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Using the emergency department to investigate smoking in young adults

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ABSTRACT

Purpose: Smoking in young adults identifies the population at risk for future tobacco-related disease. We investigated smoking in a young adult population and within high-risk groups using emergency department (ED) data in a metropolitan area.
Methods: Using the electronic health record, we performed a retrospective study of smoking in adults aged 18–30 years presenting to the ED.
Results: Smoking status was available for 55,777 subjects (90.9% of the total ED cohort); 60.8% were women, 55.0% were black, 35.3% were white, and 8.1% were Hispanic; 34.4% were uninsured. Most smokers used cigarettes (95.1%). Prevalence of current smoking was 21.7% for women and 42.5% for men. The electronic health record contains data about diagnosis and social history that can be used to investigate smoking status for high-risk populations. Smoking prevalence was highest for substance use disorder (58.0%), psychiatric illness (41.3%) and alcohol use (39.1%), and lowest for pregnancy (13.5%). In multivariable analyses, male gender, white race, lack of health insurance, alcohol use, and illicit drug use were independently associated with smoking. Smoking risk among alcohol and drug users varied by gender, race, and/or age.
Conclusions: The ED provides access to a large, demographically diverse population, and supports investigation of smoking risk in young adults.

Introduction

The demographics of cigarette smoking in the United States have shifted from a peak prevalence of approximately 80% among men born in the first half of the 20th century [1,2] to a more heterogeneous distribution influenced by gender, race and ethnicity, socioeconomic status, and education [3]. Smoking has almost been eliminated in some populations (e.g., physicians, graduate degree) yet a high burden of cigarette use persists in other demographic groups (e.g., low socioeconomic status, limited education). Surveillance of smoking in younger adults is important for tobacco control efforts as most cigarette smoking begins by age 21 years and nearly all smoking begins before age 30 years [4]. Telephone surveys remain the major source of data about adult smoking behaviors and form the basis of national estimates and trends reported by the Centers for Disease Control. However, changes in communication technology over the past decade and decreasing response rates have introduced uncertainty into smoking prevalence estimates [5,6]. In addition, telephone surveys are prone to sampling bias in small geographic areas [7] and may underestimate smoking prevalence in high-risk populations [8]. Complementary methods to assess smoking in young adult populations are needed.

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Health care providers frequently assess adults for smoking during medical visits, and data entered into an electronic health record (EHR) provides demographic information and medical diagnoses that can be used for surveillance of population health [9]. Emergency department (ED) use has increased over the past decade [10], and approximately 15% of young adults report an ED visit in the previous year [11]. Presentation to an ED is influenced by the need for urgent treatment and by limited access to outpatient care, and the ED evaluates a diverse population including uninsured patients [12]. The purpose of this study is to determine whether ED visits capture data for a large sample of young adults that can be used to investigate smoking risk. We report the tobacco smoking prevalence for adults ages 18–30 presenting for emergency care in a metropolitan area over a 4-year period (2013–2016), and investigate the relationship between smoking prevalence and patient sociodemographic variables and ED diagnoses.

Methods

Study population and setting

We performed a retrospective study using data retrieved by query of the EHR for five EDs within U.S. Census-defined metropolitan New Orleans (New Orleans–Metairie, LA) using Oracle SQL Developer (Oracle Corp., Redwood Shores, CA). All five ED sites were part of one integrated health system (Ochsner Health System) and used a shared EHR (Epic) deployed in July 2012. Institutional review board approval was obtained from Ochsner Health System and Louisiana State University Health Sciences Center in New Orleans before beginning the study. Data were retrieved for the first visit for each subject age 18–30 years to one of these five EDs between January 2013 and December 2016. Subjects with available smoking status data at the first visit were included in the study population.

To estimate the percentage of the target population assessed during the study, we used U.S. Census data. Data from the U.S. Census were retrievable for a predefined age group (18–24 years) that overlaps with our study population. We determined the number of study subjects who were 18–24 years old in 2013 and compared this subpopulation with the U.S. Census estimate for the closest year (2015) by gender and race/ethnicity for metropolitan New Orleans (https://factfinder.census.gov).

