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Temporal Trends in Smoking and Nicotine Dependence in Relation to Co-Occurring Substance Use in the United States, 2005-2016

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Abstract

Background.—Despite an overall decline in tobacco use in the United States, secular trends of smoking and nicotine dependence with co-occurring substance use are not well characterized.

Methods.—We examined self-reported tobacco and other substance use in 22,245 participants age 21–59 in the United States from six waves of the National Health and Nutrition Examination Survey (NHANES). Using Joinpoint regression, we assessed secular trends of smoking and nicotine dependence as a function of co-occurring use of alcohol, prescription opioids, marijuana/hashish, cocaine/heroin/methamphetamine, or other injection drug use. Multivariable logistic regressions were fitted to identify the potential risk factors.

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Results.—During 2005–2016, the prevalence of current smoking decreased (without co-occurring substance use: 17.0% to 12.7%; with co-occurring use of one substance: 35.3% to 24.6%; with co-occurring use of two or more substances: 53.8% to 42.2%), and moderate-to-severe nicotine dependence decreased as well (8.0% to 4.2%, 16.0% to 8.8%, and 23.9% to 15.7%, respectively). Smoking and nicotine dependence were more likely in those with co-occurring use of one substance (current smoking: odds ratio [OR]=2.22, 95% confidence interval [CI]=2.01–2.45); nicotine dependence: OR=1.88, 95% CI=1.63–2.17) and in those with co-occurring use of two or more substances (current smoking: OR=5.25, 95% CI=4.63–5.95; nicotine dependence: OR=3.24, 95% CI=2.72–3.87).

Conclusions.—Co-occurring substance use was associated with smaller reductions in tobacco use, over time, and with increased odds of nicotine dependence. This suggests that co-occurring substance users should be regarded as a tobacco-related disparity group and prioritized for tobacco control interventions.

Keywords

Smoking; Nicotine dependence; Substance use; Disparity; Trend

1. Introduction

Despite an overall decline in the past two decades, the adult smoking rate in the United States is still substantially higher than the national objective of Healthy People 2020 (12%) (Department of Health and Human Services, 2020). The U.S. Centers for Disease Control and Prevention defines the tobacco-related disparity groups for populations with excessive tobacco consumption, health and economic burdens from tobacco use, and/or limited access to tobacco-related healthcare services (Centers for Disease Control and Prevention, 2019). Tobacco related disparities have been reported in varied specific populations, including racial/ethnic minorities, sexual/gender minorities, people with low socioeconomic condition, pregnant and breastfeeding women, and people with disabilities (Fagan et al., 2007; Moolchan et al., 2007; Leventhal, 2016).

It has been argued that smokers with health behavior-related comorbidities, such as mental illness and other substance use disorders, should be a priority population for tobacco control (Williams et al., 2013). However, the tobacco-related disparity in relation to co-occurring substance use still remains under-addressed (Williams et al., 2013). Despite the literatures on the relationship of smoking with certain type of substances co-used (Ramo et al., 2012; Schauer et al., 2015; Qato et al., 2020), in the United States, no study has reported population-based temporal trends of current smoking and nicotine dependence relevant to a broader spectrum of substance use (e.g. alcohol, prescription opioids, marijuana/hashish, cocaine/heroin/ methamphetamine, and other injection drug use). In this study, we quantified the tobacco-related disparity in relation to co-occurring substance use in a national sample of adult men and women and characterized the temporal trend during 2005–2016. Such analysis is essential to further understand the potential impacts of recent social and contextual changes on tobacco-related disparities, such as evolving tobacco market relevant to new nicotine products, recent tobacco control policies and comprehensive programs, and new therapies for smoking cessation, etc.

2. Methods

2.1 Study population

Data were derived from the National Health and Nutrition Examination Survey (NHANES), a population-based cross-sectional survey assessing the U.S. population health in English- and Spanish-speaking civilian non-institutionalized adults (Zipf et al., 2013). Mobile examination center (MEC) interviews collected the information on the uses of tobacco, alcohol, drugs, and medications, which was released in two-year cycles (Borrud et al., 2014). In this study, we merged the data from six survey waves: 2005–2006, 2007–2008, 2009–2010, 2011–2012, 2013–2014, and 2015–2016. We restricted the sample to the respondents age 21–59 years, because the MEC questionnaires included questions on drug use (marijuana or hashish, cocaine, heroin, and methamphetamine, as well as intravenous use of these and other drugs) in participants age 18–59, while smoking and alcohol use were only asked among participants age 21 and above. The NHANES study was reviewed and approved by the Research Ethics Review Board from the National Center for Health Statistics. Participants gave informed written consent at the interview. Additional ethics review was exempted for this study, due to the use of a publicly-accessible non-identifiable data source.

