusted (with predictors and covariates entered simultaneously into models) logistic regressions using weighted data were used to assess associations between each outcome and country, year, age group, and country*year and, in a subsequent model, country*year*age group. Interactions were further examined by contrasting marginal estimates. Stata v15 was used.

Results

Table 2 shows the sample characteristics. Most of the sample reported that they were aged 18-19, male, White race/ethnicity, a student, and had never vaped or never smoked.

Table 2. Characteristics of the Scotland and England samples in 2017 and 2018 (4- and 16-months post-implementation of new e-cigarette retail regulations in Scotland), overall and by age group (n=8,345). N are unweighted, % are weighted.

	SCOTLAND						ENGLAND					
	2017			2018			2017			2018		
	All ages 16-19 (n=434)	16-17 (n=168)	18-19 (n=266)	All ages 16-19 (n=377)	16-17 (n=124)	18-19 (n=253)	All ages 16-19 (n=3,791)	16-17 (n=1,510)	18-19 (n=2,281)	All ages 16-19 (n=3,743)	16-17 (n=1,102)	18-19 (n=2,641)
Age group												
16-17	168 (47.3)	-	-	124 (46.9)	-	-	1510 (48.2)	-	-	1102 (47.5)	-	-
18-19	266 (52.7)	-	-	253 (53.1)	-	-	2281 (51.8)	-	-	2641 (52.5)	-	-
Sex												
Male	167 (50.6)	71 (50.5)	96 (50.7)	144 (50.8)	58 (49.9)	86 (51.6)	1606 (51.1)	677 (50.8)	929 (51.3)	1341 (51.2)	474 (51.1)	867 (51.3)
Female	267 (49.4)	97 (49.5)	170 (49.3)	233 (49.2)	66 (50.1)	167 (48.4)	2185 (48.9)	833 (49.2)	1352 (48.7)	2402 (48.8)	628 (48.9)	1774 (48.7)
Race/Ethnicity												
White	393 (91.7)	159 (95.2)	234 (88.6)	339 (89.6)	113 (90.6)	226 (88.7)	2984 (79.7)	1196 (79.6)	1788 (79.8)	2801 (77.2)	842 (76.4)	1959 (74.2)
Not White/DK/refused	41 (8.3)	9 (4.8)	32 (11.4)	38 (10.4)	11 (9.4)	27 (11.3)	807 (20.3)	314 (20.4)	493 (20.3)	942 (22.8)	260 (23.6)	682 (25.8)
Student status												
Yes	393 (90.8)	157 (93.0)	236 (88.7)	329 (90.6)	108 (90.3)	221 (87.4)	3472 (91.7)	1441 (95.2)	2031 (88.3)	3467 (91.7)	1055 (94.8)	2412 (88.9)
No/DK/refused	41 (9.2)	11 (7.0)	30 (11.3)	48 (9.4)	16 (9.7)	32 (12.6)	319 (8.3)	69 (4.8)	250 (11.7)	276 (8.3)	47 (5.2)	229 (11.1)
Vaping status												
Never	302 (69.0)	125 (73.6)	177 (64.9)	246 (64.9)	83 (65.9)	163 (64.1)	2491 (65.6)	1030 (67.9)	1461 (63.5)	2492 (66.8)	784 (70.2)	1708 (63.6)
Ever (not in past 30d)	103 (24.0)	32 (19.7)	71 (27.7)	90 (22.7)	22 (18.4)	68 (26.6)	971 (25.6)	349 (23.3)	622 (27.7)	953 (24.3)	221 (20.4)	732 (27.8)
Past-30-day	29 (7.0)	11 (6.6)	18 (7.4)	41 (12.3)	19 (15.7)	22 (9.3)	329 (8.8)	131 (8.8)	198 (8.8)	298 (8.9)	97 (9.4)	201 (8.5)
Smoking status												
Never	258 (59.8)	115 (66.5)	143 (53.9)	195 (52.7)	66 (52.6)	129 (52.8)	2239 (60.1)	986 (65.3)	1253 (55.2)	2200 (60.0)	711 (63.7)	1489 (56.6)
Ever (not in past 30d)	95 (22.4)	35 (22.1)	60 (22.6)	122 (31.3)	38 (31.1)	84 (31.5)	949 (24.6)	334 (22.3)	615 (26.7)	932 (23.6)	226 (20.8)	706 (26.1)
Past-30-day	81 (17.8)	18 (11.4)	63 (23.5)	60 (16.0)	20 (16.3)	40 (15.8)	603 (15.4)	190 (12.4)	413 (18.1)	611 (16.5)	165 (15.5)	446 (17.3)

DK=Don’t know.

Table 3 shows key outcomes by country, survey year, and age group. Overall, e-cigarette product purchasing among youth who had vaped in the past 12 months ranged from 20% to 50% and most youth purchased their products from a vape shop followed by a regular shop overall, and, in 2018 only, from the internet (Table 3).