Study variables

Smoking status for each subject was recorded in the EHR by nursing or provider staff according to routine clinical practice on or before the date of the ED visit. Primary type of tobacco product used by smokers was categorized as cigarette, cigar, or pipe. Vaping was not a categorical choice in the EHR until November 2016 and is not reported in this study. Smoking status was defined from EHR categories as daily smoker, some-day smoker, former smoker, never smoker, or unknown. Fewer than 1% were assigned other descriptions of smoking status in the structured format, and these categories were reported as follows: heavy tobacco smoker = current every day smoker, smoker, current status unknown = current every day smoker, and light tobacco smoker = current some day smoker. Current smokers were defined as daily or some-day smokers.

Demographic data included self-identified gender, age at the time of visit, race/ethnicity (white non-Hispanic, black non-Hispanic, Hispanic, or other), marital status, religion, health insurance status, and assignment to a primary care provider. Presence or absence of current alcohol or illicit drug use (yes/no) was self-reported in response to unscripted questioning. Health insurance status was determined for a subpopulation of study subjects age 18–24 years to allow comparison with available U.S. Census data. Insurance status for all men and women aged 18–24 years in the metropolitan New Orleans was retrieved from the U.S. Census (https://factfinder.census.gov) for 2013–2016 and used to estimate the percentage of uninsured by gender during the study period.

The primary diagnosis ICD9/10 code for each ED visit was documented by the emergency medicine provider at the time of discharge from the ED or admission to the hospital. For each primary diagnosis, the ICD9/10 code was converted to the text descriptor and assigned to one of 14 diagnosis categories (Online Supplement, Appendix). The ED diagnosis was categorized for more than 99% of subjects.

Statistical analyses

The participants' demographic information and medical diagnosis category by current smoking status were summarized using descriptive statistics and compared using the χ^2 test. The primary outcome was the binary current smoking status (yes/no). We used unadjusted and adjusted multivariable logistic regression models to examine the associations between current smoking status and our demographic covariates of interest.

Among potential predictors, we investigated three risk factors further: two self-reported behaviors (alcohol use and illicit drug use) and substance use disorder based on ICD codes. We determined whether the strength and direction of the associations between these predictors of interest and current smoking status differed by age, gender, and/or race/ethnicity subgroups by performing interaction analyses. For addressing multiple comparisons for interaction analyses, the significance level of 0.006 (=0.05/9) was applied based on the Bonferroni method. For those with a significant interaction ($P < .006$), multivariable logistic regressions were applied separately to evaluate an interaction of each behavioral/psychiatric risk factor and one demographic predictor, adjusting for all covariates listed in Table 1. The *P*-values, odds ratios (ORs) and their 95% confidence intervals (CIs) are reported for each model. All statistical tests were two-sided with statistical significance defined as a *P*-value < .05. All statistical analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, NC).

Results

Cohort derivation

Between January 1, 2013, and December 31, 2016, 61,336 adults age 18–30 years living in metropolitan New Orleans made at least one visit to one of five local EDs. Smoking status was available for the first ED visit for 55,777 subjects (90.9%), and these subjects form the basis of this report. For 97% of subjects, social history including smoking status was confirmed in the EHR on the date of the ED visit. Using U.S. Census data, we estimate that 29% of the adult population aged 18–24 years in metropolitan New Orleans presented to at least one of the five EDs between 2013 and 2016 and had smoking status documented. The percentage of population sampled varied by gender and race/ethnicity: 17%, 17%, and 26% for white, Hispanic, and black men, and 24%, 28%, and 41% for white, Hispanic, and black women, respectively.