2.2 Tobacco use and substance use

A current smoker was defined if a respondent has smoked at least 100 cigarettes in the lifetime and currently smokes at the time of the interview (Jaber et al., 2018). Current smokers were also asked about the average number of cigarettes smoked per day. Nicotine dependence was determined using the Heaviness of Smoking Index (HSI) (Heatherton et al., 1989, 1991; Kim et al., 2018). The HSI integrates the average daily cigarette consumption and the length of the time from waking to the first cigarette to generate a score ranged from 0 to 6, with 0–2 indicating low, 3–4 moderate, and 5–6 high levels of nicotine dependence. We used current smoking and moderate-to-high nicotine dependence as the outcomes.

Binge drinking was defined as the respondent having four or more drinks on at least one day in the prior 12 months (Rodriquez et al., 2018). Other types of co-occurring substance use were queried with several separate questions: how long has it been since you last “used marijuana or hashish”, “used cocaine, in any form”, “last used heroin”, “last used methamphetamine”, and “last used a needle to inject a drug not prescribed by a doctor”. In NHANES, “street drugs” or “illicit drug use” were general terms for the use of “marijuana or hashish, cocaine, heroin, and methamphetamine, as well as intravenous use of these and other drugs” (Fryar et al., 2009; Hollingshead et al., 2016). Street drug use in the 12 months preceding the interview was analyzed in this study. NHANES classified reported medications according to the Multum therapeutic classification scheme, and opioid medication use was identified based on self-reported use of narcotic analgesics. Similar to other national survey databases, such as the National Survey of Drug Use and Health (NSDUH), NHANES does not have sufficient information to differentiate if the participants were misusing opioid medications or obtaining the medications without a prescription (Schmidt et al., 2015). Following a previous study (Martin et al., 1999), we assessed the intensity and severity of the co-occurring substance using the aggregated number of types

of substances co-used. The pattern of other co-occurring substance use was categorized into three mutually exclusive groups: those who used no substance, those who used one type of substance (binge drinking, opioid medication use, marijuana/hashish, cocaine/heroin/methamphetamine, or the injection of drugs), and those who used two or more types of substances. Individual classes of substances were not examined individually, due to the relatively small sample size for each form of co-occurring substance use.

2.3 Covariates

The selected covariates included survey year, gender, race/ethnicity, age, socioeconomic status, education, the type of health insurance, and depression. Socio-economic status was reflected by the household poverty-to-income ratio (PIR) included in the NHANES datasets, which is a ratio of the household income to the established poverty income level for households with same category. If the PIR value is less than one, it indicates that socioeconomic condition of the respondent's household is below the poverty line in that survey year (Kant and Graubard, 2007). The depression was assessed based on the nine-item Patient Health Questionnaire (PHQ-9) included in the NHANES survey, in which the frequency of each of nine depressive items in the past two weeks was scaled at four levels, including 0 (not at all), 1 (several days), 2 (more than half the days), and 3 (nearly every day) (Rodriquez et al., 2018; Hunter et al., 2018). An overall summed score, ranged from 0 to 27, was applied to measure the severity of depression (Maurer, 2012).

2.4 Statistical analysis

The prevalence of current smoking or moderate-to-high nicotine dependence was presented as numbers and percentages adjusted for the MEC weight, which accounts for the survey design, nonresponse, and post-stratification weighting based on the U.S. census estimates (Centers for Disease Control and Prevention, 2018). The distribution of categorical covariates by current smoking and nicotine dependence was examined using the chi-square test.

We performed Joinpoint regression analysis to characterize the secular trends of current smoking and moderate-to-high nicotine dependence in groups reporting co-occurring substance use by gender, using the Joinpoint software package (Version 4.7.0.0, Statistical Methodology and Applications Branch, Surveillance Research Program, National Cancer Institute). Joinpoint regression can detect the potential turning point if a significant change occurs in the linear slope of the temporal trend and quantify the magnitude of the change by calculating the annual percent change (APC) (Kim et al., 2000; López-Campos et al., 2014). The APC values characterized the linear trends in smoking and nicotine dependence over time in the groups with 0, 1, and 2 or more forms of co-occurring substance use. We also performed pair-wise parallel tests to determine if the APC values were statistically different by comparing the group with co-occurring use of one or more substances to the group without co-occurring substance use.

We further performed multivariable logistic regressions to estimate the associations of co-occurring substance use with current smoking and moderate-to-high nicotine dependence, using the Stata statistical package (version 16.0). The models were adjusted for year

of interview, gender (men or women), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, or others), age (21–29, 30–39, 40–49, or 50–59 years), socioeconomic status (below or above the poverty line), education (below high school, high school, or above high school), the type of health insurance (no, private, Medicaid/Medicare, or others), and depression (no depression: score 0, mild: score 1–9, moderate-to-severe: score 10–27) (Manea et al., 2012). All estimates were weighted to reflect the U.S. civilian noninstitutionalized resident population. A statistical significance level from two-sided hypotheses was set at $P<0.05$.