Table 3. Proportion of youth aged 16-17 and 18-19 in Scotland and England in 2017 and 2018 who reported purchasing an e-cigarette product in the past 12 months, being refused sale of an e-cigarette product in the past 12 months, and sourcing an e-cigarette product in the past 30 days (unweighted n, weighted %).

	SCOTLAND						ENGLAND					
	2017			2018			2017			2018		
	All ages 16-19	16-17	18-19	All ages 16-19	16-17	18-19	All ages 16-19	16-17	18-19	All ages 16-19	16-17	18-19
E-cigarette product purchasing in the past 12 months, among past-12-month vapers (n=1,965)	N=99	N=33	N=66	N=97	N=32	N=65	N=910	N=356	N=554	N=859	N=244	N=615
Any purchase	27 (29.6)	6 (20.7)	21 (35.9)	41 (43.9)	17 (50.4)	24 (38.1)	245 (27.3)	92 (26.3)	153 (28.2)	284 (37.4)	95 (41.0)	189 (34.3)
Location of purchase, among past-12-month vapers who had purchased an e-cigarette product in the past 12 months (n=597)[1]	N=27	N=6	N=21	N=41	N=17	N=24	N=245	N=92	N=153	N=284	N=95	N=189
From a vape shop	15 (53.4)	1 (16.7)	14 (68.4)	27 (70.3)	14 (84.8)	13 (53.4)	141 (57.7)	54 (58.6)	87 (57.0)	170 (60.2)	54 (58.0)	116 (62.4)
From regular shop	8 (30.8)	3 (50.0)	5 (23.0)	16 (40.5)	8 (48.2)	8 (31.6)	59 (24.6)	21 (22)	38 (26.8)	73 (25.7)	22 (23.9)	51 (27.6)
From a chemist	0 (0.0)	0 (0.0)	0 (0.0)	2 (6.8)	1 (7.1)	1 (6.4)	8 (3.1)	1 (1.3)	7 (4.7)	20 (8.8)	10 (11.3)	10 (6.3)
From the internet	0 (0.0)	0 (0.0)	0 (0.0)	15 (39.0)	8 (45)	7 (32.0)	9 (3.5)	2 (2.1)	7 (4.7)	80 (26.7)	18 (19.2)	62 (34.4)
Sale refusal of e-cigarette products in the past 12 months, among past-12-month vapers (n=1,965)	N=99	N=33	N=66	N=97	N=32	N=65	N=910	N=356	N=554	N=859	N=244	N=615
Any refusal	5 (6.9)	4 (13.8)	1 (2.0)	12 (12.0)	6 (16.3)	6 (8.3)	91 (10.8)	54 (15.8)	37 (6.3)	67 (8.8)	26 (10.8)	41 (7.2)
Location of refusal, among past-12-month vapers who had been refused an e-cigarette product in the past 12 months (n=175)[1]	N=5	N=4	N=1	N=12	N=6	N=6	N=91	N=54	N=37	N=67	N=26	N=41
From a vape shop	2 (37.9)	1 (25.0)	1 (100.0)	5 (43.1)	3 (51.4)	2 (28.7)	52 (57.0)	30 (56.9)	22 (57.3)	35 (51.5)	14 (57.2)	21 (44.3)
From a regular shop	2 (41.4)	2 (50.0)	0 (0.0)	9 (67.4)	3 (48.6)	6 (78.6)	49 (53.6)	31 (55.1)	18 (50.2)	28 (38.2)	7 (22.6)	21 (58.3)
From a chemist	0 (0.0)	(0.0)	0 (0.0)	1 (5.1)	0 (0.0)	1 (14.0)	11 (11.5)	6 (11.4)	5 (11.6)	14 (22.2)	6 (23.5)	8 (20.5)
From the internet	1 (20.7)	1 (25.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	4 (4.7)	2 (3.9)	2 (6.6)	3 (6.2)	1 (6.2)	2 (6.2)
Sourcing of e-cigarette products in the past 30 days, among past-30-day vapers (n=697)[1]	N=29	N=11	N=18	N=41	N=19	N=22	N=329	N=131	N=97	N=298	N=198	N=201
From social source	18 (62.6)	10 (89.3)	8 (41.2)	22 (59.8)	14 (75.4)	8 (36.5)	195 (59.5)	88 (65.4)	107 (54.0)	163 (50.9)	52 (52.0)	111 (49.8)

Purchased from stores	11 (37.4)	1 (10.7)	10 (58.8)		19 (42.9)	7 (35.6)	12 (53.7)		101 (30.9)	31 (25.0)	70 (36.4)		122 (42.4)	33 (35.6)	89 (49.1)				
Purchased from the internet	4 (12.3)	0 (0.0)	4 (22.2)		9 (22.6)	6 (28.7)	3 (13.5)		52 (16.0)	19 (15.5)	33 (16.5)		54 (19.5)	18 (18.8)	36 (20.2)				
Taken from a store or another person	0 (0.0)	0 (0.0)	(0.0)		1 (3.6)	1 (6.1)	(0.0)		12 (3.7)	4 (3.0)	8 (4.5)		6 (2.1)	3 (2.6)	3 (1.6)				
From free samples	1 (4.0)	0 (0.0)	1 (7.2)		0 (0.0)	(0.0)	0 (0.0)		18 (5.4)	7 (5.3)	11 (5.5)		7 (2.1)	2 (1.8)	5 (2.4)				

[1] Multiple locations/sources could be selected (not mutually exclusive).

