ORIGINAL RESEARCH

Tobacco Use Prevalence and Transitions From 2013 to 2018 Among Adults With a History of Cardiovascular Disease

Lindsay M. Reynolds [iD], PhD*; Cristian Zamora [iD], MD*; Un Jung Lee, PhD; Andrew C. Stokes [iD], PhD; Emelia J. Benjamin [iD], MD ScM; Aruni Bhatnagar, PhD; Thomas J. Payne [iD], PhD; Carlos J. Rodriguez [iD], MD, MPH

BACKGROUND: Although tobacco product use and transitions have been characterized in the general population, few studies have focused on individuals with established cardiovascular disease (CVD) in a population-based sample.

METHODS AND RESULTS: We examined tobacco use prevalence and longitudinal patterns of tobacco product transitions in adults (≥18 years) of the nationally representative PATH (Population Assessment of Tobacco and Health) study, from 2013 to 2014 (Wave 1) through 2016 to 2018 (Wave 4). Prevalent CVD was classified through self-report of having had a heart attack, heart failure, stroke, or other heart condition. Factors associated with tobacco product use and transitions were investigated using survey logistic regression. We examined 2615 participants with self-reported CVD at Wave 1. Overall, 28.9% reported current tobacco use, equating to ≈6.2 million adults in the United States with prevalent CVD and current tobacco use. Among adults with CVD who are current tobacco users, the most commonly used product was cigarettes (82.8%), followed by any type of cigar (23.7%), and e-cigarette use (23.3%). E-cigarette use without concurrent cigarette use among participants with prevalent CVD was uncommon (1.1%). Factors associated with tobacco use were younger age, male sex, had lower education level, and lack of knowledge about the association between smoking and CVD. Men with prevalent CVD were less likely to use e-cigarettes compared with women (odds ratio [OR], 0.7; 95% CI, 0.5–0.9). Among cigarette users with CVD, transition rates between Waves 1 and 4 demonstrated <5% decrease in cigarette, with a 0.5% increase in e-cigarette use. Only ≈10% were in formal tobacco cessation programs.

CONCLUSIONS: Despite known harmful cardiovascular effects, over one fourth of adults with prevalent CVD use tobacco products and few quit smoking over the 4 waves of the PATH data set.

Key Words: cardiovascular disease ■ race and ethnicity ■ smoking

The use of tobacco products is a major risk factor for cardiovascular diseases (CVD), heart failure (HF), stroke, and death. Importantly, quitting tobacco products reduces mortality risk and the risk for subsequent cardiovascular events compared with persistent smoking among individuals with known CVD.[1–5] The pathophysiologic relationship between smoking with atherosclerotic and thrombotic CVD is well documented.[6] Thus, the use of tobacco products with prevalent CVD and stroke represent both a public health and an economic burden.

Population-based estimates from the Health and Retirement Study[7] reported the overall prevalence of current cigarette smoking among adults at least 50 years of age diagnosed with heart disease was 34.7% from 1992 to 2010. An older study reported that 30.9% of the patients who survived their first myocardial infarction (MI) were active smokers.[5] Although these

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CLINICAL PERSPECTIVE

What Is New?

- Almost one third of adults with established cardiovascular disease were current users of tobacco products in 2013 to 2014, and ≈1 in 5 adults with cardiovascular disease continued to use cigarettes 4 to 5 years later.
- Being young, male, non-Hispanic, less educated, poor with lack of knowledge that cigarettes cause heart disease were characteristics associated with tobacco use. Women with prevalent cardiovascular disease were more likely to use e-cigarettes compared with men.

What Are the Clinical Implications?

- Our study suggests that only ≈10% of current cigarette users with cardiovascular disease were part of formal smoking cessation program, and less than one fourth successfully quit smoking over a 4-year period, suggesting that more efforts are needed to improve the availability of tobacco cessation campaigns and tools for high-risk populations.

Nonstandard Abbreviations and Acronyms

PATH   Population Assessment of Tobacco and Health

prior data reflect a relatively high prevalence of smoking among those with documented CVD, the rates of tobacco product use have declined significantly since these data were gathered. Attitudes, perceptions, and beliefs in tobacco products have also changed, which may have significantly affected tobacco product use, especially among those having experienced adverse cardiovascular health outcomes associated with the use of tobacco products.

Another major change in the tobacco landscape over the last decade has been the introduction of electronic nicotine delivery devices such as e-cigarettes. The use of such devices has grown tremendously in popularity, particularly among former and current cigarette smokers.[8] Results from adults aged 18 to 89 years from the 2014 National Health Interview Survey found that 3.7% of adults with a history of CVD were current users of e-cigarettes.[9] However, currently it is unknown what proportion of adults with prevalent CVD are using e-cigarettes or transitioning from cigarette use to e-cigarette use, or using other tobacco products such as cigars, pipe tobacco, hookah, smokeless tobacco (moist snuff, dip, spit, or chewing tobacco), dissolvable tobacco, or snus.

To gain a better understanding of the prevalence tobacco product use and tobacco product transitions in adults with prevalent CVD (MI, HF, stroke), we (1) used baseline data collected by the PATH (Population Assessment of Tobacco and Health) study in 2013 to 2014 to estimate the prevalence of tobacco use among adults with prevalent CVD compared with those without prevalent CVD; and (2) used longitudinal PATH data through 2016 to 2018 to identify factors associated with tobacco product use and transitions among people with CVD over this time period.

METHODS

In 2011, the PATH study was established to generate longitudinal epidemiologic data on tobacco-use behavior and health in the US population.[10] As described previously, the PATH study is a large (~45 000 respondents) nationally representative, longitudinal cohort study that surveyed non-institutionalized US adults (ages ≥18 years) and youth (ages 12–17 years) about their tobacco product habits and health.[10,11] Tobacco use was estimated using PATH survey data from 2013 to 2014 (Wave 1), 2014 to 2015 (Wave 2), 2015 to 2016 (Wave 3), and 2016 to 2018 (Wave 4). The PATH study was conducted by Westat, a contract research organization, and approved by its institutional review board. Written informed consent was obtained from all adult study respondents. The survey response rates in Wave 1, 2, 3 and 4 were 74%, 83.2%, 78.4%, and 73.5%, respectively. The data and study materials are available to the public at the official PATH study website.[12]

For our study, we analyzed PATH data on adult respondents with and without prevalent CVD. Prevalent CVD was defined broadly based on self-report at Wave 1 to the question that a doctor or other health professional said that she/he had: (1) a heart attack, (2) HF, (3) a stroke, or (4) some other heart condition. Self-reported tobacco product use was obtained from Wave 1 through Wave 4. Current users of each product were defined as respondents reporting having ever used the product and having used the product at least once in the past 30 days. Tobacco products included cigarette, e-cigarette, traditional cigar, filtered cigar, cigarillo, pipe, hookah, smokeless tobacco (moist snuff, dip, spit, or chewing tobacco), dissolvable tobacco, and snus. Analysis of transitions of tobacco product use was limited to data involving cigarettes and/or e-cigarettes in the subset of adult current cigarette users with prevalent CVD who were not using e-cigarettes at Wave 1 and for whom data were available from Waves 2 to 4 (Table S1). Transitions including uptake (defined as

current use at any wave [2 to 4] but not at Wave 1), quitting (defined as current use at Wave 1 but not on a subsequent wave), and dual-use (defined as concurrent use of cigarettes and e-cigarettes in any of the subsequent waves).

