Trajectories of Tobacco and Nicotine Use Across Young Adulthood, Texas, 2014–2017

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Objectives. To examine intraindividual change in polytobacco and individual tobacco and nicotine product use across young adulthood.

Method. Participants were 2711 students from 24 Texas colleges participating in a 6-wave online study, with 6 months between each wave. Participants were aged 18 to 25 years at baseline in fall 2014 or spring 2015 and aged 20 to 28 years at wave 6. We used growth curve modeling for an accelerated longitudinal design to examine change from ages 18 to 28 years in polytobacco use (use of 2 or more products) and in use of 5 individual products (cigarettes, smokeless tobacco or snus, large cigars, cigarillos, or little cigars, hookah, and electronic nicotine delivery systems [ENDS]).

Results. There was a statistically significant decline in polytobacco use from ages 18 to 28 years. There were also statistically significant declines in ENDS, hookah, and cigar use but not in smokeless tobacco use, for which use was negligible, or in cigarette use. Importantly, cigarettes were the most used product at virtually all ages.

Conclusions. Young adults may mature out of polytobacco use with increasing age, but they may continue to use some products, most notably cigarettes, potentially the most toxic and addictive tobacco and nicotine product. (*Am J Public Health.* 2019;109: 465–471. doi:10.2105/AJPH.2018.304850)

The tobacco and nicotine landscape continues to change, and the diversity of available products is greater than ever before. Patterns of tobacco and nicotine product use are also evolving. Single product use has become less prevalent over the past decade, whereas polytobacco use, or the concurrent use of 2 or more tobacco and nicotine products, is increasingly prevalent.[1] Risk for polytobacco use is particularly high among young adults. Data from the 2012 National Adult Tobacco Survey indicate that young adults aged between 18 and 24 years had the highest prevalence of polytobacco use compared with adults older than 24 years.[2] Moreover, findings from the National Survey on Drug Use and Health indicate that polytobacco use rates increased across the 10-year period from 2002 to 2011 for young adults aged 18 to 26 years but not for older adults.[3]

Young adulthood is characterized by changes in various developmental domains and behaviors, including tobacco use.[4] Although young adulthood is widely acknowledged as the developmental period during which nicotine addiction solidifies for existing users,[5] there are also new users of tobacco and nicotine products during this period.[6] The 2011 Legacy Young Adult Cohort Study found that 32% of young adults aged 18 to 34 years who were ever-tobacco users reported initial use of 1 of 10 tobacco products after they were aged 18 years.[7] Compared with older adults, young adults may be more open to trying tobacco and nicotine products because of the increased experimentation that marks this developmental period[4] and because of tobacco marketing targeting this population.[8] Young adults may be particularly likely to experiment with noncigarette products, such as hookah, electronic nicotine delivery systems (ENDS), and cigars, because they are perceived to be less harmful and addictive and more socially acceptable than are traditional cigarettes.[9,10] Young adult cigarette users may also use these products, particularly noncombustible ones, as substitutes for cigarettes[11] and to reduce or quit cigarette use.[12]

As young adults age and transition into adult roles, such as full-time work and marriage, experimentation with multiple products may become less prevalent. Research on cigarette use indicates that some young adult cigarette users "mature out" of cigarette use in their late 20s as they transition to adulthood and assume adult roles.[13] Similarly, research on substance use indicates that although use of licit and illicit drugs increases during young adulthood, most substance use declines when people are in the mid-20s to mid-30s, with alcohol and cigarette use showing the most persistence across time.[14] On the basis of these findings, it is possible that as young adults age, they begin to mature out of all forms of tobacco use. However, because of the addictive nature of nicotine and the fact that even intermittent users may have symptoms of dependence,[15] it is also possible that as young adult polytobacco users age, they do not quit all products but rather consolidate use into fewer products. To date, few studies have examined changes in polytobacco use as young adults get older. It is therefore not known whether young adults maintain multiple product use across time or whether multiple product use decreases across time.

Given the current popularity of polytobacco use,[1] increasingly more research

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focuses on the potential consequences of this pattern of use. However, consequences cannot be fully evaluated without an understanding of the developmental changes in polytobacco use, particularly because some products are more likely to be health compromising in the long term, such as cigarettes.[16] Relatively few longitudinal studies examine polytobacco use across multiple periods,[17,18] and even fewer examine intraindividual change in young adults' polytobacco use.[19] Thus, it is not known if polytobacco use increases, decreases, or remains stable across increasing age. Moreover, with the exception of cigarettes and smokeless tobacco, there is limited longitudinal research on developmental changes in individual tobacco and nicotine product use, especially in the past decade.

