



## Short communication

## Will Electronic Nicotine Delivery System (ENDS) use reduce smoking disparities? Prevalence of daily ENDS use among cigarette smokers

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## ABSTRACT

Many smokers reported using Electronic Nicotine Delivery System (ENDS, e.g., electronic cigarettes or e-cigarettes) to quit cigarette smoking. Previous studies suggested that daily ENDS use may promote cigarette smoking cessation. We assessed variations in the prevalence of daily ENDS use among adult smokers by demographics and implications for cigarette smoking disparities. Data were from a nationally representative sample of US adults who participated in the 2014–2015 Tobacco Use Supplement to the Current Population Survey (n = 163,920). Participants reported socio-demographics, current cigarette smoking, current ENDS use, and past-year cigarette smoking cessation attempts. We estimated the prevalence of current cigarette smoking in the full sample by socio-demographics. We also estimated the prevalence of daily ENDS use among current smokers (n = 23,232) and those who attempted to quit smoking in the past year (n = 9,341) by socio-demographics. Multivariable logistic regression models were used to assess associations between daily ENDS use and socio-demographics. Prevalence of daily ENDS use was low: 1–6% among current smokers and 2–9% among those who made a past-year quit attempt, across socio-demographics. Hispanic (Adjusted odds ratio [AOR] = 0.45, 95% confidence interval [CI] = 0.29–0.69) and non-Hispanic black smokers (AOR = 0.38, 95% CI = 0.23–0.61) were less likely than non-Hispanic white smokers to use ENDS daily. Similar associations were observed among current smokers who made a past-year quit attempt (p < 0.05). Low prevalence of daily ENDS use suggests that ENDS may only promote smoking cessation in a small fraction of smokers. Lower prevalence of daily ENDS use among non-Hispanic black smokers may worsen race-related cigarette smoking disparities.

### 1. Introduction

While a recent report by the National Academy of Sciences, Engineering, and Medicine concluded that Electronic Nicotine Delivery System (ENDS, e.g., electronic cigarettes or e-cigarettes) were not harmless, it also suggested that ENDS might assist cigarette smokers to quit using combustible tobacco products. (National Academy of Sciences Engineering and Medicine, 2018) Indeed, many cigarette smokers claimed to use ENDS to quit smoking. For example, data from a US national survey found that among cigarette smokers who used ENDS, 58.4% reported using ENDS to quit smoking, and 57.9% reported using ENDS to reduce smoking. (Rutten et al., 2015) While a 2016 meta-analysis showed that ENDS use, in general, was associated with a lower likelihood of cigarette smoking cessation, (Kalkhoran and Glantz, 2016) several longitudinal studies in the UK and the US found that daily ENDS use was associated with cigarette smoking cessation and/or

reduction (Coleman et al., 2018; Brose et al., 2015; Hitchman et al., 2015; Berry et al., 2019). Furthermore, as it usually takes smokers multiple attempts to successfully quit cigarette smoking, (United States, 2004) a previous US study found that smokers who have attempted to quit cigarette smoking were more likely than those who did not quit smoking to report e-cigarette use (Rutten et al., 2015).

However, few reports have documented daily ENDS use among US adults, especially among cigarette smokers and those who have tried to quit smoking. Furthermore, it is unclear how daily ENDS use may influence cigarette smoking disparities in the US. If daily ENDS use is a potential pathway to cigarette smoking cessation, an increased prevalence of daily ENDS use among racial/ethnic minorities (especially those with the high prevalence of cigarette smoking, e.g., non-Hispanic American Indian and Alaskan Native) and smokers of lower socioeconomic statuses (SES) would result in a reduction in cigarette smoking disparities in the US. Yet, no studies to date have examined the

Abbreviation: ENDS, Electronic Nicotine Delivery System

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**Table 1**

Characteristics of the overall sample, current smokers, current smokers who made a quit attempt in the past 12 months, Tobacco Use Supplement of the Current Population Survey, 2014–2015.