In Scotland, the proportion of past-12-month vapers aged 16-17 who reported purchasing an e-cigarette product in the past 12 months was 21% in 2017 and 50% in 2018, compared with 36% in 2017 and 38% in 2018 among youth aged 18-19. These increases were not statistically significant when adjusting for covariates (all p>.05; Table 4). However, in England, the proportion of past-12-month vapers who reported purchasing an e-cigarette product increased significantly among minors aged 16-17 (26% in 2017 to 41% in 2018; AOR=1.13, 95% CI=1.05-1.21, p=.001) and among youth aged 18-19 (28% in 2017 to 34% in 2018; AOR=1.06, 1.004-1.11, p=.033) (Table 4). Contrary to hypothesised, the changes over time did not differ between Scotland and England overall (AOR=0.92, 0.42-2.01, p=.841) or by age group (AOR=0.76, 0.14-4.07, p=.749) (Table 4). When aggregating data from Scotland and England at both time points, purchasing did not significantly differ among youth aged 18-19 and minors aged 16-17 (AOR=0.87, 0.68-1.11, p=.270).

Purchasing from a vape shop increased in Scotland among minors aged 16-17, from 17% in 2017 to 85% in 2018 (AOR=1.85, 1.23-2.80, p=.003), yet did not change significantly among youth aged 18-19 or among either age group in England (all p>.05); there was also strong evidence for a difference in trends between age groups across the two countries (AOR=0.02, 0.001-0.40, p=.011) (Table 4). Contrary to hypothesised, purchasing an e-cigarette product from a regular shop or chemist (locations grouped for analyses) did not change significantly from 2017 to 2018 among either age group in Scotland or England (Table 4). Purchasing from the internet could not be modelled in regression analyses because of low cell counts (Table 3).

Table 4. Difference-in-differences analysis: Changes in purchasing an e-cigarette product in the past 12 months within Scotland and England between 2017 and 2018 (4- and 16-months post-implementation), overall and by age group (among past-12-month vapers only).

	Purchased an e-cigarette product in the past 12 months (n=1965)[2]					**Purchased from a vape shop in the past 12 months (n=597)[3]**					**Purchased from a regular shop or chemist in the past 12 months (n=597)[3]**				
	Sample n[1]	**%**	**AOR (95% CI)**	**p**		**Sample n[1]**	**%**	**AOR (95% CI)**	**p**		**Sample n[1]**	**%**	**AOR (95% CI)**	**p**	
Country*year															
SCOTLAND															
2017 (ref)	99	29.57	1.00			27	53.44	1.00			27	30.77	1.00		
			1.08					1.13					1.11		

2018	97	43.86	(0.95-1.23)	.263		41	70.27	(0.89-1.44)	.306		41	40.53	(0.87-1.42)	.385	
ENGLAND															
2017 (ref)	910	27.27	1.00			245	57.73	1.00			245	27.40	1.00		
2018	859	37.38	**1.09 (1.04-1.14)**	**.000**		284	60.17	1.03 (0.94-1.13)	.529		284	33.31	1.05 (0.96-1.14)	.278	
DIFFERENCE-IN-DIFFERENCES (DD)															
England 2017 to 2018 (ref)	1769	-	1.00			529	2.4	1.00			529	5.9	1.00		
Scotland 2017 to 2018	196	-	0.92 (0.42-2.01)	.841		68	16.8	1.55 (0.49-4.84)	.451		68	9.8	1.32 (0.38-4.59)	.661	
Country*year*age															
SCOTLAND															
Minors age 16-17															
2017 (ref)	33	20.65	1.00			6	**16.67**	1.00			6	50.00	1.00		
2018	32	50.37	1.15 (0.92-1.43)	.211		17	**84.77**	**1.85 (1.23-2.80)**	**.003**		17	48.17	0.94 (0.58-1.53)	.805	
Age 18-19															
2017 (ref)	66	35.85	1.00			21	68.35	1.00			21	22.97	1.00		
2018	65	38.11	1.03 (0.88-1.21)	.678		24	53.37	0.85 (0.64-1.13)	.274		24	31.62	1.13 (0.87-1.47)	.368	
ENGLAND															
Minors age 16-17															
2017 (ref)	356	26.27	1.00			92	58.58	1.00			92	23.31	1.00		
2018	244	41.03	**1.13 (1.05-1.21)**	**.001**		95	57.97	1.00 (0.86-1.16)	.991		95	33.34	1.08 (0.95-1.23)	.242	
Age 18-19															
2017 (ref)	554	28.17	1.00			153	57.01	1.00			153	30.84	1.00		
2018	615	34.28	**1.06 (1.004-1.11)**	**.033**		189	62.41	1.06 (0.95-1.18)	.324		189	33.29	1.02 (0.92-1.13)	.716	
TRIPLE-DIFFERENCES (DDD)															
England 2017-2018 between age groups (ref)	1769	-8.7	1.00			529	6.0	1.00			529	-7.6	1.00		
Scotland 2017-2018 between age groups	196	-27.5	0.76 (0.14-4.07)	.749		68	-83.1	**0.02 (0.001-0.40)**	**.011**		68	10.5	3.37 (0.24-47.45)	.367	

