



Factors associated with smoking cessation attempts in a public, safety-net primary care system

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ABSTRACT

Smoking cessation rates are low in safety-net settings. We conducted a retrospective analysis using electronic health record (EHR) data on adults with at least three primary care visits from 2016 to 2019 in the San Francisco Health Network (SFHN), a network of clinics serving publicly insured and uninsured San Francisco residents. We used multivariable regression to identify factors associated with 1) any cessation attempt, defined as smoking status change from “current smoker” at the index visit to “former smoker” at visit 2 or 3, and 2) a sustained cessation attempt, defined as smoking status change from “current smoker” at the index visit to “former smoker” at visits 2 and 3. We identified 7,388 adults currently smoking at the index visit; 26% (n = 1,908) made any cessation attempt, and 9% (n = 650) made a sustained cessation attempt. Factors associated with greater odds of any and sustained cessation attempts included Latinx/Hispanic ethnicity, American Indian/Alaskan Native race, and Spanish as the primary language. Meanwhile, older age, Medicaid insurance, and Chinese (i.e., Cantonese/Mandarin) as the primary language were associated with lower odds of both outcomes. Patient factors such as older age, Medicaid insurance, and speaking Chinese represent targets for improving cessation rates. Targeting interventions for these specific factors could further improve smoking cessation rates for lower cessation groups.

1. Introduction

Despite longstanding efforts to reduce tobacco use in the United States (US), smoking remains a leading cause of preventable death. (United States Surgeon General, 2014) The prevalence of smoking and burden of tobacco-caused diseases are disproportionately high in individuals with low socioeconomic status, mental illness, and communities of color. (Jamal et al., 2018; Weinberger et al., 2018) Safety-net health systems, comprised of publicly funded clinics, are the primary source of health care for uninsured or publicly insured populations at low or no cost. These systems providing care for populations with high smoking rates are uniquely poised to provide free smoking cessation services, such as cessation counseling and pharmacotherapy, though many competing priorities and limited resources make providing cessation care challenging.

Our prior work explored enablers of and barriers to delivery of cessation services within a subset of safety-net clinics. (Gubner et al., 2019) We found that competing priorities among clinic staff and the lack of care coordination made delivery of cessation counseling difficult. Ancillary clinic staff who were trained in cessation counseling (e.g., behavioral assistants) were not able to meet the demands of “warm hand offs” for counseling (where providers directly referred patients to behavioral assistants for smoking cessation counseling during the clinical encounter), leading to rescheduled visits with low follow up. (Gubner et al., 2019) Less is known about patient factors associated with smoking cessation attempts for patients who receive care in safety-net settings. Studies have shown factors linked to lower socioeconomic status like education, income, or unemployment are associated with higher smoking relapse rates among those attempting to quit, (Foulds et al., 2006; Fernández et al., 2006; Ma et al., 2015) though more data

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are needed on other patient-level factors to augment cessation care.

This study expands on prior work by identifying factors associated with smoking cessation attempts and delineating subpopulations that may benefit from more intensive efforts within the San Francisco Health Network (SFHN). The SFHN is the largest network of safety-net primary care and subspecialty health clinics serving publicly insured and uninsured patients in San Francisco. In recent years, the SFHN has undertaken quality improvement initiatives to improve cessation care. The objective of our study was to understand factors associated with cessation attempts and identify populations that may require more intensive cessation efforts.

2. Material and methods

2.1. Study setting and population

We extracted electronic health record (EHR) data from 15 primary care clinics across SFHN. Four clinics (Clinics 2–5) are academic primary care practices housed within a university-affiliated public hospital, with one clinic (Clinic 4) focusing on care for patients living with HIV. The remaining 11 clinics are community-based clinics dispersed across San Francisco with varying patient demographics (see Appendix A for clinic demographics). At each clinic visit, medical assistants (i.e., frontline medical staff) screen patients for smoking status as “current smoker,” “former smoker,” or “never smoker” using the EHR after collecting patient vitals. When patients are screened as “current smokers,” medical assistants refer patients to cessation resources specific to the clinic (e.g., on-site smoking cessation groups or counseling by the behavioral assistants) and/or general resources (e.g., the California Smoker’s Helpline). (Zhu et al., 2002) Patients may decline offers for cessation services; however, offers are still counted as delivery of medical assistant referral regardless of patient acceptance.

2.2. Study design

The study used the PRECEDE-PROCEED model, an implementation sciences framework used for assessing the health needs within a public health program, and for designing, implementing, and evaluating programs to meet these needs. (Green and Health, 2005) The first PRECEDE phase involves multiple assessments to identify barriers and appropriate solutions to incorporate in a health promotion program, while the second PROCEED phase identifies desired process and health outcomes for the program within existing clinical environments. In our prior work, we identified predisposing and reinforcing factors to increase delivery of cessation services. (Gubner et al., 2019) Here, we explore additional individual factors associated with cessation attempts to facilitate implementation of system-level interventions to improve delivery of cessation services.

We extracted data from the EHR on any patient of the 15 clinic sites who had at least three unique primary care encounters with documented smoking status between May 2016 to May 2019. The index visit was the first encounter closest to the study’s start date. We extracted data using i2i Tracks (<http://www.i2isys.com/p/i2itracks>) software and Structured Query Language (SQL).

