Title

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The effect of college attendance on young adult cigarette, e-cigarette, cigarillo, hookah and smokeless tobacco use and its potential for addressing tobacco-related health disparities

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ABSTRACT

The goal of this study was to assess the effect of college attendance on tobacco use among young adults and across subpopulations with disparities in tobacco use. Using a cohort of US youth (< 18 years) who aged into young adulthood (18–24 years) in the Population Assessment of Tobacco and Health (2013–14, 2015–16, n = 3619) and propensity score matching we estimated the effect of college attendance on past 30-day use of cigarettes, e-cigarettes, cigarillos, hookah and smokeless tobacco. In unmatched analysis, college attenders (vs. nonattenders) had lower risk of using any form of tobacco (Risk Difference (RD): −10.0; 95% CI: −13.2, −7.0), cigarettes (RD: −13.0; 95% CI: −15.4, −10.5), e-cigarettes (RD: −4.1; 95% CI: −6.8, −1.7), cigarillos (RD: −5.7; 95% CI: −7.6, −3.8), and smokeless tobacco (RD: −2.0; 95% CI: −3.4, −0.6), but not hookah (RD: −0.2; 95% CI: −2.1, 1.6). In matched analysis, these associations were all near-null, with the exception of cigarettes (matched RD: −7.1; 95% CI: −10.3, −3.9). The effect of college attendance on cigarette smoking was stable for all subpopulations we assessed including among those identifying as non-Hispanic Black or Lesbian, Gay or Bisexual as well as among those living in the South, Midwest or whose parents did not attend college. The results suggest that college attendance may reduce young adults' risk of cigarette smoking but may not reduce the risk of using other tobacco products.

1. Introduction

Since as early as the 1964 Surgeon General's report (*United States. Surgeon General's Advisory Committee on Smoking. Smoking and Health: Report of the Advisory Committee to the Surgeon General of the Public Health Service, 1964*), researchers have shown large differences in cigarette smoking across levels of education. In the United States (US), for example, the annual decline in smoking prevalence between 1974 and 1985 in the National Health Interview Survey was approximately five times higher among the most educated than among the least (Pierce et al., 1989). Across the life course, differences in tobacco use by educational attainment diverge most pronouncedly in the transition to young adulthood, where adults who do not attend college are more than twice as likely to smoke and typically smoke at higher consumption-levels than their college attending counterparts (Hu et al., 2006; Green et al., 2007; United States Public Health Service: Office of the Surgeon General, National Center for Chronic Disease Prevention and Health Promotion (U.S.) Office on Smoking and Health, 2012; Rath

et al., 2012). Moreover, the epidemiology of progression to regular smoking suggests that the typical college-aged period (18–24 years) represents a critical time when many individuals initiate smoking and experimenters transition to heavier patterns of use (Chassin et al., 1990; Trinidad et al., 2017; Choi et al., 2001).

Several studies have suggested that the effect of educational attainment on cigarette smoking could be causal (Gilman et al., 2008; Fujiwara and Kawachi, 2009; Heckman et al., 2016). While causality is best established with experimental data (Rubin, 1974), the impossibility of designing an experiment in the education setting necessitates the emulation of an experiment using observational data. A primary concern of observational studies of educational attainment and tobacco use are variables that are associated with both educational attainment and tobacco use, known as "confounding" variables. For instance, many known risk factors for tobacco use, such as poor academic performance (DeBerard et al., 2004), are also risk factors for not attending college and may also lead to disparities in use across socioeconomic groups. Past studies have exploited variables exogenous to

the choice to attend college, such as twin or sibling pairing (Gilman et al., 2008; Fujiwara and Kawachi, 2009), to create matched comparisons that are assumed to be comparable, thus controlling for confounding with their study design. Confounding can also be addressed through analysis, when suspected confounders are observed and measured (Greenland, 2011; Hernán and Robins, 2006). The use of propensity score matching (PSM) allows for the control of identified and measured confounders while also checking if balance has been achieved across confounders. PSM mimics the balance achieved in randomized experiments by constructing groups that are similar with respect to measured confounders and thus improves the ability to make a balanced comparison of the effect of college attendance on the risk of tobacco use (Austin, 2011; Ho et al., 2007).