3. Results

In the pool of 2005–2016 NHANES survey cycles, a total sample of 22,245 U.S. adults age 21–59 participated in the MEC surveys. Table 1 shows the characteristics of participants in the 2005–2016 surveys overall and by current smoking and nicotine dependence status. The self-reported race/ethnicity of the study population included 63.9% non-Hispanic Whites, 12.2% non-Hispanic Black/African Americans (AA), and 9.9% Hispanics. Compared with non-smokers, current smokers tended to be younger, male, and non-Hispanic, have income below the poverty line, have a high school or less than high school education, and to be insured through Medicaid or Medicare. Similarly, a greater proportion of non-Hispanic whites and AAs were moderately or highly addicted to nicotine compared to Hispanics. Approximately 45% of participants reported the use of at least one type of non-tobacco substances (29.8% having one type and 14.3% having at least two types). The overall prevalence of current smoking and moderate-to-high nicotine dependence was 24.0% and 10.0%, respectively. Compared to those without co-occurring use of other substances, participants with one, or two or more forms of substance co-use reported a substantially higher prevalence of current smoking (28.4% and 49.2% vs 15.2%, $P<0.001$) and nicotine dependence (11.9% and 20.0% vs 6.4%, $P<0.001$).

Figs. 1 and 2 show the changes in the weighted prevalence rates for current smoking and nicotine dependence in the three groups of co-occurring substance use (0, 1, and 2+ forms) during 2005–2016. In the group without any co-occurring substance use, the proportion of subjects self-reporting current smoking and moderate-to-high nicotine dependence fell sharply from 17.0% in 2005–2006 to 12.7% (APC= -3.67 , $P<0.05$) in 2015–2016, and 8.0% to 4.2% (APC= -6.76 , $P<0.05$), respectively. The declining trends in current smoking and nicotine dependence in participants with co-occurring use of at least one form of substances were reduced (greater absolute values of APCs implying faster changes) compared to those with no co-occurring substance use, especially for smoking among men (parallel test $P_s<0.05$, Figure 1B). Male current smoking without substance use dropped from 20.6% in 2005–2006 to 14.2% in 2015–2016 (APC= -5.83 , $P<0.05$), reflecting a 5.83% reduction, whereas the percentage of bi-annual decline (namely APC values) of current smoking with 1 and 2 forms of co-occurring substances were 1.84% and 2.86%, respectively.

Multivariable-adjusted logistic regressions showed dose-dependent relationships of the odds of current smoking and nicotine dependence with multiple forms of co-occurring substance use ($P_{trend}<0.001$) (Table 2). In comparison to participants without any co-occurring substance use, the likelihood of current smoking was higher in those with co-occurring

use of one substance (adjusted odds ratio [AOR] = 2.22, 95% confidence interval [CI] = 2.01–2.45) and in those who engaged in co-occurring use of at least two forms of substances (AOR = 5.25, 95% CI = 4.63–5.95). Compared with non-Hispanic Whites, there was a lower likelihood of current smoking in non-Hispanic AAs (AOR = 0.82, 95% CI = 0.72–0.93) and in Hispanics (AOR = 0.82, 95% CI = 0.72–0.93). A higher likelihood of current smoking was also associated with having income less than the poverty line (AOR = 1.47, 95% CI = 1.31–1.66), lower educational attainment (below high school: AOR = 2.75, 95% CI = 2.42–3.14; high school only: AOR = 2.23, 95% CI = 1.98–2.52), non-private health insurance (uninsured: AOR = 2.13, 95% CI = 1.87–2.42; Medicaid/Medicare coverage: AOR = 2.21, 95% CI = 1.89–2.58), and moderate-to-severe depression (AOR = 1.93, 95% CI = 1.66–2.24). There was no significant association between gender, age, and the risk of current smoking.

Substance co-users also had a higher likelihood of nicotine dependence (one substance, AOR = 1.88, 95% CI = 1.63–2.17; two or more substances, AOR = 3.24, 95% CI = 2.72–3.87). However, compared to non-Hispanic Whites, the odds of nicotine dependence were lower in non-Hispanic AAs (AOR = 0.47, 95% CI = 0.39–0.56) and in Hispanics (AOR = 0.05, 95% CI = 0.04–0.07). Meanwhile, moderate-to-severe nicotine dependence was more likely to be reported in older adults compared to younger adults (age 30–39 vs age 21–29: AOR = 1.72, 95% CI = 1.38–2.15; age 40–59: AOR = 2.23, 95% CI = 1.78–2.79; age 50–59: AOR = 2.28, 95% CI = 1.85–2.82), in people having household income below the poverty line (AOR = 1.61, 95% CI = 1.37–1.89), in people with lower (vs above high school) education attainment (below high school: AOR = 3.85, 95% CI = 3.22–4.59; high school: AOR = 2.77, 95% CI = 2.37–3.23), in people with non-private health insurance (uninsured: AOR = 2.39, 95% CI = 1.98–2.89; Medicaid or Medicare-insured AOR = 2.08, 95% CI = 1.67–2.60), and in people with depression (mild: AOR = 1.18, 95% CI = 1.01–1.37; moderate to severe: AOR = 2.15, 95% CI = 1.75–2.65). Gender was not significantly associated with the risk of nicotine dependence.

