Original investigation

Socioeconomic and Racial/Ethnic Differences in E-Cigarette Uptake Among Cigarette Smokers: Longitudinal Analysis of the Population Assessment of Tobacco and Health (PATH) Study

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Abstract

Introduction: Sociodemographic differences in electronic cigarette use among cigarette smokers have not been previously characterized in the US adult population.

Methods: We analyzed longitudinal data from Waves 1 and 2 of the nationally representative Population Assessment of Tobacco and Health (PATH) study. Differences by income (based on federal poverty level (FPL)) and race/ethnicity in e-cigarette uptake at Wave 2 among cigarette smokers who were e-cigarette nonusers at Wave 1 were assessed using binomial and multinomial logistic regression. We differentiated e-cigarette users who quit cigarettes (exclusive users) from those who did not quit cigarettes (dual users). E-cigarette-related attitudes/beliefs were evaluated to understand potential contributions to sociodemographic differences in e-cigarette uptake and use patterns.

Results: Among 6592 smokers who were e-cigarette nonusers at Wave 1, 13.5% began using e-cigarettes at Wave 2, of whom 91.3% were dual users. Compared with non-Hispanic Whites, non-Hispanic Black, and Hispanics were less likely to become exclusive e-cigarette users (OR [Blacks] = 0.27, 95% CI = 0.09 to 0.77; OR [Hispanics] = 0.26, 95% CI = 0.09 to 0.70). Low-income smokers were less likely than higher-income smokers to become exclusive e-cigarette users (OR [$<100\%$ FPL vs. $\geq 200\%$ FPL] = 0.48, 95% CI = 0.27 to 0.89). Black, Hispanic, and low-income smokers were more likely to believe e-cigarettes are more harmful than cigarettes and to have positive tobacco-related social norms.

Conclusions: Black, Hispanic, and low-income smokers were less likely than White and higher-income smokers to begin using e-cigarettes in the context of quitting cigarettes. Differences in e-cigarette uptake may be partly explained by perceived harm or social norms of e-cigarettes.

Implications: Results of this study show that the exclusive use of e-cigarettes is more prevalent in higher-income and White smokers. Our data suggest that higher-income and White smokers may be more likely to use e-cigarettes as a means to quit combustible cigarettes compared with low-income and racial/ethnic minority smokers. These findings suggest that sociodemographic differences in e-cigarette uptake and use patterns may contribute to widening disparities in cigarette smoking.

Introduction

E-cigarettes are rapidly gaining popularity in the United States, with a prevalence of ever use among cigarette smokers close to 50% in 2013.¹ Despite concerns regarding unknown health effects, e-cigarettes are generally considered less dangerous than cigarettes.² Evidence of e-cigarettes' effectiveness as a cessation aid for cigarette smokers is emerging, with several randomized controlled trials and observational studies finding a positive impact on cessation.^{3–7} A recent meta-analysis did find that e-cigarettes were associated with overall lower odds of quitting cigarettes; however, these findings are limited by the fact that the authors did not disaggregate exposure on frequency of e-cigarette use, which may be an important factor in the efficacy of e-cigarettes as a cessation aid.^{7,8}

Little is known about how e-cigarette uptake and use patterns differ across race/ethnicity and socioeconomic status (SES), including the extent to which e-cigarettes are used alongside cigarettes (dual use) versus used as a substitute for cigarettes (exclusive use). There is developing evidence of sociodemographic differences in e-cigarette use, with higher prevalence and awareness among non-Hispanic White and higher-SES groups.⁹ However, there have been no studies to our knowledge that examine sociodemographic differences in longitudinal e-cigarette uptake among current cigarette smokers using nationally representative data. Furthermore, there have been few studies that examine potential explanations for differences in e-cigarette use patterns among cigarette smokers, such as the impact of attitudes, beliefs, social norms, or risk perceptions on e-cigarette use behavior.

In light of the new Federal Drug Agency (FDA) mandate to regulate emerging tobacco products,¹⁰ it is important to further our understanding of e-cigarettes as both a substance-use product and a potential harm-reduction product for cigarette smokers. Part of this understanding includes exploring patterns of use by different demographics and the extent to which different sociodemographic groups use e-cigarettes as substitutes versus complements to cigarettes. This is particularly important given prominent disparities in cigarette smoking and cigarette cessation success by SES and race/ethnicity.^{11–17}

To contribute evidence on the equity impact of e-cigarettes, we examined socioeconomic and racial/ethnic differences in e-cigarette uptake and use patterns among cigarette smokers using data from the Population Assessment of Tobacco and Health (PATH) study, a longitudinal, nationally representative study of tobacco product use and its impact on health. We further assessed differences in tobacco-related attitudes and beliefs by SES and race/ethnicity, and attitudes and beliefs associated with e-cigarette uptake.