As past studies of educational effects have focused on cigarette use, it is unclear whether the effects of college attendance extends to products like e-cigarettes and hookah, which are now used more frequently by US youth (Wang et al., 2018a; Jamal et al., 2018; Cullen et al., 2018). In this manuscript, we use the nationally representative Population Assessment of Tobacco Health (PATH) Study to first assess whether college nonattenders are at higher risk for using cigarettes, e-cigarettes, cigarillos, hookah and smokeless tobacco in general. Second, we exploit the longitudinal cohort design of the PATH Study along with PSM to make estimates of the effect of college attendance on the risk for using each tobacco product. Third, because educational differences in part explain other disparities in smoking prevalence, such as racial/ethnic differences (Agaku et al., 2019), we assess whether the effect of college attendance differed across various priority populations, including among young adults who are non-Hispanic Black (henceforth Black), identified as Lesbian, Gay or Bisexual (LGB), lived in the South or Midwest, and who had parents who did not attend college. Finally, we explored differences in the social-ecological environment of college attenders and nonattenders (e.g., time spent around smokers, perceived social norms of smoking, and exposure to tobacco advertising) as potential mechanisms for a "college effect" (Sallis et al., 2015).

2. Methods

2.1. Analytical sample

Analyses were based on a cohort of Wave 1 youth (< 18 years) who aged into young adulthood (18–24 years) by Wave 3 of the Population Assessment of Tobacco and Health (n = 3619). The PATH study is an ongoing, nationally-representative, longitudinal cohort study of adults and youth in the US (Hyland et al., 2016). Wave 1 interviews were conducted from September 12, 2013 to December 14, 2014 with a response rate of 78.4% to the youth interview and Wave 3 follow-up surveys were October 12, 2015 to December 14, 2016 with a follow-up response rate that was also 78.4% for the adult interview among Wave 1 survey completers. The PATH Study was conducted by Westat and approved by Westat's institutional review board. Further design details are published (Hyland et al., 2016).

2.2. Measures

2.2.1. Outcome variables
2.2.1.1. Tobacco use. Participants were asked a series of questions about the types of tobacco products they used. Details of questions and responses are presented in Kasza et al. (2017). For our analyses, at Wave 3 we assessed past-30-day use of cigars, cigarettes, cigarillos, e-cigarettes, hookah, smokeless tobacco (excluding snus), and "any" tobacco products (i.e., any of the nine assessed in PATH) as the primary outcome variables. We also adjusted for Wave 1 past-30-day use of any tobacco products.

2.2.2. Exposure variable
2.2.2.1. College attendance. So as to characterize differences in smoking

between those who made any decision to attend college or not, we categorized "college attenders" as those who at Wave 3 were currently enrolled in a 2-year, 4-year or advanced degree program, had attended college but dropped out, or who had already received an associates, bachelors or advanced degree (Heckman et al., 2016). "Nonattenders" were thus those who at Wave 3 were not currently enrolled a 2-or-4-year degree program and had never previously attended college.

2.2.3. Matching and sub-analysis variables
2.2.3.1. Socio-demographic variables. Questions assessing sex and race/ethnicity were administered at Wave 1 and Wave 1 Census Region was coded by Westat using the address for sampling. Missing data on age, sex, race, and Hispanic ethnicity were logically assigned from other survey data as described in the PATH Study User Guide (Westat, 2017). At Wave 1, respondents' parents reported whether their own level of educational attainment, which we categorized to college attender vs. nonattender, and at Wave 3 respondents reported their sexual orientation, which we categorized to LGB vs. Straight.

2.2.3.2. Household to tobacco use. At Wave 1, respondents were asked: "Does anyone who lives with you now use any of the following: [list of tobacco products]," which we categorized for any use vs. no use.

2.2.3.3. Use of other drugs or alcohol. At Wave 1, ever use was ascertained for alcohol, marijuana, as well as for misuse of prescription drugs (i.e., Ritalin/Adderall, painkillers, sedatives, tranquilizers), cocaine or crack, methamphetamine or speed, heroin, inhalants, solvents, and hallucinogens by a series of questions: "Have you ever used [substance]?" Substances were categories as "alcohol," "marijuana," or "any drugs, excluding marijuana." Those who reported ever use were classified as "any use;" all others were classified as "no use."

