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Smoking cessation in the context of recovery from drug and alcohol problems: Prevalence, predictors, and cohort effects in a national U.S. sample

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ABSTRACT

Background: Tobacco and alcohol and other drug (AOD) use remain prominent risk factors for morbidity, mortality, and health care utilization. Moreover, these often cluster together within persons, exponentiating health risks. Little is known regarding if and when people resolving AOD problems stop smoking, who stops, and whether recent general population trends toward smoking cessation are evident also among persons more recently entering recovery.

Design and participants: National cross-sectional sample resolving AOD problems (final sample n = 2002).

Analyses: Weighted smoking/cessation prevalence; logistic regressions; Hazard-models estimated time to smoking cessation overall, and for different cohorts entering recovery during one of three decades: a) 2006–2015; b) 1996–2005; c) 1986–1995.

Results: Approximately 30% of U.S. adults in AOD recovery with a smoking history stopped smoking before entering recovery, 7% quit smoking and AOD use concurrently, 26% stopped after entering recovery; 37% still smoked. Among those quitting after entering recovery, the prevalence of smoking cessation 5- and 10-years later was 27.2% and 55.1% respectively for the 2006–2015 cohort and 14.9% and 34.5% in the 1986–1995 cohort; time to smoking cessation also was 60% shorter (5yrs vs. 8yrs). Time to smoking cessation was associated with education and income, but not 12-step participation or AOD treatment.

Conclusions: Smoking rates among those in AOD recovery are more than double that of the general population but those entering recovery in recent years are stopping and stopping sooner. It is plausible that public health-oriented tobacco policy measures and easier access to smoking cessation aids may be contributing to this salutary trend.

1. Introduction

In middle and high-income countries around the world, tobacco, alcohol, and other drug-related problems remain among the most prominent independent contributors to medical morbidity, premature mortality, and health care utilization (Apollonio et al., 2016; Kalman et al., 2005; Peacock et al., 2018). Moreover, these risk factors often cluster together within persons, exponentiating health risks. Cigarette smoking, for example, is exceptionally high among individuals with alcohol and other drug (AOD) problems (National Institute on Alcohol Abuse and Alcoholism (NIAAA), 1998; Weinberger et al., 2018) and, even when stopping AOD use, many in recovery continue to smoke heavily (Kalman et al., 2005). Smoking is a major, if not the major cause of premature mortality among individuals in recovery from an AOD problem (Hser et al., 1994; Hurt et al., 1996). Little is known, however, regarding if and when people resolving AOD problems stop smoking, who stops, and whether recent general population trends toward greater smoking cessation (Centers for Disease Control and Prevention (CDC), 2018) are reflected similarly among persons entering AOD recovery nowadays (e.g., in the past 10 years) compared to longer ago.

In more recent decades in developed nations, there have been substantial restrictions placed on where and when people can smoke and vastly increased tobacco taxes have increased costs to consumers (Gammon et al., 2016). Given price and availability are the two most prominent factors affecting consumption (Brand et al., 2007; Paschall et al., 2009) adult population smoking rates have declined steadily in the U.S., dropping from 20.9% in 2005 to 15.5% in 2016 – an overall

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29% relative decline (Centers for Disease Control and Prevention (CDC), 2018). Yet, smoking cessation among persons with, or recovering from, AOD problems has remained a challenge (Abrams et al., 2010; Evins and Kelly, 2018; Knudsen et al., 2012; Lamberg, 2004). Part of the reason for this is the fact that among those with AOD problem histories, nicotine is often the first drug to which people are exposed and often become addicted, and those with AOD problem histories also are more nicotine dependent than those without such histories making it potentially harder to quit (Hughes and Kalman, 2006). In addition, the profile, impact, and timing of the consequences from tobacco are very different than other psychoactive drugs. Tobacco-related consequences, for example, are delayed and perceived as less dramatic than the more pronounced, immediate, intoxication-related harms (e.g., accidents, injuries, violence) associated with drugs like alcohol, opioids, and methamphetamine. Thus, although a great deal of the morbidity and mortality among individuals with AOD problems may be attributable to cigarette smoking (Hser et al., 1994; Hurt et al., 1996), tobacco use often is much less of an immediate concern relative to intoxicating drugs with which individuals have problems. Furthermore, AOD-addicted individuals are less likely than individuals without AOD problems to want to stop smoking (Hughes and Kalman, 2006), and if they do, most entering treatment settings prefer to stop sequentially, rather than simultaneously, after stabilization of their AOD recovery (Kodl et al., 2006). Perhaps related to this desire to stop sequentially, are commonly heard anecdotes that participation in certain recovery-focused support organizations, such as Alcoholics Anonymous (AA)/Narcotics Anonymous (NA), may perpetuate smoking, as it may be viewed implicitly in these organizations as a harm reduction tool to utilize while stabilizing abstinence from the more immediately life-threatening alcohol or other drug use. Beyond anecdote, however, little is known from a systematic standpoint about whether participation in AA/NA is associated with prolonging smoking.

