



## Clinical Research Study

# Prevalence of electronic cigarette use and its determinants in us persons of Hispanic/Latino background: The Hispanic community health study / study of Latinos (HCHS/SOL)



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## ABSTRACT

**Objective:** To determine the prevalence and determinants of electronic nicotine delivery systems (ENDS) use among Hispanic/Latino adults from the Hispanic Community Health Study/Study of Latinos (HCHS/SOL).

**Methods:** Cross-sectional data collected between the years 2015–2017 were analyzed to assess ENDS use (ever (current: use  $\leq$  past 30 days; former: use  $>$  past 30 days) and never) among 11,623 adults (mean age 47 years $\pm$ 0.3 years; 52% women). Weighted prevalence estimates were reported, and age-adjusted logistic regression models were used to examine associations between sociodemographic and clinical exposures with ENDS use.

**Results:** The prevalence of current and former ENDS use was 2.0% and 10.4%, respectively. Having ever used ENDS was associated with prevalent coronary artery disease. Current ENDS use was higher in males and associated with higher education, English language preference, and Puerto Rican background compared with nonsmokers and cigarette-only smokers (all  $p < 0.05$ ).

**Conclusions:** Hispanic/Latino individuals who are young adults, male, US-born, and have high acculturation were more likely to report current ENDS use. These findings could inform preventive and regulatory interventions targeted to Hispanics/Latinos.

## Introduction

Electronic cigarettes, also called e-cigarettes or electronic nicotine delivery systems (ENDS), are battery-operated devices with a heating element that deliver nicotine and other chemicals to users as aerosolized vapors, without the combustion associated with traditional cigarettes.<sup>1,2</sup> ENDS were first introduced into the market in 2004; however, in 2014 as conventional cigarette use declined significantly, ENDS use increased rapidly with an estimated 13% of United States (US)

adults, including former, current, and non-cigarette smokers reporting having ever tried ENDS.<sup>3</sup>

Less is known about the use of ENDS in ethnic minorities who historically are disproportionately targeted in tobacco product marketing and bear significant tobacco-related health disparities.<sup>4</sup> Among Hispanic/Latino adults, the prevalence of tobacco use and number of cigarettes smoked per day is lower than non-Hispanic whites.<sup>4,7</sup> However, within disaggregated Hispanic/Latino background groups, combustible cigarette use is more prevalent among individuals of Puerto Ri-

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can and Cuban backgrounds than those of Mexican and Central or South American backgrounds and *higher* compared with non-Hispanic whites.<sup>6</sup> Further, US-born Hispanics/Latinos and those with greater acculturation to the US are more likely to use combustible tobacco products.<sup>6,8-10</sup>

Recent studies among adults in select, mostly non-Hispanic white, populations have profiled current ENDS users as young adults, men, multi-racial individuals, and conventional cigarette smokers.<sup>11</sup> Compared with non-Hispanic whites, Hispanics/Latinos have traditionally shown lower tobacco use prevalence. However, ENDS represent a disruptive innovations with the potential to shift patterns of tobacco use.<sup>11,12</sup> Studies have shown that experimentation with ENDS among adolescents and young adults is a risk factor for progression to combustible cigarette smoking and nicotine-dependence,<sup>13,14</sup> which could lead to a “tipping point” phenomenon,<sup>15</sup> where future generations experience a higher prevalence of nicotine dependence and tobacco-related disease compared with previous generations.<sup>11</sup> This phenomenon has the potential to exacerbate tobacco-related disparities, especially in groups with traditionally lower tobacco-use prevalence like Hispanics/Latinos. Additionally, ENDS products are becoming more popular among both youth and adults, and it is important to examine the epidemiology of ENDS use across groups of Hispanics/Latinos that have historically experienced tobacco-related disparities. Therefore, we sought to determine the prevalence and patterns of ENDS use among the Hispanic/Latino population. Leveraging data from the Hispanic Community Health Study/ Study of Latinos (HCHS/SOL), the largest and most representative population-based cohort study of US persons of Hispanic/Latino origin, we assessed demographic, socioeconomic, clinical characteristics and other forms of tobacco use status correlated with ENDS use in this population.

## Methods

### Study population

HCHS/SOL is an ongoing multi-center, population-based prospective cohort of 16,415 Hispanics/Latinos ages 18–74 years from households in four targeted US metropolitan areas (Bronx, NY, Chicago, IL, Miami, FL, and San Diego, CA). The baseline examination (2008–2011; Visit 1) and a follow-up second in-person exam (2014–2017; Visit 2) were conducted. Participants self-reported their Hispanic/Latino background. Comprehensive details on the study design, sampling method, eligibility, and examination procedures were previously published<sup>16,17</sup> and are available on the HCHS/SOL website. For the present study, we included only participants with available data in HCHS/SOL Visit 2 ( $n = 11,623$ ) where information on ENDS use was obtained. Of the 11,623 HCHS/SOL participants, 348 were excluded from the analysis for having missing value ( $n = 35$ ) or “other” ( $n = 313$ ) Hispanic/Latino background. Missing data for ENDS and combustible tobacco product use measures was minimal with less than 1% for each measure. Thus, these analyses were based on data from 11,275 participants. The study was approved by the Institutional Review Boards for the coordinating center and each field center.

### Measurement of ends use and combustible tobacco products

ENDS use status was assessed by standardized questionnaires and grouped into three categories: current, former, and never. Two questions were asked to assess ENDS use: “Have you ever smoked an e-cigarette or electronic cigarette (e.g., Blue, V2), even once?” and, if the response was yes, participants were further asked: “During the past 30 days, did you smoke an e-cigarette or electronic cigarette (e.g., Blue, V2)?” If participants had smoked [i.e., used] ENDS during the past 30 days of the interview, then they were considered current ENDS users; if participants smoked ENDS more than 30 days before the interview, then they were considered former ENDS users; and if participants had not smoked ENDS ever in their lifetimes, they were considered never ENDS users. Ever

ENDS users included all who responded ‘Yes’ to ever smoking ENDS (former and current ENDS users).