4. Discussion

In a nationally representative sample of US adults under 60 years old, we observed high prevalence levels of current smoking and nicotine dependence associated with co-occurring substance use, including alcohol, prescription opioids, marijuana/hashish, cocaine/heroin/methamphetamine, and other injection drug use. While there was a year-by-year decline in current smoking and nicotine dependence, the decline decreased as the number of co-used substances increased from zero to two or more.

The U.S. Food and Drug Administration (FDA) highlighted the importance of research on efforts in reducing tobacco-related disparities in vulnerable populations, including adolescents and young adults, women who are pregnant or of reproductive age, racial/ethnic minorities, people with low socioeconomic status, rural residents, people with co-morbid conditions (physical and/or mental health), military veterans, and sexual/gender minorities in the Lesbian, Gay, Bisexual, Transgender, Queer (LGBTQ) community (National Institutes of Health, 2017; Spinner et al., 2020). An important finding from the current study is the substantially higher odds of tobacco use among binge drinkers, people taking opioid

medications, and marijuana and/or other drug users. In line with other research (Fagan et al., 2004; Williams et al., 2013), our observation of the high correlation of tobacco and other substance use suggests a need for the extension of the tobacco-related disparity groups to include individuals with co-occurring substance use.

Despite an overall decline in smoking over time, there are still a substantial number of smokers. By the end of 2018, about 13.7% of U.S. adults were smokers (Creamer et al., 2019), still above the *Healthy People 2020* national objective of 12% (Department of Health and Human Services, 2020). Our findings emphasize significantly high prevalence rates of smoking and nicotine dependence among individuals with co-occurring substance use and further demonstrate in this group a reduction in the declining trend of smoking and nicotine dependence for 21–59 year-olds in recent years. The “effectiveness, reach, adoption, and cost efficiency” (Cohen et al., 2012) are emphasized for tobacco control interventions in the general population. Our research suggests that tobacco control efforts should be prioritized for specific disparity populations, especially for those who are hardest to reach, namely, the disparity groups including co-occurring substance use as identified in this study. Integrating efforts for alcohol, opioids, and other drugs co-occurring with tobacco use would improve the effectiveness of tobacco control strategies, thereafter potentially accelerate tobacco control and reduce the burdens of tobacco-related behaviors and diseases. We found that the decline in smoking was more evident among men than women. This suggests that tobacco control policies might have had a more significant impact on men than women. We also observed the exacerbation of effects of other substance use on tobacco use among men. Although the existing literature (Jamal et al., 2016) showed that the decline in tobacco use was not as fast for women as for men in general population, our analysis indicated a gender difference in the trend of smoking among other substance users. No or slower decline of smoking associated with one or more types of other substances co-used was significant in men but not in women.

To date, an abundance of literature reported the interplays of tobacco with any single form of substance use, but little was known about the dose-dependent effect of multiple substances on the trend in smoking prevalence. Understanding such effect is important for tobacco control interventions due to a high prevalence of polysubstance abuse among substance users. Our finding of the high co-use rate between tobacco and other substances echoes the existing evidence surrounding high dual tobacco-alcohol use (Falk et al., 2006) and tobacco-other drug use (Ramo et al., 2012). Smoking may increase the relapse risk among patients in recovery from substance use disorders (Weinberger et al., 2017). There are biological and psychological explanations for this issue. Due to the nicotine being a nicotinic acetylcholine receptor agonist, smoking can increase the mesolimbic dopamine of the brain to enhance the effects, tolerance, and antinociception, and palliate the withdrawal symptoms of some other substance use (Kohut, 2017). Therefore, nicotine-related stimuli and reinforcement-enhancing effects could play important roles in the behaviors and symptoms of polysubstance abuse (Palmatier et al., 2007). For example, nicotine decelerates the emptying process in the stomach to slow the alcohol absorption by the intestine, thus may lead to increased alcohol consumption to achieve the desired effect (Pearson, 2006). The co-use of tobacco and other substances could also be explained by some mechanistic hypotheses of drug abuse, e.g. the “addiction vulnerability hypothesis” and

the “gateway hypothesis” (Rabin and George, 2015). While the former refers to genetic and neurobiological predisposition of addictive behaviors, the latter postulates that substance users may initiate an easier “gateway” substance, such as cigarettes, and further develop to other drugs (Rabin and George, 2015). Although this study is unable to disentangle the underlying mechanism behind co-use of tobacco and other substances, we provided the first, to our knowledge, presentation of secular trends of smoking and nicotine dependence in subgroups of non-users and co-users of substances: current smoking is in a relatively steady-state among individuals with polysubstance use over the last decade, despite a decline among smokers without co-occurring substance use.