Methods

The PATH study was initiated in 2013 by the National Institutes of Health (NIH) and the FDA. More than 49 000 participants from across the United States are enrolled in PATH, with the sample drawn using a four-stage stratified area probability sample design.¹⁸ Data are collected using computer-assisted personal interviewing (CAPI) for screener and parent interviews, and audio computer-assisted self-interviewing (ACASI) for adult and youth interviews. Details on the design and methodology of the PATH study have been described previously.¹⁹

For this analysis, we analyzed the public use files from Wave 1 and Wave 2. Wave 1 interviews occurred between September 2013

and December 2014; Wave 2 interviews occurred roughly 12 months later between October 2014 and October 2015. Participants at Wave 1 who were 18 years or older and established cigarette smokers but not current e-cigarette users were eligible for analysis ($n = 8852$). There were 1633 nonrespondents at Wave 2 (18.4%), resulting in 7219 participants in our analytic sample.

Established cigarette smokers at Wave 1 were defined as participants who reported smoking at least 100 cigarettes in their lifetime, and currently smoke every day or some days. E-cigarette nonusers at Wave 1 were defined as participants not currently using e-cigarettes experimentally, every day, or some days. Experimental e-cigarette use was defined as currently using e-cigarettes every day or some days, but having never used e-cigarettes "fairly regularly." We defined uptake of e-cigarette use at Wave 2 as currently using e-cigarettes every day, some days, or experimentally. We assessed quitting smoking between waves, with Wave 2 former cigarette smokers defined as currently smoking cigarettes "not at all," and not having smoked any cigarettes in the past 30 days. The commonly accepted definition for cigarette cessation is reported cessation of 3-months or more;²⁰ however, given the short time period of interest (12-months), having at least 3-months cessation would be too restrictive for the current analysis. In addition, although participants were asked in an open response format the time since their last cigarette, only a small percentage of our sample had valid responses.

Our outcome of interest was e-cigarette transition at Wave 2. To distinguish between those who began using e-cigarettes as substitutes versus complements to cigarettes and provide a more specific reference group, we classified participants into one of four mutually exclusive Wave 2 status categories: those who began using e-cigarettes between waves and continued smoking cigarettes (dual e-cigarette users), those who began using e-cigarettes and quit smoking between waves (exclusive e-cigarette users), those who did not begin using e-cigarettes and quit smoking (former cigarette smokers), and those who did not begin using e-cigarettes and continued smoking cigarettes (no transition).

Our exposures of interest were race/ethnicity and SES at Wave 1. Race/ethnicity was categorized as non-Hispanic White, non-Hispanic Black, non-Hispanic Other Race, and Hispanic. Though race and ethnicity are two separate concepts (race referring to a cultural construct based on an individual's skin color, and ethnicity referring to one's cultural heritage), for the purpose of this paper, we combine the two concepts. Race/ethnicity is an accepted and established term, used by the Centers for Disease Control (CDC) and other agencies that release official statistics on population subgroups.¹¹ In addition, the combined term allows for mutually exclusive categories. Income and education were considered two separate proxies for SES. Income was categorized as <100%, 100–199%, and ≥200% of the Federal Poverty Level (FPL). Education was categorized as less than high school, high-school graduate or equivalent (GED), and some college or more.

To assess socioeconomic and racial/ethnic differences in uptake of e-cigarette use among current cigarette smokers, we calculated descriptive statistics and performed logistic regression analyses. Binomial logistic regression models were used to assess socioeconomic and racial/ethnic differences in uptake of any type of e-cigarette use (exclusive or dual) versus no uptake of e-cigarette use at Wave 2. We additionally employed multinomial logistic regression to assess differences in the four mutually exclusive Wave 2 status categories mentioned above. In addition to providing a more specific reference category, multinomial logistic regression provides more statistical power than

multiple binomial models by incorporating the sample size of all outcome categories.²¹ Separate models were developed to assess the association of each of the three sociodemographic measures on uptake of exclusive e-cigarette use, dual e-cigarette use, and no e-cigarette uptake plus quitting smoking compared with no transition. Models adjusted for age, geographic region, and sex. Income and education models both additionally adjusted for race/ethnicity. Income and education were excluded from race/ethnicity models as these covariates lie on the causal pathway between race/ethnicity and e-cigarette use.

In addition to capturing e-cigarette uptake, all participants at Wave 1 were asked about tobacco- and e-cigarette-related attitudes and beliefs. These included questions on social norms, perceived harm, and overall opinions/perceptions of tobacco and e-cigarettes. Questions had four- or five-item Likert style response options, which were collapsed into dichotomous responses for analyses to capture one main sentiment. For example, for the question “How would you describe your overall opinion of tobacco,” participants had five response options ranging from very negative to very positive. In analyses, responses were collapsed to capture the main sentiment of positive opinions: those who had positive or very positive opinions versus all other opinions (neutral and negative). We conducted two series of adjusted logistic regression modeling to test the association of Wave 1 attitudes and beliefs with our exposure variables and with Wave 2 e-cigarette uptake. Our first series of logistic regression models included SES and race/ethnicity as independent variables and each attitude/belief as the dependent variables in binomial logistic regression models. We then conducted a series of logistic regression models with attitudes/beliefs as independent variables and Wave 2 e-cigarette uptake as the dependent variable. We assessed the association of attitudes/beliefs with the uptake of any type of e-cigarette use (exclusive or dual) versus no e-cigarette uptake in binomial logistic regression models. We assessed the association of attitudes/beliefs on uptake of exclusive e-cigarette and dual e-cigarette versus no transition using multinomial logistic regression models.