Data were obtained on respondents' age, sex, race/ethnicity, household income, education, and US census region. Age was analyzed as a continuous variable (years at Wave 1).

Race/ethnicity was classified by self-report as non-Hispanic White, non-Hispanic Black, Hispanic, and other (including other races or respondents reporting >1 race). Education was defined as a categorical variable with 4 levels (less than high school/GED, high school graduate, some college/associate's degree, and bachelor's degree/advanced degree). Household income was categorized according to 3 levels based on 2015 Department of Health and Human Services poverty guidelines (below poverty level, <100% of poverty guideline; at or near poverty level, 100% to 199% of poverty guideline; and at or above twice poverty level, ≥200% of poverty guideline).[13] US geographic regions were defined as a categorical variable with 4 levels (Northeast, Midwest, South, and West). Other factors investigated for association with tobacco use and product transitions related to respondent beliefs of the harmfulness of cigarettes and e-cigarettes, which were assessed by the survey questions: (1) Based on what you know or believe, does smoking cause heart disease in smokers, and (2) Is using e-cigarettes less harmful, about the same, or more harmful than smoking cigarettes?

Statistical Analysis

Analyses were performed using the Wave 1 through Wave 4 PATH restricted data sets, and SAS version 9.4 (SAS Institute, Cary, NC). SAS SURVEY procedures (eg, proc surveylogistic) with the use of sampling weights were used to account for the complex survey design used for the PATH study which is different from simple random sampling. PATH is a nationally representative probability sample; thus, sampling weights allow us to generate US nationally representative estimates of this population. PATH sampling weights were calculated as the inverse of the probability of selection, adjusted or calibrated by factors from the sample and the population. Sampling weights used in all calculations accounts for the survey nature of the data, including differential probabilities of selection, non-response, and possible missingness within the data. To obtain US nationally representative estimates, sampling weights were applied to all calculations and the weighted sum over the sample represents the weighted estimate of the population totals. The PATH study

imputed missing variables of demographic characteristics which were used to create the sampling weights at PATH Wave 1 and 4 since the sampling weights are needed to all samples. Missing variables were imputed using hot deck imputation[14] or were assigned according to the information provided in house screener. The sampling weights for Waves 1, 2, and 3 relied on the imputed variables of demographic characteristics at Wave 1. Analyses were restricted to adults with all covariates available in the Wave 1 data set. Percentages were calculated using sample weights with PROC SURVEYFREQ, a modification of the Balanced Repeated Replication method, and Fay method (Fay coefficient=0.3). Odds ratios (ORs) and 95% CIs were generated using PROC SURVEYLOGISTIC and Fay method (Fay coefficient=0.3). All predictor variables of interest (age, sex, race, poverty level, education level, and census region) were included in multivariable models without a primary variable identified to assess the independent effect of each factor on tobacco use. We considered a 2-sided P value <0.05 statistically significant.

RESULTS

Of the 32 172 survey participants from Wave 1, 2615 had self-reported CVD, translating into a weighted 9.7% (95% CI, 9.2–10.2) of the US adult population having prevalent CVD in 2013 to 2014. Population characteristics of PATH study respondents (at Wave 1) stratified according to the presence of prevalent CVD are displayed in Table 1. Adult respondents with prevalent CVD were older on average compared with those without prevalent CVD and about half were female (48.5%). Lower levels of education and higher rates of living at or near poverty were reported by respondents with prevalent CVD compared with respondents without CVD. There was a similar prevalence of current tobacco use among PATH respondents with or without CVD but a higher prevalence of former tobacco users among adults with prevalent CVD. Adults with prevalent CVD were more likely to report a belief that e-cigarettes are less harmful than cigarettes compared with adults without CVD (P=0.0001). Among the prevalent CVD population in PATH, 24.4% reported having had a heart attack, 22.6% reported having had a stroke, 19.1% reported HF, and 60.5% reported having some other heart condition. Venn diagrams (Figures 1A and 1B) show overlap between all types of CVD, with 20.2% of respondents reporting >1 type of prevalent CVD. Among those with prevalent CVD, 3.5% reported having had both a heart attack and HF; 1.1% having had a heart attack and stroke, compared with 4.1%

Table 1. Characteristics of Study Population, 2013 to 2014 (PATH Wave 1 Survey, N=32 172)

	Prevalent CVD (n=2615)		No CVD (n=29 557)		*P* Value
Age (y), (n, %)					
18 to 44 y	693	15.4	19613	50.8	<0.0001
44 to 64 y	1108	36.5	7656	34.2	
≥65 y	814	48.0	2278	15.0	
Sex, (n, %)					
Men	1386	51.5	14856	47.7	0.0024
Women	1229	48.5	14701	52.3	
Race, (n, %)					
Non-Hispanic White	1766	77.1	17465	64.9	<0.0001
Non-Hispanic Black	353	10.5	4127	11.3	
Hispanic	237	8.0	5258	15.9	
Other/multi-racial*	185	4.4	2233	7.9	
Education, (n, %)					
GED or less	675	23.2	5750	16.0	<0.0001
High school diploma	590	26.6	6931	24.1	
Some college	883	30.5	10394	31.1	
Bachelor's degree	455	19.7	6332	28.8	
Poverty level, (n, %)					
Below poverty	797	26.1	9110	25.1	<0.0001
At or near poverty	692	31.2	6101	21.6	
200% above poverty	830	42.8	11572	53.4	
US Region, (n, %)					
Northeast	404	17.4	4621	18.2	0.0002
Midwest	695	24.6	6965	21.1	
South	1045	39.6	11120	36.9	
West	471	18.5	6851	23.8	
CVD risk factors, (n, %)					
Hypertension	1442	59.7	5685	24.4	<0.0001
Diabetes mellitus	817	32.4	2757	12.1	<0.0001
Obesity	921	35.5	8293	29.8	<0.0001
High cholesterol	1202	49.9	4288	20.1	<0.0001
Family history	1326	51.9	8736	31.6	<0.0001
Any tobacco use, (n, %)					
Never	250	20.4	4246	28.0	<0.0001
Former	791	50.7	8466	42.2	
Current	1502	28.9	16252	29.8	
Smoking harm belief, (n, %)					
Smoking can cause heart disease in smokers	2455	95.9	27242	93.7	0.0009
No. of cigarettes, (mean, SE)					
(In past 30 d, average number of cigarettes smoked per day on days smoked)	8.2	0.6	5.3	0.1	0.8902
Use of a Tobacco Cessation Program, (n, %)					
Yes	77	12.0	475	8.6	0.0046
No	527	88.0	5112	91.4	
E-cigarette harmfulness belief, (n, %)					
E-cigs<cigarettes	1019	40.2	12671	43.2	<0.0001
E-cigs≈cigarettes	978	49.3	11694	49.9	

(Continued)

Table 1.   Continued

	Prevalent CVD (n=2615)		No CVD (n=29 557)		*P* Value
E-cigs>cigarettes	188	10.5	1632	6.9	
Tobacco products users, (n, %)					
Cigarettes	1262	22.7	12890	22.5	
E-cigarette	379	6.3	4038	6.7	
Cigars	335	6.6	4223	7.3	
Dual (cigarettes and e-cigarettes)	321	5.3	3215	5.3	

Numbers (n) presented are unweighted counts of total participants; frequencies are weighted.