Hookah (waterpipe) and cigar smoking status were each similarly assessed by standardized questionnaire and categorized as current, former, and never smokers using questions about ever use and whether use occurred in the past 30 days of interview. Cigarette smoking status was assessed using two questions: “Have you ever smoked 100 cigarettes in your entire life?” and “Do you now smoke daily, some days or not at all?” Participants reporting at least 100 cigarettes in their entire life and reporting smoking daily or some days were considered current smokers; if participants had smoked 100 cigarettes in their entire life but did not report smoking daily or some days (i.e., not at all), then they were considered former smokers; and if participants had not smoked 100 cigarettes in their lifetime nor reported daily smoking, they were considered never smokers.<sup>6</sup>

### Measurement of socio-demographic and clinical characteristics

All study participants were asked to report their country of birth and select their Hispanic/Latino background (Central American, Cuban, Dominican, Mexican, Puerto Rican, South American). Participants also reported their age, sex, educational attainment (<high school, high school degree or more), annual household income (categorized as <\$30,000, ≥\$30,000), and health insurance status. US acculturation was assessed through several validated measures. First, participants’ nativity was classified as US-born (excluding US territories) or non-US-born (including US territories). Second, language preference was characterized based on language of interview (English or Spanish). For further characterization, we used the Short Acculturation Scale for Hispanics (SASH),<sup>18</sup> which has two subscales with responses based on a 5-point Likert scale: (1) SASH language subscale (includes items related to language preference and use (e.g., the language they speak and think)); and (2) SASH social affiliations subscale (includes items related social relations (e.g., ethnicity of close friends)). The SASH has demonstrated a high reliability overall ( $\alpha = 0.90$ ) and within each subscale (language use  $\alpha = 0.93$ ; ethnic and social relations  $\alpha = 0.72$ ). These subscales were analyzed separately with higher scores representing higher degrees of acculturation.

HCHS/SOL examinations included clinical measurements such as height, weight, blood pressure (BP), and fasting venous blood and urine specimens. Body mass index (BMI) was derived using measured height and weight and calculated as body weight in kilograms divided by the square of height in meters ( $\text{kg}/\text{m}^2$ ). Obesity status was defined as a BMI  $>30 \text{ kg}/\text{m}^2$ . BP was reported as the average of three seated measurements obtained after a 5-minute rest. Hypertension was defined as systolic BP  $\geq 140 \text{ mm Hg}$ , diastolic BP  $\geq 90 \text{ mm Hg}$ , or self-reported use of antihypertensive medication. Diabetes mellitus was determined by a fasting plasma glucose of  $\geq 126 \text{ mg}/\text{dL}$ , 2-hour post-load glucose levels of  $\geq 200 \text{ mg}/\text{dL}$ , glycated hemoglobin A1c (HbA1c) level of  $\geq 6.5\%$ , or use of anti-diabetic medication. Total cholesterol ( $\geq 240 \text{ mg}/\text{dL}$ ), high-density lipoprotein cholesterol (HDLc,  $<40 \text{ mg}/\text{dL}$ ), low-density lipoprotein cholesterol (LDLc,  $\geq 160 \text{ mg}/\text{dL}$ ), or self-reported antihyperlipidemic medication use were used to determine the presence or absence of hypercholesterolemia. Prevalent cardiovascular disease (CVD) was defined by electrocardiogram evidence of myocardial infarction and/or self-report of heart attack, coronary procedure (i.e., angioplasty, stent, bypass), or stroke. Heart failure was assessed by self-report based on clinical diagnosis.

### Statistical analyses

Summary statistics for continuous (mean and standard error (SE)) and categorical (count and percentage) characteristics were calculated for the overall study sample and by ENDS categories. All descriptive group comparisons were assessed using Wald or Rao-Scott chi-square tests from survey-specific procedures where appropriate. The type and

number of combustible tobacco products (cigarette, hookah, cigar) currently being used were assessed separately and combined to estimate concurrent product use with prevalence estimated for the overall population and within each ENDS use category (current, former, and never). Next, we estimated the prevalence of current and former ENDS use by Hispanic/Latino background. We separately compared distributions of socio-demographic and clinical characteristics between distinct tobacco-use groups. Characteristics among individuals who do not use either traditional tobacco or ENDS products ( $n = 6057$ ) (hereafter, non-tobacco users) and current combustible cigarette-only smokers ( $n = 866$ ) (hereafter cigarette-only smokers) were compared with the distribution of characteristics among ever ( $n = 932$ ) and current ( $n = 136$ ) ENDS users using means ( $\pm$ SE) and count (%), where appropriate. Finally, we used surveylogistic procedures to estimate the age-adjusted odds of ever and current ENDS use compared separately to non-tobacco users and cigarette-only smokers for each characteristic under study. All statistical tests were two-sided at a significance level of 0.05. Performed using SAS version 9.4 (SAS Institute), all analyses accounted for the appropriate sampling weights and complex sample design.

**Results**

*Overall sample characteristics*

Weighted descriptive statistics for all study characteristics for the total target population and stratified by ENDS use status are shown in Table 1. The mean age of the total sample at follow-up was 47.3 (SE=0.3) years and the majority were female (52.1%). The largest group was of Mexican background (39.0%), followed by Cuban (20.9%), and Puerto Rican (16.7%). The majority (77.5%) were born outside of the 50 US states/DC, with 65.7% being foreign/territory-born and living 10 or more years in the 50 US states/DC. One-third did not graduate high school, and more than half of the HCHS/SOL population lacked education beyond college. Regarding income, 53.7% of households earned <\$30,000 annually and the majority reported current health insurance coverage.

*Prevalence of ends use and distribution by study characteristics*

The prevalence of current ENDS use was 2.0% and former ENDS use was 10.4% (Table 1). In Fig. 1, combustible tobacco use (which included cigar, hookah, and cigarette use) was prevalent among ENDS users, with cigarette use among 67.6% of current ENDS users, while 17.9% never smoked cigarettes (data not shown). At the time of the interview, 59% of current ENDS users were also currently using one combustible tobacco product, and 14% were using 2 to 3 combustible tobacco products. Ever (current and former) ENDS use prevalence varied by Hispanic/Latino background (Fig. 2), with estimates ranging from 6.8% in persons of Central American background to 17.0% in persons of Puerto Rican background.