For those who became e-cigarette users at Wave 2, further questions were asked on reasons for using e-cigarettes. These included dichotomous questions on reasons for using e-cigarettes, such as motivations to quit cigarettes, or influence from the media. We provide descriptive statistics of reasons for using e-cigarettes stratified by race/ethnicity and SES. Because these second set of attitudes/beliefs are only asked once a participant begins using e-cigarettes, they cannot be used to predict e-cigarette use, but still provide valuable descriptive data on differences among e-cigarette users by sociodemographic characteristics.

We excluded participants with missing data for Wave 2 e-cigarette use ($n = 40$), Wave 2 cigarette smoking status ($n = 1$), Wave 1 income ($n = 568$), Wave 1 education ($n = 35$), Wave 1 race/ethnicity ($n = 17$), and Wave 1 sex ($n = 3$). For all analyses, sample weighting accounted for differential nonresponse and probabilities of selection, and under-coverage of certain populations.¹⁸ As recommended by the statistical reporting guidelines from Nicotine and Tobacco Research, we focus interpretation of our results on the magnitude and precision of the odds ratio estimates, rather than statistically significant p values.²² All analyses were performed using SAS 9.3. As the data included secondary analysis of publicly available and de-identified data, institutional review board approval was not required.

Results

After restrictions based on nonresponse in Wave 2 and exclusion of missing data, our sample included 6592 current cigarette smokers

who were e-cigarette nonusers at Wave 1. Though restricted to current e-cigarette nonusers, nearly half of participants had used an e-cigarette at least once in their lifetime. Table 1 provides descriptions of the sociodemographic and e-cigarette characteristics of the sample.

E-Cigarette Uptake

Between Wave 1 and Wave 2, 13.5% of participants began using e-cigarettes and 8.4% quit cigarette smoking (Table 1). Having used an e-cigarette at least once was a strong predictor of e-cigarette uptake at Wave 2. A large majority (91.9%) of those who transitioned to e-cigarette use became dual cigarette and e-cigarette users, whereas 8.1% became exclusive e-cigarette users (Table 1). More than half of those who transitioned to e-cigarette use became experimental users (52.8%), while 26.5% became some day users and 20.7% became every day users (data not shown). Among those who transitioned to exclusive use of e-cigarettes, a majority became every day users (68.9% every day use, 10.2% some day use, 21.0% experimental use). In contrast, the majority of those who transitioned to dual cigarette and e-cigarette use became experimental e-cigarette users (16.5% every day use, 27.9% some day use, 55.6% experimental use) (data not shown).

Differences by Income and Education

There was no difference by income in uptake of e-cigarette use when combining exclusive and dual e-cigarette use (Table 2). However, participants with income below 100% FPL were 52% less likely than those with income greater than 200% FPL to become exclusive e-cigarette users versus no transition (OR = 0.48, 95% CI = 0.27 to 0.89). Lower-income participants were also less likely than those with income greater than 200% FPL to quit cigarettes (and not use e-cigarettes) compared with no transition. There was no difference by income in uptake of dual use compared with no transition. Analyses by education produced similar results as by income, with lower education associated with reduced odds of exclusive e-cigarette use and cigarette cessation without e-cigarettes (Table 2).

Differences by Race/Ethnicity

Non-Hispanic Black and Hispanic cigarette smokers were significantly less likely than non-Hispanic White cigarette smokers to begin using e-cigarettes in any capacity between waves (Table 2, OR [Black] = 0.55, 95% CI = 0.42 to 0.72 and OR [Hispanic] = 0.56, 95% CI = 0.43 to 0.73). Compared with White cigarette smokers, Black and Hispanic cigarette smokers were also much less likely to transition to exclusive e-cigarette use (OR [Black] = 0.26, 95% CI = 0.09 to 0.77 and OR [Hispanic] = 0.26, 95% CI = 0.09 to 0.70), and dual use (OR [Black] = 0.56, 95% CI = 0.42 to 0.75 and OR [Hispanic] = 0.62, 95% CI = 0.47 to 0.81) versus no transition. Black cigarette smokers were less likely than White cigarette smokers to quit cigarettes and not use e-cigarettes, whereas Hispanic cigarette smokers and those of Other races were more likely than Whites to quit cigarettes versus no transition.