Cohort demographics

Sixty-one percent of subjects were women, 55.0% of subjects were black non-Hispanic, 35.3% were white non-Hispanic and 8.1% were Hispanic (Table 1). Most subjects were not married (83%). Religious affiliation was 68.1% Christian, 2.3% other, 24.1% none, and 5.5% unknown. A primary care provider was documented for 46.9% of the cohort. Alcohol use was reported by 40.0% of subjects and

Table 1
Demographic and behavioral characteristics and current smoking status

Characteristics*	N (%)	Current smoking %	Smoking status, row %			
			Current		Not current	
			Daily	Some day	Former	Never
Gender						
Female	33,922 (60.8)	21.7	16.9	4.8	5.9	72.4
Male	21,855 (39.2)	42.5	34.0	8.5	6.0	51.5
Age, y						
18–21	16,248 (29.1)	23.0	17.3	5.7	4.3	72.7
22–25	17,810 (31.9)	31.2	24.6	6.6	6.3	62.5
26–30	21,719 (38.9)	33.8	27.5	6.3	6.9	59.3
Race/ethnicity						
White	19,671 (35.3)	38.7	32.1	6.6	8.2	53.1
Black	30,660 (55.0)	25.9	19.9	6.0	4.8	69.2
Hispanic	4514 (8.1)	18.9	12.9	6.0	4.2	76.9
Other	899 (1.7)	22.9	16.8	6.1	4.9	72.2
Marital status						
Single	46,293 (83.0)	30.5	24.0	6.5	5.6	63.9
Married/significant other	8516 (15.3)	24.6	19.6	5.0	7.8	67.6
Divorced/separated/widowed	869 (1.6)	46.1	40.0	6.1	7.9	45.9
Others/unknown	99 (0.2)	29.3	24.2	5.1	4.0	66.7
Religion						
Baptist	15,950 (28.6)	27.1	21.2	5.9	5.0	67.9
Catholic	9883 (17.7)	29.0	22.8	6.2	6.7	64.2
Other Christian	12,141 (21.8)	29.7	23.6	6.1	6.3	64.1
Other religion	1300 (2.3)	28.1	21.5	6.6	6.1	65.9
No religion	13,456 (24.1)	35.0	28.3	6.7	6.4	58.6
Unknown/refused	3047 (5.5)	22.0	19.7	2.3	5.1	69.0
Health insurance						
Commercial	18,457 (33.2)	22.2	16.1	6.1	6.9	70.9
Medicaid	14,454 (26.0)	25.7	20.7	5.0	6.1	68.2
Other	3604 (6.5)	23.5	17.5	6.0	6.6	69.9
Uninsured	19,141 (34.4)	41.5	34.2	7.3	4.9	53.7
Primary care provider						
Yes	26,179 (46.9)	23.2	17.8	5.4	6.6	70.2
No	29,598 (53.1)	35.7	28.8	6.9	5.4	58.9
Alcohol use						
No	30,989 (55.6)	23.1	19.1	4.0	5.3	71.6
Yes	22,301 (40.0)	39.1	29.8	9.3	7.0	53.8
Unknown	2487 (4.5)	30.5	24.1	6.4	4.6	64.9
Illicit drug use						
No	37,967 (68.1)	25.0	19.7	5.3	6.2	68.7
Yes	4867 (8.7)	61.1	48.9	12.2	7.3	31.6
Unknown	12,943 (23.2)	32.1	25.5	6.6	4.8	63.2

* χ^2 $P < .0001$ for testing association between current smoking status (yes/no) with each predictor.

illicit drug use was reported by 8.7%. Alcohol use and drug use status were unknown for 4.5% and 23.2%, respectively. Thirty-four percent of subjects in our study had no health insurance. For subjects aged 18–24 years, 47% of men presenting to the ED were uninsured, compared with 31% of men in this age group overall in the same metropolitan area. For women, 29% presenting to the ED were uninsured, compared with 23% for this age group based on the U.S. Census data. For patients not included in the study, because smoking status was not documented, demographics were similar with the exception of a higher proportion of uninsured (44% vs. 34%) and lower proportion with a primary care provider (Online Supplement, Table A). As expected, there were low rates of documentation for other social history components (alcohol use, illicit drug use) when tobacco status was unknown.

Tobacco use prevalence

The primary tobacco product used was documented for 29.8% of current smokers, of whom 95.1% reported cigarette, 4.7% cigar, and less than 1% pipe smoking. The overall prevalence of current smoking was 21.7% for women and 42.5% for men. Prevalence of current smoking varied by gender, age, and race/ethnicity and was highest for white men (47.2%) and lowest for Hispanic women (10.4%) (Fig. 1).

