

## Research Article

# Epidemic of youth nicotine addiction? What does the National Youth Tobacco Survey 2017-2019 reveal about high school e-cigarette use in the USA?

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**Background:** Between 2018 and 2020, the US Food and Drug Administration announced various restrictions on e-cigarette manufacturers in response to a perceived epidemic of e-cigarette use and nicotine dependence among high school students. The stimulus came from headline figures from the 2018 and 2019 National Youth Tobacco Survey (NYTS). We analysed e-cigarette use and dependence in the NYTS in relation to lifetime history of use of tobacco products.

**Design and setting:** Nationally representative annual survey of high school students 2017 to 2019.

**Participants:** 10,186 students in 2017, 10,991 in 2018 and 10,097 in 2019.

**Measurements:** Any use of e-cigarettes in past 30 days, frequent e-cigarette use ( $\geq 20$  of past 30 days) and indicators of tobacco or nicotine dependence (strong craving in past 30 days; wanting to use within 30 minutes of waking) were analysed in relation to lifetime tobacco product use history, ranging from never use through to lifetime smoking of  $>100$  cigarettes.

**Findings:** Past-30-day e-cigarette use increased from 11.7% in 2017 to 20.8% in 2018, and 27.5% in 2019. In 2019 it was reported in 13.3% of those who had never tried any other tobacco product, 30.9% of those who had tried only a non-combustible product (OR 2.9, CI 1.9-4.5), and in 73.8 % of those who had smoked more than 100 cigarettes in their lifetime (OR 18.3, CI 8.4-40.1) Frequent use occurred in 1.0% of otherwise tobacco naive users in 2018 and 2.1% in 2019. Among otherwise tobacco naive past-30-day e-cigarette users in 2019, 8.7% reported craving and 2.9% reported wanting to use within 30 minutes of waking.

**Conclusions:** While use of e-cigarettes in US high-school students increased sharply between 2017 and 2019, frequent use and signs of e-cigarette dependence remained rare in students who had only ever used e-cigarettes and never any other tobacco product.

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**Keywords:** E-cigarettes; vaping; nicotine; addiction; dependence; cigarettes; smoking.

## Introduction

On November 15th 2018, the US Food and Drug Administration (FDA) released preliminary findings from the National Youth Tobacco Survey (NYTS) detailing e-cigarette use in 2018 among US high school students (1). Compared with 2017, a 78% increase in past-30-day e-cigarette use was noted (1). At the same time, the FDA put out a press statement quoting HHS Secretary Alex Azar: “These new data show that America faces an epidemic of youth e-cigarette use, which threatens to engulf a new generation in nicotine addiction.”(2) A statement from (then current, now former) FDA Commissioner Scott Gottlieb, issued on the same day, said: “The data from this nationally representative survey... show astonishing increases in kids’ use of e-cigarettes and other ENDS, reversing years of favorable trends in our nation’s fight to prevent youth addiction to tobacco products. These data shock my conscience”(3). Gottlieb announced a series of regulatory initiatives to address the perceived problem of youth e-cigarette use.

The FDA interpretation of the 2019 NYTS data continued in a similar vein. In congressional testimony Mitch Zeller, Director of the Center for Tobacco Products summarised the “FDA’s aggressive actions to address the youth epidemic of ENDS product use” (4), and on 2nd January 2020 the FDA issued a further enforcement policy. In the accompanying press statement, a quote from HHS Secretary Alex Azar asserted that “The United States has never seen an epidemic of substance use arise as quickly as our current epidemic of youth use of e-cigarettes.” (5)

The NYTS contains extensive data on use of a range of tobacco products, and also documents self-reported dependence. Yet, the FDA’s own publicly revealed analyses did not consider how e-cigarette use in high school students was related to patterns of use of other tobacco products, especially cigarettes and other combustible tobacco products, and did not present any analyses assessing dependence. Secondary analyses of the publicly available 2018 data have emphasised the importance of the overall tobacco context by showing that the large

increases in prevalence of past 30-day use of e-cigarettes were characterized by patterns of low vaping frequency and high multiple tobacco product use. (6)

In the UK, use of e-cigarettes by adolescents has not attracted such concern or policy intervention. Commentators have noted that e-cigarette use is strongly associated with cigarette smoking in young people and is very rare amongst never smokers (7-9). The NYTS public use data file for the 2019 survey became available in January 2020. This paper combines this with earlier data (10) to analyse e-cigarette use and indicators of tobacco dependence in the NYTS in relation to lifetime history of use of tobacco products. We used data from the 2014 and 2015 NYTS to examine which product was tried first in tobacco users' careers. We also report on time trends in prevalence of e-cigarette and combustible tobacco use in the USA.