To fill voids in the existing literature, we examined intraindividual change in polytobacco use across young adulthood. We used growth curve modeling to determine whether trajectories of polytobacco use increased, decreased, or stayed stable from ages 18 to 28 years. We also examined intraindividual change in individual product use to determine whether change in the use of individual products accounted for, or explained, potential change in polytobacco use. We used growth curve modeling to determine whether trajectories of cigarette, ENDS, hookah, cigar, and smokeless tobacco use increased, decreased, or stayed stable from ages 18 to 28 years. On the basis of a maturing out hypothesis,[14] we expected that polytobacco and single product use would decline with increasing age.

METHODS

Participants were from the first 6 waves of the Marketing and Promotions Across Colleges in Texas project (Project M-PACT). Project M-PACT is a longitudinal, rapid response, surveillance study that is tracking changes in tobacco marketing and tobacco use behaviors from a cohort of 5482 students who were initially aged 18 to 29 years and attending 1 of 24 colleges in the 5 counties surrounding the Texas cities of Austin, Dallas/Fort Worth, Houston, and San Antonio. The first wave of data was collected from October 2014 to February 2015, and follow-up waves were collected every 6 months thereafter.[20] Retention across follow-up waves ranged from 78% (wave 5) to 81% (wave 4) of the 5482 participants.

We included only participants who were aged 18 to 25 years, an age range that is typically considered to be young adults,[21] at wave 1 and those who reported current (i.e., past 30-day) use of at least 1 tobacco or nicotine product in 1 or more of the 6 waves in this study (n = 2713 of the original 5482). Of the 2713 participants, we excluded 2 because of incomplete data in the model covariates. Thus, the sample size for this study was 2711 participants. At baseline, the 2711 participants had a mean age of 20.28 years (SD = 1.89); 59.1% were female; 93.3% attended a 4-year versus a 2-year college; and 36.4% were non-Hispanic White, 33.4% were Hispanic/Latino, 14.4% were Asian, 7.7% were Black/African American, and 8.0% were another race/ethnicity or reported 2 or more races/ethnicities.

Procedure

We sent the students attending the 24 colleges an e-mail describing the study purpose and inviting them to complete an eligibility survey to participate in an online survey. To be eligible to participate, students were required to be aged 18 to 29 years and full- or part-time degree- or certificate-seeking undergraduate students attending a 4-year college or a vocational or technical program at a 2-year college. Eligible students provided informed consent and completed the online survey. We recontacted participants via e-mail and text message biannually for 5 follow-up waves. We compensated participants with a $10 e-gift card at waves 1 and 2 and a $20 e-gift card at waves 3 to 6, and we entered them into a drawing for 1 of 20 $50 e-gift cards at each wave. Of the 13 714 students who were eligible to participate, 5482 (40%) provided consent and completed the survey.

Outcome Variables

We assessed current use of 5 products (cigarettes; smokeless tobacco or snus; large cigars, cigarillos, or little cigars; hookah; and ENDS) at all 6 waves with items adapted from the Youth Tobacco Survey[22] and the Population Assessment of Tobacco and Health Survey.[23] We assessed current use of cigarettes and smokeless tobacco with the question "During the past 30 days, on how many days did you smoke/use _____?" We assessed current use of large cigars, cigarillos, or little cigars, and hookah with the question "During the past 30 days, how many days did you smoke ____ as intended (i.e., with tobacco)?" We assessed current use of ENDS with the question "During the past 30 days, have you used any ENDS product (i.e., an e-cigarette, vape pen, or e-hookah), even 1 or 2 puffs, as intended (i.e., with nicotine cartridges and/or e-liquid/e-juice)?" We dichotomized scores for all 5 products so that participants who indicated using the product on at least 1 day in the past 30 days were assigned a value of "1"; we assigned all others a value of "0."

We computed polytobacco use at all 6 waves as the sum of the 5 dichotomous tobacco and nicotine products used in the 30 days before the survey. Scores ranged from "0" = used 0 products in the past 30 days to "5" = used all 5 products in the past 30 days.

Wave 1 Sociodemographic Factors

Because males, older young adults, non-Hispanic Whites, Blacks/African Americans,[24] and students in 2-year colleges[25] generally are more likely than are their counterparts to use tobacco, we included 4 sociodemographic variables from wave 1 in all models as covariates. Covariates were age, sex ("0" = female; "1" = male), race/ethnicity (dummy-coded for Hispanic/Latino, Black/African American, Asian, and other, with White as the reference group), and type of college attended ("0" = 2-year; "1" = 4-year).

Data Analysis

We analyzed study questions using growth curve models for an accelerated longitudinal design. Participants were aged 18 to 25 years at wave 1 and 20 to 28 years at wave 6. The accelerated design used participant age as the variable to assess change, and participants contributed up to 2.5 years of data on the basis of their exact age at each wave. Thus, the models' age parameters represent the fitted trend for the entire age range of the sample, 18 to 28 years, on the basis of contributions from participants' overlapping age ranges.