2.3. Primary outcomes and measurements

The two primary outcomes were 1) any cessation attempts, a dichotomous measure defined as a transition in smoking status from “current smoker” at the index visit to “former smoker” at visit 2 or 3, and 2) sustained cessation attempts, a dichotomous measure defined as a transition in smoking status from “current smoker” at the index visit to “former smoker” at both visits 2 and 3. We included patients who had three visits during the study duration, and for those who had more than three visits, we selected the first three visits during the study period. We extracted patient factors including age, sex, primary language, race/

ethnicity, and health insurance from the EHR at the index visit. Health insurance was categorized as either Medicare, Medicaid (named “Medi-Cal” in California), Healthy San Francisco (a county-based program providing medical care to low-income adults), private, other coverage, or uninsured. Information on health comorbidities were available only at visit 3; therefore, we extracted information on hypertension, diabetes, depression, and HIV at visit 3. We focused on these four comorbidities as our health system was planning disease registries for these conditions to be co-linked to tobacco use and to facilitate chronic disease management. Comorbidities were identified using ICD-9 and ICD-10 codes listed as diagnoses within the patient’s medical record at visit 3 (See Appendix B for complete list of smoking-related health comorbidities). We examined whether medical assistant provided referrals to smoking cessation resources at any of the three visits. We also estimated smoking cessation relapse, defined as a change in smoking status from “former smoker” at visit 2 to “current smoker” at visit 3.

2.4. Data analysis

We identified patients currently smoking based on smoking status at the index visit. We described patients who did not make any cessation attempt during visits, those who made any cessation attempt at visit 2 or 3, and those who had made a sustained cessation attempt at both visits 2 and 3. We described patient demographics, health insurance, clinic, comorbidities, and medical assistant referral to smoking cessation services. We examined factors associated with the outcomes of 1) any cessation attempt, or 2) any sustained cessation attempt. We used generalized estimating equations (GEE), accounting for nesting within clinics with an exchangeable correlation structure. We considered age, sex, race/ethnicity, language, insurance status, clinic visit at visit one as fixed effects in the models. To account for varying length of time between visits, we included the covariate “time since last visit” in the model assessing for any cessation attempt (as cessation attempts could occur at visit 2 or 3), and the covariates “time between visit 1 and 2” and “time between visit 2 and 3” in the model assessing sustained cessation attempts. We did not include comorbidity data in the main models as comorbidity data were not collected at visit 1; however, we conducted a sensitivity analysis by including comorbidity data in the models to see if comorbidity data influenced results. We further characterized percentages of relapse by clinic. All analyses were completed using SAS version 9.4. This study was approved by the University of California, San Francisco Committee on Human Research (#18–26398).

3. Results

3.1. Individual characteristics among patients who currently smoke

Of the 51,554 individuals identified from 15 clinics, 7,388 individuals were currently smoking at the index visit; 1,908 (26%) made any cessation attempt, and 650 (9%) made a sustained cessation attempt (Table 1). Visits were spaced out over several months, as the average length of time between visit 1 and 2 was 94.3 days (SD 120.9 days), and between visit 1 and 3 was 197.5 days (SD 180.8 days). Average age of individuals with any or sustained cessation attempts was younger compared to individuals without any cessation attempts (any attempt: 48.7 years, standard deviation [SD] 14.5, range 18.3–93 years; sustained cessation attempt: 47.1 years, SD 15.1, range 18.4–93.0 years; no attempt: 52.9 years, SD 12.7, range 18.0–94.1). They were also more often female; identified as being Latinx/Hispanic; spoke Spanish as their primary language; or had Medi-Cal or Healthy San Francisco as their primary insurance. Individuals with any and sustained cessation attempts also had less chronic obstructive pulmonary disease (COPD), HIV, hyperlipidemia, or hypertension. Among those who did not make a cessation attempt, 89% received medical assistant referral to cessation services, compared to 66% for those with any cessation attempts and 44% for those with sustained cessation attempts.

Table 1

Demographic, comorbidities and medical assistant cessation referral characteristics among patients with at least three visits who did and did not make a smoking cessation attempt in San Francisco Health Network clinics (N = 7,388).