## Methods

### *Data*

The National Youth Tobacco Survey (NYTS) is designed to produce a nationally representative cross-sectional sample of students from US middle and high schools. It was developed to inform national and state tobacco prevention and control programs. Full details of the NYTS methodology are available elsewhere (11). Briefly, a three-stage cluster sampling procedure is used to generate a nationally representative sample of students in grades 6–12. Of 325 schools selected for the 2019 NYTS 251 (77.2%) participated, with an achieved sample of 19,018 (85.8%) from 22,153 students; the overall response rate, calculated as the product of the school-level and student-level participation rates, was 66.3% (11). The NYTS employs an anonymous, self-administered questionnaire to enquire about ever and current use of cigarettes, cigars (defined as cigars, cigarillos, or little cigars), other combustible tobacco (pipes, bidis, hookahs); non-combustible tobacco (chewing tobacco, snuff, or dip, snus, and dissolvable tobacco); and e-cigarettes. Both current use (defined as any use of each product in the past 30 days) and ever-use (ever trying) are ascertained. After being conducted via paper and pencil questionnaires since its inception in 1999, the NYTS was administered in schools using an electronic data collection method for the first time in 2019.

We derived a measure of lifetime tobacco product use history as follows: Respondents were asked “About how many cigarettes have you smoked in your entire life?” with 7 response options ranging from “I have never smoked cigarettes, not even one or two puffs” through “100 or more cigarettes (5 or more packs)”. We added further categories for those who reported ever-use of e-cigarettes but no other tobacco product; a non-combustible tobacco product, but never any combustible; and use of a combustible product (cigars, pipes, bidi, hookah) but never cigarettes. Thus, there were 10 response categories in all for lifetime tobacco use history, ranging from never use of any tobacco product (tobacco naïve) through to smoking of more than 100 cigarettes.

## *Statistical analysis*

We used the complex survey analysis module in SPSS 24 to adjust for the sampling design of the survey and to generate estimates ( $\pm 95\%$  confidence intervals) applicable to the US population. We examined the univariate association between current use of e-cigarettes and our measure of lifetime tobacco product use history. We employed a logistic regression analysis to derive estimates of the odds ratios ( $\pm 95\%$  CIs) for current e-cigarette use. We conducted similar analyses to examine use of e-cigarettes for 1-19 days and 20 or more days within the past 30 days. We examined responses to two questions (“During the past 30 days, have you had a strong craving or felt like you really needed to use a tobacco product of any kind?”; and “How soon after you wake up do you want to use a tobacco product?”) to provide an indication of dependence. We focused on high school students (sample size 10,186 in 2017, 10,991 in 2018 and 10,097 in 2019). Our report focuses primarily on data from the NYTS surveys conducted in 2017 through 2019, but we carried out similar analyses for the years 2014–2016 (see supplementary file).

In order to obtain an indication of which tobacco and nicotine products were used first and which subsequently in high school students’ using careers, we examined responses to the question “Which of the following tobacco products did you try first?”, asked in 2014; and in 2015 “Which of the following statements best applies to your cigarette or electronic cigarette use?” (Response options: I have never tried cigarettes or electronic cigarettes; I have only tried cigarettes; I have only tried electronic cigarettes; I tried cigarettes before I ever tried electronic cigarettes; I tried electronic cigarettes before I ever tried cigarettes). Neither of these questions were asked in the 2016 through to 2019 surveys.

## **Results**

The overall prevalence of past-30-day e-cigarette use among high school students in 2019 was 27.5%, an increase from 20.8% in 2018 and 11.7% in 2017 (Table 1). Prevalence was strongly associated with lifetime tobacco use history: among never users of any other tobacco product, 2.9% in 2017, 8.4% in 2018 and 13.3% in 2019 were past-30-day e-cigarette users, whilst among those who had smoked more than 100 cigarettes in their lifetime, the corresponding figures were 57.2% in 2017, 71.0% in 2018 and 73.8% in 2019. By comparison with e-cigarette users who had never used other tobacco products, the odds of use rose steeply and in a graded fashion with extent of tobacco experience. In 2019, the odds ratio among those who had minimal tobacco experience (had tried a non-combustible but never a combustible product) were already significantly raised (OR 2.9), while in those who had smoked just one cigarette the odds ratio was 8.9, rising to 18.3 in those who had smoked more than 100 cigarettes in their lifetime. Similar associations with lifetime tobacco use history were observed in 2017 and 2018. Past-30-day cigarette smoking was strongly associated with cigarette use history in all years,

and reached 88.4% in 2017, 84.5% in 2018 and 65.2% in 2019 in students who had smoked 100+ cigarettes in their lifetime.

Between 2017 and 2019, the percentage of past-30-day e-cigarette users who reported having used them on 20 or more days rose from a fifth to a third (19.7%, 210/1,066; 28.4%, 627/2207; and 33.9%, 917/2,703). However, this frequent use was strongly associated with lifetime tobacco use history: it was seen in only 0.2% of those who were otherwise tobacco naive in 2017, 1.0% in 2018 and 2.1% in 2019 (see Table 1). The observed frequency of 20+ days use increased with the extent of lifetime tobacco use, reaching 26.8% in 2017, 37.2% in 2018 and 48.8% in 2019 among students who had smoked more than 100 cigarettes.