	Overall (n = 163,920) Weighted % (95% CI)	Current smokers (n = 23,232) Weighted % (95% CI)	Current smokers who made a past-year quit attempt (n = 9,341) Weighted % (95% CI)
<i>Age</i>			
18–24 years old	12.6% (12.4, 12.9)	12.0% (11.3, 12.6)	16.7% (13.2, 20.2)
25–34 years old	17.7% (17.4, 17.8)	20.2% (19.6, 20.9)	26.0% (22.6, 29.3)
35–49 years old	24.9% (24.7, 25.2)	27.4% (26.7, 28.0)	25.0% (21.9, 28.2)
50 years old and above	44.8% (44.5, 45.1)	40.4% (39.7, 41.1)	32.3% (28.9, 35.6)
<i>Gender</i>			
Male	48.1% (47.8, 48.4)	53.8% (53.1, 54.6)	51.8% (48.0, 55.6)
Female	51.9% (51.6, 52.2)	46.2% (45.4, 46.9)	48.2% (44.4, 52.0)
<i>Race/Ethnicity</i>			
NH White	64.9% (64.6, 65.2)	71.1% (70.3, 71.8)	58.1% (54.3, 61.9)
NH Black	11.7% (11.5, 11.9)	12.5% (12.0, 13.0)	15.7% (12.9, 18.5)
NH AIAN	0.7% (0.7, 0.8)	1.2% (1.1, 1.4)	1.1% (0.4, 1.9)
NH Asian	5.6% (5.4, 5.7)	2.7% (2.4, 3.0)	5.0% (3.0, 7.0)
NH HIPI	0.2% (0.2, 0.3)	0.2% (0.2, 0.3)	0.2% (0.0, 0.5)
NH Multiple	1.3% (1.3, 1.4)	2.0% (1.7, 2.3)	2.1% (0.8, 3.2)
Hispanic	15.6% (15.3, 15.8)	10.3% (9.8, 10.8)	17.8% (14.7, 20.9)
<i>Educational attainment</i>			
< High School	11.1% (10.9, 11.3)	16.7% (16.1, 17.3)	16.2% (13.4, 19.1)
High School	27.8% (27.5, 28.1)	39.1% (38.3, 39.9)	30.5% (27.0, 34.0)
Some College	19.5% (19.2, 19.7)	22.4% (21.7, 23.0)	25.5% (22.1, 29.0)
Associate Degree	9.7% (9.6, 9.9)	9.6% (9.2, 10.1)	9.4% (7.3, 11.5)
≥ Bachelor's Degree	31.9% (31.6, 32.2)	12.2% (11.7, 12.7)	18.4% (15.5, 21.2)
<i>Annual household income</i>			
< \$25,000	24.1% (23.8, 24.3)	37.3% (36.5, 38.0)	34.6% (30.9, 38.3)
\$25,000–\$49,999	25.7% (25.4, 25.9)	28.9% (28.2, 29.6)	25.2% (22.0, 28.6)
\$50,000–\$74,999	18.1% (17.9, 18.4)	16.2% (15.6, 16.7)	18.0% (15.1, 20.9)
≥ \$75,000	32.1% (31.8, 32.4)	17.6% (17.1, 18.2)	22.2% (19.0, 25.2)

Note: NH = Non-Hispanic; AIAN = American Indian and Alaskan Native; HIPI = Hawaiian and Pacific Islander.

prevalence of daily ENDS use among cigarette smokers in populations that are disproportionately affected by cigarette smoking. Moreover, despite the more prevalent use of e-cigarettes among smokers who attempted to quit smoking, it is unclear what proportion of these smokers use ENDS daily to maximize their chances of successful cigarette smoking cessation, and how this proportion varies socio-demographics. Given the limitations of the literature, we analyzed data from the 2014–2015 Tobacco Use Supplement to the Current Population Survey (TUS-CPS) to achieve the following objectives. First, to illustrate cigarette smoking disparities by socio-demographics (including age, gender, race and ethnicity, educational attainment, and annual household income), we estimated prevalence of current cigarette smoking by socio-demographics. Second, to examine whether daily ENDS use among cigarette smokers would reduce cigarette smoking disparities, we estimated prevalence of daily ENDS use only among current cigarette smokers by socio-demographics, and tested the associations between socio-demographics and daily ENDS use among current cigarette smokers. Third, to examine whether daily ENDS use among smokers who made a quit attempt would reduce cigarette smoking disparities, we estimated prevalence of daily ENDS use only among current smokers who attempted to quit smoking in the past 12 months by socio-demographics, and tested the associations between socio-demographics and daily ENDS use among current smokers who attempted to quit smoking in the past 12 months.