Current ( $M = 38.5$ ,  $SE=1.3$ ) and former ( $M = 36.9$ ,  $SE=0.5$ ) ENDS users were younger and more likely to be males (73.3% and 60%, respectively), compared with never ( $M = 48.7$  years,  $SE=0.3$ ; 45.8% males) ENDS users. Compared with never ENDS users, current and former ENDS users were also more likely to have a higher level of education and income and were more acculturated with the majority being US-born, having greater exposure to English-language use and social networks that were predominantly non-Hispanic. Finally, clinical characteristics varied by ENDS use. Diabetes mellitus and hypertension were prevalent among never ENDS users, while hypercholesterolemia was prevalent among current ENDS users.

*Current and ever ends use profiles*

The distribution of study characteristics by ENDS use status was also compared with non-tobacco users ( $n = 6057$ ) and cigarette-only smok-

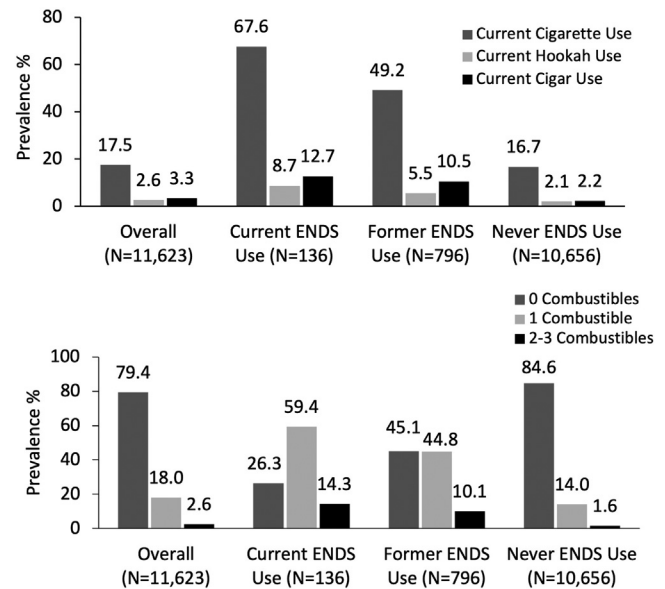


Fig. 1. Prevalence of types (top) and number of (bottom) combustible tobacco products currently being used at interview by ENDS use status, HCHS/SOL Examination 2.

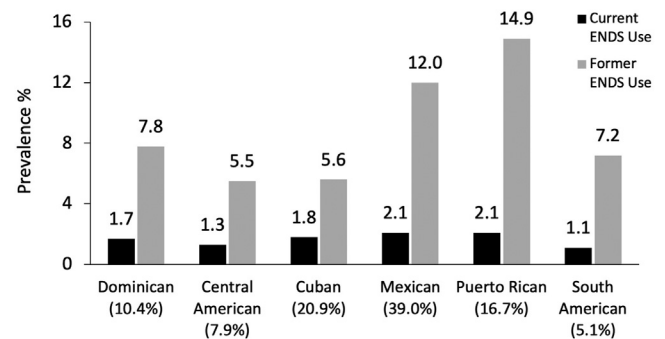


Fig. 2. Prevalence of ENDS use by Hispanic/Latino background, HCHS/SOL Examination 2.

ers ( $n = 866$ ) in Table 2. Overall, ENDS users were significantly younger than non-tobacco users and cigarette-only smokers and were more likely to be between 18 and 34 years of age. ENDS users were also predominantly male, were more likely to have an education level at high school or above, report an income of \$30,000 or higher, prefer using English, and be US-born. Regarding clinical characteristics, distributions also varied for comorbidities between categories of tobacco-use status. For example, current ENDS users had a significantly lower prevalence of obesity (29.6%) and diabetes (8.3%), compared with non-tobacco users (42.9% and 25.9%, respectively). However, current ENDS users had a higher prevalent CVD (2.8%) than cigarette-only smokers (1.3%).

*Age-adjusted odds of ends use by sociodemographic and clinical characteristics*

In age-adjusted analyses (Table 3), compared with non-tobacco users, the odds of current ENDS use varied significantly by participants' socio-demographic and acculturation characteristics. Being younger and male, with higher education levels, English language preference, Puerto Rican background, and greater language and social acculturation, were associated with higher odds of being current ENDS users. In contrast, foreign/territory-born individuals had lower odds of being current ENDS users than those US-born. The age-adjusted odds of being current-ENDS users in men was about 5 times higher than in women; those foreign-