While efforts have been made to address smoking among AOD-addicted populations during AOD treatment (Apollonio et al., 2016; Bobo et al., 1998; Joseph et al., 2004; Prochaska et al., 2004; Shi and Cummins, 2015; Thurgood et al., 2016), little is known about how smoking status changes with time in recovery, and whether persons entering AOD recovery nowadays are quitting sooner than those entering AOD recovery further in the past before the recent cultural and socio-political changes regarding tobacco use occurred. Greater knowledge would improve understanding of dynamic changes in the natural history of smoking cessation in this vulnerable population and inform the nature and timing of smoking intervention efforts and policy initiatives.

To this end, using a nationally representative sample of US adults who have successfully resolved a significant AOD problem (Kelly et al., 2017, 2018a, 2018b), this study: 1. estimates the prevalence of never, former, and current smoking, and if quit, when specifically in relation to their AOD problem resolution, smoking cessation occurred; 2. tests for demographic and clinical predictors of smoking status; and, 3. given the broad recent shifts in socio-cultural factors that have increased price, limited where and when people can smoke and vastly increased awareness of smoking-related health hazards and access to helpful pharmaceutical cessation aids (e.g., NRT; varenicline), examined the cohort effects of smoking cessation. Specifically, we investigated the hypothesis that, among those quitting smoking after resolving their AOD problem, compared to cohorts entering AOD recovery longer ago, those entering AOD recovery more recently are quitting smoking sooner.

2. Method

2.1. Procedures

The National Recovery Survey (NRS) recruited a nationally representative sample of U.S. noninstitutionalized adults who had resolved an alcohol or other drug (AOD) problem. As described in Kelly et al. (Kelly et al., 2017) the research team contracted with an internationally-recognized survey company, GfK, to recruit individuals that resolved an alcohol or other drug (AOD) problem from their KnowledgePanel, which uses address-based sampling to randomly select individuals from 97% of all U.S. households based on the U.S. Postal Service's Delivery Sequence File. See http://www.knowledgenetworks.com/knpanel/docs/knowledgepanel(R)-design-summary-description.pdf for more information on GfK's probability-based sampling methodology.

Selected participants were screened between July and August 2016. Of the 25,228 individuals screened, 2002 answered yes to the AOD problem resolution screening question, "Did you used to have a problem with drugs or alcohol, but no longer do?" and were determined to be valid responders, comprising the analyzable study sample. In order to produce unbiased estimates of population parameters from these respondents, survey weights were used (Kelly et al., 2017). While reflecting the selection probabilities of sampled units, weighting also attempts to compensate for nonresponse and under-coverage. All study procedures were approved by the Partners HealthCare Institutional Review Board.

2.2. Measures

Demographic Characteristics: Demographic data was derived both from GfK's existing KnowledgePanel data (collected prior to the survey) as well as from survey data for variables not assessed by GfK. Regarding existing demographic data, participants reported the following: a) age; b) level of education (less than high school; high school; some college; bachelor's degree or higher), race/ethnicity (White/Non-Hispanic, Black/Non-Hispanic, Other/Non-Hispanic, 2+ Races/Non-Hispanic, Hispanic), gender (Male, Female), household income (less than $25,000, $25,000-$49,999, $50,000-$74,999, $75,000-$99,999, $100,000 or greater), marital status (married, widowed/divorced/separated, never married, living with partner), and current employment status (yes/no).

Smoking/Nicotine: The questionnaire included 19 items about non-AOD addictive substances. Participants reported on lifetime use of cigarettes, e-cigarettes, or another tobacco/nicotine product (specified by participant). For those who smoked cigarettes, they reported on the following: 1) age of first use; 2) age of first regular use (at least once per week); 3) years of regular use; and 4) number smoked per day since began regular smoking. If they were currently still smoking, participants reported the number of cigarettes smoked in a typical day during the past 7-days, as well as, a number of quit attempts. If not currently still smoking, participants reported age when stopped and the number of quit attempts before successfully quitting. For those with lifetime use of e-cigarettes and/or another nicotine/tobacco product, the questionnaire assessed the same behaviors, save for age of first regular use and years of regular use, quantity-related variables, and quit attempts. The questionnaire also included an item on lifetime use of non-psychosocial smoking cessation resources, including a) nicotine replacement (e.g., gum), b) medication (e.g., varenicline), or c) e-cigarettes.