2.2.3.4. Psychosocial variables. At Wave 1, mental health and substance use problems were assessed using scales from the Global Appraisal of Individual Needs–Short Screener (McDonell et al., 2009). The internalizing subscale (Cronbach's α = 0.81) included 4 items of depressive and anxiety symptoms. The externalizing subscale (Cronbach's α = 0.72) included experience with 5 conduct and behavioral items. Adolescents were scored on how many items they had experienced in the past month or past 2 to 12 months (Conway et al., 2018; Green et al., 2018). At Wave 1, sensations seeking (Cronbach's α = 0.75) was assessed by 3 items modified from the Brief Sensation Seeking Scale (Stephenson et al., 2003). At Wave 1, high school scholastic performance was categorized in two levels (mostly B's or greater vs. less than mostly B's).

2.2.3.5. Self-reported physical health. At Wave 1, respondents recorded their perceived physical health by responding to the question: "in general, would you say your overall health is…." with the response options "Excellent," "Very Good," "Good," "Fair," "Poor."

2.2.4. Exploratory measures of social-ecological environment
2.2.4.1. Perceived social norms. At Wave 3, respondents recorded the perceptions of norms regarding cigarette smoking in general, "In general, do you think most people disapprove of smoking cigarettes?" ("Definitely yes/Probably yes" vs. "Probably not/Definitely not") and among people important to them, "Thinking about the people who are important to you, how would you describe their views on… Smoking cigarettes" ("Very Negative/Negative" vs. "Neither positive nor negative/Positive/Very Positive").

2.2.4.2. Time around smokers. At Wave 3, respondents were asked, "during the past seven days, about how many hours were you around others who were smoking [whether or not you were smoking yourself]? Include time in your home, in a car, at work, or outdoors." Responses

were recorded in hours.

2.2.4.3. Friends who smoke.
At Wave 3, respondents were also asked whether people who they considered important to them used cigarettes ("Yes" vs. "No").

2.2.4.4. Exposure to tobacco ads.
At Wave 3, respondents recorded exposure to different types of tobacco advertising using the question, "In the past 30 days, have you noticed cigarettes or other tobacco products (not including e-cigarettes or electronic nicotine products) being advertised in any of the following places? Choose all that apply." Responses included "At gas stations, convenience stores," "On billboards," "In newspapers or magazines," "On radio," "On television," "At events like fairs, festivals, or sporting events," "At nightclubs, bars, or music concerts," "On websites or social media sites," "Somewhere else (SPECIFY)." We categorized responses as seeing "Any" vs. "No" advertising.

2.3. Managing missing data

Missing data were observed on several of the variables (Supplementary Table 1). These missing data were imputed using the Amelia II algorithm in R with 5 imputed datasets, and by assuming a missing at random pattern (Honaker et al., 2011). Imputation diagnostics suggested the Amelia II algorithm provided imputed values that accurately predicted the observed values for the ordinal variables in our dataset and the majority of the continuous values (Supplementary Fig. 1).

2.4. Statistical analysis

To calculate prevalence estimates and their corresponding 95% CIs, we used the single-wave population and replicate weights for Wave 3, created by Westat using the Balanced Repeated Replication method with Fay's adjustment ($\rho = 0.3$) that when combined with the use of a probability sample allowed for computed estimates that were representative of the non-institutionalized, civilian US population of young adults (Hyland et al., 2016; Westat, 2017).

To calculate propensity scores, we first obtained imputed data sets, then estimated propensity scores, and finally averaged the propensity score for each individual across the imputed data sets (Myers et al., 2015). Separate logistic models were fitted for each of the imputed data sets, with college attendance set as the dependent variable and potential confounders entered as covariates in the regression model. We estimated each respondent's propensity to attend college and averaged the final resulting propensity score for each individual across imputations. Using the resulting propensity scores, each college attender was matched to the closest nonattender(s) using the nearest-neighbor method with optimizations assessed for choice of matching ratios and caliper and by matching without replacement (Austin et al., 2007). Standardized mean differences of each covariate (before and after matching) were used to judge whether the matching improved balance across all imputed data sets. We chose the ratio and caliper that provided the lowest average imbalance across all imputed data sets and assured covariates had standardized mean differences that were < |0.1|, which in all cases was a 1:1 matching ratio with 0.1 caliper (Supplementary Tables 3–8). The final sample size for the resulting matched sample was n = 2480. To explore whether the effect of college attendance on the risk of tobacco use was stable across subpopulations, we also performed the same methods just outlined separately in subsamples for each subpopulation of interest, resulting in additional matched subsamples (Green and Stuart, 2014). The subpopulations we focused on included young adults who identified as Black (matched sample n = 350), LGB (matched sample n = 240), who lived in the South (matched sample n = 920) or Midwest (matched sample n = 546), and whose parents did not attend college (matched sample