Sociodemographic predictors of smoking

Gender, age, race/ethnicity, marital status, religion, health insurance, primary care provider, alcohol use, and illicit drug use each correlated with smoking prevalence in univariate and multivariable analyses (Table 2). Male gender was associated with higher odds of smoking than female gender (OR = 2.21). Nonwhite race/ethnicity was associated with a lower odds of smoking than white, with an OR = 0.42 for black and OR = 0.24 for Hispanic subjects. Compared with commercial insurance, the risk of smoking was increased for uninsured (OR = 2.94) and Medicaid-insured subjects (OR = 2.50). Smoking prevalence was higher for single (OR = 1.33) or divorced/separated (OR = 2.12) adults compared with married adults. Subjects with no religious affiliation had similar smoking risk compared with those reporting a Christian religion (OR = 1.05), whereas subjects reporting other religious affiliation had lower smoking risk (OR = 0.74).

ED diagnoses associated with smoking

Trauma, acute infection, musculoskeletal, gastrointestinal, and genitourinary diagnoses were the most common ED diagnosis categories and comprised 62.3% of all ED diagnoses (Table 3). Primary psychiatric and substance use disorder diagnoses were 2.2% and 0.9% of all ED diagnoses, respectively. Pregnancy-related diagnoses were 8.9% of all ED diagnoses for women. Among ED diagnosis categories, the prevalence of current smoking was highest for subjects presenting with substance use disorder (58.0%) and psychiatric diagnoses (41.3%), and lowest for women evaluated for diagnoses related to pregnancy (13.5%). Compared with ED visits for trauma, subjects with ED visits for substance use disorder, psychiatric, musculoskeletal, and head and neck diagnoses are more likely to be current smokers, whereas subjects with ED visits for neurologic, cardiovascular, and pregnancy-related diagnoses are less likely to be current smokers (Table 4).

Effect modification of smoking status by sociodemographic factors in high-risk groups

We were interested in testing the hypothesis that impact of high-risk behaviors (alcohol use, illicit drug use, and substance use disorder) on smoking differs by age, gender, and race status. The significant levels of the interactions of one of the selected risk behavior variables and one of the selected sociodemographic factors are summarized in the Online Supplement, Table B. Among nine testing interactions, the interactions of race-alcohol use, gender-illicit drug use, age-alcohol use, and age-illicit drug use were significant ($P < .006$). As shown in Table 5(a), the magnitude of association between alcohol use and current smoking was higher in Hispanics compared with the other race groups (Hispanic adjusted OR = 3.60, non-Hispanic white OR = 1.52 and non-Hispanic black OR = 1.99). In addition, among those with illicit drug use, we observed a higher odds of smoking for females than males (Table 5(b), OR = 4.49 vs. 2.81). As shown in Table 5(c), age modified the effect of alcohol use and illicit drug use on smoking. For alcohol users, the highest risk of smoking was found in the youngest age subgroup (OR = 2.56, 1.78 and 1.56 for age 18–21, 22–25, 26–30 years, respectively). For subjects with illicit drug use, subjects with the youngest age also had a higher risk of current smoking than the

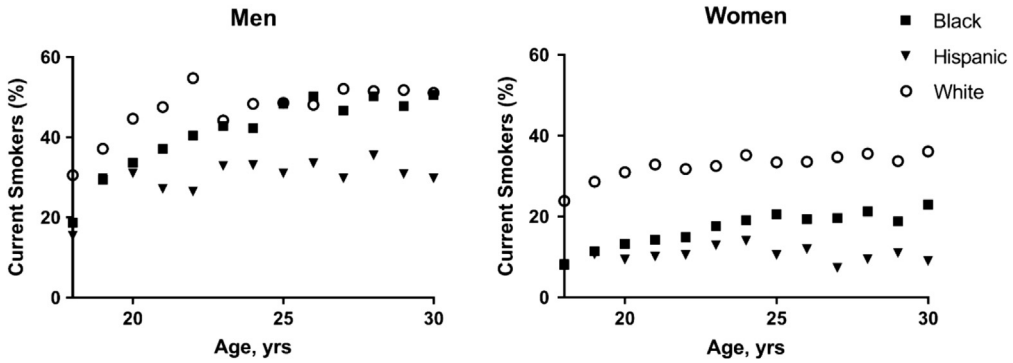

Fig. 1. Prevalence of current smoking by gender, age, and race/ethnicity for all subjects.

other two older age groups (OR = 3.87, 3.19 and 3.13 for age 18–21, 22–25, 26–30 years, respectively).