	Mean (SD) or n (%)		
	Patients who smoke and did not make any smoking cessation attempt (N = 5,480)	Patients who smoke and made any smoking cessation attempt (N = 1,908)	Patients who made a sustained smoking cessation attempt (N = 650)
Age	52.9 (12.7)	48.7 (14.5)	47.1 (15.1)
Sex			
Male	3,835 (69.98%)	1,254 (65.72%)	418 (64.31%)
Female	1,645 (30.02%)	654 (34.28%)	232 (35.69%)
Race/ethnicity			
Latinx/Hispanic	743 (13.72%)	444 (23.74%)	183 (28.86%)
American Indian/ Alaska Native	56 (1.03%)	23 (1.23%)	9 (1.42%)
Asian	982 (18.13%)	257 (13.74%)	82 (12.93%)
Black or African American	1,820 (33.60%)	557 (29.79%)	156 (24.61%)
Native Hawaiian or other Pacific Islander	62 (1.14%)	25 (1.34%)	8 (1.26%)
White	1,540 (28.43%)	463 (24.76%)	157 (24.76%)
Other	214 (3.95%)	101 (5.40%)	39 (6.15%)
Language			
English	4,445 (81.62%)	1,499 (79.31%)	505 (78.42%)
Spanish	291 (5.34%)	246 (13.02%)	98 (15.22%)
Chinese (i.e., Cantonese/Mandarin)	548 (10.06%)	94 (4.97%)	27 (4.19%)
Other	162 (2.97%)	51 (2.70%)	14 (2.17%)
Insurance			
Healthy San Francisco	165 (3.40%)	111 (6.52%)	42 (7.12%)
Medi-Cal	2,758 (56.88%)	1,027 (60.34%)	359 (60.85%)
Medicare	1,132 (23.35%)	324 (19.04%)	108 (18.31%)
Private	44 (0.91%)	16 (0.94%)	5 (0.85%)
Other coverage	606 (12.50%)	179 (10.52%)	58 (9.83%)
Uninsured	144 (2.97%)	45 (2.64%)	18 (3.05%)
Comorbidities			
Asthma	532 (9.71%)	184 (9.64%)	63 (9.69%)
Chronic obstructive pulmonary disease	932 (17.0%)	227 (11.9%)	59 (9.08%)
Depression	1,868 (34.09%)	659 (34.54%)	221 (34.00%)
Diabetes	943 (17.21%)	323 (16.93%)	93 (14.31%)
HIV	762 (13.91%)	208 (10.90%)	69 (10.62%)
Hyperlipidemia	1,313 (23.96%)	397 (20.81%)	135 (20.77%)
Hypertension	2,310 (42.15%)	683 (35.80%)	197 (30.31%)
Ischemic vascular disease	324 (5.91%)	112 (5.87%)	30 (4.62%)
Heart failure	255 (4.65%)	91 (4.77%)	29 (4.46%)
Chronic kidney disease	599 (10.93%)	189 (9.91%)	52 (8.0%)
Clinic			
Clinic 1	1,083 (19.76%)	213 (11.16%)	61 (9.38%)
Clinic 2	4 (0.07%)	8 (0.42%)	3 (0.46%)
Clinic 3	635 (11.59%)	368 (19.29%)	129 (19.85%)
Clinic 4	517 (9.43%)	143 (7.49%)	46 (7.08%)
Clinic 5	617 (11.26%)	372 (19.50%)	111 (17.08%)
Clinic 6	267 (4.87%)	139 (7.29%)	62 (9.52%)
Clinic 7	12 (0.22%)	2 (0.10%)	1 (0.15%)
Clinic 8	399 (7.28%)	67 (3.51%)	22 (3.38%)
Clinic 9	236 (4.31%)	40 (2.10%)	17 (2.62%)
Clinic 10	16 (0.29%)	4 (0.21%)	3 (0.46%)
Clinic 11	366 (6.68%)	120 (6.29%)	39 (6.00%)
Clinic 12	301 (5.49%)	94 (4.93%)	33 (5.08%)
Clinic 13	215 (3.92%)	69 (3.62%)	23 (3.54%)
Clinic 14	258 (4.71%)	106 (5.56%)	36 (5.54%)
Clinic 15	554 (10.11%)	163 (8.54%)	64 (9.85%)
Received any medical assistant referral to	4,890 (89.23%)	1,263 (66.19%)	285 (43.85%)

Table 1 (continued)

	Mean (SD) or n (%)
	Patients who smoke and did not make any smoking cessation attempt (N = 5,480)
	Patients who smoke and made any smoking cessation attempt (N = 1,908)
	Patients who smoke and made a sustained smoking cessation attempt (N = 650)
smoking cessation resources across three visits	

3.2. Cessation attempts

Within the cohort of individuals who were smoking at the index visit, we examined individuals who made any cessation attempt during visits across all clinics (Fig. 1). Academic, hospital-based clinics (Clinics 2–5) had some of the highest percentages of any cessation attempts, though certain clinics (Clinic 2) had low numbers of patients who smoke at baseline. Among those who had made a cessation attempt at visit 2, on average 45% relapsed at visit 3 (range 0–50%) (Appendix C).

3.3. Factors associated with cessation attempts

Several factors were associated with higher odds of making any cessation attempt (Table 2). They included being female (AOR 1.17, 95%CI 1.04–1.32); self-identifying as American Indian/Alaskan Native (AI/AN) race (AOR 1.74, 95%CI 1.06–2.86) or Latinx/Hispanic ethnicity (AOR 1.27, 95%CI 1.05–1.52); and having Spanish as the primary language (AOR 1.56, 95%CI 1.26–1.94). Patients of academic, hospital-based clinics also had higher odds of making any cessation attempts. For every one week increase in time since last visit, the odds of having any cessation attempt increased by 0.3% (95%CI 0.03–0.6%). Patient factors associated with lower odds of any cessation attempt included older age (AOR 0.98, 95%CI 0.98–0.99), speaking Chinese (i.e., Cantonese/Mandarin) (AOR 0.68, 95%CI 0.49–0.95), and having Medi-Cal insurance (AOR 0.82, 95%CI 0.70–0.96).