**Table 1**  
Sociodemographic and clinical characteristics by ENDS use status (n = 11,275), HCHS-SOL Visit 2.

Characteristics	ALL N = 11,275	Current ENDS Users N = 136 (2.0%)	Former ENDS Users N = 796 (10.4%)	Never ENDS Users N = 10,656 (87.6%)	p-value*
<b>Sociodemographic</b>					
Age, years					<0.0001
Age, year categories	47.3 ± 0.3	38.5 ± 1.3	36.9 ± 0.5	48.7 ± 0.3	<0.0001
18–24	147 (2.7)	7 (7.4)	35 (6.5)	105 (2.2)	
25–34	1171 (21.2)	38 (39.6)	239 (45.3)	891 (17.9)	
35–44	1441 (21.5)	27 (23.5)	144 (25.1)	1266 (21.0)	
45–54	2983 (22.8)	29 (17.3)	191 (14.2)	2753 (23.9)	
55–64	3505 (16.6)	24 (9.4)	146 (6.7)	3326 (17.9)	
65+	2376 (15.3)	11 (2.8)	41 (2.1)	2315 (17.1)	
Female	7342 (52.1)	49 (26.7)	412 (40.0)	6860 (54.2)	<0.0001
Education Level					0.0169
Less than high school	3893 (30.1)	24 (15.8)	200 (25.9)	3660 (30.9)	
High school graduate/GED eq.	2503 (24.8)	34 (23.4)	204 (26.2)	2262 (24.7)	
Some college/college graduate	4290 (45.1)	62 (60.8)	333 (47.8)	3886 (44.5)	
Household Annual Income					0.0097
<\$30K	6169 (53.7)	55 (37.8)	369 (49.9)	5733 (54.5)	
≥\$30K	4383 (46.3)	68 (62.2)	387 (53.9)	3949 (45.5)	
Health Insurance, yes	8490 (73.3)	106 (79.1)	571 (69.8)	7794 (66.7)	0.2035
Language Preference					<0.0001
English	2144 (25.5)	80 (62.9)	387 (53.9)	1671 (21.3)	
Spanish	9479 (74.5)	56 (37.1)	409 (46.1)	8985 (78.7)	
Hispanic Background					<0.0001
Dominican	1021 (10.4)	8 (9.4)	47 (8.0)	959 (10.6)	
Central American	1207 (7.9)	5 (5.4)	42 (4.4)	1157 (8.4)	
Cuban	1645 (20.9)	20 (20.7)	75 (11.8)	1544 (22.0)	
Mexican	4806 (39.0)	53 (43.0)	334 (47.1)	4406 (38.0)	
Puerto Rican	1801 (16.7)	32 (18.6)	211 (25.1)	1555 (15.8)	
South American	795 (5.1)	7 (2.9)	40 (3.7)	748 (5.3)	
Nativity					<0.0001
Foreign-born	9823 (77.5)	67 (38.3)	453 (49.9)	9272 (81.6)	
US-born	1800 (22.5)	69 (61.7)	343 (50.1)	1384 (18.4)	
Years in the US					<0.0001
Less than 10 years	1062 (11.6)	7 (4.4)	41 (6.5)	1011 (12.4)	
10 years or more	8715 (65.7)	59 (33.7)	411 (43.3)	8217 (69.1)	
US born	1800 (22.6)	69 (61.8)	343 (50.2)	1384 (18.5)	
SASH language (range 1–5)	2.2 (0.03)	3.2 (0.10)	3.0 (0.06)	2.1 (0.03)	<0.0001
SASH social (range 1–5)	2.3 (0.01)	2.6 (0.07)	2.5 (0.03)	2.2 (0.01)	<0.0001
Field Center					<0.0001
Bronx	2649 (29.0)	38 (31.2)	230 (33.4)	2367 (28.3)	
Chicago	3089 (15.8)	30 (11.8)	189 (15.8)	2867 (15.9)	
Miami	2852 (29.3)	24 (22.2)	118 (16.3)	2702 (31.0)	
San Diego	3033 (25.9)	44 (34.7)	259 (34.5)	2720 (24.8)	
<b>Clinical</b>					
BMI kg/m <sup>2</sup>	29.9 ± 0.1	26.7 ± 0.8	30.3 ± 0.4	29.9 ± 0.1	0.2036
Blood pressure					
SBP mmHg	120.8 ± 0.3	117.8 ± 1.5	114.5 ± 0.7	121.5 ± 0.3	<0.0001
DBP mmHg	72.0 ± 0.2	70.8 ± 1.3	70.4 ± 0.5	72.2 ± 0.2	0.0019
Lipids					
Triglycerides mg/dL	126.8 ± 1.4	102.0 ± 5.8	126.2 ± 4.8	127.5 ± 1.5	<0.0001
HDLc mg/dL	50.0 ± 0.2	49.2 ± 2.1	48.7 ± 0.9	50.2 ± 0.2	0.2042
LDLc mg/dL	114.8 ± 0.5	103.4 ± 3.7	110.3 ± 1.6	115.6 ± 0.7	<0.0001
Comorbidities					
Obesity (>30 kg/m <sup>2</sup> )	4925 (42.2)	54 (29.6)	351 (44.1)	4502 (42.3)	0.071
Diabetes mellitus	3841 (25.4)	24 (8.3)	192 (17.2)	3610 (26.8)	<0.0001
Hypertension	4798 (31.7)	38 (17.7)	195 (14.9)	4547 (34.0)	<0.0001
Hypercholesterolemia	5454 (43.1)	52 (32.2)	341 (38.3)	5046 (34.0)	0.0157
Prevalent CVD <sup>1</sup>	992 (7.1)	12 (6.4)	63 (7.4)	916 (7.1)	0.9540
HF	179 (1.2)	2 (0.4)	14 (1.3)	162 (1.2)	0.7138

SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; HDLc, high-density lipoprotein cholesterol; LDLc, low-density lipoprotein cholesterol.

Values are presented as mean±SE or n (%).

<sup>1</sup> Prevalent CVD = baseline ECG report of possible history of myocardial infarction (MI), and self-reported history of MI, cardiac procedure (angioplasty, stent, bypass), or stroke at follow-up.

\* Comparisons between current, former, and never ENDS users. All statistics weighted.

**Table 2**  
Sociodemographic and clinical characteristics among non-tobacco users, cigarette-only smokers, and ENDS use types, HCHS-SOL Visit 2.