Substance use history: Participants answered a series of questions about 15 substances/classes of substances based on items from the Global Appraisal of Individual Needs (GAIN-I) (Dennis et al., 2002): 1) alcohol, 2) marijuana, 3) cocaine, 4) heroin, 5) narcotics other than heroin (e.g., pharmaceutical opioids), 6) methadone, 7) buprenorphine and its formulations (e.g., "suboxone"), 8) amphetamines (including methylenedioxymethamphetamine, or MDMA), 9) methamphetamine ("crystal meth"), 10) benzodiazepines, 11) barbiturates, 12) hallucinogens, 13) synthetic drugs (e.g., synthetic cannabinoid-like "K2″ and synthetic cathinones such as "bath salts"), 14) inhalants, and 15) steroids, as well as other (specified by participant). For each substance used 10 or more times lifetime, participants provided information on: a) Age of first use; b) age of first regular use (i.e., at least once per week); c)

Table 1
Demographic and clinical characteristics of the sample.

	Never Smokers (NS; 19.15%)	Former Smokers (FS; 50.90%)	Current Smokers (CS; 29.95%)	FS vs. NS R^2 (p)	CS vs. NS R^2 (p)	CS vs. FS R^2 (p)
Age (in years), M(SE)	43.15 (1.21)	49.6 (.68)	44.14 (.86)	.03 (< .001)	.00 (.505)	.02 (< .001)
Male, n(%)	230.7(60.88)	659.8(65.51)	297.9(50.26)	.00 (.247)	.01 (.025)	.02 (< .001)
Education, n(%)				.00 (.247)	.03 (.025)	.02 (< .001)
Less than college	282.4(74.52)	801.4(79.58)	536.5(90.53)			
Bachelor's Degree or Higher	96.5(25.48)	205.7(20.42)	56.1(9.47)			
Race/Ethnicity, n(%)				.00 (.645)	.00 (.396)	.00 (.052)
White, Non-Hispanic	226.4(59.74)	638.8(63.44)	349.8(59.03)			
Black, Non-Hispanic	45.7(12.06)	120.9(12.01)	104.6(17.65)			
Other, Non-Hispanic	27.4(7.23)	44.1(4.38)	43.7(7.37)			
Hispanic	72.7(19.17)	188.8(18.75)	81.6(13.76)			
2+ Races, Non-Hispanic	6.8(1.80)	14.3(1.42)	13.0(2.19)			
Household Income, n(%)				.00 (.330)	.01 (.029)	.02 (< .001)
< 50.000 USD	193.2(50.99)	470.5(46.72)	365.3(61.64)			
50,000+ USD	185.7(49.01)	536.5(53.28)	227.3(38.36)			
Marital status, n(%)				.00 (.173)	.00 (.162)	.01 (.001)
Not Married	185.4(48.93)	433.0(43.00)	330.4(55.75)			
Married or living with partner	193.5(51.07)	574.0(57.00)	262.2(44.25)			
Employed, n(%)	225.6(59.53)	571.9(56.79)	286.1(48.28)	.00 (.522)	.01 (.02)	.01 (.022)
Primary substance, n(%)				.00 (.692)	.01 (.001)	.01 (< .001)
Marijuana	35.7(12.06)	111.4(12.45)	70.0(13.05)			
Alcohol	198.1(66.89)	565.2(63.13)	249.1(46.41)			
Other Drug	62.4(21.06)	218.7(24.42)	217.6(40.54)			
Age of onset (primary substance), M(SE)	19.4 (.49)	19.94 (.26)	20.37 (.44)	.00 (.329)	.00 (.144)	.00 (.41)
Number of substances used, M(SE)	2.52 (.14)	3.40 (.11)	3.89 (.17)	.02 (< .001)	.05 (< .001)	.01 (.019)
Age when resolved substance use problem, M(SE)	32.75 (.91)	36.55 (.53)	34.41 (.67)	.02 (< .001)	.00 (.145)	.01 (.013)
Years since substance use problem resolution, M(SE)	11.40 (.77)	13.54 (.42)	10.11 (.54)	.01 (.015)	.00 (.17)	.02 (< .001)
Any outpatient treatment, M(SE)	37.6(9.91)	145.8(14.48)	149.9(25.29)	.00 (.127)	.03 (< .001)	.01 (< .001)
Any inpatient treatment, M(SE)	33.7(8.90)	125.8(12.50)	137.4(23.19)	.00 (.199)	.03 (< .001)	.01 (< .001)
Number of arrests, M(SE)	4.69 (1.84)	3.55 (.43)	6.40 (.94)	.00 (.546)	.01 (.409)	.02 (.006)
Number of 12-step meetings attended in past 3 months (full sample), M(SE)	1.63 (.51)	2.44 (.53)	3.81 (1.35)	.00 (.271)	.00 (.130)	.00 (.345)
Psychological distress, M(SE)	4.65 (.39)	4.01 (.22)	6.47 (.36)	.00(.148)	.02 (.001)	.04 (< .001)
Happiness, M(SE)	3.77 (.07)	3.85 (.04)	3.58 (.06)	.00 (.336)	.01 (.045)	.02 (< .001)
Self esteem, M(SE)	3.59 (.08)	3.61 (.05)	3.3 (.08)	.00 (.894)	.01 (.009)	.01 (.001)
Quality of life, M(SE)	3.65 (.06)	3.78 (.04)	3.43 (.05)	.00 (.064)	.01 (.005)	.03 (< .001)
Recovery capital, M(SE)	45.14 (.91)	48.29 (.41)	45.2 (.61)	..02 (.002)	.00 (.958)	.02 (< .001)