Patient factors associated with sustained cessation attempts were similar to any cessation attempt, though unlike any cessation attempt, female sex was no longer associated with higher odds of having a sustained cessation attempt. Also similarly, odds of having a cessation attempt increased by 0.6% with every additional week between visit 1 and 2 (95%CI 0.1%–1.0%), though odds of sustaining the attempt decreased by 0.8% with every additional week between visit 2 and 3 (95%CI 0.3%–1.4%). Sensitivity analysis including comorbidity data did not significantly change results for either outcome of any or sustained cessation attempts (Appendix D).

4. Discussion

In our study, we used EHR data to measure cessation attempts in a safety-net setting. About a quarter of individuals who smoked made any cessation attempt. Safety-net clinics were able to deliver basic cessation interventions such as medical assistant referrals to cessation resources at high percentages to those identified as currently smoking. Consistent with prior studies, (Hispanics, 2018; Yuan et al., 2020; Rohde et al., 2013) patients of Hispanic/Latinx descent were more likely to make any or sustained cessation attempts. However, older patients, those insured by Medi-Cal, and those with Chinese as their primary language were less likely to make cessation attempts, warranting further consideration.

We found that 26% of patients in our safety-net health system attempted cessation and 9% sustained their quit attempts over two subsequent visits. This is higher than the un-assisted population recent quit attempt rate of 5%–7%, (Babb et al., 2017) and lower than

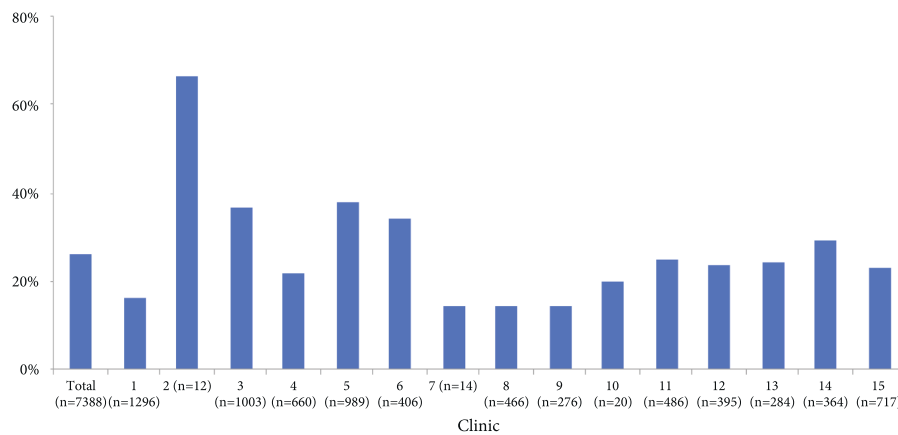


Fig. 1. Cumulative rate of any cessation attempts across San Francisco Health Network clinics from May 2016 to May 2019 (N = 7,388).

abstinence rates observed in randomized clinical trials of behavioral counseling and pharmacotherapy where participants are being observed and monitored frequently (30%-40%). (Clinical Practice Guideline Treating, 2008) The higher proportion of quit attempts among patients in our safety-net system compared to those in the general population may be attributed to a robust health system infrastructure that prioritizes tobacco cessation, deploys an implementation science and quality improvement framework, and uses the EHR to both measure and streamline clinical workflows. Being able to demonstrate quit attempts at a systems level in routine clinical care is a benefit, even if there is relapse, and the ability to measure quit attempt between visits, even if lasting 24 h, is a positive step towards long-term cessation. (Farkas et al., 1996).

While there are studies on delivery and receipt of smoking cessation services within safety net health settings, few studies provide estimates of cessation attempts or relapse. In a study of primary care patients recruited from a safety net hospital, patients who received patient navigation and financial incentives for smoking cessation had higher abstinence rates than those who did not (11% vs. 2%) at 12-months. (Lasser et al., 2017) However, these interventions were not integrated within the EHR. Studies from general primary care settings also estimate 36%-39% of patients make a past-year cessation attempt and 15%-20% maintain cessation at one year. (Wadland et al., 1999; Stevens et al., 2016; Bold et al., 2015; Bailey et al., 2018) In our previous study, we found comparable rates of cessation among patients seeking primary care in four safety net clinics. (Gubner et al., 2019) Our findings highlight the need for more studies that examine system-level estimates of smoking cessation and relapse for patients engaged in primary care to guide implementation of system-level interventions for cessation.

Given that half of the patients who had made a quit attempt at visit 2 relapsed to smoking by visit 3, higher intensity counseling services may be needed to increase efficacy of quit attempts. (García-Rodríguez et al., 2013; Chaiton et al., 2016) Although we found percentages of medical assistant referral were high to those currently smoking, tailored and more intensive cessation services may be needed. We found odds of making and sustaining cessation attempts decreased with older age. This is consistent with national surveys finding that older adults who smoke are less interested in quitting, make fewer quit attempts, and are less likely achieve sustained cessation, (Centers for Disease Control and Prevention, 2011) though counseling and multimodal cessation interventions are just as efficacious in older adults compared to younger adults. (Chen and Wu, 2015) Similarly, our finding of Chinese-speaking individuals being less likely to make and sustain cessation attempts is concordant with other studies. (Rafful et al., 2013; Guan et al., 2020) Evidence suggests that Chinese-speaking individuals respond to evidence-based cessation methods such as physician counseling, Smoker's Helpline, and nicotine replacement therapies (NRT), and this

disparity may be addressed through tailoring of cessation interventions to meet cultural and linguistic needs. (Guan et al., 2020) Future studies should highlight focus on developing more targeted, intensive interventions for these specific groups.