Discussion

Current telephone surveys provide smoking data for states and regions of the country, but do not support detailed analyses in subpopulations defined demographically, socioeconomically, or geographically because of limited sample size [13]. The EHR contains smoking data collected to meet government standards (Meaningful Use), and may be used to estimate overall smoking prevalence [14]. In New York City, EHR data yielded results comparable with established survey data [9] and findings were consistent across different EHR platforms [15]. Our study extends this approach and demonstrates the feasibility of using the ED for assessment of tobacco smoking in young adults. We found that ED care provided EHR documentation for a large cohort of young adults, with nearly one-third of the local population presenting during the 4-year study interval.

Thirty percent of our ED cohort were current smokers, similar to smoking rates for adults aged 18–34 years reported in the Behavioral Risk Factor Surveillance Survey (BRFSS) for Louisiana in 2013 (29%) [16]. Consistent with national surveys, we observed the highest prevalence of smoking among white men and the lowest prevalence for Hispanic women [3]. The prevalence of current smoking for white men and black men in our study exceeded 50% by age 25 years, higher than reported for Louisiana in the BRFSS [16]. We also observed that smoking prevalence for black men at age 25 years was twice that observed for age 18 years, suggesting decreasing smoking prevalence among the youngest black men and/or later adoption of smoking [17,18]. Smoking prevalence for black women was less than half of that observed for white women, a larger difference by race/ethnicity for women than is reported nationally [3]. Smoking in the U.S. Hispanic populations varies by country of origin [19] and was lower for Hispanic than black or white subjects in our study. Married subjects had a lower prevalence of smoking compared with single or divorced/separated subjects, consistent with other population-based studies [20]. The effect of religion on smoking varies by religion [21] and observance [22]. Self-reported religious affiliation was not associated with decreased smoking prevalence for Christian religion in our study, but was associated with decreased smoking prevalence for non-Christian religions as a group. We observed the highest smoking prevalence by insurance status in uninsured and Medicaid-insured subjects, consistent with national surveys [3]. Multivariable analyses confirmed the smoking risks associated with gender, race/ethnicity, marital status, religion, and insurance status.

Several diagnoses are strongly associated with smoking, including psychiatric diseases (schizophrenia, bipolar illness) [23] and substance use disorder [24]. When these conditions were the primary ED diagnosis in our study, we observed the expected association with higher smoking prevalence. By contrast, the lowest smoking prevalence by diagnosis was observed for women evaluated for pregnancy and was similar to national rates reported for

Table 2
Odds ratios of current smoking status for the demographic and behavioral characteristics

Characteristics	Univariate model	Multivariable model[†] (n = 55,542)
	OR (95% CI)[*]	OR (95% CI)[*]
Gender		
Female	1	1
Male	2.67 (2.57, 2.77)[‖]	2.21 (2.12, 2.31)[‖]
Age, y		
18–21	1	1
22–25	1.52 (1.44, 1.59)[‖]	1.53 (1.45, 1.62)[‖]
26–30	1.71 (1.63, 1.79)[‖]	1.79 (1.69, 1.88)[‖]
Race/ethnicity		
White	1	1
Black	0.55 (0.53, 0.58)[‖]	0.42 (0.40, 0.44)[‖]
Hispanic	0.37 (0.34, 0.40)[‖]	0.24 (0.22, 0.27)[‖]
Other	0.47 (0.40, 0.55)[‖]	0.48 (0.41, 0.58)[‖]
Marital status		
Married/significant other	1	1
Single	1.34 (1.27, 1.42)[‖]	1.33 (1.25, 1.41)[‖]
Divorced/separated/ widowed/others	2.60 (2.25, 2.99)[‖]	2.12 (1.81, 2.48)[‖]
Religion		
Christian	1	1
Other religion	0.98 (0.87, 1.11)	0.74 (0.64, 0.85)[‖]
No religion	1.36 (1.30, 1.41)[‖]	1.05 (1.01, 1.11)[‡]
Unknown/refused	0.88 (0.81, 0.96)[§]	0.78 (0.71, 0.86)[‖]
Health insurance		
Commercial	1	1
Medicaid	1.22 (1.16, 1.28)[‖]	2.50 (2.35, 2.66)[‖]
Other	1.08 (0.99, 1.17)	1.20 (1.10, 1.31)[‖]
Uninsured	2.49 (2.38, 2.60)[‖]	2.94 (2.79, 3.10)[‖]
Primary care provider		
Yes	1	1
No	1.83, (1.77, 1.90)[‖]	1.31 (1.26, 1.37)[‖]
Alcohol use		
No	1	1
Yes	2.15 (2.07, 2.23)[‖]	1.83 (1.75, 1.91)[‖]
Unknown	1.47 (1.34, 1.60)[‖]	1.18 (1.07, 1.30)[§]
Illicit drug use		
No	1	1
Yes	4.69 (4.41, 4.99)[‖]	3.40 (3.17, 3.64)[‖]
Unknown	1.41 (1.35, 1.47)[‖]	1.30 (1.24, 1.37)[‖]