Attitudes and Beliefs

Table 3 presents tobacco- and e-cigarette-related attitudes and beliefs stratified by income and race/ethnicity. More cigarette smokers with income below 100% FPL compared with greater than 100% FPL had overall positive opinions of tobacco, believed most people and people close to them have positive opinions of tobacco, and believed e-cigarettes are more harmful than cigarettes. Lower-income cigarette

Table 1. Baseline Characteristics of Sample and Use of E-Cigarettes and Smoking Cessation at Wave 2^a

	Baseline characteristics <i>n</i> (%)		
	Total (<i>n</i> = 6592)	Wave 2 e-cigarette user (<i>n</i> = 914)	Wave 2 e-cigarette nonuser (<i>n</i> = 5678)
Sex			
Male	3363 (55.61)	466 (54.74)	2897 (55.74)
Female	3229 (44.39)	448 (45.26)	2781 (44.26)
Age			
18–24	1274 (13.08)	241 (17.97)	1033 (12.31)
25–34	1491 (24.10)	208 (26.13)	1283 (23.78)
35–44	1232 (19.71)	194 (23.45)	1038 (19.13)
45–54	1257 (20.20)	155 (17.48)	1092 (20.62)
55–64	936 (15.69)	92 (11.77)	844 (16.31)
65–74	330 (5.73)	22 (2.85)	308 (6.18)
74+	82 (1.49)	2 (0.35)	80 (1.66)
Geographical Region			
Northeast	994 (17.90)	124 (15.80)	870 (18.22)
Midwest	1868 (25.18)	265 (25.59)	1603 (25.11)
South	2585 (39.49)	370 (42.03)	2215 (39.10)
West	1145 (17.43)	155 (16.58)	990 (17.57)
Race/Ethnicity			
Non-Hispanic White	4285 (68.79)	671 (76.19)	3614 (67.63)
Non-Hispanic Black	1022 (14.45)	81 (9.23)	941 (15.26)
Hispanic	828 (10.98)	88 (7.90)	740 (11.46)
Non-Hispanic Other	457 (5.78)	74 (6.69)	383 (5.64)
Income			
<100% FPL	2757 (38.07)	394 (38.65)	2363 (37.97)
100–199% FPL	1811 (27.41)	248 (27.56)	1563 (27.39)
≥200% FPL	1024 (34.52)	272 (33.78)	1752 (34.64)
Education			
< High School	1147 (16.18)	134 (13.59)	1013 (16.58)
High School or GED	2413 (39.17)	342 (38.86)	2071 (39.22)
Some or more college	3032 (44.65)	438 (47.56)	2594 (44.20)
Ever used E-cigarette at Wave 1 ^b			
Yes	3404 (52.84)	628 (70.18)	2776 (50.06)
No	2839 (47.16)	262 (29.82)	2577 (49.94)
Wave 2 Outcomes <i>n</i> (%)			
New E-cigarette user			
Yes	914 (13.48)	914 (100)	0 (0)
No	5678 (86.52)	0 (0)	5678 (100)
Type of E-cigarette user			
Exclusive E-cigarette User	76 (1.09)	76 (8.06)	0(0)
Dual Cigarette and E-cigarette User	838 (12.40)	838 (91.94)	0(0)
Quit Smoking Cigarettes ^c			
Yes	527 (8.37)	76 (8.06)	451 (8.42)
No	6065 (91.63)	848 (92.94)	5227 (91.58)

^aAdult (aged 18+) current smokers and e-cigarette nonusers at Wave 1. Percentage estimates calculated using sample weights, numbers based on unweighted data.

^bE-cigarette ever use defined as having ever used an e-cigarette in lifetime, even one or two times, at Wave 1.

^cQuit smoking refers to participants who did not smoke a cigarette in the past 30 days at Wave 2 and report currently smoking cigarettes “not at all.”

smokers were less likely than higher-income smokers to believe most people disapprove of using e-cigarettes. Differences remained in adjusted analyses (Table 4). Among Wave 2 new e-cigarette users, more low-income users reported using e-cigarettes because of portrayals in the media and advertising, and because people who are important to them use e-cigarettes (Table 3).

Due to space constraints, results of education and attitudes/beliefs are shown in Supplementary Tables 1 and 2. Similar to results by income, participants with less than a high-school degree were more likely than those with higher education to have overall positive opinions of tobacco, believe most people and people close to them

have positive opinions of tobacco, and believe e-cigarettes are more harmful than cigarettes. These associations remained in adjusted analyses. Among new e-cigarette users, lower education was associated with using e-cigarettes because of depictions in the media. Higher education was associated with using e-cigarettes because they do not smell.