whether the substance was a perceived problem (yes/no); d) whether they were still using the substance (yes/no); and e) if no longer using that substance, age at which they stopped. Also, from the list of substances deemed to be a problem, participants chose their *primary* substance ("drug of choice") (Dennis et al., 2002).

Treatment and other recovery support services: The questionnaire assessed the history of participation in inpatient or residential treatment, outpatient addiction treatment and mutual-help organizations (MHOs) (Institute of Behavioral Research, 2002). If they responded yes to either treatment service, they then reported the number of treatment episodes. We assessed for lifetime attendance to help with their AOD problem at 11 different MHOs (e.g., Alcoholics Anonymous (AA), SMART Recovery, LifeRing Secular Recovery etc. For each MHO attended, participants reported a) whether they ever attended regularly (at least once per week), b) number of meetings in the past 90 days, and c) age of first attendance.

Criminal justice history: The questionnaire adapted items in this area from the Form-90 (Miller and Del Boca, 1994). Participants reported whether they had ever been arrested (yes/no). If yes, they reported how many times they had been arrested (censored at 51).

Psychosocial wellbeing indices: Several domains of psychological and social functioning were measured. The Kessler-6 (Kessler et al., 2003) is a 6-item scale assessing psychological distress that asks participants to rate how often, from 0 = *none of the time* to 4 = *all of the time*, they felt each of six symptoms (e.g., nervousness and depression) during the past 30 days (α = 0.93). Quality of life was assessed using the EUROHIS-QOL (Schmidt et al., 2006), which is a widely used 8-item measure adapted from the World Health Organization Quality of Life – Brief Version (WHOQOL-BREF). Responses are Likert-scaled from 1 to 5 (e.g., "How satisfied are you with your personal relationships; 1 = *very dissatisfied* to 5 = *very satisfied*; (α = .83; current sample α = .90). Participants rated their happiness on a Likert scale from 1 = *completely unhappy* to 5 = *completely happy* (Meyers and Smith, 1995). They also rated the extent to which "I have high self-esteem" is true on a Likert scale from 1 = *not very true* to 5 = *very true* (Robins et al., 2001). The survey also included the 10-item, Brief Assessment of Recovery Capital (BARC-10) (Vilsaint et al., 2016). Likert-scaled: 1 = *strongly disagree* to 6 = *strongly agree*, which demonstrated excellent internal consistency (current sample α = .93).

2.3. Analytic plan

We calculated the prevalence of each smoking group (never, former, and current smokers). We then compared the distribution of demographic and clinical correlates between groups and reported pseudo R-squared estimates for each covariate independently. We then explored

Table 2
Characteristics of smoking behaviors in current and former smokers.

	Former Smokers	Current Smokers	R^2 (*p*)
Age when started smoking, M(SE)	15.29 (.17)	15.63 (.25)	.00 (.267)
Age when started smoking regularly, M(SE)	16.88 (.17)	17.06 (.28)	.00 (.574)
Number of years smoking regularly, M(SE)	18.6 (.58)	24.6 (.88)	.03 (0)
Average number of cigarettes smoked per day since smoking regularly, M(SE)	17.02 (.57)	13.96 (.55)	.01 (0)
Nicotine replacement (e.g., patch or gum), n(%)	221.0(21.94)	194.5 (32.82)	.01 (0)
Medication (e.g., Chantix, Zyban), n(%)	121.1(12.03)	121.3 (20.47)	.01 (.001)
E-cigarettes, n(%)	119.5(11.86)	159.9 (26.98)	.03 (0)
No nicotine replacement, medication or e-cigarette use, n(%)	652.9(64.83)	288.3 (48.66)	.02 (0)
Age when quit smoking cigarettes, M(SE)	34.29 (.55)	–	–
Years since quit smoking cigarettes, M(SE)	15.41 (.51)	–	–
Years to quit cigarettes after substance use problem resolution, M(SE)	−2.18 (.45)	–	–
Number of cigarettes smoked in past week, M(SE)	–	13.86 (.91)	–
Number of cigarette quit attempts, M(SE)	–	5.38 (.66)	–