[1] Unweighted sample size. All other data are weighted.

[2] Among past-12-month vapers.

[3] Among past-12-month vapers who had purchased an e-cigarette product in the past 12 months.

Associations (AOR, 95% CI, p) are based on marginal effects and are adjusted for country, year, age group, sex, student status, race/ethnicity, smoking status, and vaping status.

Significant results (p<.05) are shown in **bold.**

The unadjusted and adjusted models used to obtain these estimates are shown in Table 7 below.

In Scotland, the proportion of past-12-month vapers who reported being refused sale of an e-cigarette product in the past 12 months was 14% in 2017 and 16% in 2018 among minors aged 16-17, and 2% in 2017 and 8% in 2018 among youth aged 18-19 (Table 3). Contrary to hypothesised, these increases were not statistically significant (p>.05; Table 5). Corresponding prevalence estimates in England were 16% and 11% among minors aged 16-17 (statistically significant decrease; AOR=0.94, 0.89-0.995, p=.034) and 6% and 7% among youth aged 18-19 (not statistically significant; p>.05) (Table 5). Contrary to hypothesised, the change over time did not differ between Scotland and England overall (AOR=1.97, 0.58-6.67, p=.281) or by age group (AOR=3.78,0.23-61.43, p=.350) (Table 5). When aggregating data from Scotland and England at both time points, e-cigarette sale refusal among past-12-month vapers was lower among youth aged 18-19 than minors aged 16-17 (AOR=0.40, 0.28-0.57, p<.001).

Table 5. Difference-in-differences analysis: Changes in being refused sale of, and sourcing, an e-cigarette product within Scotland and England between 2017 and 2018 (4- and 16- months post-implementation), overall and by age group.

	Refused sale of an e-cigarette product in the past 12 months (n=1965)[2]				Sourced an e-cigarette product in the past 30 days (n=697)[3]							
					Social source				Purchased from a store			
	Sample n[1]	%	AOR (95% CI)	p	Sample n[1]	%	AOR (95% CI)	p	Sample n[1]	%	AOR (95% CI)	p
Country*year												
SCOTLAND												
2017 (ref)	99	6.87	1.00		29	62.64	1.00		29	37.36	1.00	
2018	97	12.02	1.03 (0.94-1.13)	.520	41	59.75	0.97 (0.77-1.22)	.794	41	42.91	1.06 (0.84-1.33)	.618
ENGLAND												
2017 (ref)	910	10.81	1.00		329	59.46	1.00		329	**30.95**	1.00	
2018	859	8.85	0.98 (0.95-1.01)	.108	298	50.85	0.93 (0.85-1.01)	.069	298	**42.37**	**1.11 (1.03-1.2)**	**.009**
DIFFERENCE-IN-DIFFERENCES (DD)												
England 2017 to 2018 (ref)	1769	-2.0	1.00		627	-8.6	1.00		627	11.4	1.00	
Scotland 2017 to 2018	196	5.2	1.97 (0.58-6.67)	.281	70	-2.9	1.21 (0.41-3.56)	.731	70	5.5	0.8 (0.27-2.38)	.681

Country*year*age														
SCOTLAND														
Minors age 16-17														
2017 (ref)	33	13.77	1.00			11	89.26	1.00			11	10.74	1.00	
2018	32	16.27	0.97 (0.81-1.16)	.710		19	75.39	0.89 (0.65-1.22)	.483		19	35.63	1.25 (0.90-1.73)	.188
Age 18-19														
2017 (ref)	66	2.01	1.00			18	41.21	1.00			18	58.79	1.00	
2018	65	8.27	1.07 (0.99-1.16)	.091		22	36.52	0.95 (0.69-1.30)	.740		22	53.71	0.95 (0.70-1.28)	.728
ENGLAND														
Minors age 16-17														
2017 (ref)	356	15.84	1.00			131	65.38	1.00			131	25.04	1.00	
2018	244	10.82	**0.94 (0.89-0.995)**	**.034**		97	51.95	**0.87 (0.77-0.99)**	**.040**		97	35.61	1.12 (0.99-1.26)	.084
Age 18-19														
2017 (ref)	554	6.29	1.00			198	53.97	1.00			198	36.42	1.00	
2018	615	7.16	1.01 (0.98-1.03)	.731		201	49.76	0.98 (0.89-1.09)	.716		201	49.09	**1.11 (1.002-1.23)**	**.045**
TRIPLE-DIFFERENCES (DDD)														
England 2017-2018 between age groups (ref)	1769	5.9	1.00			627	9.2	1.00			627	2.1	1.00	
Scotland 2017-2018 between age groups	196	3.8	3.78 (0.23-61.43)	.350		70	9.2	1.04 (0.06-17.27)	.980		70	-30.0	0.23 (0.01-3.67)	.301