n = 1850), as there are known disparities in tobacco use among these subpopulations and there was sufficient sample size to make comparisons within these subpopulation (Agaku et al., 2019; CDCTobaccoFree, 2019). In a sensitivity analysis, we also assessed whether excluding those who had finished or dropped out of college affected the primary results of tobacco use (matched sample n = 2200). After matched samples were obtained, we estimated the differences in the risk of using various forms of tobacco in young adulthood between college attenders and nonattenders in both the matched and unmatched datasets. Finally, we also explored potential mechanisms for the "college effect" by exploring differences in the socio-ecological environment between college attenders and nonattenders using logistic and linear regression in the full dataset.

Risk differences (RDs) were calculated using logistic regression, mean differences (MDs) using linear regression and their corresponding 95% CIs using 1000 draws from the multivariate normal distribution with the mean vector equal to the model coefficients and the variance equal to the coefficient covariance matrix (King et al., 2000). All analyses were performed using R, version 3.5.2 (R Foundation for Statistical Computing).

3. Results

A total of 31.4% (95% CI: 29.0, 33.7) of the young adults who attended college used at least one form of tobacco at Wave 3 compared to 42.0% (95% CI: 39.1, 44.9) among those who did not attend. Among young adults who did not attend college, cigarettes (27.1%; 95% CI: 24.8, 29.5) were the most commonly used tobacco product (Fig. 1), followed by e-cigarettes (21.8%; 95% CI: 19.6, 24.1), cigarillos (13.9%; 95% CI: 12.1, 15.8), hookah (8.7%; 95% CI: 7.0, 10.6), and smokeless tobacco (6.6%; 95% CI: 5.1, 8.4). Among young adults who attended college, e-cigarettes (17.5%; 95% CI: 15.6, 19.5) were the most commonly used tobacco product, followed by cigarettes (13.6%; 95% CI: 12.0, 15.5), hookah (8.5%; 95% CI: 7.0, 10.3), cigarillos (7.9%; 95% CI: 6.7, 9.2), and smokeless tobacco (4.5%; 95% CI: 3.6, 5.6).

The balance assessment step of our PSM procedures (Fig. 2) suggested imbalance between young adult college attenders and nonattenders—as indicated by standardized mean differences above |0.1|—with respect to 10 of the 18 covariates that we assessed as well as the overall propensity score. The matched dataset resulting from the
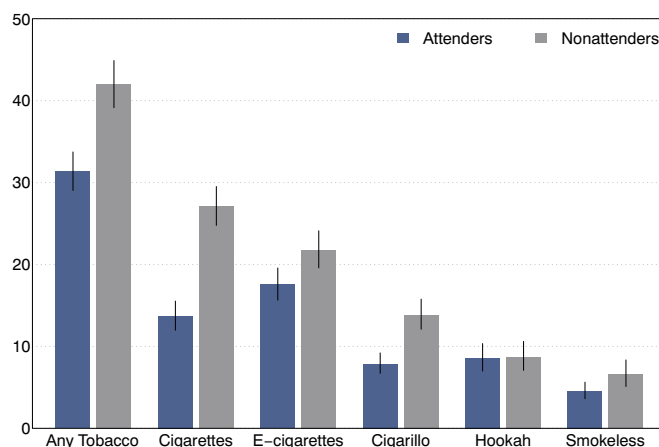
Fig. 1. Prevalence of tobacco product use at Wave 3 by college attendance among the cohort of youth (< 18 years) who aged into early adulthood (18–24 years) between Waves 1 and 3 of the PATH Study, United States, 2013–14, 2015–16.