[*] Odds ratio (95% confidence interval) based on logistic regression.
[†] Adjusted for all factors listed in Table 1 and primary medical diagnosis of emergency department visit.
[‡] $P < .05$.
[§] $P < .01$.
[‖] $P < .001$.

Table 3
Current smoking status by primary medical diagnosis of emergency department visit

Diagnosis*	Total (%)	Smoking status, row %				
		Current	Current		Not current	
			Daily	Some day	Former	Never
Trauma	8236 (14.8)	32.6	25.7	6.9	5.1	62.4
Acute infection	6939 (12.4)	31.2	24.7	6.5	5.8	63.0
Musculoskeletal	6732 (12.1)	32.5	26.0	6.5	5.1	62.4
Gastrointestinal	6692 (12.0)	27.8	21.8	6.0	6.2	66.1
Genitourinary	6161 (11.1)	26.7	20.9	5.8	5.7	67.6
Other	4984 (8.9)	30.9	24.2	6.7	6.4	62.7
Head and neck	4933 (8.8)	32.4	26.5	5.9	5.2	62.4
Respiratory	3072 (5.5)	28.3	22.4	5.9	8.1	63.5
Pregnancy	3005 (5.4)	13.5	10.4	3.1	8.8	77.8
Dermatologic	1700 (3.1)	29.9	23.2	6.7	5.3	64.8
Psychiatric	1222 (2.2)	41.3	33.7	7.6	7.6	51.1
Neurologic	949 (1.7)	24.4	17.1	7.3	6.6	69.0
Cardiovascular	633 (1.1)	22.5	17.9	4.6	6.8	70.8
Substance use disorder	514 (0.9)	58.0	47.9	10.1	4.5	37.6

* χ^2 $P < .0001$ for testing association between current smoking status (yes/no) with diagnosis.

this population [25]. Further analysis of high-risk groups in our study suggested that among those who reported illicit drug use, women were at higher risk of smoking than men, and younger adults had the highest risk of smoking. For those subjects who reported alcohol use, current smoking varied by race/ethnicity and age, with the highest risk observed among Hispanic and younger adults.

Data about the representativeness of ED-based assessment of smoking prevalence for the general population are conflicting. In a large study of tobacco use among ED patients in northern Canada, smoking prevalence was higher than national survey estimates but matched regional estimates [26]. By contrast, smoking rates exceed other relevant population estimates in smaller samples from urban EDs [27–29]. Most patients report that they seek care in the ED because of the seriousness of their condition, whereas others report limited access to clinics and/or lack of insurance [12]. ED populations may be enriched for cigarette smokers if the decision to seek care is linked to diagnoses exacerbated by smoking (e.g., asthma exacerbations or bronchitis) or smoking-related diseases. In our study, however, the respiratory diagnosis category was not associated with increased smoking risk, likely because of the delayed onset of symptoms for most tobacco-related lung diseases. Cigarette smokers may also be over-represented in ED populations because smoking prevalence is higher among uninsured populations [3]. However, our large sample supported analyses within demographic categories including insurance status.