[1] Unweighted sample size. All other data are weighted.

[2] Among past-12-month vapers.

[3] Among past-30-day vapers.

Associations (AOR, 95% CI, p) are based on marginal effects and are adjusted for country, year, age group, sex, student status, race/ethnicity, smoking status, and vaping status.

Significant results (p<.05) are shown in **bold.**

The unadjusted and adjusted models used to obtain these estimates are shown in Table 8 below.

In both Scotland and England, most minors aged 16-17 and youth aged 18-19 who had been refused sale of an e-cigarette product in the past 12 months were refused sale from a vape shop, followed by regular shop (Table 3). Locations of refusal could not be modelled in regression analyses because of low cell counts.

In both Scotland and England, most minors aged 16-17 who had vaped in the past 30 days sourced their e-cigarette

product(s) socially, while most youth aged 18-19 who had vaped in the past 30 days sourced their e-cigarette product(s) from stores or socially (Table 3). There was little evidence for any changes in Scotland between 2017 and 2018 in either sourcing socially or purchasing from a store, although there was some evidence for some changes in England (Table 5). Sourcing from the internet, taking from a store or another person, and from free samples were selected by some participants but could not be modelled in regression analyses because of low cell counts. When aggregating data from Scotland and England at both time points, sourcing from a store was more common among youth aged 18-19 than minors aged 16-17 (AOR=1.70, 1.19-2.44, p=.004) but sourcing socially did not statistically differ between age groups when adjusting for covariates (AOR=0.72, 0.52-1.02, p=.061).

Discussion

At the time of this study, both Scotland and England had retail regulations prohibiting the sale of e-cigarette products to under-18s, with Scotland's regulations in place since April 2017 and England's since 2015. Scotland also mandated retailer registration. Despite this, in 2018 (16 months post-regulations), 50% of youth vapers aged 16-17 (i.e., minors) in Scotland reported purchasing an e-cigarette product in the past 12 months, of whom 85% reported purchasing from a vape shop, and the corresponding rate in England was 41% (of whom 58% reported purchasing from a vape shop).

Except purchasing an e-cigarette product from a vape shop, contrary to hypothesised, any past-12-month purchasing, past 12-month purchasing from a regular shop/chemist, past-12-month sale refusal, past-30-day socially sourcing, and past-30-day purchasing from a store did not change significantly from the short- (four months) to longer-term (16 months) post-implementation in Scotland overall or in comparison to England, nor was there any evidence for differences in changes by age group (minors vs. legal purchasing age). Unexpectedly, purchasing from a vape shop in the past 12 months increased among minors in Scotland but not among youth of legal purchasing age or either age group in England; however, the change among minors in Scotland was limited by very small numbers of vapers, and hence lack of statistical power, and so should be interpreted with caution.

Overall, our findings are consistent with US and Canadian studies which have found a lack of compliance with e-cigarette age-of-sale laws (Kilcommons et al., 2020; Levinson, 2018; Ohri-Vachaspati et al., 2019); for example, in California, 45% of vape and tobacco shops sold e-cigarette products to underage test purchasers (a higher rate than other retailers) (Ohri-Vachaspati et al., 2019). They are also consistent with US findings that some minors report easy access to e-cigarette products from some retailers few minors were refused purchase of e-cigarette products despite the illegality of such sales, and that youth vaping prevalence continued to increase despite the introduction of a law prohibiting the sale of e-cigarettes to minors (Schiff et al., 2021; Debchoudhury et al., 2022). In Scotland specifically, SCOTTS Trading Standards found a 13% failure rate for test purchases from premises selling e-cigarettes in 2018/2019, primarily due to sales to under-18s (SCOTSS Trading Standards, 2019). Better enforcement of age-of-sale regulations in Scotland, and England, is therefore required. For example, rather than a registration system, a more comprehensive licensing system similar to

that recommended by the World Health Organization Framework Convention on Tobacco Control for tobacco products (World Health Organization, 2013) may facilitate better enforcement of policies against selling products to youth (Kuipers et al., 2021).