the distribution of time to smoking cessation indexed to AOD problem resolution. Using this distribution, we subset the data for remaining analyses to include current smokers and former smokers who quit after resolving their AOD problem. We constructed a Kaplan-Meier curve to examine the time from AOD problem resolution to smoking cessation. We then investigated whether cohort effects modified time to smoking cessation using Cox regression where we compared time to smoking cessation between groups who resolved their AOD problem in 10-year intervals. We subset the sample to include individuals who resolved their AOD problem in 2006–2015, 1996–2005, and 1986–1995. Individuals who resolved their AOD problem prior to 1986 were not included in the cohort analysis due to small sample sizes. Subsequently, we conducted an exploratory analysis to see if demographics (age, sex, education, income), primary substance, MHO attendance (lifetime, past 90 days, regular attendance) or AOD treatment (any inpatient and any outpatient) were related to time to smoking cessation after AOD problem resolution using Cox regressions. The proportional hazards assumption was assessed for all Cox models using Kaplan-Meier curves and log-log plots. Variables that violated proportional hazards assumptions were modeled as fixed main effects and time-varying covariates. Analyses were design-based and incorporated survey weights using Stata, V14 (StataCorp, 2015).

3. Results

3.1. Prevalence of smoking among U.S. adults who have resolved an AOD problem

Of the 2002 participants included in the dataset, 2000 reported whether they were a never smoker (NS), former smoker (FS), or current (CS), and were thus retained in the analysis. The prevalence of NS was 19.15% (95% CI: 16.73, 21.84). The majority were FS (50.90%; 95% CI: 47.74, 54.04) followed by CS (29.95%; 95% CI: 27.09, 32.98).

3.2. Correlates of smoking status among U.S. adults who have resolved an AOD problem

As shown in Table 1, FS tended to be older (49.6 years) than NS (43.2 years; $R^2_{NSvFS} = 2.9\%$, $p < 0.001$) and CS (44.1 years; $R^2_{CSvFS} = 2.4\%$; $p < 0.001$), and more likely to be male (FS: 65.5%, CS: 50.3%; $R^2_{FSvCS} = 1.7\%$, $p < 0.001$), married or living with a partner (FS: 57.0%, CS: 44.3%; $R^2_{FSvCS} = 1.2\%$, $p = 0.001$) and have a higher household income relative to CS (Income < $50,000USD: FS: 46.7%, CS: 61.6%; $R^2_{FSvCS} = 1.6\%$, $p < 0.001$). Relative to NS and FS, CS reported lower educational attainment (Bachelor's degree or higher: CS: 9.5%; NS: 25.5%, $R^2_{CSvNS} = 3.4\%$, $p < 0.001$; FS: 20.4%, $R^2_{CSvFS} = 1.7\%$, $p < 0.001$). CS had poorer psychosocial functioning on all domains (psychological distress, happiness, self-esteem, quality of life, recovery capital) relative to FS ($p < 0.01$), and on most domains, with the exception of happiness ($p = 0.045$) and recovery capital ($p = 0.958$), relative to NS. Lastly, CS had more arrests (Mean = 6.4) than FS (Mean = 3.6; $R^2_{CSvFS} = 2.3\%$, $p = 0.006$).

Several meaningful differences in substance use history and service utilization also were present between groups. CS were more likely to report that their primary substance had been a drug other than alcohol or marijuana (40.5%) and less likely to report alcohol as their primary substance (46.4%) relative to NS (Other drug: 21.1%; Alcohol: 66.9%; $R^2_{CSvNS} = 1.4\%$; $p = 0.001$) and FS (Other drug: 24.4%; Alcohol: 63.1%; $R^2_{CSvFS} = 1.1\%$; $p < 0.001$). NS reported using fewer substances (Mean = 2.5) relative to FS (Mean = 3.4; $R^2_{NSvFS} = 2.4\%$, $p < 0.001$) and CS (Mean = 3.9; $R^2_{NSvCS} = 5.4\%$, $p < 0.001$). NS were younger when they resolved their AOD problem relative to FS (NS: 32.8 years; FS: 36.6 years; $R^2_{NSvFS} = 1.5\%$, $p < 0.001$). CS were more likely to have resolved their problem recently relative to FS (CS: 10.1 years; FS: 13.5 years; $R^2_{CSvFS} = 1.9\%$; $p < 0.001$). CS were more likely to report receiving inpatient or outpatient treatment (Inpatient: 23.2%; Outpatient: 25.3%) relative to FS (Inpatient: 12.5%, $R^2_{CSvFS} = 1.4\%$, $p < 0.001$; Outpatient: 14.5%, $R^2_{CSvFS} = 1.3\%$, $p < 0.001$) and NS (Inpatient: 8.9%, $R^2_{CSvNS} = 2.7\%$, $p < 0.001$; Outpatient: 9.9%, $R^2_{CSvNS} = 2.9\%$, $p < 0.001$). The average number of 12-step mutual help meetings attended in the past 3 months ranged from 1.63 among NS to 3.81 among CS, but did not significantly differ between groups.