Table 4
Odds ratios of current smoking status for primary medical diagnosis of emergency department visit

Diagnosis	Univariate model OR (95% CI)*	Multivariable model† (n = 55,542) OR (95% CI)*
Trauma	1	1
Acute infection	0.94, (0.88, 1.01)	1.07 (0.99, 1.15)
Musculoskeletal	1.00, (0.93, 1.07)	1.12 (1.04, 1.21)§
Gastrointestinal	0.80, (0.74, 0.86)‖	0.97, (0.89, 1.05)
Genitourinary	0.75, (0.70, 0.81)‖	0.99 (0.91, 1.07)
Other	0.93, (0.86, 1.00)‡	0.97, (0.90, 1.06)
Head and neck	1.00, (0.92, 1.07)	1.15, (1.06, 1.25)§
Respiratory	0.82, (0.75, 0.90)‖	0.94, (0.85, 1.04)
Pregnancy	0.32, (0.29, 0.36)‖	0.63, (0.56, 0.71)‖
Dermatologic	0.89, (0.79, 0.99)‡	0.97, (0.86, 1.10)
Psychiatric	1.46, (1.29, 1.65)‖	1.46, (1.27, 1.68)‖
Neurologic	0.67, (0.57, 0.78)‖	0.77, (0.65, 0.92)§
Cardiovascular	0.60, (0.49, 0.73)‖	0.61, (0.49, 0.75)‖
Substance use disorder	2.86, (2.38, 3.42)‖	1.41, (1.14, 1.74)§

* Odds ratio (95% confidence interval) based on logistic regression.
† Adjusted for all factors listed in Table 1.
‡ $P < .05$.
§ $P < .01$.
‖ $P < .001$.

Table 5
Subgroup analyses for the selected factors on current smoking status

(a) strength and direction of the association between alcohol use and current smoking by race/ethnicity subgroups

Alcohol use	Race/Ethnicity		
	White (n = 19,601) OR (95% CI)*	Black (n = 30,583) OR (95% CI)*	Hispanic (n = 4491) OR (95% CI)*
No	1	1	1
Yes	1.52 (1.42, 1.62)§	1.99 (1.88, 2.11)§	**3.60 (3.03, 4.28)**§
Unknown	0.99 (0.84, 1.15)	1.32 (1.15, 1.52)‡	1.57 (1.05, 2.34)†

(b) Strength and direction of the association between illicit drug use and current smoking by gender subgroups

Illicit drug use	Gender	
	Female (n = 33,796) OR (95% CI)*	Male (n = 21,751) OR (95% CI)*
No	1	1
Yes	**4.49 (4.05, 4.99)**§	2.81 (2.57, 3.07)§
Unknown	1.37 (1.28, 1.47)§	1.23 (1.15, 1.32)§

(c) Strength and direction of the associations between alcohol, illicit drug use and current smoking by age subgroups

Characteristics	Age		
	18–21 (n = 16,181) OR (95% CI)*	22–25 (n = 17,740) OR (95% CI)*	26–30 (n = 21,626) OR (95% CI)*
Alcohol Use			
No	1	1	1
Yes	**2.56 (2.34, 2.80)**§	1.78 (1.66, 1.92)§	1.56 (1.46, 1.67)§
Unknown	1.07 (0.88, 1.30)	1.39 (1.16, 1.66)§	1.16 (0.99, 1.37)
Illicit Drug Use			
No	1	1	1
Yes	**3.87 (3.43, 4.35)**§	3.19 (2.83, 3.59)§	3.13 (2.78, 3.52)§
Unknown	1.23 (1.11, 1.36)§	1.36 (1.25, 1.48)§	1.30 (1.20, 1.40)§

The highest odds ratio in each subgroup analysis is in bold.
* Odds ratio (95% confidence interval) based on multivariable logistic regression adjusting for all predictors listed in Table 1.
† $P < .05$.
‡ $P < .01$.
§ $P < .001$.