### *Indicators of dependence in e-cigarette users*

Table 2 shows responses to questions indicating aspects of dependence and tobacco use behaviour by lifetime tobacco use history. Among past-30-day e-cigarette users who were otherwise tobacco naive, responses consistently pointed to minimal or absent dependence. In 2019, in response to the question “During the past 30 days, on how many days did you use any tobacco product(s)?”, 52.2% chose the 0 days option. Only 8.7% reported any experience of craving for tobacco products, and 2.9% reported wanting to use within 30 minutes. Approximately 85% of responses to the question “How soon after you wake up do you want to use a tobacco product?” were comprised by “I do not want to use tobacco” (51.8%) and “I rarely want to use tobacco” (34.2%). 18.2% said they had used e-cigarettes on only one day in their life, and 46.9% had used them 10 days or fewer. This pattern of responding contrasted markedly with that seen in e-cigarette users with a lifetime history of smoking more than 100 cigarettes: 65.0% of these reported experiencing craving; 48.7% wanted to use within 30 minutes of waking, and only 7.6% said “I do not want to use tobacco” and 10.6% that they rarely wanted to use. The pattern of responses to these dependence indicators by lifetime tobacco use history was similar in 2017 and 2018 (Table 2).

### *Which product used first by tobacco use history*

Table 3 shows, by lifetime tobacco use history, which product respondents reported using first in their tobacco career. The more cigarettes students reported having smoked in their lifetime, the higher the chances were that cigarettes were the first product used: in 2014, just over three quarters (76.5%) of current e-cigarette users who had smoked more than 100 cigarettes named cigarettes as the first tobacco product they had used, while just 2.2% had used e-cigarettes first. Among those who had smoked 1 or more puffs but never a whole cigarette in their lifetime, 49.3% reported the cigarette as first product used and 18.8% had first used e-cigarettes. In 2015, 87.7% of current e-cigarette smokers who had smoked more than 100 cigarettes said cigarettes were the first product they had tried, while 7.6% identified e-cigarettes as the first product tried. Among those who had had

smoked just 1 or more puffs of a cigarette in their lifetime, 53.1% had tried cigarettes first, and 25.4% had tried e-cigarettes first.

### *Trends in use of cigarettes, combustibles and e-cigarettes in NYTS 1999-2019*

There has been a continuing decline in current cigarette smoking in high school students, from 28.5% in 1999 to 8.1% in 2018 (see Figure). The proportion who have ever tried a combustible product has likewise declined from 66.9% in 1999 to 33.4% in 2019. The advent of e-cigarettes, first monitored in the 2011 NYTS, appears to have had little if any impact on this declining trend. Prevalence of past-30-day e-cigarette use rose from 1.4% in 2011 to 27.5% in 2019. The increase in the proportion who have ever tried an e-cigarette has been even more marked, going from 4.5% in 2011 to 47.0% in 2019. This has occurred without any discernible impact on the slope of declining cigarette and combustible use.

## **Discussion**

Our analysis of data from the NYTS confirms the headline reports of a large increase in past-30-day use of e-cigarettes from 2017 to 2019. However, there was a strong association between lifetime history of use of tobacco products and use of e-cigarettes: in 2019, high school students who had smoked more than 100 cigarettes in their lifetime were some 18 times more likely to have used e-cigarettes in the past 30 days than students who had only ever used e-cigarettes and never other tobacco products. In 2018, use of e-cigarettes on 20 or more days in the past month was seen in only 1.0% of those who were otherwise tobacco naive and in 2019 the figure was only 2.1%.

It is notoriously problematic to draw inferences about direction of causality from cross-sectional data. In principle, the strong and graded association observed between likelihood of using e-cigarettes in the past 30 days and lifetime history of use of tobacco products could point to an effect of using e-cigarettes on subsequent uptake and use of cigarettes and other combustible products. This appears to be the view adopted by the FDA. While it may well be the case that in some individual instances initial trying of an e-cigarette led on to trying and using cigarettes, the data strongly suggest that this is not the dominant pattern observed at the level of the whole population. Among high school students we found that, for the great majority of those with any substantial cigarette smoking history, cigarettes were the first tobacco product tried, prior to any use of e-cigarettes. Clearly, for these students their use of cigarettes and the development of characteristic nicotine dependence must be attributed to cigarettes as the uptake product, rather than to e-cigarettes. Similarly, the observed rapid decline in trying combustible products and in the prevalence of cigarette smoking since 1999 has not yet given any sign of being reversed through the upsurge of e-cigarette use since 2011 (12). At the population level, therefore, the NYTS fails to give evidence of e-cigarettes acting as a gateway to smoking in

adolescents. Rather it seems that e-cigarettes may be displacing cigarettes and becoming the preferred nicotine product. In these circumstances, there is plausibility to the suggestion that, by helping adult smokers to quit, e-cigarettes are likely to reduce the overall tobacco disease burden in the USA (13).

We found little evidence of substantial nicotine addiction attributable to the use of e-cigarettes. In 2019, among all students who were past-30-day-cigarette users but had never tried any other tobacco product, responses consistently pointed to minimal dependence with only 8.7% reporting any craving for tobacco products, and 2.9% reporting wanting to use within 30 minutes of waking. Over 46% reported using an e-cigarette on 10 or fewer days in their lifetime. Only 2.1% were classified as frequent users of e-cigarettes on 20 or more days in the past month. This contrasted markedly with students who had smoked more than 100 cigarettes (so meeting the US definition for regular cigarette smoking), where 65.0% reported craving, 48.7% wanted to use within 30 minutes of waking, and 66.1% used e-cigarettes on 20 or more days in the past month. This group had mostly started their tobacco careers with cigarettes, and their pattern of dependence typifies that attributable to cigarette use.