Variables relating to cigarette smoking were examined in the FS and CS groups (Table 2). FS and CS were similar in terms of average age when they began smoking (FS: 15.3; CS: 15.6) and average age when they started smoking regularly (FS: 16.9; CS: 17.1). Compared to FS, CS had smoked cigarettes regularly for more years (FS: 18.6, CS: 24.6; $R^2 = 3.4\%$, $p < 0.001$), but smoked fewer cigarettes per day since smoking regularly (FS: 17.0, CS: 14.0; $R^2 = 1.3\%$, $p < 0.001$). Additionally, CS were more likely than FS to have used nicotine replacement products (FS: 21.9%, CS: 32.8%; $R^2 = 1.1\%$, $p < 0.001$), medications for smoking cessation (FS: 12.0%, CS: 20.5%; $R^2 = 1.0\%$, $p = 0.001$), or e-cigarettes (FS: 11.9%, CS: 27.0%; $R^2 = 2.7\%$, $p < 0.001$).

On average, FS reported quitting cigarettes when they were 34 years old, which was approximately 15 years prior to completing this survey and 2.2 years prior to AOD problem resolution (Fig. 1). Among individuals in recovery with a smoking history, 30% quit smoking prior to entering recovery, 7% quit smoking and entered recovery concurrently (i.e., within the same year), 26% quit smoking after entering recovery and 27% were still smoking. CS reported smoking an average of 14 cigarettes per day in the past week and had attempted to quit cigarettes five times.

3.3. Characterizing time to smoking cessation after AOD problem resolution

Among FS that quit after AOD problem resolution, the median number of years to smoking cessation was 15 (Fig. 2). Analyzing only

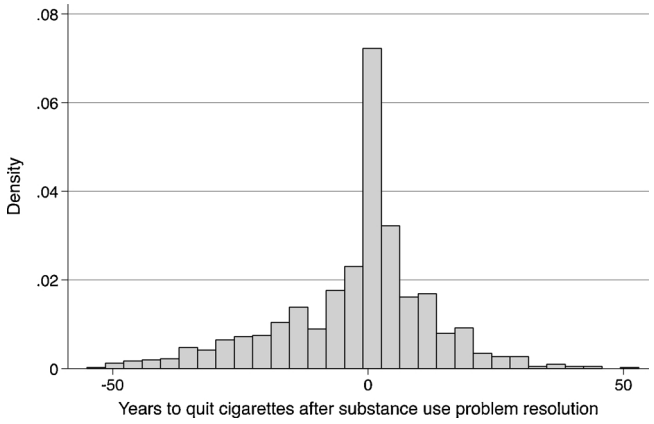

Fig. 1. Distribution of time to smoking cessation in relation to AOD problem resolution among former smokers.

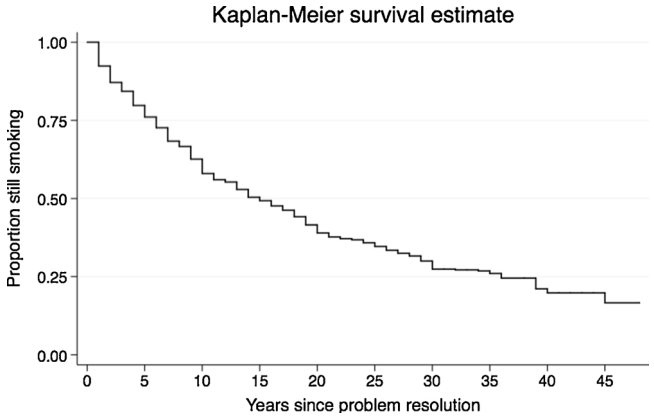

Fig. 2. Time to smoking cessation after AOD problem resolution (in years).

Table 3
Time to smoking cessation by problem resolution cohort (n = 915).

AOD Resolution Cohort (%)	Cumulative incidence (5 years)	Cumulative incidence (10 years)	Survival Time (in years)	
			25%	50%
2006-2015 (53.95%)	0.2717	0.5513	5	10
1996-2005 (28.70%)	0.2406	0.3949	6	–
1986-1995 (17.34%)	0.1493	0.3447	8	–
Total (100%)	0.2334	0.4077	6	15

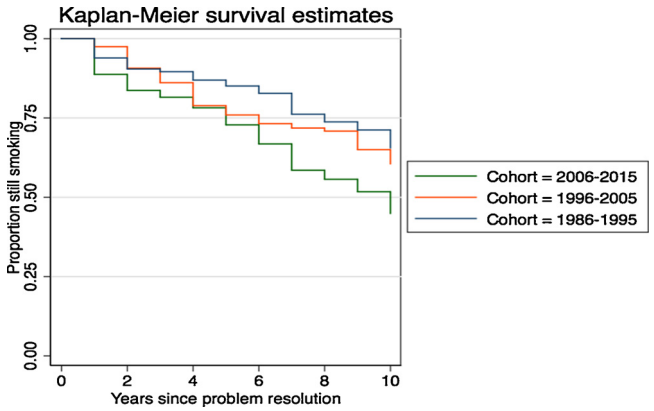

Fig. 3. Time to smoking cessation by recency of AOD problem resolution.