Non-Hispanic Black and Hispanic cigarette smokers were more likely than non-Hispanic White smokers and those of Other races to have overall positive opinions of tobacco and believe most people and people close to them have positive opinions of tobacco. Black and Hispanic cigarette smokers were also more likely to believe

Table 2. Binomial and Multinomial Logistic Regression Models:^a E-Cigarette Transitions Between Wave 1 and Wave 2 (*n* = 6592)^b

Sociodemographic characteristic	Any e-cigarette uptake vs. no e-cigarette uptake		Uptake of exclusive e-cigarettes vs. no transition		Uptake of dual e-cigarettes and cigarettes vs. no transition		No e-cigarette uptake and quit cigarettes vs. no transition	
	<i>n</i> (%)	Adjusted OR (95% CI)	<i>n</i> (%)	Adjusted OR (95% CI)	<i>n</i> (%)	Adjusted OR (95% CI)	<i>n</i> (%)	Adjusted OR (95% CI)
Model 1: Income ^c								
<100% FPL	394 (13.69)	1.01 (0.83–1.24)	22 (0.65)	0.48 (0.27–0.89)	372 (13.04)	1.01 (0.82–1.25)	155 (5.96)	0.56 (0.42–0.73)
100–199% FPL	248 (13.56)	1.04 (0.87–1.26)	25 (1.40)	1.06 (0.62–1.83)	223 (12.15)	1.00 (0.82–1.23)	120 (6.69)	0.68 (0.51–0.91)
≥200% FPL	272 (13.19)	REF	29 (1.32)	REF	243 (11.87)	REF	176 (9.21)	REF
Model 3: Education ^c								
< High School	134 (11.32)	0.86 (0.68–1.08)	8 (0.70)	0.49 (0.19–1.28)	126 (10.62)	0.86 (0.68–1.09)	63 (6.01)	0.60 (0.40–0.88)
High School or GED	342 (13.37)	0.94 (0.79–1.14)	20 (0.74)	0.46 (0.25–0.85)	322 (12.63)	0.96 (0.80–1.16)	136 (5.81)	0.62 (0.48–0.79)
Some or more college	438 (14.36)	REF	48 (1.53)	REF	390 (12.83)	REF	252 (9.04)	REF
Model 2: Race/Ethnicity ^d								
Non-Hispanic White	671 (14.93)	REF	61 (1.37)	REF	610 (13.56)	REF	275 (6.95)	REF
Non-Hispanic Black	81 (8.61)	0.55 (0.42–0.72)	5 (0.39)	0.26 (0.09–0.77)	76 (8.22)	0.56 (0.42–0.75)	54 (5.01)	0.66 (0.46–0.92)
Hispanic	88 (9.69)	0.56 (0.43–0.73)	5 (0.44)	0.26 (0.09–0.70)	88 (10.46)	0.62 (0.47–0.81)	88 (10.46)	1.42 (1.10–1.82)
Non-Hispanic Other	74 (15.61)	0.97 (0.68–1.39)	5 (0.65)	0.43 (0.14–1.32)	69 (14.96)	1.09 (0.75–1.57)	34 (10.88)	1.61 (1.04–2.49)

Abbreviations: OR: odds ratio; CI: confidence interval; FPL: federal poverty level

^aMultinomial regression analyses conducted with no transition (continuing as cigarette smoker and no e-cigarette uptake) as the reference group.^bAnalyses conducted using sample weights. Numbers based on unweighted data.^cIncome models adjusted for race/ethnicity, age, sex, geographic region^dRace/ethnicity models adjusted for age, sex, geographic region^eEducation models adjusted for race/ethnicity, age, sex, geographic region**Table 3.** Tobacco- and E-Cigarette-Related Attitudes and Beliefs Stratified by Income and Race/Ethnicity

Attitude/belief	Income (FPL) (<i>n</i> = 6592)			Race/ethnicity (<i>n</i> = 6592)			
	<100%	100–199%	>200%	White	Black	Hispanic	Other
Overall positive opinions of tobacco**++	17.47	12.46	8.88	11.65	18.51	17.25	9.50
Most people have positive opinions of tobacco**++	11.57	7.06	3.33	4.94	15.30	13.26	7.43
People close to you have positive opinions of tobacco**++	14.46	10.67	5.90	7.77	17.29	18.91	9.45
Believe e-cigarettes are more harmful than cigarettes**++	7.96	6.61	5.71	5.68	9.78	11.08	5.17
Most people disapprove of using e-cigarettes**+	49.15	47.83	55.62	51.24	48.12	55.71	46.87
(Among wave 2 e-cigarette users <i>n</i> = 914)							
Use E-cigarettes because....							
People in the media or other public figures use them**++	22.08	10.06	12.54	11.71	30.42	22.25	30.82
Can use it in places where smoking cigarettes is not allowed	77.60	74.77	79.58	77.40	83.79	78.08	69.14
They might be less harmful to me than cigarettes+	73.95	74.22	78.57	75.71	83.13	59.97	82.23
They might be less harmful to people around me than cigarettes	82.99	78.10	78.00	79.08	85.18	76.63	86.70
It comes in flavors I like	68.21	62.36	63.37	64.58	65.99	60.91	72.61
Using them helps people to quit smoking cigarettes	71.24	76.36	72.00	73.95	74.97	62.73	70.24
They don't smell	66.74	69.16	74.27	69.46	68.48	73.38	73.52
Using it feels like smoking a regular cigarette+	41.33	47.77	49.20	48.43	42.42	33.93	33.98
They are more acceptable to nontobacco users+	60.52	67.89	65.92	64.25	68.20	57.94	68.05
People who are important to me use them*	24.18	14.93	17.32	17.34	18.13	25.34	36.31
Like socializing while using them*	35.07	27.30	30.23	28.28	41.80	32.90	49.16
The advertising for them appeals to me**++	18.71	11.21	9.19	12.00	30.10	14.00	17.42