In 2014, the FDA deemed e-cigarettes to be a tobacco product and so brought them within their regulatory competence. It appears that high school students in the US disagree with the FDA's classificatory scheme, as close to half of past-30-day e-cigarette users who had never tried any other product denied using a tobacco product in the past month. At the very least, this suggests their self-concept is not that of being a tobacco product user. This perception of e-cigarettes as something different and separate from tobacco could serve to reduce their chances of progression to using conventional tobacco products.

In summary, data from the NYTS survey do not provide support for claims of a new epidemic of nicotine addiction stemming from use of e-cigarettes, nor for concerns that declines in youth tobacco addiction stand to be reversed after years of progress. While use of e-cigarettes has increased markedly, especially since 2017, there has been no accompanying surge in nicotine dependence. Symptoms of dependence were rare among students who use e-cigarettes without having used any other tobacco products.

This paper is not intended as a challenge to the current direction of FDA policy on the regulation of e-cigarettes. That would be presumptuous on our part. Rather, we have sought to examine the evidence brought forward to support new regulatory initiatives. We find a gaping chasm between the vision of an epidemic of e-cigarette use threatening to engulf a new generation in nicotine addiction and the reality of the evidence contained in the NYTS. As patterns of youth nicotine and tobacco use continue to evolve, careful surveillance of survey findings will remain of critical importance.

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## Figures and Tables

Table 1 Past-30-day e-cigarette use (% +95% CI) by lifetime tobacco use history in high school students: top, NYTS 2017, middle NYTS 2018, bottom NYTS 2019

Lifetime tobacco use history											
	E-cigs only, never any other tobacco product	Used tobacco, but not combustible	Tried combustible, but not cigarette	1 or more puffs, but never whole cigarette	1 cigarette	2 to 5 cigarettes	6 to 15 cigarettes	16 to 25 cigarettes	26 to 99 cigarettes	100+ cigarettes	Total
Used 1-19 days%	2.8 (2.0-3.8)	15.7 (8.7-26.7)	16.1 (13.1-19.3)	15.2 (11.8-19.3)	21.1 (14.8-29.1)	29.4 (24.0-35.4)	27.8 (20.6-36.5)	33.3 (24.0-44.2)	31.0 (23.0-40.2)	31.5 (25.6-38.1)	9.3 (7.8-10.9)
N	165	23	144	123	29	108	59	33	60	97	841
Used 20+ days %	0.2 (0.1-0.4)	1.7 (0.4-7.0)	2.3 (1.3-3.9)	2.7 (1.5-4.8)	2.8 (1.0-7.3)	3.4 (1.9-6.0)	11.3 (7.1-17.5)	8.0 (3.9-15.8)	13.4 (7.6-22.7)	26.8 (18.5-37.2)	2.3 (1.6-3.3)
N	8	2	24	20	4	14	26	15	20	77	210
Any past 30 days use	2.9 (2.1-4.0)	17.3 (10.3-27.5)	18.6 (15.3-22.5)	18.2 (13.9-23.3)	23.2 (16.4-31.8)	33.1 (27.2-39.5)	38.5 (28.1-50.1)	41.3 (30.8-52.7)	44.4 (37.1-52.0)	57.2 (47.1-66.7)	11.7 (9.8-13.8)
N	173	25	168	143	33	122	85	48	80	174	1066
Base	6341	153	1110	888	173	393	216	124	193	326	10015
OR	1.00	6.9 (3.7-12.9)	7.6 (5.7-10.2)	7.4 (5.4-10.1)	10.1 (6.0-16.8)	16.4 (11.7-23.0)	20.8 (12.2-35.5)	23.4 (15.3-35.6)	26.5 (17.7-39.8)	44.4 (27.9-70.7)	
Smoked cigs in past 30 days %	-	-	0.1 (0-0.7)	4.2 (3.1-5.7)	10.7 (6.0-18.4)	28.4 (22.0-34.9)	46.3 (35.6-57.4)	61.6 (50.3-71.8)	69.8 (59.7-78.2)	88.4 (81.2-93.1)	7.6 (6.5-8.8)