CVD indicates cardiovascular disease; and PATH, Population Assessment of Tobacco and Health.

*Other includes American Indian or Alaska Native, Asian, Native Hawaiian, Other Pacific Islander or Multiple races, non-Hispanic.

and 3.1%, respectively, for those with prevalent CVD who consume tobacco products.

Tobacco Use Among Adults With Prevalent CVD

At Wave 1, current tobacco product use was reported by 28.9% (95% CI, 26.6–31.3) of adults with prevalent CVD equating to 6.2 million (95% CI, 5.7–6.7 million) US adults. Current use of cigarettes, cigars, e-cigarettes, and dual products was similar among those with CVD as in those without CVD. As depicted in Figure 2A and 2B, among those with prevalent CVD who reported current tobacco use, cigarette smoking was the most commonly used tobacco product at 82.8% (95% CI, 80.6–84.8) or 5.2 million (95% CI, 4.7–5.6 million). This is followed by use of any type of cigar (traditional, cigarillo, or filtered cigars) at 23.7% (95% CI, 20.9–26.8) or 1.4 million (95% CI, 1.2–1.6 million), and e-cigarette use at 23.3% (95% CI, 21.1–25.6) or 1.4 million (95% CI, 1.3–1.6 million). Current smokeless tobacco use was reported by 8.2% (95% CI, 6.9–9.7) or 0.5 million (95% CI, 0.4–0.6 million), while use of other tobacco products was uncommon [pipe, 3.7% (95% CI, 2.8–5.0) or 0.2 million (95% CI, 0.2–0.3 million); hookah, 3.0% (95% CI, 2.2–4.0) or 0.2 million (95% CI, 0.1–0.2 million); snus, 1.2% (95% CI, 0.7–1.9) or 0.07 million (95% CI, 0.04–0.1 million); dissolvable, 0.3% (95% CI, 0.1–0.8) or 0.02 million (95% CI, 0.004–0.04 million)] among US adults with prevalent CVD. Regardless of the type of CVD (heart attack, HF, stroke or other CVD), cigarette use was the most common tobacco product consumed among adults with prevalent CVD.

Among adults with prevalent CVD, current use of any tobacco product was associated with lower age (OR, 0.7; 95% CI, 0.5–0.9). Current use of any tobacco product was higher in men compared with women, particularly for cigar use. The odds of cigarette and cigar use were also higher among men compared with women. However, men with prevalent CVD were 30% less likely to use e-cigarettes compared with women. Hispanic participants were 60% less likely than non-Hispanic White participants to currently use any tobacco product and had lower odds for current cigarette or cigar use. Non-Hispanic Black participants had almost twice the likelihood of cigar use compared with non-Hispanic White participants. Additionally, non-Hispanic Black participants had significantly lower odds, being almost half as likely, of using e-cigarettes compared with non-Hispanic White participants. Overall, Hispanic participants had 50% lower odds than non-Hispanics Black participants of using any tobacco product and were less likely to use cigarettes or cigars. In contrast to race-ethnic differences observed for current use of any tobacco product, there were no differences in the odds of using e-cigarettes between Hispanic and non-Hispanic Black participants (Table 2).

Lower levels of education among adults with CVD were associated with higher likelihoods of using any tobacco products, with high school graduates and less than high school graduates having an increased odds of current tobacco use compared with having a bachelor's degree. Current cigarette and e-cigarette use was more likely among those who did not complete high school compared with having a bachelor's degree. There were no statistically significant differences in cigars users with prevalent CVD and education levels. Current use of any tobacco product significantly varied by income. Lower levels of household income were associated with higher likelihoods of using any tobacco product and respondents living below the poverty line were twice as likely to report current use of any tobacco product (cigarettes, cigars, and e-cigarettes) compared with those living at twice the poverty level or above (Table 2). There were no significant differences in current use of any tobacco product among adults with prevalent CVD across regions in the United States.

The majority of adults with prevalent CVD reported knowing or believing that smoking can cause heart disease in smokers (95.9%). A significant proportion reported belief that e-cigarettes were less harmful (40.2%) than combustible cigarettes. Respondents with prevalent CVD who reported knowing or believing smoking
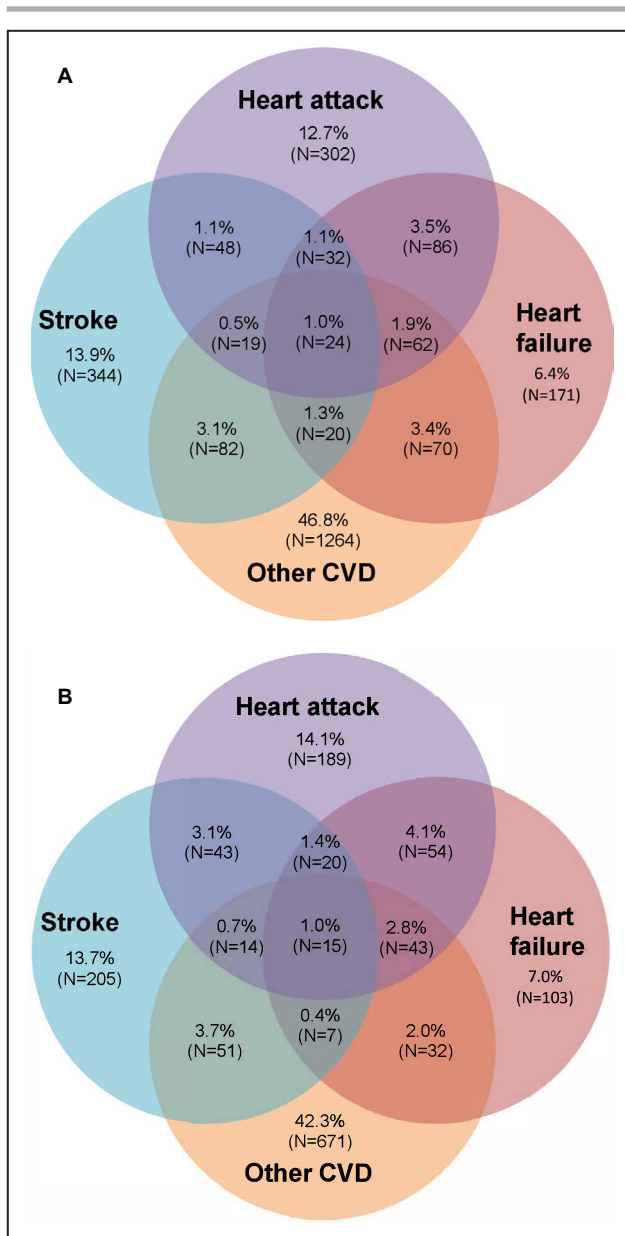
Figure 1. Venn diagram between all types of cardiovascular disease.
A, Among those prevalent cardiovascular disease (n=2615). **B**, Among those prevalent cardiovascular disease who use tobacco (current users) (n=1502). Venn diagram showing overlap between all types of cardiovascular diseases. Numbers presented are unweighted counts and weighted percentages of the population totals. CVD indicates cardiovascular disease.