Notes: The bars indicate the prevalence of tobacco use among college attenders (blue) and nonattenders (grey) with their corresponding 95% CIs. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
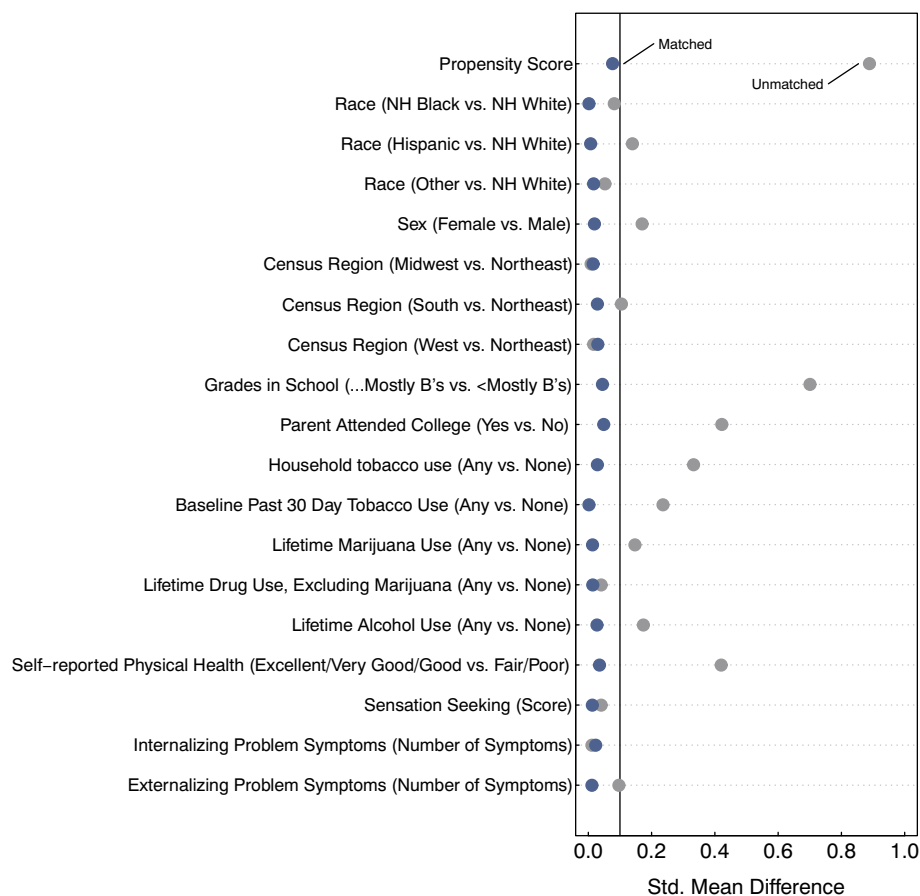
Fig. 2. Standardized mean differences showing the balance improvement obtained by propensity score matching for college attendance and nonattendance, among the cohort of youth (< 18 years) who aged into early adulthood (18–24 years) between Waves 1 and 3 of the PATH Study, United States, 2013–14, 2015–16.

Note: Each dot in the figure indicates the standardized mean difference of the covariate between attenders and nonattenders in either the unmatched sample (grey dots) or in the matched sample. Nearest-neighbor matching was used to balance the matched sample with a 1:1 matching ratio and a caliper of 0.1. Standardized mean difference values < |0.1| indicate good balance.

final matching algorithm improved balance on all variables, such that after matching all standardized mean differences were below |0.1| for each covariate and the overall propensity score. Additional analyses in the supplementary appendices also show that good balance was achieved among the various sub-samples that we assessed the effect of college attendance among, with only minor exceptions among the LGB sub-sample (Supplementary Tables 3–7).