Characteristics	Groups				Group Comparisons			
	Non-Tobacco Users <sup>1</sup> (NT) N = 6057	Cigarette-Only Smokers <sup>2</sup> (CS) N = 866	Ever ENDS Users N = 932	Current ENDS Users N = 136	P value NT ~ Ever ENDS Users	P value NT ~ Current ENDS Users	P value CS ~ Ever ENDS Users	P value CS ~ Current ENDS Users
<b>Sociodemographic</b>								
Age, years	48.6 ± 0.3	51.3 ± 0.6	37.1 ± 0.5	38.5 ± 1.3	<0.0001	<0.0001	<0.0001	<0.0001
Age, year categories					<0.0001	0.0588	<0.0001	<0.0001
18–24	61 (2.4)	1 (0.2)	42 (6.7)	7 (7.4)				
25–34	447 (16.3)	44 (9.3)	277 (44.4)	38 (39.6)				
35–44	813 (23.1)	85 (19.2)	171 (24.8)	27 (23.5)				
45–54	1670 (25.3)	265 (30.4)	220 (14.7)	29 (17.3)				
55–64	1768 (15.9)	328 (26.2)	170 (7.1)	24 (9.4)				
65+	1298 (17.1)	143 (14.8)	52 (2.2)	11 (2.8)				
Female	4550 (65.8)	480 (48.3)	461 (37.9)	49 (26.7)	<0.0001	<0.0001	0.0013	<0.0001
Highest Education Level					0.0259	0.0113	<0.0001	<0.0001
Less than high school	2144 (31.1)	334 (38.6)	224 (24.4)	24 (15.8)				
High school graduate/GED eq.	1274 (24.5)	208 (28.3)	238 (25.8)	34 (23.4)				
Some college/college graduate	2147 (44.4)	269 (33.1)	395 (49.8)	62 (60.8)				
Household Annual Income					0.0153	0.006	<0.0001	<0.0001
<\$30K	3294 (57.1)	543 (67.4)	424 (48.0)	55 (37.8)				
≥\$30K	2591 (42.9)	282 (32.7)	426 (52.0)	68 (62.2)				
Health Insurance, yes	4319 (71.9)	608 (72.6)	677 (71.2)	106 (72.6)	0.7816	0.2477	0.6392	0.3209
Language of Interview					<0.0001	<0.0001	<0.0001	<0.0001
English	5390 (85.5)	703 (79.8)	465 (44.6)	56 (37.1)				
Spanish	667 (14.5)	163 (20.2)	467 (55.4)	80 (62.9)				
Hispanic Background					<0.0001	0.3706	<0.0001	0.0182
Dominican	599 (11.3)	49 (5.4)	55 (8.2)	8 (9.4)				
Central American	782 (10.6)	67 (6.5)	47 (4.6)	5 (5.4)				
Cuban	736 (21.2)	241 (36.4)	95 (13.2)	20 (20.7)				
Mexican	2649 (39.4)	260 (25.0)	387 (46.4)	53 (43.0)				
Puerto-Rican	692 (11.5)	191 (23.4)	243 (24.0)	32 (18.6)				
South American	469 (5.9)	38 (3.3)	47 (3.5)	7 (2.9)				
Nativity	5523 (87.9)	736 (82.8)	520 (48.0)	67 (38.3)	<0.0001	<0.0001	<0.0001	<0.0001
Foreign-born	534 (12.1)	130 (17.2)	412 (52.0)	69 (61.7)				
US-born								
Years in the US	589 (13.8)	101 (15.6)	48 (6.2)	7 (4.4)	<0.0001	<0.0001	<0.0001	<0.0001
Less than 10 years	4908 (74.1)	634 (67.2)	470 (41.8)	59 (33.7)				
10 years or more	534 (12.1)	130 (17.2)	412 (52.0)	69 (61.8)				
US born								
SASH language (range 1–5)	1.9 ± 0.0	2.0 ± 0.1	3.0 ± 0.1	3.2 ± 0.1	<0.0001	<0.0001	<0.0001	<0.0001
SASH social (range 1–5)	2.2 ± 0.0	2.1 ± 0.0	2.5 ± 0.0	2.6 ± 0.1	<0.0001	<0.0001	<0.0001	<0.0001
Field Center					<0.0001	0.0588	0.0184	<0.0001
Bronx	1264 (26.3)	208 (26.4)	268 (33.1)	38 (31.2)				
Chicago	1779 (17.2)	195 (14.9)	219 (15.2)	30 (11.9)				
Miami	1482 (32.5)	317 (44.6)	142 (17.2)	24 (22.2)				
San Diego	1532 (24.0)	146 (14.0)	303 (34.5)	44 (34.7)				
<b>Clinical</b>								
BMI kg/m <sup>2</sup>	30.0 ± 0.1	28.6 ± 0.3	30.0 ± 0.4	28.7 ± 0.8	0.994	0.2444	0.0051	0.9934
Blood pressure								
SBP mmHg	121.1 ± 0.4	124.0 ± 0.9	115.0 ± 0.6	117.8 ± 1.5	<0.0001	0.0735	<0.0001	0.0006
DBP mmHg	72.0 ± 0.2	73.0 ± 0.6	70.5 ± 0.5	70.8 ± 1.3	0.0092	0.6031	0.0033	0.2539
Lipids								
Triglycerides mg/dL	123.9 ± 1.7	140.3 ± 4.4	122.3 ± 4.2	102.0 ± 5.8	0.9329	0.0009	0.0107	<0.0001
HDLc mg/dL	51.0 ± 0.3	49.6 ± 0.9	48.8 ± 0.8	49.2 ± 2.1	0.0254	0.6619	0.7382	0.977
LDLc mg/dL	115.9 ± 0.8	116.2 ± 1.7	109.2 ± 1.5	103.4 ± 3.7	0.0001	0.0023	0.0047	0.0034
Comorbidities								
Obesity (>30 kg/m <sup>2</sup> )	2591 (42.9)	282 (32.6)	405 (41.7)	54 (29.6)	0.6502	0.0202	0.0043	0.5941
Diabetes mellitus	2015 (25.9)	254 (23.8)	216 (42.4)	24 (8.3)	<0.0001	<0.0001	<0.0001	<0.0001
Hypertension	2517 (32.7)	380 (40.2)	233 (15.3)	38 (17.7)	<0.0001	0.0041	<0.0001	<0.0001
Hypercholesterolemia	40.9 (1.0)	47.7 (2.5)	37.3 (2.2)	32.2 (5.8)	0.7816	0.2477	0.6392	0.3209
Prevalent CVD <sup>3</sup>	6.4 (0.4)	9.9 (1.3)	7.2 (1.3)	6.4 (2.8)	0.0735	0.1288	0.5704	0.0075
HF	75 (1.1)	16 (1.8)	16 (1.2)	2 (0.4)	0.8524	0.2477	0.4582	0.3209

SBP, systolic blood pressure; DBP, diastolic blood pressure; BMI, body mass index; HDLc, high-density lipoprotein cholesterol; LDLc, low-density lipoprotein cholesterol.

Values are presented as mean±SE or n (%).

<sup>1</sup> Includes those reporting never use of cigarette, cigar, or hookah.

<sup>2</sup> represents current combustible cigarette-only smokers.