causes heart disease in smokers were significantly up to 50% to 70% less likely to report using of any tobacco product, particularly e-cigarettes or cigars. However, the belief that smoking cigarettes causes heart disease in smokers was not significantly associated with lower odds for current cigarette use (OR, 0.58; 95% CI, 0.34–1.00) (Table 2). Current use of e-cigarettes did vary by the general perception of harmfulness of using e-cigarettes compared with smoking cigarettes. The prevalence of

current e-cigarette uses and dual-use was higher among adults reporting the belief that e-cigarettes are less harmful than cigarettes compared with those who believe that e-cigarettes are more harmful than cigarettes (Figure 3).

Tobacco Product Transitions Among Adults With Prevalent CVD

Figure 4 shows prevalence of cigarette and e-cigarette use among adults with prevalent CVD from the PATH Wave 1 survey in 2013 to 2014 to the PATH Wave 4 survey in 2016 to 2018. At Wave 1, the prevalence of cigarette or e-cigarettes use, was reported by 23.7% of adults with CVD, only slightly higher than at Wave 4 (22.9%). Combustible cigarettes remained the most commonly used tobacco product from Waves 1 through 4. Table 3 shows the transitions through Waves 2, 3, and 4 of current cigarette smokers with prevalent CVD but without concurrent e-cigarette use at Wave 1. At Wave 2, only 10.1% of adults cigarette smokers with prevalent CVD were no longer combustible cigarette or e-cigarette smokers; however, 1.5% were using e-cigarettes without cigarettes use and 12.2% were dual-users. A minimal decrease in cigarette use was observed between Waves 2, 3, and 4 (4.6%). A slight uptake of e-cigarette use (0.8%) along with a ≈2.6% decrease of dual-use was observed between Waves 2 to 4. At Wave 2, dual use was more common than use of e-cigarettes alone and a similar trend persisted over time through Wave 4. Only ≈10% had transitioned to using formal tobacco cessation programs at Wave 2 (the same proportion of adults who were no longer using combustible cigarette or e-cigarette). The uptake of formal tobacco cessation programs at subsequent waves was <2%.

DISCUSSION

According to our data 28.9% or an estimated 6.2 million adults in the United States with prevalent CVD were current tobacco users in 2013 to 2014. Cigarette smoking remains the most commonly used tobacco product among US adults with prevalent CVD, the next most commonly used tobacco products among adults with CVD are cigars and e-cigarettes. Despite well-documented benefits of smoking cessation after CVD diagnosis, only 18% of current cigarette smokers with CVD in 2013 to 2014 were no longer cigarette smokers in 2016 to 2018. Our study provides recent estimates of the prevalence of tobacco product use and rates of tobacco product transitions among adults living with CVD, based on a large nationally representative, longitudinal cohort study. In contrast to other tobacco products, our study findings show higher odds for e-cigarette use among women compared with men and among non-Hispanic White adults compared with non-Hispanic Black adults.
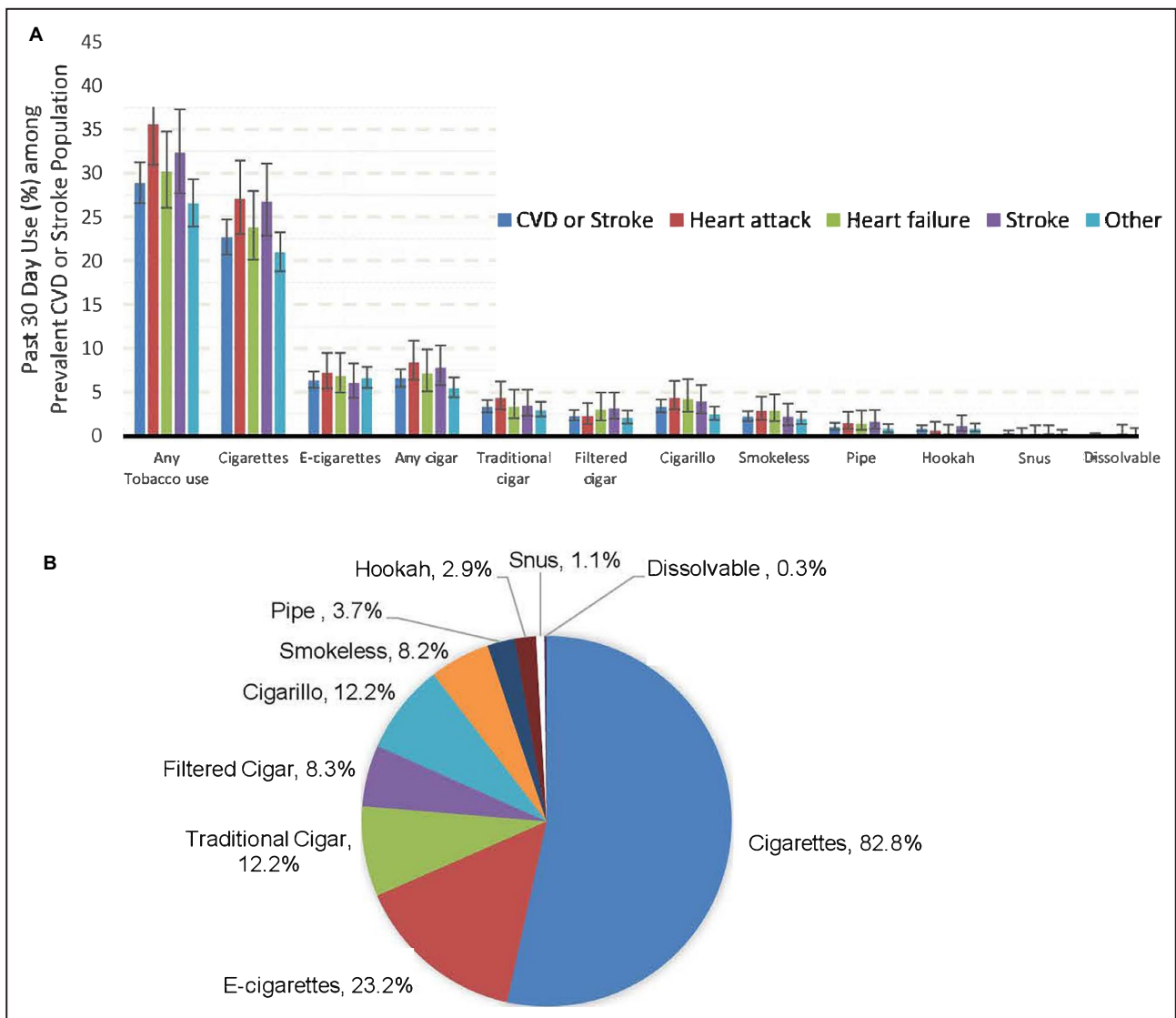
Figure 2. **A**, Prevalence of tobacco product use among adults with history of cardiovascular disease. Estimates of the prevalence of current tobacco product use (past 30-day use) are from a nationally representative sample of US adults (aged ≥18 years), subset to those with self-reported prevalent cardiovascular disease (heart attack, heart failure, stroke, or other heart condition); weighted sample size=22 805 585; unweighted sample size=2615. For any tobacco product, the proportions are not additive given that some participants use >1 tobacco product but were only counted once. **B**, Type of tobacco product use among adults with cardiovascular disease who use tobacco (n=1502). Participants using ≥2 tobacco products were counted for each tobacco product used. Percentages were weighted to the US adult population. CVD indicates cardiovascular disease.