In our study, academic clinics had higher percentages of cessation attempts than community-based clinics. These results are likely attributed to differences in patient population characteristics associated with smoking and cessation. For instance, patients in community clinics were slightly older, more likely to belong to Asian communities, and as previously discussed, these groups may face more challenges with cessation.

We also found that individuals with Medi-Cal insurance had lower odds of making and sustaining cessation attempts, aligning with studies showing that low-income populations may face barriers with attempting cessation despite desires to quit. (Siahpush et al., 2009) This is important, as safety-net health systems are required to meet minimum criteria to obtain incentives from public insurers while balancing many competing demands. The Public Hospital Redesign and Incentives in Medi-Cal program (PRIME) requires evidence-based quality improvement goals for clinics, including screening for smoking status and counseling every two years. (Kaslow et al., 2018) However, best practices guidelines recommend assessments at every encounter to optimize cessation, (Fiore et al., 2008) highlighting how more intensive interventions than those required by public insurers may be needed to improve outcomes. Safety-net clinics can meet minimum requirements for reimbursement, while also striving to achieve high best practice rates at each encounter. Safety-net health systems can do so by 1) assigning responsibilities to health team members so that cessation services are provided by a multidisciplinary team, (Clinical Practice Guideline Treating Tobacco Use and Dependence, 2008) 2) providing guidance to medical teams on who should be providing these services at every visit to avoid redundancy and waste of resources, and 3) streamlined infrastructure particularly with the use of EHR to ensure efficient delivery of cessation resources.

In the past decade, financial incentive programs for meaningful use of EHRs have increased tobacco screening, documentation of smoking status, and delivery of cessation services in safety-net settings. (Bailey et al., 2017; Kruse et al., 2014; Polubriaginof et al., 2018; Vidrine et al., 2013) These incentive programs offer opportunities for safety-net systems to further innovate solutions to addressing cessation disparities, and using EHRs as a tool in health systems improvement offers one potential solution. Our study demonstrates how EHRs can be an effective tool for rapidly identifying populations with specific care needs and factors associated with cessation attempts. (Gubner et al., 2019; Fiore et al., 2019)

By combining the individual-level factors elucidated here with known regulatory and policy structures, such as financial incentive

Table 2
Factors associated with smoking cessation attempts among patients who smoke and had at least three visits in San Francisco Health Network clinics.

	Any cessation attempt		Sustained cessation attempt	
	AOR (95%CI)	p value	AOR (95% CI)	p value
Age	0.98 (0.98, 0.99)	<0.0001	0.97 (0.97, 0.98)	<0.0001
Sex				
Male (ref.)	–	–	–	–
Female	1.17 (1.04, 1.32)	0.008	1.20 (0.99, 1.46)	0.061
Race/ethnicity				
White (ref.)	–	–	–	–
American Indian/Alaskan Native	1.74 (1.06, 2.86)	0.028	2.28 (1.05, 4.96)	0.037
Asian	1.01 (0.82, 1.25)	0.913	1.05 (0.73, 1.49)	0.806
Black	1.01 (0.87, 1.17)	0.894	0.83 (0.64, 1.09)	0.178
Latinx/Hispanic	1.27 (1.05, 1.52)	0.014	1.53 (1.15, 2.05)	0.004
Native Hawaiian or other Pacific Islander	0.99 (0.61, 1.59)	0.958	1.13 (0.51, 2.48)	0.761
Other	1.14 (0.88, 1.47)	0.322	1.42 (0.94, 2.14)	0.096
Language				
English (ref.)	–	–	–	–
Spanish	1.56 (1.26, 1.94)	<0.0001	1.62 (1.15, 2.27)	0.006
Chinese (i.e., Cantonese/Mandarin)	0.68 (0.49, 0.95)	0.023	0.56 (0.31, 0.98)	0.043
Other	0.89 (0.63, 1.26)	0.515	0.72 (0.38, 1.36)	0.313
Insurance type				
Medicare (ref.)	–	–	–	–
Healthy San Francisco	0.86 (0.65, 1.14)	0.303	0.75 (0.48, 1.18)	0.216
Medi-Cal	0.82 (0.71, 0.96)	0.012	0.74 (0.57, 0.96)	0.023
Private	0.60 (0.33, 1.08)	0.089	0.49 (0.18, 1.29)	0.148
Other coverage	0.84 (0.68, 1.05)	0.129	0.79 (0.54, 1.14)	0.209
Uninsured	0.76 (0.54, 1.07)	0.113	0.79 (0.46, 1.35)	0.394
Clinic				
Clinic 1 (ref.)	–	–	–	–
Clinic 2	4.15 (1.55, 11.12)	0.005	2.86 (0.68, 12.02)	0.151
Clinic 3	2.44 (1.99, 3.00)	<0.0001	2.68 (1.87, 3.82)	<0.0001
Clinic 4	1.29 (1.00, 1.66)	0.047	1.35 (0.86, 2.11)	0.192
Clinic 5	2.62 (2.14, 3.21)	<0.0001	2.54 (1.77, 3.65)	<0.0001
Clinic 6	2.28 (1.77, 2.94)	<0.0001	3.21 (2.12, 4.87)	<0.0001
Clinic 7	0.53 (0.11, 2.48)	0.423	0.67 (0.08, 5.62)	0.708
Clinic 8	1.27 (0.88, 1.83)	0.208	1.60 (0.84, 3.04)	0.151
Clinic 9	0.99 (0.66, 1.48)	0.950	1.61 (0.85, 3.06)	0.146
Clinic 10	0.82 (0.28, 2.42)	0.712	1.65 (0.45, 6.15)	0.452
Clinic 11	1.57 (1.21, 2.03)	<0.001	1.80 (1.14, 2.83)	0.011
Clinic 12	1.77 (1.32, 2.38)	<0.001	2.25 (1.37, 3.70)	0.001
Clinic 13	1.45 (1.06, 2.00)	0.021	1.50 (0.86, 2.62)	0.157
Clinic 14	1.86 (1.40, 2.46)	<0.0001	2.12 (1.30, 3.43)	0.002
Clinic 15		0.001		0.001