Percent of participants who agree with the statement. Percentage estimates calculated using sample weights.

p* < .05 and *p* < .0001 in chi-square analysis for Income.+*p* < .05 and ++*p* < .0001 in chi-square analysis for Race/Ethnicity.

e-cigarettes are more harmful than cigarettes, and Hispanic cigarette smokers were more likely than other race/ethnicities to believe most people disapprove of using e-cigarettes. These findings remained in

adjusted analyses (Table 4). Among new e-cigarette users at Wave 2, White users were less likely to use e-cigarettes because people in the media use them and more likely to use e-cigarettes because they “feel

Table 4. Logistic Regression Models: Tobacco-Related Attitudes and Beliefs Associated With Income, Race/Ethnicity, and Wave 2 Status^a

Wave 1 attitude/belief	Income and race/ethnicity as predictors of attitudes/beliefs					Attitudes/Beliefs as predictors of e-cigarette use ^b				
	Income (FPL) ^d (n = 6592)		Race/Ethnicity ^e (n = 6592)			Wave 2 e-cigarette status (n = 6592)				
	<100% FPL	100–199% FPL	Black	Hispanic	Other	Any e-cigarette uptake vs. no e-cigarette uptake	Exclusive e-cigarettes vs. no transition ^c	Dual e-cigarettes vs. no transition ^c	Quit cigarettes vs. no transition ^c	
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)	
Overall positive opinions of tobacco	2.30 (1.86–2.84)	1.45 (1.16–1.82)	1.68 (1.36–3.06)	1.60 (1.25–2.05)	0.81 (0.55–1.18)	0.94 (0.74–1.19)	0.84 (0.40–1.77)	0.94 (0.73–1.21)	0.86 (0.58–1.28)	
Most people have positive opinions of tobacco	3.77 (2.78–5.13)	2.10 (1.53–2.89)	3.39 (2.65–4.35)	3.12 (2.39–4.08)	1.64 (0.98–2.72)	0.64 (0.43–0.96)	0.54 (0.07–4.40)	0.65 (0.43–1.00)	1.08 (0.68–1.72)	
People close to you have positive opinions of tobacco	2.61 (2.00–3.41)	1.83 (1.41–2.48)	2.43 (1.95–3.04)	2.88 (2.30–3.61)	1.29 (0.80–2.06)	0.80 (0.62–1.04)	0.90 (0.40–2.04)	0.79 (0.61–1.03)	1.01 (0.71–1.42)	
Believe e-cigarettes are more harmful than cigarettes	1.40 (1.08–1.82)	1.12 (0.84–1.48)	1.77 (1.30–2.41)	2.19 (1.58–3.03)	0.96 (0.60–1.53)	0.38 (0.24–0.61)	0.13 (0.01–1.91)	0.41 (0.25–0.65)	0.99 (0.64–1.54)	
Most people disapprove of using e-cigarettes	0.78 (0.68–0.90)	0.72 (0.62–0.83)	0.87 (0.73–1.02)	1.25 (1.04–1.51)	0.88 (0.68–1.14)	0.67 (0.57–0.77)	0.37 (0.20–0.68)	0.71 (0.62–0.83)	1.23 (1.01–1.49)	

Abbreviations: OR: odds ratio; CI: confidence interval; FPL: federal poverty level.

^aAnalyses conducted using sample weights. Numbers based on unweighted data.^bWave 2 e-cigarette models adjusted for age, sex, geographic region.^cMultinomial regression analyses conducted with no transition (continuing as cigarette smoker and no e-cigarette uptake) as the reference group.^dIncome models adjusted for race/ethnicity, age, sex, geographic region with ≥200% FPL as reference group.^eRace/ethnicity models adjusted for age, sex, geographic region with non-Hispanic White as reference group.

like smoking a regular cigarette.” Fewer Hispanic users reported using e-cigarettes because they may be less harmful than cigarettes and because they are more acceptable to nontobacco users. Finally, Black e-cigarette users and users of Other races were more likely to use e-cigarettes because of appealing advertising, and for socializing reasons. All participants who became e-cigarette users were equally likely to report using e-cigarettes because they help them quit smoking, regardless of SES or race/ethnicity (Table 3).

When assessing attitudes/beliefs associated with initiating e-cigarette use (Table 4), believing most people have positive opinions of tobacco, e-cigarettes are more harmful than cigarettes, and most people disapprove of using e-cigarettes was associated with reduced odds of any e-cigarette uptake. In adjusted multinomial models, believing most people disapprove of using e-cigarettes was associated with reduced odds of transition to exclusive and dual e-cigarette use compared with no transition. Holding this belief was also associated with increased odds of quitting cigarettes with no e-cigarette uptake compared with no transition. Believing e-cigarettes are more harmful than cigarettes was associated with decreased likelihood of becoming a dual user.