From a clinical perspective, our findings highlight the need for increased awareness among primary care practitioners, psychiatrists, physicians of any specialties, pharmacists, as well as other mental health professionals, of the magnitude of the risks from co-use of tobacco and other substances, which were much larger than either class of substance use separately. Nicotine dependence is often overlooked in addiction treatments, in which treatment efforts prioritize the reduction of other substance use over tobacco-use cessation (Prochaska et al., 2004; Prochaska, 2010). Tobacco use was mistakenly regarded as being less harmful compared to other drug use (Prochaska, 2010; Lamb and Ginsburg, 2018). While nicotine dependence treatment substantially depending on primary care physicians has not yielded significant quitting rates, other healthcare providers are not well involved in the “5A” procedure of smoking cessation (ask, advise, assess, assist, and arrange) in the clinical practice for their patients who are smokers (Tong et al., 2010). The combination of addiction treatments with medical services for mental health is a trend in healthcare reform, especially among high-risk populations, such as pregnant women (Goodman, 2015). Therefore, it could be feasible to integrate evidence-based smoking cessation therapies (e.g. enhanced nicotine replacement) with other substance abuse treatments. The existing literature has showed the success of adding a smoking cessation option to the practice standard of healthcare facilities for substance use disorders treatment (Boatner et al., 2020), in terms of enhancement for alcohol treatment (Prochaska et al., 2004; Kalman et al., 2010). It is noteworthy that the effectiveness of patient-oriented interventions depends on how well patients adhere to clinical treatment guidelines. For example, smoking cessation may be more fruitful among patients who receive medication assisted treatment for opioid use disorder than those who are not enrolled or newly enrolled but not well-maintained with the treatment.

It is particularly of high importance for practitioners who prescribe opioid analgesics to be aware of the connections between opioid medication use and tobacco use, especially as the country is experiencing an epidemic of prescription opioid misuse. The existing precautions for opioid prescribing include asking patients about personal and family history of the uses of varied nicotine products and other substances (Yoon et al., 2015). However, it should be of great value for practitioners to gather information about tobacco use when considering a prescription of opioid analgesics. Furthermore, the legalization of marijuana and the popularity of e-cigarettes in recent years might increase the risks of the co-use and addiction, especially in young adults. Future studies should disentangle how these dynamic policy and marketing changes impact on the population-level spatiotemporal trends of tobacco use and dependence.

Our results were generated from a nationally representative large sample of civilian noninstitutionalized adults living in the United States. NHANES survey has a high response rate with a reliable weighting method (Khare et al., 1994). Even so, this study had several limitations. The method of ascertaining binge drinking changed between 2009–2010 and 2011–2012 from “days have 5 or more drinks/past 12 months” to “days have 4/5 or more drinks/past 12 months”. Ideally, five drinks for men and four drinks for women, respectively, on a single occasion within the past 2 weeks (Hunsberger et al., 2020) is the standard for defining binge drinking. However, the adjustment to the four-drink cutoff has been made due to the inconsistency of the questionnaire design of NHANES over years. We followed the NHANES in using “street drugs” as a general term for illicit drug use regardless of the legal recreational use of marijuana/hashish in some of the states over time. The cross-sectional nature of the data prohibited us from determining causal relationships between tobacco use and other substance use. This survey was conducted among noninstitutionalized adults; thus, our results may only have generalizability to the community-dwelling nonelderly (<60 years old) U.S. adults. Due to the availability of data, we only looked at adults age 21–59, but these findings are still relevant, as current cigarette smoking prevalence was the highest among 25–64 year-olds (Creamer et al., 2019). The validity of self-reported substance use was unknown. The critical gaps in data collection for self-administered use of opioid medication for nonmedical use or opioid overdose have been long noticed (Schmidt et al., 2015). While self-reported opioid medication use at a home setting was available, we are uncertain if these medications were obtained with a prescription or not, and if obtained with a prescription, if used as prescribed or not. The Centers for Disease Control and Prevention (CDC) recently reported that opioid overdose deaths have increased by 38.4% since the start of the COVID-19 pandemic (Centers for Disease Control and Prevention, 2020). Opioid addiction and overdose deaths in the U.S. are caused by both prescription (opioid analgesics) and illicit opioid (for example, heroin) use. Not all individuals who prescribed opioid medications become dependent on or misuse them, and unfortunately the cross-sectional study bore the limitation of not identifying the patients who actually misused opioid medications. Due to small sample sizes for several substances reported in the NHANES, we were unable to examine the differences in smoking and nicotine dependence between users of different substances. In addition, restricted geographic information of national NHANES data limited our ability to examine small-area geographic variation and the roles of local drug use policies (e.g. tobacco control policies and the legalization of marijuana) and neighborhood disadvantages (e.g. rural-urban context, socioeconomic deprivation, and racial/ethnic segregation) in smoking and other substance co-use. Future research should, under a multilevel framework, elucidate social and neighborhood contextual influences on the trends of the prevalence of smoking and nicotine dependence in relation to co-occurring substance use.