When using logistic regression models on the unmatched dataset (Fig. 3), we observed differences between college attenders and non-attenders in terms of the risk of using any form of tobacco (RD: −10.0; 95% CI: −13.2, −7.0), cigarettes (RD: −13.0; 95% CI: −15.4, −10.5), e-cigarettes (RD: −4.1; 95% CI: −6.8, −1.7), cigarillos (RD: −5.7; 95% CI: −7.6, −3.8), and smokeless tobacco (RD: −2.0; 95% CI: −3.4, −0.6), but comparable risk of using hookah (RD: −0.2; 95% CI: −2.1, 1.6). When using the balanced datasets there were no differences between college attenders and nonattenders in terms of the risk for using any form of tobacco (matched RD: −3.5; 95% CI: −7.3, 0.1), e-cigarettes (matched RD: −1.5; 95% CI: −4.6, 1.5), cigarillos (matched RD: −2.0; 95% CI: −4.4, 0.3), smokeless tobacco (matched RD: −1.0; 95% CI: −2.6, 0.7) and hookah (matched RD: 1.0; 95% CI: −1.3, 3.2). However, the differences between college attenders and nonattenders remained for cigarettes (matched RD: −7.1; 95% CI: −10.3, −3.9).

Moreover, the effect of college attendance on the risk for cigarette use was stable across the sociodemographic subpopulations that we assessed (Fig. 4). Specifically, the risk of cigarette use was 13.8 percentage points (matched RD; 95% CI: −24.5, −2.3) lower among college attenders who identified as LGB than among nonattenders who identified as LGB, 8.2 percentage points (matched RD; 95% CI: −15.7, −1.6) lower among college attenders who identified as Black than among nonattenders who identified as Black, and 9.2 percentage points (matched RD; 95% CI: −12.8, −5.5) lower among first-generation college attenders than among nonattenders whose parents were also
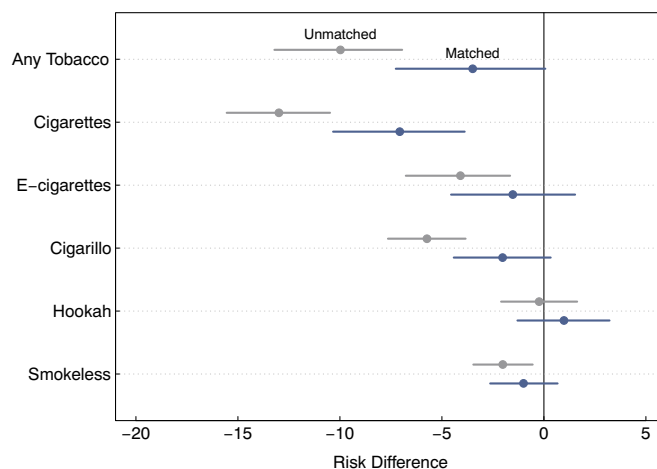

Fig. 3. Differences in the risk of using tobacco by college attendance in the full unmatched sample and the propensity score matched sample, among the cohort of youth (< 18 years) who aged into early adulthood (18–24 years) between Waves 1 and 3 of the PATH Study, United States, 2013–14, 2015–16.

Notes: Each dot in the figure indicates the difference in risk of using the specific tobacco product corresponding to the row between college attenders and nonattenders and line segments indicate 95% CIs for those risk difference estimates. Negative values indicate lower risk among college attenders vs. non-attenders while values at 0 indicate no difference. Grey dots and segments were estimated using the full unmatched sample and blue dots and segments were estimated using the matched sample. Nearest-neighbor matching was used to balance the matched sample with a 1:1 matching ratio and a caliper of 0.1. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
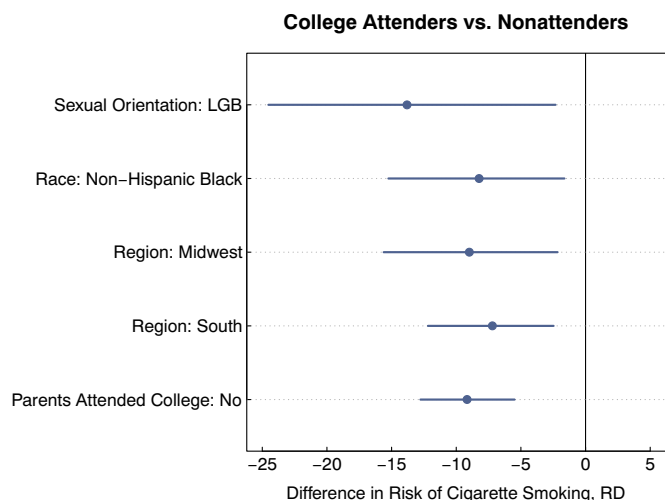
College Attenders vs. Nonattenders