NYTS 2017

Lifetime tobacco use history											
	E-cigs only, never any other tobacco product	Used tobacco, but not combustible	Tried combustible, but not cigarette	1 or more puffs, but never whole cigarette	1 cigarette	2 to 5 cigarettes	6 to 15 cigarettes	16 to 25 cigarettes	26 to 99 cigarettes	100+ cigarettes	Total
Used 1-19 days%	7.4 (6.2-8.9)	23.8 (16.3-33.3)	23.4 (19.2-28.2)	24.1 (20.2-28.4)	31.4 (24.1-39.8)	37.9 (31.8-44.4)	35.5 (28.7-42.9)	33.6 (25.2-43.1)	31.7 (23.6-40.7)	33.8 (28.4-39.6)	15.0 (13.7-16.5)
N	490	36	253	209	66	162	91	58	75	140	1580
Used 20+ days %	1.0 (0.7-1.4)	5.2 (2.4-11.1)	4.9 (3.2-7.6)	7.4 (5.3-10.4)	8.0 (4.9-12.8)	15.0 (10.6-20.8)	19.7 (12.6-29.3)	33.2 (24.7-43.1)	36.3 (27.7-45.8)	37.2 (29.8-45.4)	5.7 (4.8-6.8)
N	60	10	66	64	19	71	39	55	80	163	627
Any past 30 days use	8.4 (7.0-10.1)	29.0 (20.6-39.1)	28.3 (23.7-33.4)	31.5 (26.4-37.1)	39.4 (31.3-48.1)	52.9 (45.9-59.9)	55.1 (46.5-63.4)	66.8 (55.5-76.4)	68.0 (59.2-75.6)	71.0 (62.9-78.0)	20.8 (18.8-22.8)
N	550	46	319	273	85	233	130	113	155	303	2207
Base	6664	225	1194	902	209	464	241	175	240	433	10708
OR		4.4 (2.8-7.2)	4.3 (3.4-5.5)	5.0 (4.0-6.4)	7.1 (5.0-10.0)	12.3 (9.1-16.6)	13.4 (9.6-18.9)	22.0 (13.3-36.3)	23.2 (15.5-34.6)	26.8 (17.7-40.5)	
Smoked cigs in past 30 days %			0.1 (0.0-0.9)	5.4 (3.8-7.6)	13.4 (8.6-20.2)	29.2 (24.1-34.7)	48.5 (39.8-57.3)	56.0 (44.8-66.5)	63.6 (55.7-70.8)	84.5 (80.6-87.8)	8.1 (7.1-9.3)

NYTS 2018

Lifetime tobacco use history											
	E-cigs only, never any other tobacco product	Used tobacco, but not combustible	Tried combustible, but not cigarette	1 or more puffs, but never whole cigarette	1 cigarette	2 to 5 cigarettes	6 to 15 cigarettes	16 to 25 cigarettes	26 to 99 cigarettes	100+ cigarettes	Total
Used 1-19 days%	11.3 (10.2-12.4)	22.1 (14.5-32.0)	29.4 (25.5-33.5)	33.9 (29.2-39.1)	36.9 (29.6-44.8)	33.7 (28.8-38.9)	38.2 (30.5-46.5)	37.9 (27.9-48.9)	26.4 (21.3)	25.1 (18.2-33.5)	18.1 (17.0-19.2)
N	741	34	302	260	71	126	68	55	52	77	1786
Used 20+ days %	2.1 (1.6-2.6)	8.9 (5.0-15.2)	13.4 (10.4-17.1)	17.6 (13.8-22.1)	21.0 (14.3-29.9)	25.1 (19.3-32.0)	29.4 (20.2-40.8)	42.0 (30.5-54.3)	44.1 (29.5-59.8)	48.8 (37.0-60.7)	9.4 (8.1-10.9)
N	130	15	145	133	41	91	67	51	82	162	917
Any past 30 days use	13.3 (12.0-14.8)	30.9 (22.9-40.3)	42.7 (37.0-48.5)	51.5 (45.9-57.1)	57.9 (48.8-66.4)	58.8 (50.9-66.3)	67.6 (57.6-76.3)	79.8 (63.3-90.1)	70.5 (52.5-83.8)	73.8 (56.0-86.2)	27.5 (25.3-29.7)
N	871	49	447	393	112	217	135	106	134	239	2703
Base	6702	158	1027	771	197	364	194	132	184	297	10026
OR		2.9 (1.9-4.5)	4.9 (3.9-6.1)	8.9 (5.6-8.6)	8.9 (6.2-12.8)	9.3 (6.7-12.9)	13.6 (9.0-20.5)	25.7 (11.4-58.3)	15.6 (7.3-33.5)	18.3 (8.4-40.1)	
Smoked cigs in past 30 days %				5.6 (3.9-8.0)	13.1 (8.0-20.9)	16.3 (12.4-21.3)	28.3 (22.6-34.8)	40.3 (29.8-51.9)	47.6 (34.8-60.8)	65.2 (50.8-77.3)	5.8 (4.6-7.3)

NYTS 2019



Table 2 Indicators of dependence in current e-cigarette users by lifetime tobacco use history: high school students NYTS 2017 to 2019