Dual use of cigarettes and e-cigarettes is more common among the prevalent CVD population than current use of e-cigarettes alone.

Given the elevated risks for mortality and subsequent cardiovascular events associated with persistent smoking, the prevalent CVD population represents a population particularly vulnerable to the effects of tobacco.[1–3] Based on our results, almost one third of adults with established CVD were current users of tobacco products in 2013 to 2014 and ≈1 in 5 adults with CVD were still using cigarettes 4 to 5 years later. This prevalence is higher than data from the general US population

according to the 2018 National Health Interview Survey and 2020 Smoking Cessation Surgeon General Report where almost 20% of US adults reported currently using any tobacco product, including cigarettes (14%).[15,16] The 2013 to 2014 National Adult Tobacco Survey reported a 17% rate of every day or someday cigarette smoking among adults in the general US population.[17] We found a higher prevalence (23.2%) of current cigarette smokers among PATH respondents with prevalent CVD (Figure 2A). Differences in tobacco use prevalence among different surveys could be attributed to different definitions of a current cigarette smoker but they do

Table 2. Factors Associated With Tobacco Product Use Among Adults With Prevalent CVD or Stroke in 2013 to 2014

	Effect	Any tobacco OR (95% CI)	Cigarettes OR (95% CI)	Cigars OR (95% CI)	E-Cigarettes OR (95% CI)
Age, y	45 to 64 vs 18 to 44	0.7 (0.5–0.9)	0.7 (0.5–0.9)	0.5 (0.4–0.7)	0.6 (0.4–0.7)
	≥65 vs 18 to 44	0.3 (0.2–0.3)	0.2 (0.1–0.2)	0.2 (0.1–0.2)	0.1 (0.1–0.2)
Sex	Men vs women	2.2 (1.7–2.8)	1.3 (1.1–1.7)	3.4 (2.4–4.8)	0.7 (0.5–0.9)
Race	Non-Hispanic Black vs Non-Hispanic White	0.9 (0.7–1.3)	1.0 (0.8–1.4)	1.8 (1.2–2.6)	0.4 (0.2–0.8)
	Hispanic vs non-Hispanic White	0.4 (0.3–0.6)	0.5 (0.3–0.7)	0.5 (0.3–0.8)	0.5 (0.3–0.8)
	Hispanic vs Non-Hispanic Black	0.5 (0.3–0.8)	0.5 (0.3–0.7)	0.3 (0.2–0.5)	1.2 (0.6–2.3)
	Other/multi-racial[†] vs Non-Hispanic White	1.2 (0.8–1.8)	1.4 (0.9–2.1)	1.2 (0.7–1.9)	0.7 (0.4–1.1)
Education	Less than high school/GED vs bachelor's/advanced degree	1.9 (1.3–3)	4.7 (3.2–6.9)	1.1 (0.6–2)	2.5 (1.4–4.4)
	High school graduate vs bachelor's/Advanced Degree	1.4 (1.1–2)	2.8 (2–3.9)	0.8 (0.5–1.5)	1.8 (1.1–3.2)
	Some college/associate degree vs bachelor's/advanced degree	1.1 (0.8–1.5)	2.1 (1.5–3)	0.9 (0.5–1.6)	1.7 (1.1–2.7)
Region	Northeast vs West	1.0 (0.7–1.4)	1.2 (0.8–1.8)	1.1 (0.7–1.7)	0.9 (0.5–1.7)
	Midwest vs West	0.9 (0.7–1.3)	1.1 (0.8–1.6)	1.2 (0.7–2.0)	1.2 (0.8–1.8)
	South vs West	0.9 (0.6–1.2)	1.1 (0.8–1.5)	1.0 (0.6–1.6)	1.0 (0.7–1.5)
Poverty	Below vs ≥200% poverty line	1.9 (1.3–2.6)	2.3 (1.7–3.1)	2.5 (1.7–3.7)	1.9 (1.3–2.6)
	At or near poverty vs ≥200% poverty line	1.4 (1.1–1.8)	1.7 (1.3–2.1)	1.5 (1–2.2)	1.6 (1.1–2.3)
*Perception of harmfulness	Belief that smoking causes heart disease in smokers	0.4 (0.2–0.8)	0.5 (0.3–1)	0.5 (0.3–0.9)	0.3 (0.2–0.7)

All predictor variables of interest (age, sex, race, poverty level, education level, and census region) were included into the multivariable model without a primary variable identified to assess the independent effect of each factor on tobacco use.

CVD indicates cardiovascular disease; and OR indicates odds ratio.

*OR obtained from univariate analysis.

†Other includes American Indian or Alaska Native, Asian, Native Hawaiian, Other Pacific Islander or Multiple races, non-Hispanic.

suggest a higher, or at least similar, prevalence of tobacco use, and cigarette use, among adults with prevalent CVD compared with the general US population.