Fig. 4. Differences in the risk of using tobacco by college attendance in propensity score matched samples, among subpopulations of the cohort of youth (< 18 years) who aged into early adulthood (18–24 years) between Waves 1 and 3 of the PATH Study, United States, 2013–14, 2015–16.
Notes: RD = risk difference; each dot in the figure indicates the difference in risk of using cigarettes between college attenders and nonattenders and line segments indicate 95% CIs for those risk difference estimates. Negative values indicate lower risk among college attenders vs. nonattenders while values at 0 indicate no difference. Each risk difference was estimated in a separate subsample corresponding with subpopulation specified in the row. Nearest-neighbor matching was used within this subsample to balance the covariates. All matched samples were balanced with a 1:1 matching ratio and a caliper of 0.1.

nonattenders. Further, when comparing geographic locations with a high prevalence of cigarette use, the risk of cigarette use was 9.0 percentage points (matched RD; 95% CI: −15.6, −2.2) lower among college attenders from the Midwest than among nonattenders from the Midwest and 7.2 percentage points (matched RD; 95% CI: −12.2.2.5) lower among college attenders from the South than among than nonattenders from the South.

When comparing how the socio-ecological environment differed between college attenders and nonattenders (Table 1), we found that college attenders had a lower probability of knowing someone who they perceived to be important to them who smoked cigarettes than nonattenders (RD: −8.6; 95% CI: −11.9, −5.3) and of being exposed to tobacco advertising (RD: −7.3; 95% CI: −10.7, −4.1). College attenders also had a higher probability of perceiving social disapproval of cigarette smoking in general (RD: 7.2; 95% CI: 4.3, 10.0) and from people they perceived to be important to them (RD: 17.6; 95% CI: 14.8, 20.4). College attenders also spent less time with smokers (MD (h):

Table 1
Differences in socio-ecological risk and protective factors between college attenders and nonattenders among the cohort of youth (< 18 years) who aged into early adulthood (18–24 years) between Waves 1 and 3 of the PATH Study, United States, 2013–14, 2015–16, n = 3619.

Variable	RD or MD	95% CI	
Perceived norm of cigarette smoking (general)	7.2	4.2	10.0
Perceived norm of cigarette smoking (among people important)	17.6	14.8	20.4
Had friends who smoked	−8.6	−11.9	−5.3
Exposed to tobacco advertising in past 30 days	−7.3	−10.7	−4.1
Hours spent around smokers while they were smoking in past 7 days	−3.1[a]	−4.1	−2.2

Note: Higher RD and MD values favor college nonattenders while lower values favor college attenders.
[a] Value is mean difference; MD = mean difference; RD = risk difference.

−3.1, 95% CI: −4.1, −2.2) than nonattenders.

A sensitivity analysis revealed that including or excluding those who had graduated or dropped-out of college did not qualitatively impact the results or interpretation of the results (Supplementary Fig. 2).

4. Discussion

In this nationally representative cohort of US young adults, we found that college attendance reduced the risk of cigarette smoking but not the risk of using other tobacco products. For cigarette use, the protective effect of college attendance extended across populations with noted tobacco disparities, highlighting the potential that increasing access to college education could have on reducing disparities in cigarette smoking. College attenders perceived stronger norms against smoking cigarettes, had fewer friends who smoked and were less likely to be exposed to other smokers or to tobacco advertising, which may help to explain the effect of college attendance on the risk of cigarette smoking.

The finding that college attendance reduces the risk for cigarette smoking is consistent with past studies that relied on other methodological approaches (Gilman et al., 2008; Fujiwara and Kawachi, 2009; Heckman et al., 2016). We add to this literature in several unique ways. Most notably, we found that although the prevalence of e-cigarette, cigarillo and smokeless tobacco use was lower among college attenders and that these differences were explained by differences in pre-college risk factors suggesting the absence of a "college effect." Moreover, we found that cigarettes were the most frequently used product among college non-attenders, while e-cigarettes were the most frequently used product among college attenders and there was no difference between college attenders and nonattenders in terms of the risk of using hookah. One possible explanation for these results is that there are fewer prevention and health education mechanisms in place that discourage use of e-cigarettes and hookah among college attenders. For instance, there is a common misconception that e-cigarettes and hookah are safer than cigarettes, and this is associated with use (Strong et al., 2019); hookah lounges are highly prevalent around college campuses (Kates et al., 2016); and less than half of colleges include restrictions on hookah smoking in their smoke-free air laws (Wang et al., 2018b). Scaling out interventions that focus on such intermediary variables may increase the potency of the college effect on reducing use of non-cigarette tobacco products.