Discussion

This analysis represents one of the first attempts to use longitudinal nationally representative data to assess socioeconomic and racial/ethnic differences in e-cigarette uptake and use patterns by adult cigarette smokers. We found that, although lower-SES smokers are equally likely as their higher-SES counterparts to begin using e-cigarettes as complements to cigarettes, they are less likely to substitute cigarettes with e-cigarettes. Non-Hispanic Black and Hispanic cigarette smokers were less likely than non-Hispanic White cigarette smokers to begin using e-cigarettes between waves in any context, including transition to exclusive e-cigarette use.

There were differences in tobacco-related attitudes and beliefs among different subgroups of participants. Low-SES and racial/ethnic minority participants had more positive tobacco-related opinions and social norms compared with higher-SES and White participants. When asked about social norms of e-cigarettes in particular, Hispanic participants were more likely to believe most people disapprove of using e-cigarettes compared to other race/ethnicities. Low-SES, Black and Hispanic cigarette smokers were more likely than high-SES and White cigarette smokers to believe e-cigarettes are more harmful than cigarettes. Finally, influence from the media and advertising were stronger reasons for using e-cigarettes among low-SES and minority participants, whereas White participants were more likely to use e-cigarettes because of their similarity in feeling to combustible cigarettes. Positive social norms related to overall tobacco and negative social norms related to e-cigarettes were both associated with not initiating e-cigarette use, as was the belief that e-cigarettes were more harmful to health than combustible cigarettes.

E-cigarettes are unique because, though they are a tobacco-related product and regulated as such in the United States, they are also considered a harm-reduction product for cigarette smokers and may be an effective aid to quitting smoking.²³ In 2016, the Royal College of Physicians in United Kingdom issued a report supporting the use of e-cigarettes as a substitute for combustible cigarette smoking.²⁴ In the United States, much of the scientific and regulatory discourse has revolved around the potential harms of e-cigarettes to health. However, a 2018 report from the National Academies of Science, Engineering and Medicine concluded that e-cigarettes

contain significantly fewer toxins than conventional cigarettes and may help smokers quit combustible cigarettes.²⁵ Our findings, therefore, should be interpreted in the context of growing literature on both sociodemographic patterns in tobacco-related product use, as well as disparities in use of cigarette cessation products.

Our finding that Black and Hispanic cigarette smokers were less likely to begin using e-cigarettes in any context is consistent with previous studies demonstrating lower prevalence of e-cigarette use among minority populations compared with Whites.^{9,26–31} In a recent report by the Centers for Disease Control and Prevention, 4% of White adults reported currently using e-cigarettes every day or some days, compared to 2% of Black adults, and 2% of Hispanic adults.¹¹ A 2016 systematic review by Hartwell et al. similarly found greater prevalence of e-cigarette awareness, ever use, and current use among White populations.⁹ Our results suggest these patterns remain when looking at recent uptake over time among current cigarette smokers. Posited reasons behind racial/ethnic differences in tobacco product use include sociocultural influences, social norms, and targeted marketing strategies.^{11,32,33} In this analysis, we found Black and Hispanic cigarette smokers held more positive social norms related to overall tobacco use compared with White cigarette smokers, and positive tobacco-related social norms were associated with reduced likelihood of e-cigarette use. Social pressures and norms have been an important force in driving down cigarette rates.^{32,34} Retaining positive norms around cigarettes may reduce a smoker’s likelihood to use e-cigarettes, a product often marketed as a healthier alternative to cigarettes. Interestingly, Hispanic cigarette smokers were more likely than other race/ethnicities to believe most people disapprove of e-cigarette use, and this belief was associated with lower likelihood of using e-cigarettes. Furthermore, Hispanic and Black cigarette smokers were twice as likely to believe e-cigarettes are more harmful than cigarettes. Our results warrant further investigation into whether negative risk perceptions or social norms impact differential e-cigarette behaviors by race/ethnicity.

For those who began using e-cigarettes between waves, significantly more racial/ethnic minorities compared with Whites reported using e-cigarettes because of depictions in the media. Furthermore, nearly one-third of Black e-cigarette users reported using e-cigarettes because of appealing advertising, compared with 12% of White users and 14% of Hispanic users. Similar findings were found among low-SES e-cigarette users in this study. There is a long history of tobacco companies using marketing strategies to target vulnerable populations and communities of color.³⁵ Future studies should investigate whether similar patterns exist of targeted e-cigarette marketing. Our finding that White cigarette smokers were more likely to transition to exclusive e-cigarette use is also consistent with evidence showing that minority cigarette smokers are less likely to engage with cessation treatments, such as nicotine replacement therapy (NRT).^{15,17,36} Previous studies have suggested that this disparity is attributed to provider and system-level factors, and negative attitudes/beliefs related to NRT.^{15,37} Our results suggest attitudes around social norms and harmfulness of e-cigarettes may be playing a role, consistent with evidence on NRT disparities.