E-cigarette purchases were most common from vape shops and regular shops. A minority of youth vapers aged 16-17 reported being refused sale of an e-cigarette product in the past 12 months, although sale refusal was higher among minors aged 16-17 than youth aged 18-19 who were of legal purchasing age. Most vapers aged 16-17 sourced their e-cigarettes socially, while most vapers aged 18-19 sourced their e-cigarettes either from stores or socially.

Our study found that most past-30-day vapers, particularly minors aged 16-17, reported sourcing their e-cigarette products socially, consistent with previous research showing the popularity of socially sourcing e-cigarette products among youth (Nguyen, 2019; Schiff et al., 2021).

Our study has limitations. First, e-cigarette purchasing and sale refusal were asked for a 12-month timeframe, which spanned the implementation date for the 2017 survey and meant that 18-year-olds were underage for some portion of the past 12 months; however, key findings were similar for the past-30-day sourcing measure. Second, sample sizes were small in Scotland, particularly among youth aged 16-17, reducing statistical power and precluding some planned analyses. Third, sale refusal was asked of all past-12-month vapers and not only of those who attempted to purchase an e-cigarette product; as such, the proportion of youth who were refused sale is likely greater among those who attempted to purchase e-cigarettes than the proportion reported in this study.

In conclusion, youth vapers in Scotland, compared to England, showed no significant changes in purchasing (except from a vape shop specifically), sale refusal, and sourcing of e-cigarette products, from four to 16 months post-implementation. Changes did not differ among minors compared with those of legal purchasing age. Findings also suggest low compliance with age-of-sale regulations in Scotland and England.

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Tables

Table 6. Difference-in-differences analysis: Changes in vaping behaviours and intentions within Scotland and England between 2017 and 2018 (4- and 16-months post-implementation), overall and by age group.

	Ever tried vaping (n=8,345)					Past-30-day vaping (n=8,345)					Intention to vape (n=5,531)[2]			
	n[1]	%	AOR (95% CI)	p		n[1]	%	AOR (95% CI)	p		n[1]	%	AOR (95% CI)	p
Country*year														
SCOTLAND														
2017 (ref)	434	30.97	1.00			434	7.01	1.00			302	40.25	1.00	
2018	377	35.08	1.01 (0.96-1.07)	.691		377	12.33	**1.05 (1.01-1.09)**	**.022**		246	29.56	**0.89 (0.82-0.96)**	**.003**
ENGLAND														
2017 (ref)	3791	34.36	1.00			3791	8.79	1.00			2491	39.17	1.00	
2018	3743	33.23	0.99 (0.97-1.004)	.130		3743	8.92	0.997 (0.98-1.01)	.649		2492	37.65	0.98 (0.95-1.003)	.080
DIFFERENCE-IN-DIFFERENCES (DD)														
England 2017 to 2018 (ref)	7534	-1.13	1.00			7534	0.13	1.00			4983	-1.53	1.00	
Scotland 2017 to 2018	811	4.11	1.19 (0.79-1.81)	.398		811	5.32	**2.05 (1.11-3.76)**	**.021**		548	-10.70	**0.63 (0.42-0.95)**	**.029**
Country*year*age														
SCOTLAND														
Age 16-17														
2017 (ref)	168	26.36	1.00			168	6.62	1.00			125	40.11	1.00	
2018	124	34.12	1.01 (0.92-1.10)	.905		124	15.71	1.06 (0.99-1.14)	.085		83	23.56	**0.84 (0.74-0.94)**	**.003**
Age 18-19														
2017 (ref)	266	35.10	1.00			266	7.36	1.00			177	40.40	1.00	
2018	253	35.92	1.02 (0.95-1.09)	.644		253	9.35	1.03 (0.99-1.07)	.152		163	35.01	0.94 (0.85-1.04)	.245
ENGLAND														
Age 16-17														
2017 (ref)	1510	32.07	1.00			1510	8.77	1.00			1030	38.68	1.00	
2018	1102	29.76	**0.96 (0.93-0.99)**	**.014**		1102	9.35	0.99 (0.97-1.02)	.571		784	37.36	0.97 (0.92-1.01)	.123
Age 18-19														
2017 (ref)	2281	36.48	1.00			2281	8.80	1.00			1461	39.67	1.00	
2018	2641	36.37	1.01 (0.98-1.03)	.587		2641	8.52	1.00 (0.99-1.01)	.983		1708	37.93	0.98 (0.95-1.02)	.385
TRIPLE-DIFFERENCES (DDD)														

England 2017-2018 between age groups (ref)	7534	2.20	1.00			7534	-0.86	1.00			4983	-0.42	1.00	
Scotland 2017-2018 between age groups	811	-6.94	0.80 (0.34-1.85)	.595		811	-7.11	0.72 (0.21-2.45)	.597		548	11.16	1.70 (0.73-3.98)	.218

[1] Unweighted sample size. All other data are weighted.

[2] Among never vapers only.

Associations (AOR, 95% CI, p) are based on marginal effects and are adjusted for country, year, age group, sex, student status, and race/ethnicity.