We also found that the effects of college attendance on the risk of cigarette use extended across populations with smoking-related disparities. This finding substantiates past studies that have shown that differences in education attainment can help explain other smoking-related disparities (Agaku et al., 2019) by suggesting with that these differences in the case of college attendance may be causal. By extension, this suggests that increasing college attendance among populations vulnerable to smoking may improve health outcomes in those populations by reducing the risk of smoking. Where sample size allows, future studies should also investigate whether the effect of college attendance extends to other populations with notable disparities in tobacco use, such as Americans Indians and Alaskan Natives (Agaku et al., 2019).

When considering the potential mechanism by which college might prevent cigarette smoking we found evidence suggesting that differences in the social-ecological environment between attenders and nonattenders may at least partially play a part (Sallis et al., 2015). In our results, college attenders were more likely to perceive strong anti-smoking norms, less likely to socialize with smokers and were exposed to fewer tobacco advertisements. Continuing to scale out policies, such as smoke-free air laws, that make college campuses less amenable to smoking, as well as considering policies that govern the quantity, type and location of retailer outlets and marketing (Luke et al., 2017) around college campuses, may further increase the effect that college

attendance has on tobacco use.

There is also a need for tobacco prevention efforts that reach beyond the college campus to impact nonattending tobacco users who use tobacco at higher rates. Comprehensive tobacco control programs that reach both college attenders and non-attenders should be applied in all state and local jurisdictions (U.S. Department of Health and Human Services, 2014). Increasing the minimum age of tobacco sales to 21 could reduce both youth and young adult tobacco use regardless of college attendance; however, coverage of this policy remains low (Leas et al., 2019). Targeted interventions that focus on places where nonattending populations congregate should become a programmatic focus. For instance, some tobacco control interventions targeting young adults have been implemented in bars and could be applied more broadly (Ling et al., 2014). Additionally, ensuring that broader implementation of effective workplace-focused cessation programs at workplaces that employ a large number of young adults may improve cessation outcomes among smokers in these organizations (Syamlal et al., 2019).

While our study has many strengths, there are some limitations that should be noted. Although follow-up rates were relatively high for the PATH Study, the nonresponse to the follow-up survey could impact our results. Also, although matching drastically improved balance on the many potential confounders that were included in the PATH Study, there is always a potential that additional unmeasured confounders are driving the observed associations. However, these would need to be substantial and operate in the opposite direction of the observed confounders to bring back any effect of college attendance on the risk of using e-cigarettes, cigarillos, hookah or smokeless tobacco. Thirdly, while capturing the most inclusive definition of college attendance, our measure may suppress further variation between college attenders that could not be captured due to the short time window of the study and merit future research. For instance, there may be differences between 2-year and 4-year degree programs (Heckman et al., 2016), public or private universities, or between schools that have stronger or weaker tobacco control policies. Finally, given the small sample size of LGB young adults, we had relatively low power to detect the effects of college attendance on cigarette use among this subsample; however, despite the small sample and associated low precision, the effect was comparable in magnitude and did not cross the null.

While considering these important limitations, our study suggests that increasing access to college in the US could have a positive effect on reducing cigarette smoking, including by addressing tobacco-related disparities. Strengthening existing tobacco control efforts on college campuses—e.g., by ensuring all tobacco products are included in smoke-free air laws—and creating new policies to counteract other environmental exposures, such as the proliferation of hookah lounges, may further strengthen the "college effect" on cigarettes and other tobacco products. Interventions that reach beyond the college campus must be considered to address the higher use rates among nonattending young adults.

Contributions

Concept and design: Leas.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: All authors.
Critical revision of the manuscript for important intellectual content: All authors.
Statistical analysis: Leas, Benmarhnia.
Administrative, technical, or material support: Pierce, Trinidad.
Supervision: Pierce, Trinidad.

Funding details

Declaration of competing interest

None to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ypmed.2019.105954.

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