Table 4
Predictors of time to smoking cessation after AOD problem resolution (in years).

	Bivariate Associations			
	HR	SE	t	p
Cohort (ref = 2006-2015)				
Main Effect (1996-2005)	0.755	0.217	−0.98	0.329
Time-Varying Effect (1996-2005)	1.018	0.050	0.38	0.707
Main Effect (1986-1995)	0.690	0.126	−2.03	0.043
Age (> median age of 56 years)	1.035	0.129	0.28	0.781
Male	1.286	0.169	1.92	0.056
Bachelor's degree or higher education				
Main Effect	2.132	0.429	3.76	< 0.001
Time-Varying Effect	0.973	0.017	−1.59	0.111
Income 50,000 USD or greater				
Main Effect	2.216	0.415	4.26	< 0.001
Time-Varying Effect	0.967	0.016	−2.03	0.042
Primary substance (ref = marijuana)				
Main Effect (Alcohol)	1.011	0.326	0.03	0.974
Time-Varying Effect (Alcohol)	1.013	0.032	0.39	0.693
Main Effect (Other Drug)	0.395	0.14	−2.63	0.009
Time-Varying Effect (Other Drug)	1.063	0.036	1.83	0.068
12-step Lifetime				
Main Effect	0.902	0.172	−0.54	0.587
Time-Varying Effect	1.000	0.016	−0.01	0.993
12-step 90 days				
Main Effect	0.659	0.188	−1.46	0.145
Time-Varying Effect	1.044	0.027	1.66	0.098
12-step regular attendance				
Main Effect	0.715	0.134	−1.79	0.073
Time-Varying Effect	1.009	0.016	0.57	0.569
Any outpatient treatment				
Main Effect	1.133	0.268	0.53	0.595
Time-Varying Effect	0.972	0.023	−1.20	0.232
Any inpatient treatment				
Main Effect	0.748	0.166	−1.31	0.192
Time-Varying Effect	1.001	0.021	0.06	0.951

those who quit smoking after AOD problem resolution or were current smokers, which was determined by recency of problem resolution stratified in 10-year intervals (i.e., comparing those resolving their AOD problem between 2006–2015, 1996–2005, and 1986–1995), we found that more recent AOD problem resolution was associated with shorter time to smoking cessation after AOD problem resolution relative to individuals who resolved their AOD problem between 1986–1995 (Table 3; Fig. 3). Specifically, at five and ten years after AOD problem resolution, the cumulative incidence of smoking cessation was 27.2% and 55.1%, respectively, for the 2006–2015 cohort as compared to 14.9% and 34.5% in the 1986–1995 cohort. Also, the time to smoking cessation was significantly shorter for the 2005–2016 cohort, compared to the 1986–1995 cohort (5yrs vs. 8yrs; see Table 3). There were no significant differences in time to smoking cessation between the 2006–2015 and the 1996–2005 cohorts.

Education and income were the only demographic characteristics related to time to smoking cessation, such that individuals with a higher income (greater than or equal to $50,000 USD; HR = 2.13; 95% CI: 1.44, 3.16) or a bachelor's degree or higher education (HR = 2.22; 95% CI: 1.54, 3.20) had a shorter time to smoking cessation (Table 4). The magnitude of the hazard ratio declined modestly over time, but this attenuation was only significant for income (p = 0.042). There were no significant differences in time to smoking cessation by age or sex. People who reported a primary substance other than alcohol or marijuana had a longer time to smoking cessation after AOD problem resolution (HR = 0.40; 95% CI: 0.20, 0.79). There were no significant differences in the time to smoking cessation by 12-step attendance (lifetime, past 90-day or regular attendance) or formal treatment

(outpatient or inpatient).

4. Discussion

This is the first study to estimate the smoking, and smoking cessation, prevalence, as well as the timing and correlates of smoking cessation in relation to alcohol and other drug problem resolution in a national U.S. sample. Findings are consistent with other studies which find higher rates of tobacco use histories among heavily alcohol/drug-involved samples and provides valuable estimates of the overall prevalence of smoking/smoking cessation, and the dynamic shifts in, and factors associated with, time to smoking cessation after people resolve a significant AOD problem. From a clinical and public health standpoint, this study provides potentially good news in that this historically more vulnerable and hard to reach population of smokers appears to be quitting smoking sooner following AOD problem resolution than in prior years.