	Lifetime tobacco use history										Total
	E-cigs only, never any other tobacco product	Used tobacco but not combustible	Tried combustible but not cigarette	1 or more puffs, but never whole cigarette	1 cigarette	2 to 5 cigarettes	6 to 15 cigarettes	16 to 25 cigarettes	26 to 99 cigarettes	100+ cigarettes	
Felt craving in past month %	3.8 (1-11)	-	17.4 (11-27)	15.9 (9-26)	19.5 (8-39)	18.0 (10-30)	29.4 (19-43)	39.9 (25-57)	41.6 (31-53)	66.7 (57-75)	26.6 (22-32)
How soon after waking want											
Do not want to use %	73.6 (67-80)	42.1 (23-64)	51.6 (41-62)	52.5 (43-62)	55.4 (35-74)	31.3 (22-42)	23.1 (13-38)	17.0 (6-41)	13.3 (7-25)	6.5 (3-13)	38.9 (34-44)
I rarely want to use %	21.3 (16-28)	50.8 (27-75)	28.0 (20-37)	30.9 (24-39)	28.0 (12-53)	46.5 (35-58)	42.7 (29-58)	34.3 (21-51)	38.8 (26-53)	12.8 (9-19)	29.7 (26-34)
Within 30 minutes	-	-	9.3	4.4	12.6	7.5	8.3	19.3	15.8	45.7	13.6
Thinking of quitting?											
I do not use tobacco %	64.8 (57-72)	43.3 (23-65)	48.8 (36-62)	41.7 (32-52)	48.9 (28-70)	26.9 (18-38)	13.2 (8-21)	14.4 (4-40)	10.1 (4-25)	7.2 (4-14)	33.8 (29-39)
N days used tob prod in mth											
0 days %	55.4 (45-65)	48.6 (28-70)	32.3 (22-44)	38.8 (30-49)	39.5 (19-65)	22.9 (13-37)	14.5 (9-23)	3.6 (1-13)	15.1 (8-28)	6.2 (3-13)	28.3 (24-33)
N days used e-cigs in life											
1 day	20.2 (14-29)	17.6 (7-40)	6.3 (4-11)	7.2 (4-14)	3.9 (1-14)	5.0 (2-12)	8.1 (4-17)	2.8 (4-18)	2.0 (5-9)	4.0 (2-9)	8.0 (6-10)
1-10 days	65.1	60.5	37.0	27.3	35.6	37.7	30.2	6.9	14.1	14.1	33.4
% used 20+ days in mth											
0 days	5.3 (2-11)	9.4 (2-37)	13.7 (9-21)	16.4 (11-25)	9.2 (3-24)	11.1 (7-18)	27.8 (20-37)	19.3 (10-35)	30.3 (17-47)	44.9 (34-56)	20.0 (16-25)
1-2 days	63.8 (55-72)	63.6 (36-85)	43.9 (34-54)	47.3 (40-54)	62.5 (45-78)	39.9 (28-53)	33.0 (21-48)	27.6 (13-50)	21.6 (13-33)	21.2 (14-30)	41.1 (36-46)
20+ days	5.3	9.4	13.8	16.4	9.2	11.1	27.8	19.3	20.2	45.0	20.0
Base n	173	25	168	143	33	122	85	48	80	174	1051

NYTS 2017

	Lifetime tobacco use history										Total
	E-cigs only, never any other tobacco product	Used tobacco but not combustible	Tried combustible, but not cigarette	1 or more puffs, but never whole cigarette	1 cigarette	2 to 5 cigarettes	6 to 15 cigarettes	16 to 25 cigarettes	26 to 99 cigarettes	100+ cigarettes	
Felt craving in past month %	8.6 (6-12)	12.3 (5-27)	17.6 (13-23)	19.9 (15-26)	34.4 (22-49)	28.4 (22-36)	44.0 (34-54)	50.0 (38-62)	56.5 (48-65)	74.5 (69-79)	30.3 (28-33)
How soon after waking want											
Do not want to use %	60.4 (55-66)	48.3 (31-66)	49.7 (42-57)	45.1 (39-52)	28.8 (19-41)	28.8 (23-35)	23.2 (15-34)	20.9 (10-38)	12.2 (7-20)	8.8 (5-14)	38.0 (35-41)
I rarely want to use %	28.1 (23-33)	28.4 (11-55)	28.4 (24-34)	26.5 (21-33)	45.6 (32-60)	34.4 (28-42)	33.4 (23-46)	20.7 (13-31)	24.6 (17-34)	6.4 (4-10)	26.1 (24-29)
Within 30 minutes	3.4 (2-6)	4.8 (1-17)	6.2 (4-10)	10.8 (7-16)	8.6 (4-19)	15.1 (10-23)	16.8 (11-24)	22.8 (13-36)	25.4 (18-34)	51.4 (44-59)	15.7 (14-18)
N days used tob prod in mth											
0 days %	49.7 (44-55)	33.8 (19-52)	40.0 (34-46)	34.6 (28-41)	37.2 (26-50)	23.4 (16-32)	28.9 (19-41)	9.5 (4-22)	10.7 (7-17)	9.5 (7-14)	31.6 (29-34)
N days used e-cigs in life											
1 day	12.7 (9-17)	3.6 (1-14)	8.2 (5-13)	7 (4-12)	5.7 (2-16)	8.1 (5-14)	3.0 (1-8)	0.8 (1-6)	3.4 (1-9)	1.6 (1-4)	7.2 (6-9)
1-10 days	49.1 (44-55)	28.6 (15-49)	31.6 (24-40)	30.2 (24-37)	26.0 (17-37)	24.2 (18-32)	18.1 (10-30)	9.7 (5-17)	9.9 (6-15)	9.2 (6-14)	28.6 (26-32)
N days used e-cigs in p30 days											
1-2 days	53.1 (48-59)	37.2 (21-56)	36.8 (29-46)	31.5 (26-38)	27.3 (19-38)	28.2 (21-37)	23.5 (15-34)	16.0 (11-23)	17.8 (12-26)	14.2 (10-20)	33.1 (30-36)
20+ days	11.4 (9-15)	18.0 (8-34)	17.3 (11-26)	23.6 (18-30)	20.2 (13-31)	28.4 (21-38)	35.6 (24-49)	49.8 (39-61)	53.4 (42-65)	52.4 (45-60)	27.6 (25-31)
Base n	550	46	319	273	85	233	130	113	155	303	2207