We found no significant difference in uptake of e-cigarettes as complements to cigarettes by income or education. Evidence from the literature on socioeconomic differences in e-cigarette use is contradictory, with some studies finding income and education are positively associated with e-cigarette use, and others finding no significant differences by SES.^{9,38,39} When exploring the type of e-cigarette uptake, we found lower-SES cigarette smokers were less likely

than higher-SES smokers to initiate e-cigarette use and quit cigarettes between waves. This is despite the fact that e-cigarette users of differing SES levels were equally likely to report using e-cigarettes to help quit cigarette smoking. These findings are not surprising given the growing SES disparity in cigarette smoking, which is largely attributed to disparities in quit success.^{40,41} As of 2016, approximately 25% of Americans living below the FPL smoke cigarettes, compared with just 14% of those living above the FPL.⁴² Inverse gradients are also observed between smoking and education, with lower education associated with greater prevalence and intensity of current smoking.¹² Evidence suggests that lower-SES cigarette smokers are just as likely as higher-SES smokers to attempt to quit, but significantly less likely to be successful in quit attempts.^{40,41,43} Our data corroborate this evidence, with lower-SES smokers just as likely to begin using e-cigarettes alongside cigarettes, but less likely to successfully quit while using e-cigarettes. Proposed reasons behind the SES disparity in cessation success include perceived financial barriers in access to cessation products, reduced social support, greater tobacco-promoting social norms, and exposure to life stress.³²

Our data suggest that lower-SES smokers differed from higher-SES smokers in tobacco and e-cigarette related social norms and perceived harm, but that these attitudes and beliefs are not necessarily a driver of differences in exclusive e-cigarette use by SES. Ultimately, financial barriers and lack of social support may be a stronger predictor than attitudes and beliefs of transitioning to exclusive e-cigarette use among lower-SES cigarette smokers. For example, higher-SES cigarette smokers likely have additional resources beyond just e-cigarettes to help quit cigarettes. In this case, e-cigarettes alone may not be enough to help cigarette smokers quit. Low-SES smokers may have less access to or knowledge of additional resources, and lesser support from friends or family to quit due to competing priorities.⁴⁴

Our results should be taken in light of several limitations. First, we only had data on smoking within the past 30 days and so do not know whether those who quit smoking will be successful in their quit attempts. Relapse is high among established cigarette smokers, and many of those who transitioned to exclusive e-cigarette use may relapse and become cigarette smokers again. However, evidence suggests that lower-SES and racial/ethnic minority cigarette smokers are less successful in quit attempts.¹³ If similar relapse disparities exist among e-cigarette users, relapse would not significantly change our conclusions. Secondly, 18% of the eligible sample at Wave 1 were nonrespondents at Wave 2. However, the replicate weights used in this analysis adjust for both complex study design and nonresponse, and so the findings should still be generalizable to the US adult noninstitutional population, accounting for attrition. Thirdly, our definition of e-cigarette user at Wave 2 included those who use e-cigarettes experimentally, which may be too broad to define someone as an established e-cigarette user. However, including experimental e-cigarette users allowed us to capture more people who transitioned during this relatively short period of time (12 months). Lastly, our sample was restricted to participants who were not current e-cigarette users at Wave 1, but not restricted to never e-cigarette users. There may be sociodemographic differences in past e-cigarette use that affect future initiation, but we wished to capture any uptake of e-cigarettes over time, regardless of the intensity of usage or history of use. Future studies might explore whether disparities exist in transition to frequent e-cigarette use or differences in uptake by e-cigarette naïve cigarette smokers.

Despite a need for more evidence on their health risks, e-cigarettes may be a useful product for cigarette smokers wishing to quit

smoking. As the debate around e-cigarettes' efficacy in helping smokers quit cigarettes continues, it is important to keep in mind whether their benefits as a cessation aid are equitable across populations. Our results suggest that transition to exclusive use of e-cigarettes is more prevalent in higher-SES and non-Hispanic White cigarette smokers. Differences in type of e-cigarette use may be partially explained by sociocultural differences in social norms and risk perceptions, particularly for racial/ethnic variance. If e-cigarette use is shown to be effective as a cessation aid or harm-reduction measure, public health professionals and policy makers should consider whether sociodemographic differences in e-cigarette uptake and use patterns among cigarette smokers contribute to widening disparities in cigarette smoking and the associated burden of disease.

Supplementary Material

Supplementary Tables 1 and 2 can be found online at <http://www.ntr.oxford-journals.org>

Funding

Research was supported by the National Heart, Lung, and Blood Institute of the National Institutes of Health and the Center for Tobacco Products under Award Number P50HL120163.

Declaration of Interests

The authors of this manuscript have no competing interests to disclose.

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