## 2. Methods

### 2.1. Study population

We conducted a cross-sectional analysis using data from the 2014–2015 Tobacco Use Supplement to the Current Population Survey (TUS-CPS), a nationally representative survey of US non-institutionalized adults (<https://cancercontrol.cancer.gov/brp/tcrb/tus-cps/>). TUS-CPS is administered as part of the U.S. Census Bureau's

CPS and comprised of approximately 240,000 individuals per wave, including self-respondents (respondents answered questions about themselves) and proxy respondents (respondents answered questions about their household members). The survey is a key source of national, state, and sub-state level data from U.S. households regarding smoking, use of tobacco products, and tobacco-related norms, attitudes, and policies. We analyzed the latest available data collected during July 2014, January 2015, and May 2015 cycles, with response rates at 56.4%, 56.7%, and 54.1%, respectively. This research only involved the use of de-identified data, which is not considered human subjects research and requires no IRB review or approval per National Institutes of Health policy and 45 CFR 46.

### 2.2. Measures

Only self-respondents were included in this analysis (overall n = 163,920). Participants reported whether they currently used cigarettes (every day, some days, not at all), whether they currently used ENDS (every day, some days, not at all), and the number of days used ENDS in the past 30 days. Participants who reported smoking cigarettes either every day or some days were classified as current smokers (n = 23,232); among those, 9,341 reported making a quit attempt in the past year. Participants who reported using ENDS every day or reported using ENDS 30 out of the past 30 days were classified as daily ENDS users. Participants also reported socio-demographics including age (categorized into 18–24, 25–34, 35–49, and 50 years old and above), sex (male, female), race/ethnicity (categorized into non-Hispanic white, non-Hispanic black, non-Hispanic American Indian or Alaskan Native, non-Hispanic Asian, non-Hispanic Hawaiian and Pacific Islander, non-Hispanic multiple races, and Hispanic), education (< high school, high school graduate, some college, associate degree, ≥ bachelor's degree), and annual household income (< \$25,000, \$25,000–\$49,999, \$50,000–\$74,999, ≥ \$75,000).

### 2.3. Statistical analysis

We estimated the weighted prevalence of current cigarette smoking in the overall population and the weighted prevalence of daily ENDS use among current cigarette smokers and among smokers who made a past-year quit attempt. We also calculated these prevalence estimates by socio-demographics. Weighted multivariable logistic regressions were used to examine the association between daily ENDS use and socio-demographics. All analyses were conducted in SAS® Enterprise version 9.4 (SAS Institute: Cary, NC) using proc survey procedures.

### 3. Results

Characteristics of the sample are reported in Table 1. In the overall sample, 44.8% of the sample were 50 years or older, 51.9% were female, 64.9% were non-Hispanic white, 31.9% received a bachelor's degree, and 32.1% reported ≥\$75,000 annual household income. Compared to the overall sample, current smokers were older (40.4% were 50 years or older), and were more likely to be female (46.2%), non-Hispanic white (71.1%), have a lower annual household income (17.6% were ≥\$75,000 annual household income), and have a lower educational attainment (12.2% received a bachelor's degree). Additionally, current smokers who made a past-year quit attempt had similar characteristics as overall current smokers, except that they were younger (32.3% were 50 years or older) and more racially diverse (58.1% were non-Hispanic white).

Weighted prevalence estimates of current cigarette smoking and daily ENDS use are presented in Table 2. Overall, 2.8% (unweighted n = 639) of US adult smokers reported daily ENDS use, and 4.7% (unweighted n = 421) of those who made a past-year quit attempt reported daily ENDS use. The prevalence of daily ENDS use was low among current cigarette smokers in general (1–6%) and those who

attempted to quit smoking in the past year (2–9%). The weighted multivariable logistic regressions showed that non-Hispanic blacks and Hispanics were less likely than non-Hispanic whites to use ENDS daily among both current cigarette smokers and those who had made a past-year quit attempt (p < 0.05). Among current smokers, those who were 50 years old and above were less likely than those who were 18–24 years old to report daily ENDS use (p < 0.05). No significant associations were observed between gender, income, education, and daily ENDS use (p > 0.05).