NYTS 2018

	Lifetime tobacco use history										Total
	E-cigs only, never any other tobacco product	Used tobacco but not combustible	Tried combustible, but not cigarette	1 or more puffs, but never whole cigarette	1 cigarette	2 to 5 cigarettes	6 to 15 cigarettes	16 to 25 cigarettes	26 to 99 cigarettes	100+ cigarettes	
Felt craving in past month %	8.7 (7-11)	19.6 (9-39)	22.3 (18-28)	21.5 (17-27)	25.2 (17-35)	29.8 (24-37)	42.1 (34-50)	40.3 (30-52)	52.3 (41-64)	65.0 (57-72)	25.9 (23-29)
How soon after waking want											
Do not want to use %	51.8 (47-56)	27.9 (15-46)	31.8 (26-38)	40.4 (34-47)	34.5 (24-46)	19.2 (14-26)	16.6 (11-25)	12.9 (7-23)	9.1 (5-17)	7.6 (5-12)	33.3 (30-37)
I rarely want to use %	34.2 (31-38)	37.2 (22-55)	35.9 (31-42)	27.5 (23-32)	30.2 (22-41)	37.7 (31-45)	26.6 (18-38)	34.1 (23-47)	16.6 (10-26)	10.6 (7-16)	30.1 (28-33)
Within 30 minutes	2.9 (2-5)	10.3 (3-28)	11.9 (9-16)	11.5 (8-16)	14.4 (7-26)	17.3 (11-25)	27.0 (18-39)	23.4 (16-34)	37.3 (27-48)	48.7 (41-57)	15.6 (13-18)
N days used tob prod in mth											
0 days %	52.2 (48-57)	27.8 (17-43)	37.4 (31-44)	39.9 (34-46)	42.0 (31-54)	26.9 (20-35)	18.6 (12-28)	22.8 (15-34)	11.2 (5-19)	7.5 (4.8-11.5)	35.8 (33-37)
N days used e-cigs in life											
1 day	18.2 (15-23)	5.6 (2-15)	8.2 (5-13)	10.9 (7-16)	15.9 (8-28)	3.1 (2-6)	3.3 (1-11)	0.7 (0.1-4)	0.1 (0-0.9)	1.9 (1-8.5)	10.0 (8-12)
1-10 days	46.9 (42-52)	28.7 (18-42)	30.3 (24-38)	35.4 (29-43)	39.3 (29-51)	19.4 (14-27)	17.7 (12-25)	9.5 (4-21)	4.1 (2-9)	6.9 (3-14)	30.6 (28-34)
N days used e-cigs in p30 days											
1-2 days	45.1 (41-49)	31.2 (21-44)	32.1 (25-40)	29.1 (24-35)	29.9 (20-42)	16.1 (11-23)	14.4 (8-25)	12.2 (7-21)	4.2 (2-9)	8.4 (5-13)	28.9 (26-32)
20+ days	15.5 (13-19)	28.6 (16-46)	31.3 (26-37)	34.1 (28-41)	36.3 (26-48)	42.7 (35-50)	43.5 (32-56)	52.6 (41-64)	62.5 (52-72)	66.1 (58-74)	34.2 (31-37)
Base n	871	49	447	393	112	217	135	106	134	239	2703

NYTS 2019

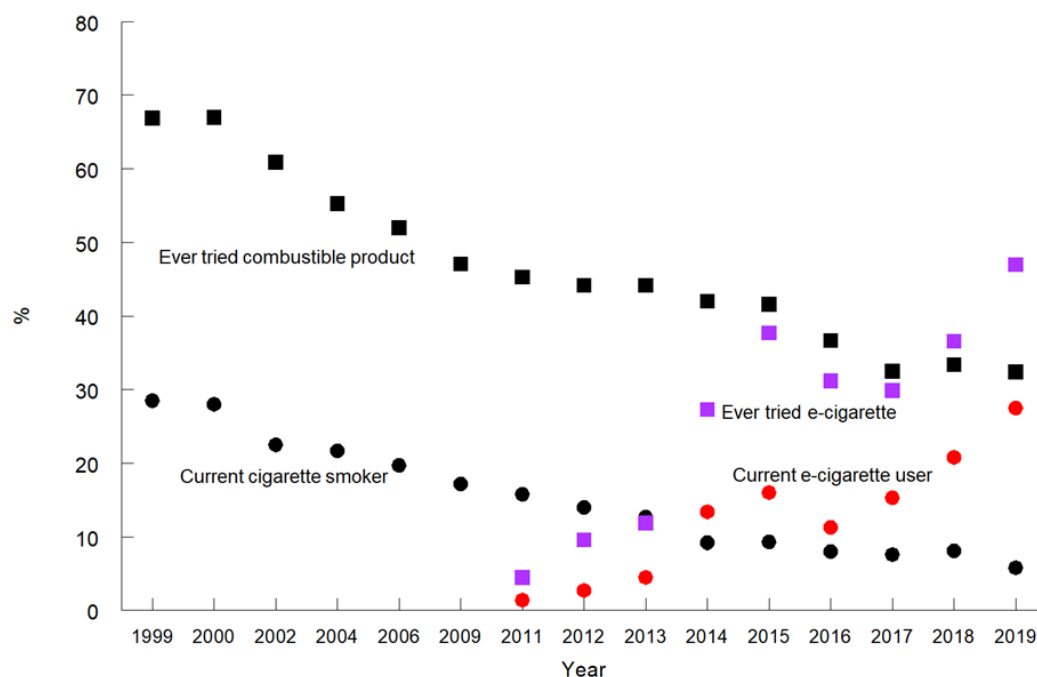
Table 3: Temporal order of first use of e-cigarettes and cigarettes by lifetime tobacco use history: among current (past 30 days) e-cigarette users.