<sup>3</sup> Prevalent CVD = baseline ECG report of possible history of MI, and self-reported history of MI, cardiac procedure (angioplasty, stent, bypass), or stroke at follow-up. All statistics weighted.

**Table 3**

Age-adjusted weighted logistic regression analysis of the association between sociodemographic and clinical characteristics and use of ENDS (Ever or Current) vs. Non-Tobacco Users.

Characteristic	Category	Ever ENDS Users vs. Nonsmokers		Current ENDS Users vs. Nonsmokers	
		OR	95% CI	OR	95% CI
<b>Sociodemographic</b>					
Age <sup>‡</sup> (ref: ≥45 years)	<45 years	4.38	3.61 – 5.32	3.32	2.03 – 5.44
Sex (ref: Female)	Male	2.85	2.27 – 3.57	4.9	3.00 – 8.02
Education (ref: < HS)	HS/GED	0.93	0.67 – 1.28	1.43	0.67 – 3.04
	Some college+	0.98	0.75 – 1.26	2.03	1.01 – 4.09
Household Income (ref: <\$30 K annual)	≥\$30 K annual	1.96	0.76 – 1.21	1.49	0.92 – 2.41
Health Insurance (ref: No)	Yes	1.35	1.05 – 1.74	1.98	1.00 – 3.93
Language preference (ref: Spanish)	English	5.09	3.92 – 6.62	7.59	4.30 – 13.42
Hispanic background (ref: Mexican)	Dominican	0.67	0.43 – 1.07	0.81	0.29 – 2.38
	Central American	0.37	0.25 – 0.55	0.47	0.16 – 1.40
	Cuban	0.73	0.48 – 1.11	1.15	0.52 – 2.54
	Puerto Rican	2.83	2.08 – 3.87	2.09	1.03 – 4.24
	South American	0.59	0.37 – 0.95	0.51	0.18 – 1.44
Nativity (ref: US-born)	Foreign-born	0.2	0.15 – 0.25	0.12	0.07 – 0.19
Years in the US (ref: US-born)	Less than 10 years	0.13	0.08 – 0.21	0.07	0.03 – 0.20
	10 years or more	0.22	0.17 – 0.28	0.13	0.07 – 0.22
SASH language	Continuous	2.15	1.95 – 2.36	2.52	2.11 – 3.01
SASH social	Continuous	2.19	1.80 – 2.68	3.08	1.97 – 4.80
Field Site (ref: Bronx)	Chicago	0.62	0.47 – 0.82	0.54	0.28 – 1.02
	Miami	0.45	0.32 – 0.64	0.63	0.30 – 1.32
	San Diego	1.07	0.80 – 1.45	1.22	0.64 – 2.33
<b>Clinical</b>					
Obesity (ref: BMI <30 kg/m <sup>2</sup> )	BMI ≥30 kg/m <sup>2</sup>	1.04	0.84 – 1.30	0.6	0.36 – 0.99
Diabetes mellitus (DM) (ref: absent)	DM (present)	1.1	0.84 – 1.45	0.46	0.26 – 0.81
Hypertension (HTN) (ref: absent)	HTN (present)	1.17	0.89 – 1.52	1.18	0.62 – 2.26
Hypercholesterolemia (HC) (ref: absent)	HC (present)	1.3	1.05 – 1.62	0.97	0.57 – 1.65
Prevalent CVD (ref: no history)	Prevalent CVD (history)	2.33	1.52 – 3.56	1.9	0.70 – 5.15
Heart failure (HF) (ref: no history)	HF (history)	2.98	1.16 – 7.70	0.86	0.19 – 3.83

<sup>‡</sup> Values were not adjusted for ageOR, odds ratios; CI, confidence interval.

born had about 90% lower odds of being current-ENDS users compared to those US-born. For clinical measures, both obesity (OR 0.60, 95% CI: 0.36, 0.99) and diabetes mellitus (OR 0.46, 95% CI: 0.26, 0.81) were associated with lower odds of current ENDS use.

The ever ENDS use profile was similar to current ENDS use except by Hispanic/Latino background. Those of Central (OR 0.37, 95% CI: 0.25, 0.55) or South American (OR 0.59, 95% CI: 0.37, 0.95) backgrounds were less likely to be ever ENDS users compared with those of Mexican background. Finally, ever ENDS use was associated with additional clinical factors suggestive of greater CVD risk including hypercholesterolemia (OR 1.30, 95% CI: 1.05, 1.62), prevalent CVD (OR 2.33, 95% CI: 1.52, 3.56), and heart failure (OR 2.98, 95% CI: 1.16, 7.70).

When ENDS use status was compared with cigarette-only smokers, sociodemographic characteristic associations were generally consistent with effects observed when compared with non-tobacco users for both ever and current ENDS users (Table 4). For clinical characteristics, the models suggested no significant differences in the odds of current ENDS use. Only obesity status was associated with ever ENDS use, where those with obesity had 40% greater odds of ever ENDS use compared to those without.

## Discussion

In a large and diverse population-based sample of US Hispanic/Latino adults surveyed between 2014 and 2017, we report that 2.0% were current ENDS users, while 10.4% were former ENDS users. We identified that those who are young adults, males, with higher edu-

cation, and greater acculturation (i.e., US-born, English language preference) had higher odds of current ENDS use. Hispanic/Latino adults that were ever ENDS users (both former and current) had similar sociodemographic associations as current ENDS users but had more prevalent CAD. As evidence continues to mount demonstrating the potentially harmful impact of ENDS use on health,<sup>19</sup> our results provide new information that is critical to understanding the patterns of ENDS use among Hispanics/Latinos residing in the US. Our study also identifies ENDS user profiles that may be at a disproportionately higher risk of tobacco-related health disparities.