Table 2 (continued)

	Any cessation attempt		Sustained cessation attempt	
	AOR (95%CI)	p value	AOR (95% CI)	p value
	1.50 (1.18, 1.92)		2.04 (1.34, 3.12)	
Visit				
Visit 2 (ref.)	–	–	–	–
Visit 3	0.71 (0.64, 0.80)	<0.0001		
Time				
Time since last visit (week)	1.003 (1.0003, 1.006)	0.028		
Time between visit 1 and 2 (week)			1.006 (1.001, 1.010)	0.013
Time between visit 2 and visit 3 (week)			0.992 (0.986, 0.997)	0.004

programs that affect health system reimbursement and cessation care delivery, the PRECEDE-PROCEED model can be used to develop more targeted interventions for delivering cessation services in these contexts. For example, the SFHN implemented a new EPIC Enterprise EHR in 2019. We adapted the EHR to align with cessation efforts and to assist with evaluation of cessation programs on a systems-wide level using the PRECEDE-PROCEED model to support cessation services. Efforts from this work have led to creation of a tobacco registry, an improved tobacco screening tool embedded within the new EHR, and templates to document counseling interventions. The registry is being used to track delivery of cessation services and drive practice changes in delivery of cessation care. Our findings also helped with development and implementation of chronic disease registries co-linked with tobacco use to facilitate our health system's management of comorbid conditions. The SFHN is using these disease registries to offer interventions including targeted telephone or in-person outreach, linking cessation counseling with efforts to improve blood pressure or diabetes care.

Several opportunities for interventions among subgroups exist. Although patients from Black/African American, Latinx/Hispanic, and Asian communities are more likely to smoke less than their White counterparts, they also face disproportionately worse smoking-related health outcomes. (Trinidad et al., 2011; Trinidad et al., 2009; Sakuma et al., 2016) These disparities can be attributed to structures of systemic racism, including barriers to accessing care, lower delivery of cessation services, and increased targeted marketing of tobacco products to racial/ethnic minorities, making cessation more challenging among these communities. (Hispanics, 2018; CDC TobaccoFree, 2019; Bailey et al., 2018; Vijayaraghavan et al., 2018) Patients identifying as Latinx/Hispanic or AI/AN had higher odds of any and sustained cessation attempts compared to patients identifying as White, potentially because these populations tend to smoke less cigarettes per day, (Hispanics, 2018; Yuan et al., 2020; Rohde et al., 2013) a known factor associated with higher odds of quitting. (Trinidad et al., 2011) Spanish-speaking and Latinx/Hispanic-identifying individuals may also have had greater availability of language-concordant and culturally informed cessation resources. (Weber et al., 2017) Future work should explore reasons for cessation success in these populations to adopt best practices in improving smoking cessation for other groups.

There were several limitations. EHR smoking status data relied on self-report and were not biochemically verified, leading to a potential misclassification bias. We did conduct a separate manual chart review for a subset of patients to ensure quality of smoking assessments and receipt of medical assistant referrals were accurate, reducing potential for misclassification. (Polubriaginof et al., 2018) We were unable to capture nicotine dependence measures within the EHR, highlighting a potential role for including these measures in subsequent iterations of

our tobacco registry. Our results may underestimate cessation attempts by not including attempts made in between visits or those made by individuals with less than three visits during the study period. Because comorbidity data was only available for Visit 3, we did not incorporate comorbidities into our main analysis, though our sensitivity analysis incorporating comorbidity data did not find significant difference in results. The quality of smoking status data collection could have varied across clinic sites leading to potential misclassification bias, (Auerbach and Bates, 2020) though all clinics had the same EHR with a structured format for data collection. Sample sizes for certain racial/ethnic groups were small (e.g., AI/AN, Native Hawaiian or other Pacific Islander), and our findings need to be validated in studies with larger samples from these populations. Our findings paradoxically showed that medical assistant referrals were less common among patients who had made any or sustained cessation attempts. Because medical assistants were required to document referrals to cessation services only among patients who currently smoke at each visit, those who made a quit attempt and transitioned to “former smokers” did not have such documentation in the EHR. Finally, insurance status was only collected at visit 1 and fluctuations in insurance status may have affected treatment access, though this was likely minimal as our safety-net health care system provides treatment for all San Francisco residents regardless of insurance status.