Among adults with CVD, the only tobacco product with a higher likelihood of use among women compared with men was e-cigarettes. It is unclear why women with prevalent CVD were more likely to use e-cigarettes compared with men. This finding is in agreement with findings from the 2014 National Health Interview Survey which reported a higher prevalence of use of e-cigarette use among women compared with men with CVD.[18] Similar to a study involving people with prior MI, we found that the belief that cigarettes smoking causes heart disease was not significantly

associated with a lower odds of current cigarette use in this population.[19]

Our study, along with previous studies,[7] found racial and ethnic differences in tobacco use among adults in the United States with a diagnosis of heart disease. The highest prevalence of current cigarette use was reported by non-Hispanic Black participants (35%), followed by Hispanic participants (23%) and non-Hispanic White participants (22%). However, in multivariable models, odds of current cigarette use were similar among non-Hispanic Black participants compared with non-Hispanic White participants, but there was a significantly lower odds for current cigarette use among Hispanic participants compared with
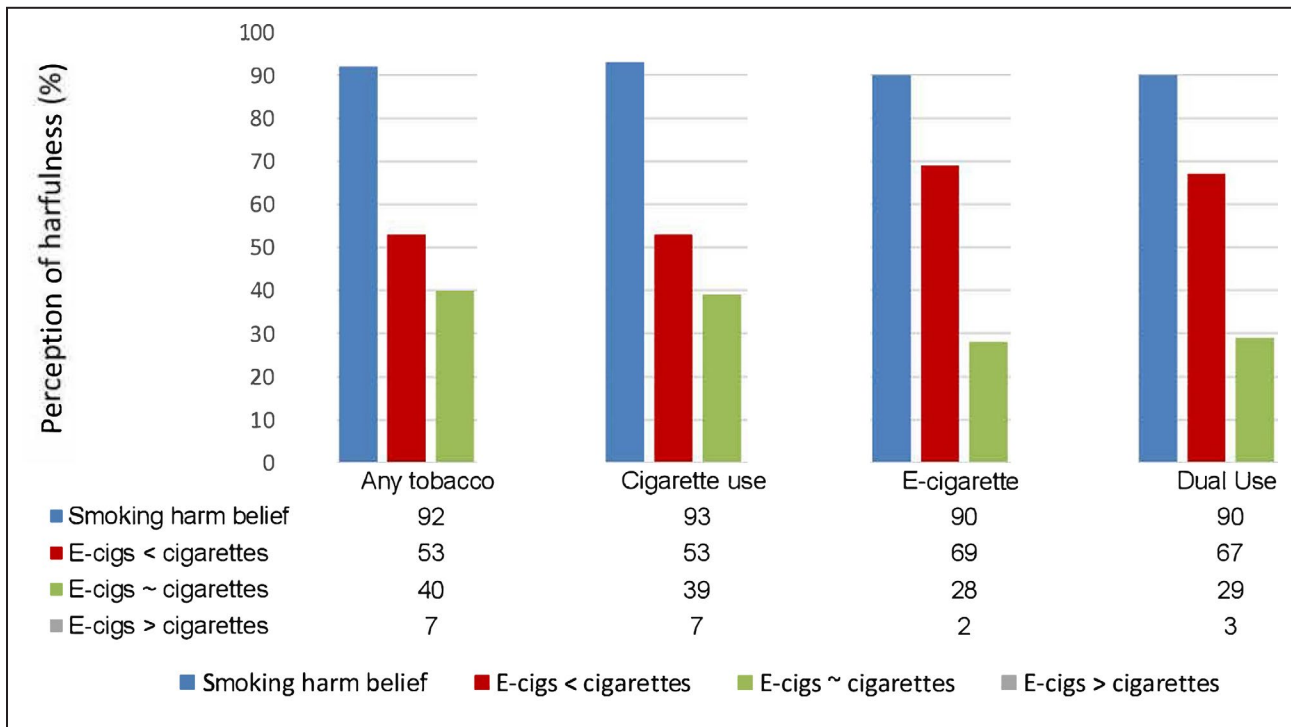
Figure 3. Perception of harmfulness among tobacco users with prevalent cardiovascular disease (n=1502).
Dual denotes concurrent cigarette and e-cigarette use. CVD indicates cardiovascular disease.

non-Hispanic White and Black participants. While our findings do not speak to the causes of these apparent racial-ethnic differences in current cigarette use among adults with prevalent CVD, they may be reflective of other demographic and CVD risk factors that vary by race/ethnicity.[20] Among adults with CVD, we found non-Hispanic Black adults were 80% more likely and Hispanic adults were 50% less likely to be using cigars compared with non-Hispanic White adults. In contrast, non-Hispanic Black and Hispanic adults were 60% and 50%, respectively, less likely to be using e-cigarettes compared with non-Hispanic White adults. Additionally, lower income levels were also associated with higher odds for cigar and e-cigarette use among adults with CVD.

Because of the lack of comprehensive studies of cigar and e-cigarette use among adults with CVD, some of our comparisons use prior literature in the general US population. Our findings in adults with CVD are in agreement with previous studies of the general US adult population showing a higher prevalence of cigar and e-cigarette use among individuals with lower educational attainment, poverty and younger adults, and differences in prevalence of cigar and e-cigarette use by race/ethnicity.[21,22] The use of cigars by individuals with lower income in the general population has been hypothesized to be influenced by lower taxes on cigars than cigarettes, which have

made some cigars cheaper than cigarettes.[23] Our findings are in contrast to results from studies of the general US adult population, such as the 2015 National Health Interview Survey which did not observe an increased prevalence of cigar use among adults with lower income levels.[21]

Consistent with previous findings among adults with CVD,[9,24] our results indicate that dual use of e-cigarettes and cigarettes is more common than e-cigarette use alone among adults with prevalent CVD. Our findings may help inform the design of future studies trying to determine the health risks of e-cigarette use in adults with CVD, as they should consider the common rates of dual use of combustible cigarette and e-cigarettes reported by adults with prevalent CVD in our study. Additionally, since dual use of cigarettes and e-cigarettes is more common than use of e-cigarette alone among the population with prevalent CVD, our findings indicate a need for a better understanding of the health consequences of dual use of cigarettes and e-cigarettes among adults with CVD.