Direct comparison between our approach and established surveillance methods is limited by the relatively small sample size available from telephone surveys. The annual BRFSS telephone survey, a primary source for CDC smoking prevalence estimates, collected smoking data for 597 subjects aged 18–30 years in the same metropolitan area between 2013 and 2016, compared with 55,777 subjects in our study (https://www.cdc.gov/brfss/smart/smart_data.htm). Importantly, an unbiased standard is not available to determine the representativeness of EHR and telephone-based approaches in small geographic areas. We are unable to exclude a bias for increased emergency department use by smokers for reasons not explained by the variables included in our model, and suggest that our approach is complementary to traditional survey methods.

Limitations of this study include reliance on routine assessment and documentation of smoking status by nurses and providers at the point of care. The introduction of a new EHR in our health care system was accompanied by selection of smoking status from a structured menu for 91% of our study population. Nearly all subjects

had EHR documentation of social history review including smoking status at the time of the ED visit. However, data quality in the EHR depends significantly on the accuracy of documentation, and studies of longitudinal smoking data collection in established EHRs [30] and complex smoking documentation schemes within EHRs [31] have identified important challenges. For our study, use of a recently implemented EHR with a structured smoking data field and a cross-sectional study design increased the likelihood of tobacco assessments that were recent or synchronous with the ED visit. The outcome variable selected for our multivariable models (current smoking) limited the effect of misclassification (daily vs. some day smokers) on our analyses. Another limitation of our study is reliance on EHR documentation for other self-reported social history (alcohol and illicit drug use) and demographics, as these data are not subject to stringent quality assessments applied to prospective studies [32]. Whether there was a difference in the quality of smoking data among defined subgroups in this study is unknown.

Health system-based data plays an increasing role in population health, and can provide a continuous assessment of major disease burdens, including smoking, obesity, [9] and other chronic conditions [33]. We found that patient assessments in the ED can provide data for a large cross-section of the young adult population, including subjects with limited access to routine health screening. Smoking surveillance in young adults using the EHR complements currently available telephone surveys, is less resource intensive, and may guide local, targeted public health interventions. In addition, data available through the EHR can support investigation of the spatial epidemiology of smoking [34] and may provide a platform for longitudinal assessment of the smoking burden in high-risk populations.

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Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.annepidem.2018.11.007.

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Appendix

Online Supplement, Table A
Demographic characteristics for patients without smoking status (n = 5559)

Characteristics	N (%)
Gender	
Female	3064 (55.1)
Male	2495 (44.9)
Age	
18–21 y	1645 (29.6)
22–25 y	1836 (33.0)
26–30 y	2078 (37.4)
Race/ethnicity	
White	1689 (30.4)
Black	3311 (59.6)
Hispanic	486 (8.8)
Other	71 (1.3)
Marital status	
Single	4814 (86.6)
Married/significant other	648 (11.7)
Divorced/separated/widowed	68 (1.2)
Others/unknown	29 (0.5)
Religion	
Baptist	1664 (29.9)
Catholic	781 (14.1)
Other Christian	1058 (19.0)
Other religion	125 (2.3)
No religion	1556 (28.0)
Unknown/refused	375 (6.7)
Health insurance	
Commercial	1432 (25.9)
Medicaid	1372 (24.8)
Other	273 (4.9)
Uninsured	2460 (44.4)
Primary care provider	
Yes	1999 (36.0)
No	3560 (64.0)
Alcohol use	
No	442 (8.0)
Yes	308 (5.5)
Unknown	4809 (86.5)
Illicit drug use	
No	351 (6.3)
Yes	89 (1.6)
Unknown	5119 (92.1)

Online Supplement, Table B
Interactions of the selected risk behaviors and demographic factors associated with current smoking status

Interaction	*P*-value*
Race/ethnicity*alcohol use	**<.001**
Race/ethnicity*illicit drug use	.031
Race/ethnicity*substance use Disorder	.066
Gender*alcohol	.095
Gender*illicit drug use	**<.001**
Gender*substance use disorder	.029
Age*alcohol use	**<.001**
Age*illicit drug use	**.001**
Age*substance use disorder	.030

* Based on logistic regression with the main effects of the selected risk behavior and demographic factors adjusted for all factors listed in Table 1. The subgroup analyses (Table 5) were performed for the top four interactions (in bold).