Significant results (p<.05) are shown in **bold.**

The unadjusted and adjusted models used to obtain these estimates are shown in Table 9 below.

Table 7. Logistic regression models: Unadjusted and adjusted associations between purchasing an e-cigarette product in the past 12 months and: country, year, age group. Interactions between country and year and country, year, and age group are also shown.

		Purchased an e-cigarette product in the past 12 months (n=1965) [2]				Purchased from a vape shop in the past 12 months (n=597) [3]				Purchased an e-cigarette product from a regular shop or chemist past 12 months (n=597) [3]			
		Sample n [1]	%	OR (95% CI)	p	Sample n [1]	%	OR (95% CI)	p	Sample n [1]	%	OR (95% CI)	p
COUNTRY													
England (ref)		1769	32.2	1		529	59.1	1		529	30.8	1	
Scotland	**Unadjusted**	196	36.7	1.22 (0.87-1.69)	.244	68	63.4	1.20 (0.69-2.08)	.515	68	36.6	1.30 (0.74-2.28)	.366
	Adjusted [4]			*1.14 (0.77-1.69)*	*.508*			*1.19 (0.69-2.07)*	*.531*			*1.26 (0.70-2.26)*	*.436*
YEAR													
2017 (ref)		1009	27.5	1		272	57.3	1		272	27.8	1	
2018	**Unadjusted**	956	38.1	**1.62 (1.31-1.99)**	**<.001**	325	61.4	1.19 (0.83-1.69)	.343	325	34.2	1.35 (0.93-1.97)	.119
	Adjusted [4]			***1.63 (1.29-2.07)***	***<.001***			*1.19 (0.83-1.70)*	*.352*			*1.29 (0.88-1.90)*	*.186*
AGE GROUP													
16-17 (ref)		665	38.8	1		210	60.0	1		210	31.7	1	
18-19	**Unadjusted**	1300	24.8	0.92 (0.74-1.13)	.431	387	58.8	1.04 (0.73-1.49)	.819	387	30.9	1.01 (0.69-1.49)	.947
	Adjusted [4]			*0.87 (0.68-1.11)*	*.270*			*1.04 (0.72-1.51)*	*.831*			*0.94 (0.63-1.41)*	*.775*
INTERACTIONS													
Country*Year	**Unadjusted**	1965	-	1.17 (0.6-2.28)	.651	597	-	1.86 (0.61-5.64)	.271	597	-	1.16 (0.36-3.70)	.801
	Adjusted [4]			*0.92 (0.42-2.01)*	*.841*			*1.55 (0.49-4.84)*	*.451*			*1.32 (0.38-4.59)*	*.661*
Country*Year* Age group	**Unadjusted**	1965	-	0.41 (0.1-1.75)	.230	597	-	**0.01 (0.001-0.27)**	**.005**	597	-	2.46 (0.21-29.10)	.476
	Adjusted [4]			*0.76 (0.14-4.07)*	*.749*			***0.02 (0.001-0.40)***	***.011***			*3.37 (0.24-47.45)*	*.367*

[1] Unweighted sample size. All other data are weighted.

[2] Among past-12-month vapers.

[3] Among past-12-month vapers who had purchased an e-cigarette product in the past 12 months.

[4] Adjusted for variables listed and covariates (sex, student status, race/ethnicity, vaping status, smoking status).

Interactions were added as an additional step.

Significant results (p<.05) are shown in **bold.**

Table 8. Logistic regression models: Unadjusted and adjusted associations between being refused sale of, and sourcing, an e-cigarette product and: country, year, age group. Interactions between country and year and country, year, and age group are also shown. [1]Unweighted sample size. All other data are weighted.