### 4. Discussion

Previous research showed that daily ENDS use was associated with smoking cessation. (Coleman et al., 2018; Brose et al., 2015; Hitchman et al., 2015; Berry et al., 2019) We found that daily ENDS use was uncommon among US adult smokers, supported by previous studies. (Mirbolouk et al., 2016; Dai and Leventhal, 2019) Our study also provided a novel finding that even among current smokers who made a past-year quit attempt, the prevalence of daily ENDS use was low (< 10%) across socio-demographic groups. If the relationship between daily ENDS use and cigarette smoking cessation is causal, the lack of difference in daily ENDS use by education and income, and between non-Hispanic white and some racial/ethnic minority groups, indicates that ENDS, as it is currently regulated, are unlikely to reduce disparities in smoking by race/ethnicity and SES.

Moreover, it is noteworthy that daily ENDS use was less prevalent among non-Hispanic black smokers than non-Hispanic white smokers, in general, and among those who made a past-year quit attempt, despite their comparable prevalence of cigarette smoking. It has been documented that non-Hispanic blacks and non-Hispanic white adults in the US have comparable prevalent of cigarette smoking. (Wang et al., 2018) Therefore, a higher prevalence of daily ENDS use among non-Hispanic

**Table 2**

Prevalence of cigarette smoking and daily Electronic Nicotine Delivery System (ENDS) use by age, gender, race/ethnicity, income, and educational attainment, Tobacco Use Supplement of the Current Population Survey, 2014–2015.

	Current cigarette smoking (n = 163,920)	Daily ENDS use among current smokers (n = 23,232)		Daily ENDS use among current smokers who made a past-year quit attempt (n = 9341)	
	Weighted % (95% CI)	Weighted % (95% CI)	AOR (95% CI)	Weighted % (95% CI)	AOR (95% CI)
<b>Age</b>					
18–24 years old	13.0% (12.2, 13.7)	3.7% (2.5, 4.8)	Reference	5.0% (3.1, 7.0)	Reference
25–34 years old	15.7% (15.2, 16.2)	3.3% (2.6, 3.9)	0.93 (0.64, 1.35)	5.5% (4.3, 6.7)	1.15 (0.71, 1.85)
35–49 years old	15.0% (14.5, 15.4)	2.7% (2.2, 3.1)	0.75 (0.52, 1.08)	4.7% (3.8, 5.6)	0.98 (0.61, 1.57)
50 years old and above	12.3% (12.0, 12.6)	2.4% (2.1, 2.7)	<b>0.66 (0.46, 0.94)</b>	4.1% (3.4, 4.8)	0.83 (0.53, 1.31)
<b>Gender</b>					
Male	15.3% (15.0, 15.6)	2.7% (2.3, 3.0)	Reference	4.7% (4.0, 5.5)	Reference
Female	12.1% (11.9, 12.4)	3.0% (2.6, 3.3)	1.06 (0.87, 1.28)	4.7% (3.9, 5.4)	0.94 (0.75, 1.20)
<b>Race/Ethnicity</b>					
NH Whites	15.0% (14.7, 15.2)	3.3% (2.9, 3.6)	Reference	5.6% (4.9, 6.2)	Reference
NH Black	14.6% (13.9, 15.2)	1.2% (0.7, 1.7)	<b>0.38 (0.23, 0.61)</b>	2.2% (1.1, 3.3)	<b>0.40 (0.23, 0.69)</b>
NH AIAN	23.4% (20.6, 26.1)	2.5% (0.7, 1.7)	0.74 (0.33, 1.67)	3.2% (0.4, 6.1)	0.57 (0.23, 1.44)
NH Asian	6.7% (6.0, 7.4)	2.0% (0.2, 3.9)	0.62 (0.24, 1.58)	3.0% (0.0, 6.9)	0.50 (0.12, 2.06)
NH HIPI	13.5% (9.7, 17.4)	5.8% (0.0, 14.2)	1.73 (0.37, 8.15)	3.7% (0.0, 9.0)	0.62 (0.14, 2.76)
NH Multiple	20.3% (17.9, 22.6)	5.4% (2.3, 8.5)	1.59 (0.86, 2.93)	8.5% (2.9, 14.1)	1.47 (0.71, 3.06)
Hispanic	9.0% (8.5, 9.5)	1.5% (0.9, 2.0)	<b>0.45 (0.29, 0.69)</b>	2.2% (1.1, 3.3)	<b>0.38 (0.22, 0.64)</b>
<b>Educational attainment</b>					
< High School	20.6% (19.8, 21.3)	2.1% (1.5, 2.6)	Reference	3.6% (2.5, 4.8)	Reference
High School	19.2% (18.8, 19.6)	2.8% (2.4, 3.2)	1.19 (0.87, 1.64)	4.3% (3.5, 5.1)	1.02 (0.69, 1.52)
Some College	15.7% (15.2, 16.2)	3.4% (2.7, 4.0)	1.40 (1.00, 1.96)	5.5% (4.3, 6.7)	1.28 (0.85, 1.94)
Associate Degree	13.5% (12.9, 14.1)	3.4% (2.5, 4.2)	1.42 (0.96, 2.10)	6.0% (4.2, 7.7)	1.37 (0.85, 2.20)
≥ Bachelor's Degree	5.2% (5.0, 5.4)	2.5% (1.8, 3.2)	1.02 (0.70, 1.56)	4.5% (3.0, 6.0)	0.96 (0.57, 1.60)
<b>Income</b>					
< \$25,000	21.2% (20.7, 21.6)	2.6% (2.2, 3.0)	Reference	4.1% (3.4, 4.9)	Reference
\$25,000–\$49,999	15.4% (15.0, 15.8)	2.8% (2.3, 3.3)	1.00 (0.80, 1.27)	4.9% (3.8, 5.8)	1.08 (0.80, 1.45)
\$50,000–\$74,999	12.2% (11.7, 12.6)	2.7% (2.0, 3.3)	0.92 (0.68, 1.23)	4.5% (3.2, 5.7)	0.93 (0.64, 1.36)
≥ \$75,000	7.5% (7.2, 7.8)	3.3% (2.6, 4.0)	1.13 (0.85, 1.52)	5.9% (4.4, 7.4)	1.25 (0.86, 1.81)