Our study is among the first to characterize the prevalence of ENDS use among Hispanics/Latinos from diverse social backgrounds. We found that those of Puerto Rican background and those having a higher level of acculturation to the US (English-language preference, being US-born) were significantly more likely to use ENDS than those with lower levels of acculturation, which extends previous findings on tobacco use among immigrants<sup>6,20</sup> to include ENDS use. Recent immigrants or those with less time in the US may still hold on to the beliefs and practices of their origin culture, which might have a protective effect on smoking beliefs and practices in their new cultural environment.<sup>21</sup> Additionally, compared with non-smokers, current and former smokers with greater English proficiency are more likely to be exposed to advertisements for ENDS products when cravings peak or when searching for tobacco substitutes or smoking cessation options.<sup>20</sup> Our results support previous findings that maintenance of cultural norms and Spanish language preference among Hispanics/Latinos may reduce ENDS use initiation.<sup>14</sup>

**Table 4**

Age-adjusted weighted logistic regression analysis of the association between sociodemographic and clinical characteristics and use of ENDS (Ever or Current) vs. Cigarette-Only Smokers.

Characteristics	Category	Ever ENDS Users vs. Cigarette-Only Smokers		Current ENDS Users vs. Cigarette-Only Smokers	
		OR	95% CI	OR	95% CI
<b>Sociodemographic</b>					
Age <sup>†</sup> (ref: $\geq 45$ years)	<45 years	7.85	5.96 – 10.34	5.96	3.59 – 9.88
Sex (ref: female)	Male	1.25	0.92 – 1.67	2.21	1.33 – 3.68
Education (ref: < HS)	HS/GED	1.12	0.73 – 1.72	1.87	0.73 – 4.79
	Some college+	1.79	1.26 – 2.55	4.08	1.80 – 9.27
Household Income (ref: <\$30 K annual)	$\geq$ \$30 K annual	1.78	1.27 – 2.49	2.65	1.49 – 4.70
Health Insurance (ref: No)	Yes	1.37	0.99 – 1.90	1.86	0.89 – 3.89
Language preference (ref: Spanish)	English	2.94	2.07 – 4.17	4.32	2.29 – 8.17
Hispanic background (ref: Mexican)	Dominican	0.85	0.48 – 1.49	0.87	0.34 – 2.19
	Central American	0.31	0.18 – 0.55	0.35	0.12 – 1.04
	Cuban	0.33	0.23 – 0.49	0.54	0.25 – 1.16
	Puerto Rican	0.84	0.55 – 1.28	0.56	0.26 – 1.17
	South American	0.59	0.26 – 1.31	0.48	0.14 – 1.72
Nativity (ref: US-born)	Foreign-born	0.35	0.25 – 0.51	0.22	0.12 – 0.41
Years in the US (ref: US-born)	Less than 10 years	0.18	0.09 – 0.33	0.1	0.04 – 0.28
	10 years or more	0.41	0.29 – 0.59	0.26	0.14 – 0.48
SASH language	Continuous	1.62	1.41 – 1.88	1.96	1.53 – 2.50
SASH social	Continuous	2.52	1.86 – 3.41	3.26	2.08 – 5.11
Field site (ref: Bronx)	Chicago	0.55	0.36 – 0.84	0.48	0.24 – 0.95
	Miami	0.36	0.25 – 0.52	0.57	0.28 – 1.17
	San Diego	1.77	1.14 – 2.74	2.58	1.18 – 5.64
<b>Clinical</b>					
Obesity (ref: BMI <30 kg/m <sup>2</sup> )	BMI $\geq$ 30 kg/m <sup>2</sup>	1.41	1.05 – 1.88	0.7	0.40 – 1.23
Diabetes (DM) (ref: absent)	DM (present)	1.33	0.98 – 1.80	0.63	0.35 – 1.14
Hypertension (HTN) (ref: absent)	HTN (present)	0.92	0.67 – 1.27	0.88	0.47 – 1.65
Hypercholesterolemia (HC) (ref: absent)	HC (present)	1.04	0.76 – 1.43	0.78	0.43 – 1.40
Prevalent CVD (ref: no history)	Prevalent CVD (history)	1.34	0.82 – 2.16	1.05	0.39 – 2.81
Heart failure (HF) (ref: no history)	HF (history)	1.54	0.46 – 5.17	0.5	0.11 – 2.33

<sup>†</sup> Values were not adjusted for ageOR, odds ratios; CI, confidence interval.

These findings offer valuable information for public health initiatives and policy efforts addressing the needs of Hispanics/Latinos living in the US. These findings also can support the development of culturally-tailored interventions to reduce ENDS use among acculturated young Hispanic/Latino adults who are not current tobacco smokers. Future research is needed to examine the joint role of other environmental factors such as family and peer-level factors, marketing strategies and their combined influence on ENDS use among foreign-born individuals and young adults, particularly men.

Since 2014, the prevalence of current ENDS use among adults has ranged between 3 and 5% compared with the prevalence of combustible cigarettes.<sup>22,23</sup> Nationally representative studies have found that overall, adults with lower SES and those who are racial or ethnic minorities were less likely to use ENDS.<sup>24,25</sup> Specifically, compared with non-Hispanic whites, Hispanics/Latinos have a historically low prevalence of current ENDS use. Our results show that among diverse Hispanics/Latinos in the US, estimates of ENDS use are comparable with earlier reports<sup>24,26,27</sup> and those assessed most recently.<sup>22</sup> Early analyses of the 2013–2014 National Adult Tobacco Survey found a low prevalence of current ENDS use among Hispanics/Latinos (2.7%) and non-Hispanic whites (3.6%).<sup>26</sup> Data from the 2013–2014 National Health and Nutrition Examination Survey (NHANES) estimated the prevalence of current ENDS use among Hispanics/Latinos between 1.6 (Mexican Americans) to 2.5 (Other Hispanics/Latinos) and 2.8 for non-Hispanic whites.<sup>27</sup> In the 2016–2018 Behavioral Risk Factor Surveillance System,<sup>24</sup> 2.6% of Hispanics/Latinos were current ENDS users compared with 5.9% of non-Hispanic whites. By 2019, using data from the National Health Interview Survey,<sup>22</sup> prevalence of current ENDS use among Hispanics/Latinos was

relatively stable (2.8%) but a significant increase in current ENDS use was noted among non-Hispanic whites (5.1%).<sup>22</sup> However, these aforementioned studies did not include diverse representative population-based samples of the Hispanic/Latino population. Importantly, our study provides new information about differences in ENDS usage by Hispanic/Latino background groups suggesting that previous estimates of ENDS use among aggregate samples of Hispanics/Latinos are not generalizable across Hispanic/Latino subpopulations. We found that Hispanic/Latino individuals of Puerto Rican and Mexican backgrounds were more likely to try ENDS (being either current or former users) than those of Dominican, South American, Cuban, or Central American backgrounds. Possible reasons for such differences may be due to the differences in use of combustible tobacco<sup>6,28</sup> and acculturation<sup>29,30</sup> in Hispanic/Latino groups.