To better understand the implications of e-cigarette use on the prevalence of cigarette smoking among adults with CVD, our study leveraged longitudinal data collected from 2013 through 2018. Importantly, a slight decrease in current combustible cigarette use and dual-use along with a reduced number of combustible cigarettes and increased e-cigarette use over
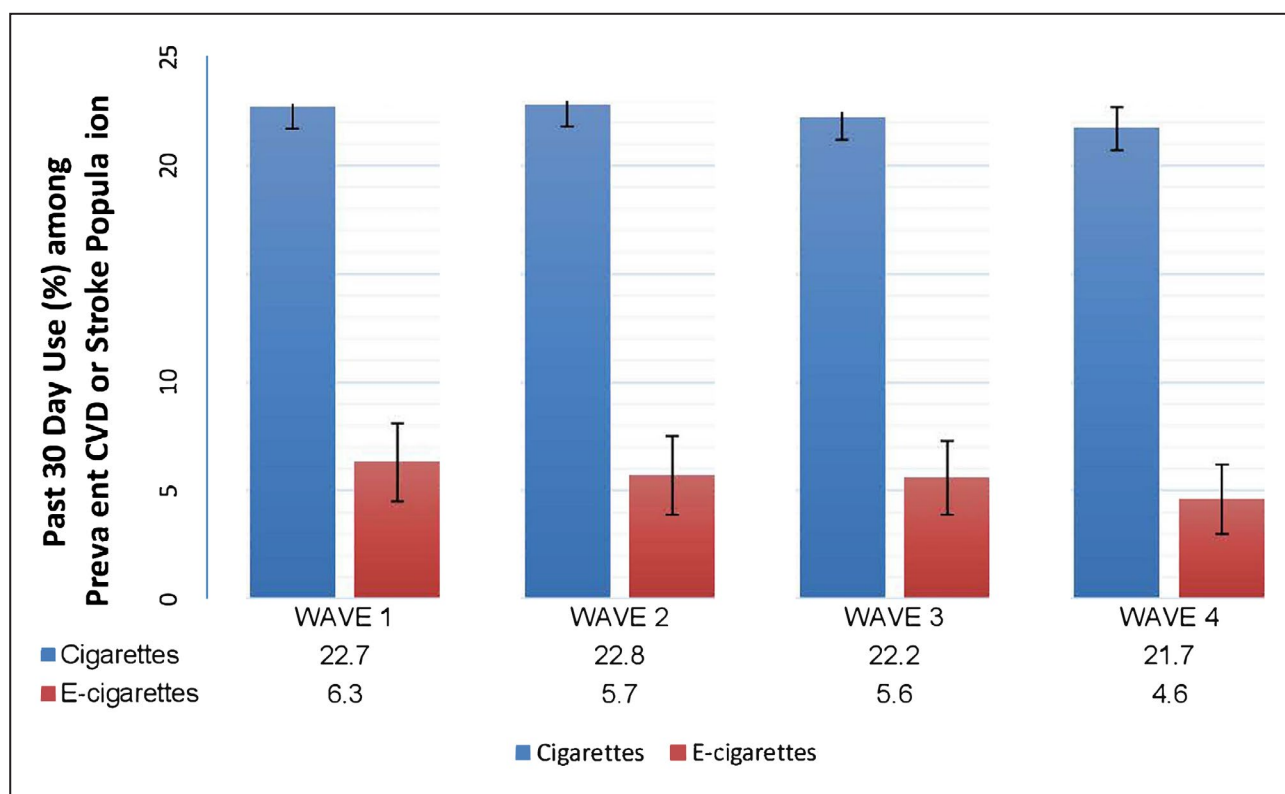
Figure 4. Prevalence of cigarette and e-cigarette use in PATH (Population Assessment of Tobacco and Health) Waves 1 to 4 among prevalent cardiovascular disease.
Wave 1 data were collected from 2013 to 2014, Wave 2 from 2014 to 2015, Wave 3 from 2015 to 2016, and Wave 4 from 2016 to 2018. CVD indicates cardiovascular disease.

time was seen among adults with CVD suggesting that a small number of combustible cigarette users are either increasing e-cigarette use or quitting combustible cigarettes entirely. It is important to note that this study sought to gather information from a broader high-risk population by defining CVD inclusive of MI, HF, and stroke. In contrast, another contemporary study involving patients with MI failed to show a significant predictor of cessation of tobacco products, and the recent diagnosis of MI was not associated with change in the number of cigarettes per day.[19] Previous results indicate that e-cigarette use is not associated with successful tobacco cessation among current and former smokers.[25,26] In contrast, more

Table 3. Transitions of Current Cigarette Smokers With Prevalent CVD* at Wave 1 Through Wave 4

	2014 to 2015	2015 to 2016	2016 to 2018
	(Wave 2)	(Wave 3)	(Wave 4)
	n=672	n=599	n=476
Past 30-D Product Use	(%, 95% CI)	(%, 95% CI)	(%, 95% CI)
Cigarette	76.2 (72.7–79.3)	72.8 (68.4–76.8)	72.1 (67.5–76.25.4)
E-cigarette	1.5 (0.8–2.8)	1.3 (0.6–2.9)	2.3 (1.1–4.7)
Dual-use	12.2 (9.9–15.0)	11.9 (9.2–15.3)	9.6 (6.8–13.4)
Neither	10.1 (7.6–13.4)	14.0 (11.0–17.6)	16.0 (13.0–19.6)
No. of cigarettes used in the past 30 d, weighted mean (SE)	6.2 (0.5)	5.0 (0.4)	7.4 (2.1)
Formal tobacco cessation programs	10.1% (6.5–15.6)	10.8% (6.6–17.3)	11.8% (7.8–17.5)

Numbers (n) presented are unweighted counts of total participants; frequencies are weighted.
Percent (95%, CI) of specific product use was obtained at each wave assessment.
Dual denotes concurrent cigarette and e-cigarette use.
CVD indicates cardiovascular disease.
*Transitions consist of all current cigarette smokers without concurrent e-cigarette use with prevalent cardiovascular disease at Wave 1 (2013–2014) (n=937).

recent analyses have found that the increasing frequency of e-cigarette use is associated with a higher rate of quitting smoking, particularly when accompanied by behavioral support.[27–30] Additionally, a recent study of all adult PATH respondents found every day e-cigarette use to be associated with quitting cigarettes.[31] Our study suggests that the impact of e-cigarettes on helping adults with prevalent CVD quit combustible cigarettes may actually be quite small but further work is needed.

Populations with prevalent CVD should be a focus of public health tobacco cessation efforts. All insurance plans should provide a comprehensive tobacco cessation benefit that enrollees with prevalent CVD can access without barriers (co-payments, prior authorization, limits on treatment duration). Currently, the Centers for Medicare and Medicaid Services provides a total annual benefit covering 2 quit attempts and up to 8 sessions (phone, individual or group).[32] Availability and accessibility of tobacco cessation resources is an important component of a tobacco-free approach for adults with CVD.[33] Unfortunately, enrollment to a formal tobacco cessation program seems to be challenging, as only ≈10% of current cigarette users with existing CVD in our study were using formal cessation counseling and less than one fourth overall successfully quit tobacco use over a period of 4 years. A dose-response relationship exists with higher intensity counseling (length and number of sessions) producing the highest cessation rates.[32] The authors of this study suggest that healthcare reform and public health policies should improve system access and availability of higher intensity of tobacco cessation counseling support for high-risk populations such as those with prior MI, HF, or stroke.

Limitations

There are a number of limitations to our findings. For instance, misclassification of tobacco use and CVD status was possible, as we lacked biomarker quantification of tobacco exposure, and CVD status was based on self-report and was not verified or adjudicated. Another limitation of our study is that because of the relatively few e-cigarette users in the subset of adult PATH respondents with CVD compared with the overall PATH population, our study of adults with CVD was not powered to examine the dose-effects e-cigarette use on the rates of quitting smoking or on the number of cigarettes used, thus the relationship between e-cigarette use and cigarette smoking cessation remains unclear. The analysis of tobacco product use transition was limited to the subset of adults with prevalent CVD at Wave 1, for whom data were available from Waves 2 to 4, probably evaluating a more complaint group. Given the nature of PATH data collection, the heart condition pathologies included in the 'Other CVD' category could not be specified. Finally, the time passed since diagnosis and duration of CVD was not investigated, which likely influences tobacco product transition rates. Additional studies with longer follow-up and variables capturing time since CVD diagnosis will be required to better understand tobacco product transitions within the prevalent CVD population.