In keeping with previous research (Guydish et al., 2011; Kalman et al., 2005; National Institute on Alcohol Abuse and Alcoholism (NIAAA), 1998; Weinberger et al., 2018), history of regular cigarette smoking was high at more than 80%, with between one quarter and one-third still actively smoking. Compared to U.S. general population estimates of smoking prevalence (i.e., 15.5%), estimates here suggest current cigarette smoking in this recovering population is more than double. As noted previously, the greater tenacity of smoking in this population could reflect a greater severity profile characterized by an earlier age of smoking onset and greater severity of nicotine dependence (Hughes and Kalman, 2006). Of note, a large proportion (30%) of ever smokers (CS or FS) reported quitting smoking prior to resolving their AOD problem. Correlates of this suggest those stopping smoking prior to AOD problem resolution have a less severe clinical profile characterized by lower rates of AOD treatment utilization, for example. Also, current smokers reported significantly worse quality of life as measured by several indices of psychological well-being and functioning, and higher psychiatric distress. As noted in other studies (Taylor et al., 2014), it is unclear whether cigarette smoking is a cause, correlate, or consequence of this worse functioning. More prospective research is needed to confirm this.

In the sample of those quitting cigarettes after AOD problem resolution, while median time to smoking cessation was 15 years after AOD problem resolution, those entering AOD recovery in more recent years (2006–2015) had a shorter time to quitting smoking relative to those who had resolved their AOD problem between 1986–1995. This is suggestive of a possible impact of several potential factors including higher cigarette prices and restrictions on when and where one can smoke, and greater access to and lower costs of many pharmaceutical smoking cessation aids (West et al., 2018). Although there is now greater attention to smoking cessation in clinical settings treating AOD problems (Shi and Cummins, 2015), receipt of formal AOD treatment was not related to sooner smoking cessation suggesting it may be the broader socio-cultural and pharmaceutical changes regarding cigarette smoking that is driving quicker cessation rather than addressing smoking cessation in AOD treatment, but this should be examined in more detail as this is fairly recent development in AOD treatment. Of note too, was that despite anecdotes about community 12-step participation potentially prolonging smoking, we did not find any association, suggesting that while there may be some in those organizations that view stopping smoking too soon in AOD recovery as a potential relapse hazard, such a view may not be prevalent or impactful.

Also, of all the predictor variables examined, sooner smoking cessation was associated only with socioeconomic variables (higher education and income). The exact mechanisms through which these variables confer this benefit is unclear but could be direct (e.g., greater exposure to knowledge of health harms; financial ability to purchase smoking cessation aids) or indirect (greater general access to recovery resources [“recovery capital”]) which may diminish stress-related cues that may perpetuate smoking. Further explanatory research is needed.

4.1. Limitations

The study’s findings should be considered in light of important limitations. It should be kept in mind that the term “resolution of an AOD problem” used in this paper may certainly overlap with but not necessarily signify diagnostic remission. This study was intended to capture the broader population of individuals who perceive at least some kind of self-defined problem with AOD use, including those with substance use disorder. This level of AOD problem severity has high public health significance because there are a large proportion of individuals who engage in consequential AOD use (e.g., driving while intoxicated/get a DUI), but do not meet diagnostic criteria for AOD disorder. Given that participants are reporting retrospectively on their smoking history and AOD problem resolution it is possible that survival bias could impact results from this study. Future research should attempt to capture dynamic shifts longitudinally in the same individuals over time. Related to this, more generally, our study is cross-sectional and correlational; therefore, appropriate caution should be taken when making inferences about dynamic changes in the same individuals, as well as any causal connections among variables. Future research should attempt to capture dynamic shifts longitudinally in the same individuals over time.

4.2. Conclusion

Smoking is a major contributor to morbidity and premature mortality among individuals with AOD histories. Little was known regarding the prevalence of smoking, and timing and predictors of cessation in recovering AOD populations. Using a nationally-representative sample of Americans who report resolving a significant AOD problem, this study suggests smoking rates are more than double those of the general population. Also, many in AOD recovery quit smoking prior to, and often close to, resolving their AOD problem. Those that persist tend to have more severe clinical histories. Among those quitting smoking following AOD problem resolution, it can take many years to quit, but a greater proportion is quitting and quitting sooner in more recent times among this historically hard to reach and vulnerable population.

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Contributors

Author Kelly conceived the study and wrote the protocol. Authors Kelly, Greene, Bergman, Hoeppner, managed the literature searches and summaries of previous related work. Author Greene undertook the statistical analysis, and author Kelly wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Conflict of interest

The authors have no conflict of interest, including specific financial interests and relationships and affiliations relevant to the subject of this manuscript.

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