Differences in sampling design, data collection approaches, and classification of ENDS use status may explain the moderate heterogeneity in prevalence estimates between nationally representative US studies. The slightly lower prevalence estimates in our study compared with previous studies may be due to differences in survey collection years, or the sampling procedures for HCHS/SOL, which emphasized representation of six major Hispanic/Latino background groups, including Central and South American backgrounds, and older adults (45+ years), background groups with a low prevalence of ENDS use in our study. Details on ENDS use duration can also vary between studies. For instance, 2013–2014 NHANES surveyed participants about ENDS use in the past 5 days,<sup>27</sup> while our study and others<sup>22,24,26</sup> included more detailed tobacco-use assessments such as participants' recent use of ENDS during the past 30 days. Future studies on changes in ENDS use prevalence in the US will

need to utilize consistent measures of ENDS use to increase comparability.

Nationally, the largest and steepest increase in prevalence over time has occurred among youth or young adults (ages 18–24 years).<sup>23</sup> Our findings were consistent with data from nationally representative studies<sup>22,24,27</sup> showing that ENDS use among US adults was most prevalent among younger individuals. Among Hispanic/Latino adults, we found a high prevalence of ENDS use among younger age groups (<45 years), and a significant emergence of prevalent ENDS use among adults who never smoked combustible cigarettes. ENDS use may serve to promote cigarette smoking among previous non-tobacco users<sup>31</sup> and increase health risks from chronic exposure to toxic substances in ENDS products.<sup>32</sup> Initially, ENDS products were introduced in the market as a potential smoking cessation tool but our study suggest that 18% of Hispanic/Latino persons who used ENDS never smoked cigarettes. Future research is needed to characterize and understand the features and experiences that draw a previously non-tobacco use population to become ENDS users. Additionally, surveillance must be continued to monitor changes over time in the prevalence of ENDS use among non-smokers.

Consistent with previous findings,<sup>24,33</sup> dual-nicotine product use was also prevalent among current ENDS users in our study. Nearly 68% of current ENDS users were current cigarette smokers. We also noted significant poly-tobacco use among ENDS users with 14.3% of current ENDS users currently smoking 2–3 combustible tobacco products (i.e., cigarettes, cigars, and hookah). Certain populations may be particularly likely to engage in dual/poly-nicotine produce use, which could increase tobacco-related health disparities and adverse health outcomes. Importantly, later-stage tobacco-related cancer disparities exist for Hispanics/Latinos.<sup>34</sup> Hispanic/Latino cigarette smokers are less likely than non-Hispanic white smokers to be screened and counseled to quit smoking or receive recommendations to use evidence-based cessation treatments/strategies,<sup>5,8</sup> potentially limiting cessation success. Coupled with other health-related disparities experienced by Hispanic/Latino communities in the US (i.e., lack of access to health care, lack of culturally sensitive healthcare providers, low health literacy, underrepresentation in clinical trials for smoking cessation strategies, targeting by tobacco industry marketing),<sup>35</sup> the adverse effect of tobacco use can be significantly exacerbated among Hispanic/Latino dual/poly-nicotine product users. Additional research is needed to understand the long-term health trajectories and tobacco-related health disparities for Hispanic/Latino ENDS users who engage with two or more other tobacco products.

#### Strengths and limitations

Our study offers a comprehensive analysis of the largest survey of ENDS use prevalence among a diverse sample of Hispanics/Latinos in the US. Importantly, using data from the HCHS/SOL allowed us to characterize the distribution of ENDS use among six distinct Hispanic/Latino background groups where culture and experiences are diverse and evident in variations seen regarding health behaviors and outcomes. This level of diversity in Hispanic/Latino background has been a limitation for other national surveys.<sup>26,27</sup> Additionally, we report the prevalence of ENDS use by sociodemographic and clinical characteristics. Nonetheless, the study has several potential limitations that should be addressed. The HCHS/SOL data collected self-reported measures of tobacco use, which have been shown to be reliable in longitudinal studies but not validated against biomarkers (i.e., urinary cotinine). The HCHS/SOL also lacked information about biochemical measures of tobacco use, type of ENDS delivery mechanisms (i.e., tank, mod, or voltage pen); and type of ENDS liquid, nicotine dose, or flavors used. While the study provided weighted estimates that were adjusted for survey nonresponse, a moderate level of nonresponse may have introduced selection bias into the study; although using door-to-door survey methods helped avoid systematic biases associated with telephone surveys.<sup>36–39</sup> Finally, HCHS/SOL did not recruit individuals living in rural or suburban locations, therefore the study populations may not be fully representative of

the US Hispanic/Latino population. Still, approximately 75% of the total US Hispanic/Latino population resides within the ten largest metropolitan areas,<sup>40</sup> four of which are covered by the HCHS/SOL sites.

#### Conclusions

In summary, our study provides a recent and detailed assessment of prevalence estimates of ENDS use in a large and most well-characterized population-based cohort of US Hispanic/Latino adults in the US. These data will serve as the basis for future research in this area and may inform the Food and Drug Administration in the regulation of ENDS to protect public health. In practice, public health messaging efforts to the Hispanic/Latino population should consider targeting greater acculturated younger Hispanics/Latinos and creating bilingual messaging efforts that may be more appropriate for less acculturated, older Hispanics/Latinos. These findings could inform preventive and regulatory interventions targeted to Hispanics/Latinos.

#### Declaration of Competing Interest

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#### Supplementary materials

Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.ajmo.2022.100029>.

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