Overall, our study is among the first to report national trends of smoking and nicotine dependence with co-occurring substance use, including binge drinking, opioid medication use, and use of other drugs, in the recent years. Despite a year-by-year decline in current smoking and nicotine dependence, we observed substantially higher prevalence and slower declining trends of smoking and nicotine dependence in participants with co-occurring substance use than those without co-occurring substance use. Therefore, it is important to

identify individuals, who smoke and have co-occurring substance use, as a tobacco-related disparity group and incorporate strategies targeting substance use into tobacco control interventions.

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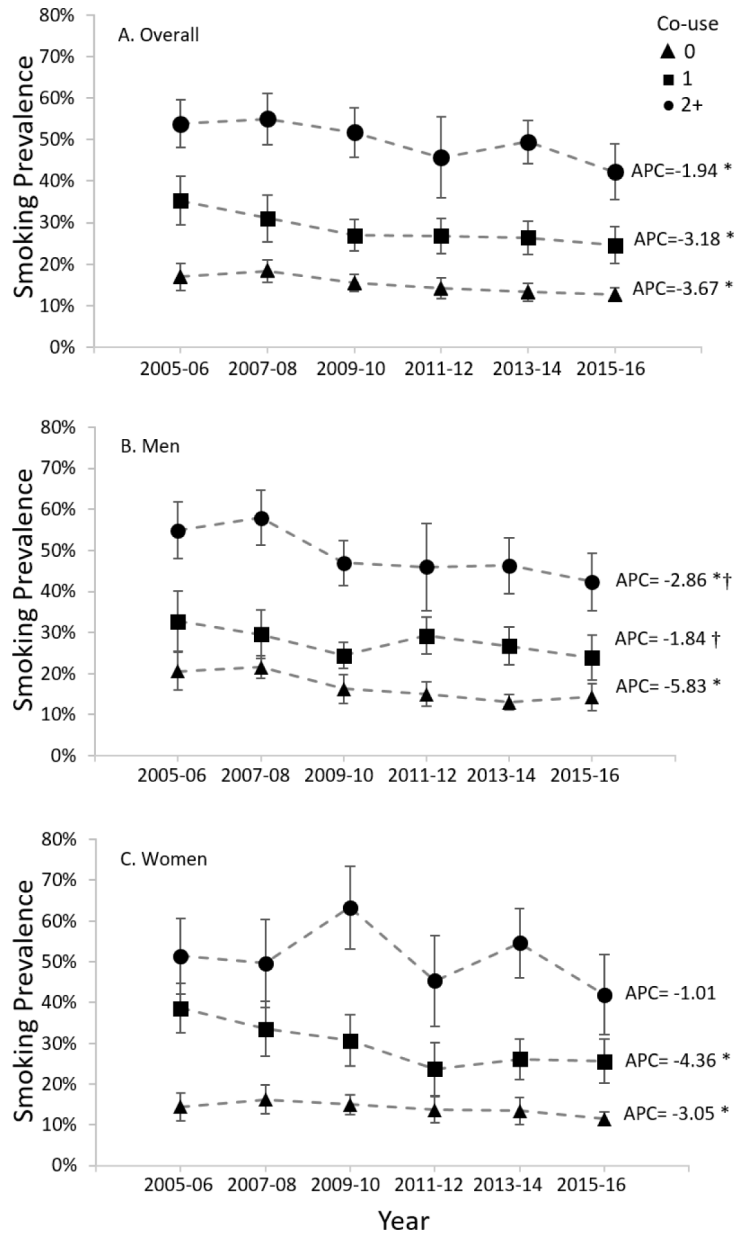
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Highlights:

- Despite overall decline, the U.S. prevalence of smoking still remains high.
- Higher prevalence of smoking and nicotine dependence among other substance users.
- Smoking and nicotine dependence declined more slowly among other substance users.
- Substance co-users should be regarded as a tobacco-related disparity group.
- Smokers with co-occurring substance use should be prioritized in tobacco control.

**Fig. 1.**

Trends in the prevalence of smoking by the number (0, 1, 2+) of co-occurring substance use (namely groups who used no substance, who used one type of substance from binge drinking, opioid medication use, marijuana/hashish, cocaine/heroin/methamphetamine, or the injection of drugs, and who used two or more types of substance) in the United States, 2005–2016. (APC: annual percent change - from Joinpoint regression modeling estimation; * $P < 0.05$ for the Joinpoint regression; † $P < 0.05$ for the parallel test compared to the group without co-occurring substance use. The vertical lines indicate the limits of 95% confidence interval).