		Refused sale of an e-cigarette product in the past 12 months (n=1965) [2]					Sourced an e-cigarette product in the past 30 days from a social source (n=697) [3]					Sourced an e-cigarette product in the past 30 days from a store (n=697) [3]			
		Sample n [1]	%	OR (95% CI)	p		Sample n [1]	%	OR (95% CI)	p		Sample n [1]	%	OR (95% CI)	p
COUNTRY															
England (ref)		1769	9.9	1			627	44.8	1.00			627	36.6	1.00	
Scotland	**Unadjusted**	196	9.4	0.95 (0.55-1.66)	.864		70	39.1	1.27 (0.75-2.15)	.383		70	40.7	1.19 (0.70-2.02)	.527
	Adjusted [4]			*0.96 (0.54-1.73)*	*.902*				*1.39 (0.80-2.04)*	*.240*				*1.08 (0.62-1.90)*	*.784*
YEAR															
2017 (ref)		1009	10.4	1			358	40.3	1.00			358	31.5	1.00	
2018	**Unadjusted**	956	9.2	0.87 (0.62-1.22)	.414		339	48.1	0.73 (0.53-1.01)	.056		339	42.4	**1.60 (1.15-2.24)**	**.006**
	Adjusted [4]			*0.79 (0.56-1.13)*	*.194*				*0.73 (0.53-1.02)*	*.069*				***1.59 (1.13-2.25)***	***.008***
AGE GROUP															
16-17 (ref)		665	11.4	1			258	48.4	1.00			258	41.4	1.00	
18-19	**Unadjusted**	1300	7.8	**0.45 (0.32-0.62)**	**<.001**		439	37.8	**0.66 (0.47-0.91)**	**.013**		439	30.4	**1.82 (1.29-2.57)**	**.001**
	Adjusted [4]			***0.40 (0.28-0.57)***	***<.001***				*0.72 (0.52-1.02)*	*.061*				***1.70 (1.19-2.44)***	***.004***
INTERACTIONS															
Country*Year	**Unadjusted**	1965	-	2.31 (0.72-7.44)	.161		697		1.25 (0.43-3.67)	.681		697	-	0.77 (0.26-2.26)	.631
	Adjusted [4]			*1.97 (0.58-6.67)*	*.281*				*1.21 (0.41-3.56)*	*.731*				*0.80 (0.27-2.38)*	*.681*
Country*Year* Age group	**Unadjusted**	1965	-	2.03 (0.14-29.29)	.604		697	-	1.51 (0.09-23.99)	.771		697	-	0.17 (0.01-2.67)	.209
	Adjusted [4]			*3.78 (0.233-61.43)*	*.350*				*1.04 (0.06-17.27)*	*.980*				*0.23 (0.01-3.67)*	*.301*

[2]Among past-12-month vapers.

[3]Among past-30-day vapers.

[4] Adjusted for variables listed and covariates (sex, student status, race/ethnicity, vaping status, smoking status).

Interactions were added as an additional step.

Significant results (p<.05) are shown in **bold.**

Table 9. Logistic regression models: Unadjusted and adjusted associations between being vaping behaviours and intentions and: country, year, age group. Interactions between country and year and country, year, and age group are also shown.

		Ever tried vaping (n=8,345) [2]				Past-30-day vaping (n=8,345) [2]				Intention to vape (n=5,531) [3]			
		Sample n [1]	%	OR (95% CI)	p	Sample n [1]	%	OR (95% CI)	p	Sample n [1]	%	OR (95% CI)	p
COUNTRY													
England (ref)		7534	33.80	1		7534	8.85	1		4983	38.41	1	
Scotland	**Unadjusted**	811	32.88	0.96 (0.81-1.13)	.626	811	9.49	1.08 (0.82-1.42)	.583	548	35.44	0.88 (0.72-1.07)	.200
	Adjusted [4]			*0.84 (0.69-1.04)*	*.107*			*0.99 (0.73-1.34)*	*.933*			*0.82 (0.67-1.01)*	*.064*
YEAR													
2017 (ref)		4225	34.01	1		4225	8.61	1		2793	39.29	1	
2018	**Unadjusted**	4120	33.4	0.97 (0.88-1.07)	.585	4120	9.23	1.08 (0.91-1.28)	.368	2738	36.92	0.90 (0.80-1.02)	.094
	Adjusted [4]			*0.92 (0.82-1.04)*	*.190*			*1.03 (0.86-1.24)*	*.765*			***0.85 (0.76-0.97)***	***.012***
AGE GROUP													
16-17 (ref)		2904	36.15	1		2904	10.63	1		2022	37.83	1	
18-19	**Unadjusted**	5441	31.16	**1.28 (1.16-1.42)**	**<.001**	5441	7.12	0.93 (0.78-1.1)	.387	3509	38.40	1.05 (0.93-1.18)	.402
	Adjusted [4]			*1.04 (0.92-1.18)*	*.491*			***0.69 (0.57-0.83)***	***<.001***			*0.98 (0.87-1.11)*	*.746*
INTERACTIONS													
Country*Year	**Unadjusted**	8345	-	1.27 (0.91-1.76)	.162	8345	-	**1.84 (1.06-3.19)**	**.031**	5531	-	**0.66 (0.45-0.99)**	**.045**
	Adjusted [4]			*1.19 (0.79-1.81)*	*.398*			***2.05 (1.11-3.76)***	***.021***			***0.63 (0.42-0.95)***	***.029***
Country*Year* Age group	**Unadjusted**	8345	-	0.65 (0.33-1.28)	.208	8345	-	0.55 (0.18-1.66)	.287	5531	-	1.76 (0.77-4.02)	.182
	Adjusted [4]			*0.8 (0.34-1.85)*	*.595*			*0.72 (0.21-2.45)*	*.597*			*1.70 (0.73-3.98)*	*.218*

[1] Unweighted sample size. All other data are weighted.

[2] Among the full sample.

[3] Among never vapers.

[4] Adjusted for variables listed and covariates (sex, student status, race/ethnicity, smoking status). Interactions were added as an additional step.

Significant results (p<.05) are shown in **bold.**