Note: NH = Non-Hispanic; AIAN = American Indian and Alaskan Native; HIPI = Hawaiian and Pacific Islander. The adjusted odds ratios controlled for all variables in the table. Bolded estimates were statistically significant (p < 0.05).

whites than non-Hispanic blacks may mean a greater proportion of non-Hispanic white smokers than non-Hispanic black smokers would successfully quit cigarette smoking through daily ENDS use. If daily ENDS use does lead to cigarette smoking cessation, this will create a disparity in cigarette smoking between non-Hispanic whites and non-Hispanic blacks.

One limitation of our study is that the data were collected during 2014–2015 when some of the recently popular high nicotine delivery ENDS products (e.g., JUUL) were not available. Therefore, our findings may not reflect the ENDS use patterns after the introduction of these products into the US market. However, a recent analysis of the 2014–2018 National Health Interview Survey data found that the prevalence of current ENDS use among US adults remained around 3–4%, (Dai and Leventhal, 2019) which suggest that the availability of high nicotine delivery ENDS products may have little impact on adult use. Additionally, the low prevalence of daily ENDS use did not allow us to examine statistical interactions between demographic variables. Finally, TUS-CPS did not collect information on sexual orientation, which is another population that has a high prevalence of cigarette smoking. (Hoffman et al., 2018) The strength of this study includes that our large, nationally representative sample allowed for the examination of daily ENDS use prevalence by socio-demographic subgroups.

In conclusion, daily ENDS use, a behavior that has been suggested to be associated with cigarette smoking cessation, was uncommon among US adult smokers, including those who had attempted to quit smoking. ENDS may perpetuate cigarette smoking disparities, and in some cases, may worsen race/ethnicity-related cigarette smoking disparities. Identifying ways to increase the use of FDA-approved smoking cessation treatments among low SES and minority smokers as part of a comprehensive tobacco control program would be a more promising solution.

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#### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. Opinions and comments expressed

in this article belongs to the authors and do not necessarily reflect those of the US Government, the Department of Health and Human Services, the National Institutes of Health, and the National Institute on Minority Health and Health Disparities.

#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2019.101020>.

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