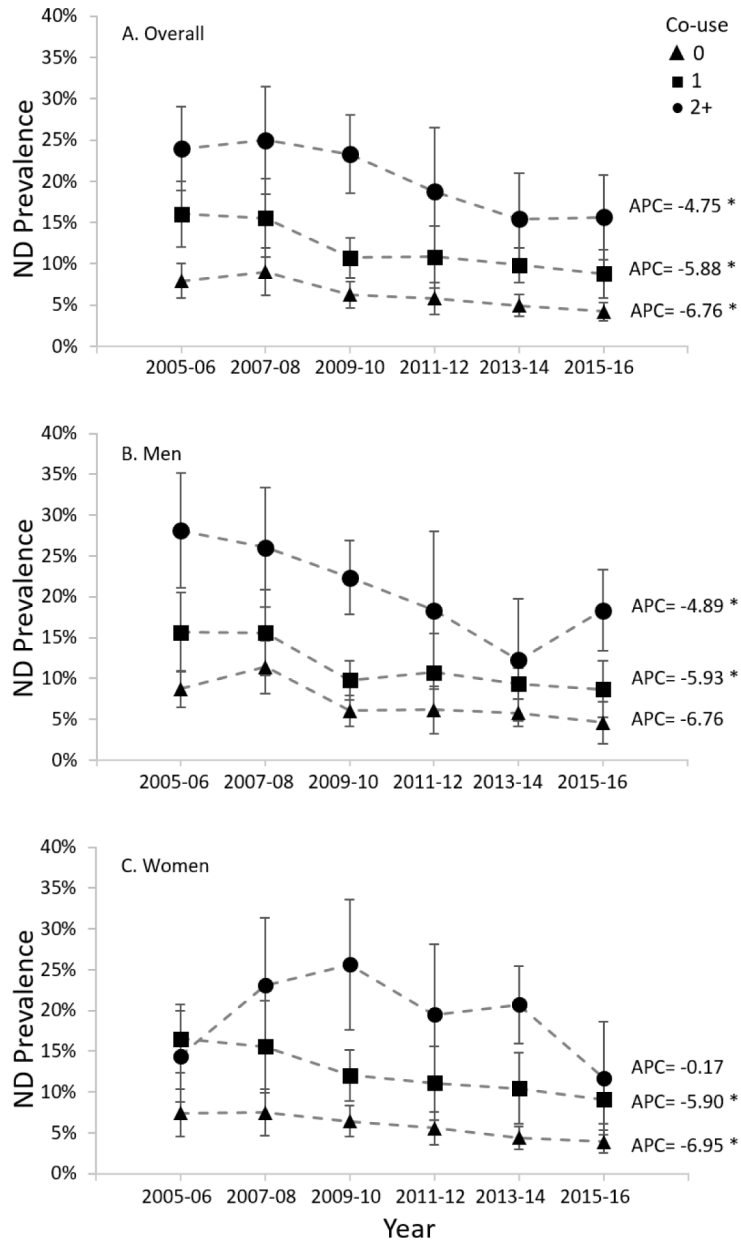


Fig. 2. Trends in the prevalence of nicotine dependence (ND) by the number (0, 1, 2+) of co-occurring substance use (namely groups who used no substance, who used one type of substance from binge drinking, opioid medication use, marijuana/hashish, cocaine/heroin/methamphetamine, or the injection of drugs, and who used two or more types of substance) in the United States, 2005–2016. (APC: annual percent change - from Joinpoint regression modeling estimation; * $P < 0.05$ for the Joinpoint regression; † $P < 0.05$ for the parallel test compared to the group without co-occurring substance use. The vertical lines indicate the limits of 95% confidence interval).

Table 1.

Characteristics of participants by current smoking and moderate-to-high nicotine dependence in the United States, 2005–2016.

Variables	All	Current Smoking		Nicotine Dependence	
	N(%) ^a	Weighted % ^b	P for Chi-2	Weighted % ^b	P for Chi-2
	22,245	5,551		2,135	
Forms of co-occurring substance use	21,517		<0.001		<0.001
0	12,721 (55.9%)	15.2%		6.4%	
1	5,958 (29.8%)	28.4%		11.9%	
2 or more	2,838 (14.3%)	49.2%		20.0%	
Year	22,245		0.022		0.003
2005–2006	3,307 (16.3%)	26.9%		12.3%	
2007–2008	3,701 (16.6%)	26.8%		13.0%	
2009–2010	4,032 (16.6%)	23.8%		9.9%	
2011–2012	3,653 (16.6%)	22.8%		9.3%	
2013–2014	3,817 (16.8%)	22.9%		8.1%	
2015–2016	3,735 (17.1%)	21.0%		7.4%	
Gender	22,245		<0.001		<0.001
Men	10,697 (49.2%)	26.6%		11.2%	
Women	11,548 (50.8%)	21.4%		8.8%	
Race/Ethnicity	22,245				
Non-Hispanic White	8,735 (63.9%)	25.6%		12.5%	
Non-Hispanic AA	4,803 (12.2%)	27.3%		9.3%	
Hispanic	3,907 (9.9%)	17.1%		1.8%	
Others	4,800 (14.0%)	18.6%		4.8%	
Age	22,245		0.016		<0.001
21–29	5,325 (23.3%)	26.2%		7.2%	
30–39	5,850 (24.8%)	23.8%		9.2%	
40–59	5,774 (26.7%)	23.7%		11.6%	
50–59	5,296 (25.3%)	22.5%		11.5%	
Socioeconomic status	20,462		<0.001		<0.001
Above poverty line	15,687 (84.3%)	21.1%		8.5%	
Below poverty line	4,775 (15.7%)	38.9%		17.9%	
Education	22,228		<0.001		<0.001
Below high school	5,101 (16.0%)	37.2%		17.9%	
High school	4,942 (21.7%)	33.6%		16.1%	
Above high school	12,185 (62.3%)	17.3%		5.8%	
Health insurance	22,245		<0.001		<0.001
No insurance	6,454(22.6%)	35.4%		15.6%	
Private	11,603 (62.5%)	17.4%		6.7%	
Medicaid/Medicare	2,125 (6.6%)	40.8%		18.2%	