5. Conclusions

The EHR can help identify factors associated with smoking cessation attempts to evaluate opportunities in improving cessation services, and to identify subpopulations that may require more intensive, directed efforts. (Kawamoto and McDonald, 2020; Zheng et al., 2020) Public health systems can enhance regulatory and financial policies by enhancing the efficacy of smoking cessation services, and by targeting subpopulations with high needs to reduce health disparities in safety-net settings.

Appendix A. . Demographics by type of clinics

	Academic clinics(N = 21314)	Community clinics(N = 30240)
Age	50.2 (16.5)	52.8 (15.5)
Sex		
Male	10,347 (49%)	14,300 (47%)
Female	10,967 (51%)	15,940 (53%)
Race/ethnicity		
Latinx/Hispanic	8,701 (41%)	6,388 (21%)
American Indian or Alaska Native	164 (1%)	144 (0.5%)
Asian	4,337 (21%)	10,686 (36%)
Black or African American	2,558 (12%)	5,133 (17%)
Native Hawaiian or other Pacific Islander	171 (1%)	338 (1%)
White	3,358 (16%)	6,029 (20%)
Other	1,740 (8%)	1,057 (4%)
Language		
English	12,359 (58%)	17,406 (58%)
Spanish	6,200 (29%)	4,360 (14%)
Chinese (i.e., Cantonese/Mandarin)	1,374 (7%)	6,804 (23%)
Other	1,220 (6%)	1,554 (5%)
Insurance		
Healthy San Francisco	1,910 (10%)	1,809 (7%)
Medi-Cal	10,262 (54%)	12,677 (47%)
Medicare	3,784 (20%)	5,417 (20%)
Private	304 (2%)	295 (1%)
Other coverage	2,092 (11%)	6,094 (23%)
Uninsured	551 (3%)	624 (2%)
Any Smoking Cessation Attempt*	891 (33%)	1,017 (22%)
Sustained Cessation Attempt*	289 (12%)	361 (8%)

*For cessation attempts, only individuals with at least three primary care encounters with smoking status were included, leading to N = 2664 for academic clinics and N = 4724 for community clinics as the denominator.

6. Ethics approval and consent to participate

This study was approved by the University of California, San Francisco Committee on Human Research (#18-26398).

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Authors contributions

M.V., H.R., and E.C. conceptualized the design of the study. T.L. performed data analysis with guidance from M.V. and L.W.S. L.W.S. and M.V. wrote the manuscript with support from K.C., E.S., T.L., E.C., and H.R. All authors contributed to the final version of the manuscript.

Declaration of Competing Interest

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

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Not applicable.

Prior presentations.

This work was presented as a poster presentation at the San Francisco Bay Area Collaborative Research Network 2020 Annual Meeting and the American Society of Addiction Medicine 2021 Annual Meeting.

Appendix B. . International classification of diseases 9 or 10 diagnoses extracted to characterize presence of comorbidities

Diagnosis	ICD9 code	ICD10 code
Asthma	493	J45
Chronic Obstructive Pulmonary Disease	491–494, 496	J41–44, J47
Depression	290, 296, 298, 300, 301, 309, 311	F01, F32-F34, F43
Diabetes	250, 357, 362, 366, 648	E10, E11, E13, Q24
HIV	042, V08	B20, Z21
Hyperlipidemia		E78
Hypertension	401–404	I10-13
Ischemic vascular disease	411, 413, 414, 429, 433, 434, 437, 440, 444, 445	I20, I24, I25, I63, I65-67, I70, I75, T82
Heart failure	398, 402, 404, 428	I09, I11, I13, I50
Kidney disease		A18, A52, B52, C64, C68, D30, D41, D59, E08-E11, E13, E74, I12, I13, I70, I72, K76, M10, M32, M35, N00-08, N13-19, N25, N26, Q61, Q62, R94

Appendix C. . The relapse rate at visit 3 among patients who smoke who made any quit attempts in visit 2

	n (%)
Overall	536 (45%)
By clinic	
Clinic 1	62 (50%)
Clinic 2	3 (50%)
Clinic 3	105 (45%)
Clinic 4	37 (45%)
Clinic 5	112 (50%)
Clinic 6	31 (33%)
Clinic 7	1 (50%)
Clinic 8	22 (50%)
Clinic 9	10 (37%)
Clinic 10	0 (0%)
Clinic 11	32 (45%)
Clinic 12	29 (47%)
Clinic 13	21 (48%)
Clinic 14	30 (45%)
Clinic 15	41 (39%)

Appendix D. . Factors associated with making any or sustained smoking cessation attempts among people who smoke in San Francisco health Network clinics