	Lifetime tobacco use history										Total
	E-cigs only, never any other tobacco product	Used tobacco, but not combustible	Tried combustible, but not cigarette	1 or more puffs, but never whole cigarette	1 cigarette	2 to 5 cigarettes	6 to 15 cigarettes	16 to 25 cigarettes	26 to 99 cigarettes	100+ cigarettes	
Cigarettes	0.6 (.1-9)	2.9 (3-20.7)	1.8 (5-6)	49.3 (42-57)	65.7 (50-78)	55.4 (47-64)	58.2 (46-70)	62.3 (49-74)	64.9 (51-77)	76.5 (70-82)	47.5 (43-52)
N	1	1	5	92	38	104	77	52	77	237	684
Cigars, cigarillos %			23.3 (15-34)	14.9 (9-24)	6.7 (3-17)	17.4 (12-25)	12.3 (7-20)	9.9 (5-18)	15.9 (9-28)	8.8 (6-12)	12.7 (10-15)
N	0	0	45	26	4	29	18	9	19	32	182
Chew, snuff, dip %		48.3 (25-73)	12.9 (9-19)	8.7 (5-16)	5.6 (2-14)	10.5 (5.5-19.4)	7.6 (4-14)	16.7 (9-29)	15.0 (9-24)	8.6 (5-14)	9.7 (7-13)
N	0	7	25	14	4	13	10	12	19	28	132
E-Cigarettes	87.1 (81-91)	48.9 (25-74)	49.8 (40-62)	18.8 (14-26)	13.4 (7-26)	8.7 (5-15)	15.3 (7-31)	8.0 (3-19)	2.1 (0.7-6.0)	2.2 (1-4)	22.9 (19-27)
N	123	5	98	45	8	17	17	5	4	8	330
Base	146	13	204	194	59	177	128	83	122	317	1443

NYTS 2014

	Lifetime tobacco use history										Total
	E-cigs only, never any other tobacco product	Used tobacco, but not combustible	Tried combustible, but not cigarette	1 or more puffs, but never whole cigarette	1 cigarette	2 to 5 cigarettes	6 to 15 cigarettes	16 to 25 cigarettes	26 to 99 cigarettes	100+ cigarettes	
Only tried cigarettes	0.7 (.1-5)		1.2 (.4-4)	2.5 (.5-10)		1.4 (.4-5)	1.4 (.3-6)	4.1 (1.3-12)	1.1 (.3-4)	2.2 (1-5)	1.6 (1-3)
n	1	0	4	3		3	2	3	2	6	24
Only tried e-cigs	87.1 (79-92)	92.2 (76-98)	84.7 (79-89)	15.5 (11-22)	5.4 (.8-29)	5.6 (3-12)	2.5 (.5-11)	5.0 (1-20)		0.7 (.2-2.0)	30.2 (27-34)
n	133	20	233	29	1	9	3	2		3	433
Tried cigs first			1.2 (.4-3)	53.1 (45-61)	50.4 (37-64)	67.7 (59-76)	73.5 (62-82)	76.8 (64-86)	82.9 (69-92)	87.7 (82-92)	50.0 (46-55)
n			3	106	27	123	80	54	85	231	709
Tried e-cigs first	5.7 (3-12)	3.3 (.4-23)	9.7 (6-15)	25.4 (19-34)	40.2 (26-56)	21.5 (16-29)	21.6 (13-33)	13.3 (7-24)	15.3 (7-30)	7.6 (4-13)	15.2 (13-17)
N	9	1	26	56	17	40	23	10	12	17	211
Base	151	23	273	202	47	183	110	70	100	263	1422

NYTS 2015



**Figure 1.** Time trends in use of e-cigarettes (ever-tried & current) and combustible (ever-tried combustible product and current cigarette) NYTS 1999–2019. E-cigarette use ascertained from 2011 onwards

## Declarations

**Funding:** JB received unrestricted research funding from Pfizer, who manufacture smoking cessation medications. RW undertakes research and consultancy for and receives travel funds and hospitality from manufacturers of smoking cessation medications (Pfizer, GlaxoSmithKline and Johnson and Johnson). All authors declare no financial links with tobacco companies or e-cigarette manufacturers or their representatives.

**Potential competing interests:** JB received unrestricted research funding from Pfizer, who manufacture smoking cessation medications. RW undertakes research and consultancy for and receives travel funds and hospitality from manufacturers of smoking cessation medications (Pfizer, GlaxoSmithKline and Johnson and Johnson). All authors declare no financial links with tobacco companies or e-cigarette manufacturers or their representatives.