Variables	All	Current Smoking		Nicotine Dependence	
	N(%) ^a	Weighted % ^b	P for Chi-2	Weighted % ^b	P for Chi-2
Others	2,063 (8.3%)	29.2%		12.5%	
Depression			<0.001		<0.001
No	8,547 (39.7%)	20.1%		7.6%	
Mild	11,167 (51.9%)	23.8%		9.8%	
Moderate-to-severe	1,803 (8.4%)	46.0%		24.2%	

Note: AA, African Americans; PHQ, Patient Health Questionnaire; SD, standard deviation. Chi-2, chi square test.

^aReported numbers represents non-missing data.

^bPercentages are weighted to be nationally representative.

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Table 2.

Factors associated with current smoking and moderate-to-high nicotine dependence in the United States, 2005–2016.

Variables	Current Smoking (n ^a =20,573)	Nicotine Dependence (n ^a =20,520)
	AOR (95% CI)	AOR (95% CI)
Any substance use		
0	Reference	Reference
1	2.22 (2.01, 2.45)	1.88 (1.63, 2.17)
2 or more	5.25 (4.63, 5.95)	3.24 (2.72, 3.87)
<i>P</i> for trend	<0.001	<0.001
Year		
2005–2006	Reference	Reference
2007–2008	0.91 (0.70, 1.18)	0.98 (0.72, 1.32)
2009–2010	0.75 (0.59, 0.96)	0.70 (0.55, 0.90)
2011–2012	0.68 (0.53, 0.88)	0.61 (0.46, 0.82)
2013–2014	0.73 (0.57, 0.93)	0.55 (0.43, 0.72)
2015–2016	0.64 (0.50, 0.83)	0.54 (0.40, 0.71)
<i>P</i> for trend	<0.001	<0.001
Gender		
Men	Reference	Reference
Women	0.96 (0.88, 1.05)	0.91 (0.80, 1.02)
Race/Ethnicity		
Non-Hispanic Whites	Reference	Reference
Non-Hispanic African Americans	0.82 (0.72, 0.93)	0.47 (0.39, 0.56)
Hispanics	0.30 (0.25, 0.35)	0.05 (0.04, 0.07)
Others	0.62 (0.52, 0.73)	0.30 (0.23, 0.40)
Age		
21–29	Reference	Reference
30–39	1.13 (0.99, 1.29)	1.72 (1.38, 2.15)
40–59	1.20 (1.04, 1.37)	2.23 (1.78, 2.79)
50–59	1.14 (0.99, 1.31)	2.28 (1.85, 2.82)
Socioeconomic status		
Above poverty line	Reference	Reference
Below poverty line	1.47 (1.31, 1.66)	1.62 (1.38, 1.90)
Education		
Above high school	Reference	Reference
High school	2.23 (1.98, 2.52)	2.77 (2.37, 3.23)
Below high school	2.75 (2.42, 3.14)	3.85 (3.22, 4.59)
Health insurance		
Private	Reference	Reference
No insurance	2.13 (1.87, 2.42)	2.39 (1.98, 2.89)

Variables	<u>Current Smoking (n^a=20,573)</u>	<u>Nicotine Dependence (n^a=20,520)</u>
	AOR (95% CI)	AOR (95% CI)
Medicaid/Medicare	2.21 (1.89, 2.58)	2.08 (1.67, 2.60)
Others	1.70 (1.46, 1.99)	1.70 (1.31, 2.19)
Depression		
No	Reference	Reference
Mild	1.04 (0.93, 1.16)	1.18 (1.01, 1.37)
Moderate-to-severe	1.93 (1.66, 2.24)	2.15 (1.75, 2.65)

Note: CI, confidence interval; AOR, adjusted odds ratio; CI, confidence interval.

^aThe total sample size for the multivariate logistic regressions.

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