CONCLUSIONS

Findings from this study provide important information to estimate the potential impact of future public health efforts targeting tobacco use among adults with prevalent CVD. By examining the rates of tobacco product transition among people living with CVD, and identifying factors associated with tobacco product use, including race/ethnicity, education, and perceptions of harm, our findings may inform communication and outreach programs on which subpopulations with prevalent CVD may benefit most from targeted efforts and smoking cessation tools. As smoking cessation substantially reduces the risk of subsequent CVD events among adults living with CVD,[2,4,5] our findings that more than 1 in 4 adults with CVD were currently using tobacco products and that few quit smoking over a 4-year span support the need for additional smoking cessation campaigns and tools to be available and requires a stronger commitment from a multidisciplinary team (primary care, social worker, psychologist, cardiologist) to provide smoking cessation therapies and counseling to the population with prevalent CVD.

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Disclosures

None.

Supplementary Material

Table S1

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SUPPLEMENTAL MATERIAL

Table S1. Baseline characteristics of current cigarette users without concurrent e-cigarette use among adults with prevalent CVD who did or did not participate in follow-up Waves for the transition analysis.

		Wave 1 Characteristics (N=937)	Adult at wave 1 but not wave 2 (N=265)	Wave 2 (N=672)	P value*	Adult at wave 2 but not wave 3 (N=73)	Wave 3 (N=599)	P value**	Adult at wave 3 but not wave 4 (N=148)	Wave 4 (N=476)	P value***
Age (years)	(1) 1 = 18 to 44 years old	244(22.5)	71 (23.8)	173 (21.9)	0.10	16 (15.5)	157 (22.7)	0.39	32 (17.9)	138 (25.4)	<0.01
	(2) 2 = 44 to 64 years old	488 (53.5)	123 (47.4)	365 (56.0)		38 (59.4)	327 (55.6)		74 (51.8)	263 (56.4)	
	(7) 7 = 65 years old or older	205 (24.0)	71 (28.8)	134 (22.1)		19 (25.1)	115 (21.7)		42 (30.2)	75 (18.2)	
Sex	Male	526 (58.4)	162 (62.6)	364 (56.6)	0.11	42 (65.5)	322 (55.5)	0.11	78 (55.5)	260 (56.6)	0.82
	Female	411 (41.6)	103 (37.4)	308 (43.4)		31 (34.5)	277 (44.5)		70 (44.5)	216 (43.4)	
Race	non-Hispanic White	586 (66.7)	159 (71.3)	427 (65.0)	0.13	46 (67.5)	381 (64.7)	0.37	100 (69.5)	296 (63.0)	0.50
	non-Hispanic Black	161 (18.1)	33 (13.7)	128 (19.8)		11 (13.8)	117 (20.5)		23 (16.0)	97 (21.4)	
	Hispanic	89 (8.4)	21 (6.9)	68 (8.9)		8 (8.0)	60 (9.0)		17 (9.7)	48 (9.1)	
	Other/multi-racial	76 (6.8)	27 (8.0)	49 (6.4)		8 (10.8)	41 (5.8)		8 (4.8)	35 (6.5)	
Education	GED or less	331 (36.9)	100 (41.0)	231 (35.2)	0.36	26 (36.6)	205 (35.1)	0.47	58 (38.2)	155 (34.1)	0.82
	High school diploma	224 (27.7)	65 (27.8)	159 (27.7)		22 (33.0)	137 (27.0)		32 (26.0)	111 (27.4)	
	Some college	297 (28.3)	75 (25.5)	222 (29.4)		22 (25.9)	200 (29.9)		46 (28.9)	164 (30.3)	
	Bachelor's degree	78 (7.1)	18 (5.7)	60 (7.7)		3 (4.5)	57 (8.1)		12 (7.0)	46 (8.2)	
Poverty level	Below poverty	384 (43.4)	88 (47.5)	296 (42.3)	0.23	33 (43.6)	263 (42.1)	0.83	69 (43.3)	206 (41.7)	0.75
	At or near poverty	264 (31.0)	48 (25.2)	216 (32.6)		23 (34.4)	193 (32.4)		48 (34.1)	153 (32.1)	
	200% above poverty	204 (25.6)	44 (27.4)	160 (25.1)		17 (22.0)	143 (25.5)		31 (22.6)	117 (26.2)	
US Region	Northeast	145 (17.4)	46 (20.2)	99 (16.2)	0.11	13 (17.9)	86 (16.0)	0.25	16 (12.6)	72 (16.7)	0.64
	Midwest	241 (24.1)	56 (19.8)	185 (25.8)		11 (14.5)	174 (27.2)		48 (29.7)	129 (25.5)	
	South	403 (43.1)	124 (46.4)	279 (41.8)		36 (49.8)	243 (40.8)		56 (39.1)	199 (41.7)	
	West	148 (15.4)	39 (13.6)	109 (16.2)		13 (17.8)	96 (16.0)		28 (18.7)	76 (16.0)	
CVD risk factors	Hypertension	531 (58.8)	140 (56.7)	391 (59.6)	0.47	44 (61.1)	347 (59.5)	0.80	87 (59.7)	273 (59.2)	0.91
	Diabetes	291 (32.2)	68 (26.2)	223 (34.7)	0.03	25 (34.5)	198 (34.7)	0.96	55 (38.8)	149 (33.0)	0.19
	Obesity	304 (32.6)	61 (24.5)	243 (35.9)	<0.01	18 (24.6)	225 (37.3)	0.06	50 (31.4)	181 (38.6)	0.06
	High cholesterol	445 (49.5)	112 (44.5)	333 (51.6)	0.08	41 (53.3)	292 (51.4)	0.76	73 (51.6)	231 (51.0)	0.89

	Family history	465 (50.8)	106 (43.5)	359 (53.6)	<0.01	36 (46.7)	323 (54.5)	0.28	77 (51.9)	261 (55.2)	0.51
Smoking harm belief	Smoking can cause heart disease in smokers	877 (93.7)	246 (94.2)	631 (93.5)	0.67	68 (92.7)	563 (93.6)	0.76	140 (96.0)	446 (92.8)	0.20
E-cigarette harmfulness belief	E-cigs < cigarettes	377 (47.9)	105 (48.1)	272 (47.8)	0.83	30 (47.0)	242 (47.9)	0.83	28 (46.4)	230 (48.9)	0.34
	E-cigs ~ cigarettes	341 (43.1)	87 (42.0)	254 (43.6)		29 (46.3)	225 (43.2)		26 (40.3)	208 (43.3)	
	E-cigs > cigarettes	74 (9.0)	22 (9.9)	52 (8.6)		4 (6.7)	48 (8.9)		10 (13.3)	38 (7.8)	

*p value for comparison of baseline characteristics between adult at wave 1 but not wave 2 and wave 2

**p value for comparison of baseline characteristics between adult at wave 2 but not wave 3 and wave 3

***p value for comparison of baseline characteristics between adult at wave 3 but not wave 4 and wave 4

Table S1 has only the adults at each wave who participated in all previous wave studies and excludes the adults who were missed between waves.