	0.98 (0.98, 0.99)	<0.0001	0.98 (0.97, 0.98)	<0.0001
Age				
Sex				
Male (ref.)	–	–	–	–
Female	1.20 (1.06, 1.35)	0.004	1.22 (1.00, 1.49)	0.055
Race/ethnicity				
White (ref.)	–	–	–	–
American Indian/Alaskan Native	1.75 (1.06, 2.88)	0.028	2.41 (1.10, 5.28)	0.029
Asian	1.01 (0.82, 1.26)	0.901	1.07 (0.75, 1.53)	0.710
Black	1.02 (0.87, 1.19)	0.804	0.87 (0.67, 1.15)	0.328
Latinx/Hispanic	1.28 (1.06, 1.54)	0.011	1.56 (1.17, 2.09)	0.003
Native Hawaiian or other Pacific Islander	0.98 (0.60, 1.58)	0.919	1.16 (0.53, 2.55)	0.703
Other	1.14 (0.88, 1.48)	0.308	1.43 (0.95, 2.17)	0.086
Language				
English (ref.)	–	–	–	–
Spanish	1.56 (1.25, 1.94)	< 0.0001	1.59 (1.13, 2.24)	0.008
Chinese (i.e., Cantonese/Mandarin)	0.69 (0.49, 0.96)	0.026	0.54 (0.30, 0.96)	0.035
Other	0.89 (0.63, 1.25)	0.487	0.71 (0.37, 1.35)	0.294
Insurance type				
Medicare (ref.)	–	–	–	–
Healthy San Francisco	0.87 (0.65, 1.15)	0.328	0.74 (0.47, 1.16)	0.187
Medi-Cal	0.83 (0.71, 0.97)	0.017	0.73 (0.56, 0.95)	0.019
Private	0.61 (0.34, 1.09)	0.093	0.49 (0.19, 1.30)	0.151
Other	0.86 (0.69, 1.07)	0.163	0.78 (0.54, 1.14)	0.203
Uninsured	0.77 (0.55, 1.09)	0.139	0.80 (0.47, 1.38)	0.423
Clinic				
Clinic 1 (ref.)	–	–	–	–
Clinic 2	4.15 (1.54, 11.19)	0.005	3.07 (0.74, 12.64)	0.121
Clinic 3	2.44 (1.98, 3.00)	< 0.0001	2.75 (1.91, 3.97)	< 0.0001
Clinic 4	1.25 (0.88, 1.78)	0.204	1.18 (0.66, 2.10)	0.582

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(continued)

Age	0.98 (0.98, 0.99)	<0.0001	0.98 (0.97, 0.98)	<0.0001
Clinic 5	2.59 (2.10, 3.18)	<0.0001	2.58 (1.78, 3.76)	<0.0001
Clinic 6	2.27 (1.76, 2.93)	<0.0001	3.18 (2.08, 4.85)	<0.0001
Clinic 7	0.53 (0.11, 2.47)	0.418	0.68 (0.08, 5.79)	0.726
Clinic 8	1.26 (0.87, 1.83)	0.226	1.59 (0.83, 3.06)	0.163
Clinic 9	0.99 (0.66, 1.48)	0.950	1.68 (0.89, 3.17)	0.110
Clinic 10	0.81 (0.27, 2.39)	0.699	1.61 (0.44, 5.91)	0.474
Clinic 11	1.57 (1.21, 2.04)	<0.001	1.84 (1.17, 2.91)	0.009
Clinic 12	1.72 (1.27, 2.34)	<0.001	2.17 (1.29, 3.65)	0.009
Clinic 13	1.46 (1.06, 2.01)	0.021	1.55 (0.87, 2.73)	0.132
Clinic 14	1.83 (1.37, 2.45)	<0.0001	2.13 (1.30, 3.49)	0.003
Clinic 15	1.50 (1.18, 1.92)	0.001	2.08 (1.35, 3.19)	<0.001
Visit				
Visit 2 (ref.)	–	–		
Visit 3	0.71 (0.64, 0.80)	<0.0001		
Time				
Time since last visit (week)	1.00 (1.00, 1.01)	0.024		
Time between visit 1 and visit 2 (week)			1.01 (1.00, 1.01)	0.016
Time between visit 2 and visit 3 (week)			0.99 (0.99, 1.00)	0.004
Comorbidities				
Asthma	0.95 (0.78, 1.14)	0.564	0.95 (0.70, 1.29)	0.750
Chronic obstructive pulmonary disease	0.92 (0.77, 1.10)	0.373	0.79 (0.57, 1.08)	0.142
Depression	1.03 (0.92, 1.16)	0.618	1.08 (0.89, 1.31)	0.423
Diabetes	0.98 (0.83, 1.15)	0.794	0.95 (0.72, 1.25)	0.713
HIV	1.04 (0.78, 1.38)	0.802	1.16 (0.72, 1.86)	0.542
Hyperlipidemia	1.07 (0.92, 1.24)	0.406	1.15 (0.90, 1.47)	0.275
Hypertension	0.98 (0.86, 1.11)	0.719	0.82 (0.66, 1.02)	0.079
Ischemic heart disease	1.28 (1.01, 1.63)	0.045	1.16 (0.74, 1.81)	0.509
Heart failure	1.30 (1.00, 1.70)	0.051	1.35 (0.84, 2.17)	0.222
Kidney disease	0.95 (0.78, 1.16)	0.644	0.83 (0.59, 1.17)	0.292

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