We examined intraindividual change in polytobacco use using multilevel growth curve models that we fit using the SAS version 9.4 (SAS Institute, Cary, NC) MIXED procedure, in which outcomes were nested within participants. We regressed the number of tobacco and nicotine products used in the past 30 days on participant's age. We centered age at 18 years, the youngest possible age in the study. Before adding the sociodemographic covariates to the model, we established an unconditional growth model (i.e., a model without these covariates) following recommendations from Singer and Willett.[26] We compared 3 unconditional growth models: a linear age effect, a quadratic age effect, and a log-linear age effect. We computed the log-linear age effect by adding 1 to age centered at 18 years so that the minimum log-transformed value was zero. Examination of the Akaike information criterion for the unconditional models indicated that a log-linear age growth model was the best unconditional growth model for the polytobacco use outcome. Thus, we fit the conditional log-linear age model for number of products by adding the 4 sociodemographic covariates to the model.

We examined intraindividual change in use of each individual product using multilevel growth curve modeling and the SAS GLIMMIX procedure with a logit link for a binary and dichotomous distribution. Similar to the model for polytobacco use, the 5 past 30-day tobacco and nicotine product outcomes for these models were nested within participants. We tested unconditional and conditional models identical to those for the polytobacco use outcome. Like the polytobacco use outcome, the log-linear age effects growth model represented an equivalently good or better fitting model than did the linear and quadratic effects models for each of the individual products, except for ENDS and hookah, for which the quadratic and linear models, respectively, were a slightly better fit. We ultimately fit each of the products using log-linear age for the sake of consistency. However, results for linear and log-linear models were consistent; thus, the choice between a linear and log-linear model did not affect any conclusions.

RESULTS

Before assessing study questions, we examined the mean number of products used and the prevalence of individual product use at each of the 6 study waves (Table 1). The mean number of products used was highest at wave 1 (1.27) and lowest 2.5 years later at wave 6 (0.82). Examination of individual product use indicated that cigarettes were the most prevalent product used at each of the 6 waves, followed by ENDS and hookah, cigars, and then smokeless tobacco (Table 1).

Results from the unconditional growth model (i.e., no sociodemographic covariates included) examining intraindividual change in polytobacco use from ages 18 to 28 years indicated that there was a statistically significant negative effect of polytobacco use with increasing age (B = –0.35; $t[10\,311] = -13.52$; $P < .001$). Addition of the sociodemographic covariates in the conditional model also resulted in a statistically significant negative effect of polytobacco use and a statistically significant positive effect of sex across increasing age ($t[10\,311] = -13.52$; $P < .001$; Table 2). Findings indicated that the number of tobacco and nicotine products used declined with increasing age and that males used more products than did females across all ages (Figure 1).

Regarding individual products (Table 2), there were statistically significant declines from ages 18 to 28 years for ENDS ($t[10\,604] = -10.08$; $P < .001$), hookah ($t[10\,449] = -9.89$; $P < .001$), and cigar ($t[10\,523] = -4.18$; $P < .001$) use but no statistically significant change across age for cigarette ($t[10\,625] = 0.49$; $P = .621$) and smokeless tobacco ($t[10\,383] = 1.20$; $P = .232$) use (Figure 2). Thus, ENDS, hookah, and cigar use declined across increasing age, but there was no change in cigarette and smokeless tobacco use. Regarding the covariates, males were more likely than were females to currently use all products, except hookah. Compared with non-Hispanic Whites, all other races/ethnicities were more likely to use hookah; Blacks/African Americans were less likely to use ENDS and cigarettes but more likely to use cigars; and Asians were less likely to use ENDS, cigarettes, and cigars. There were no differences between non-Hispanic Whites and Hispanics in cigarette, ENDS, cigar, or smokeless use. Finally, 4-year college students were more likely to use hookah than were 2-year students.

Examination of Figure 2 indicates 3 notable trends: (1) prevalence of cigarette use was highest at virtually all ages compared with use of all other tobacco and nicotine products; (2) likelihood of cigar and smokeless tobacco use was relatively low across increasing age, particularly for smokeless use, which was negligible; and (3) likelihood of ENDS and

TABLE 1—Prevalence of Past 30-Day Tobacco and Nicotine Use and Mean Number of Products Used by Study Wave: Texas, 2014–2017

Product	Wave 1, Fall 2014 (n = 2711), % or Mean (SD)	Wave 2, Spring 2015 (n = 2115), % or Mean (SD)	Wave 3, Fall 2015 (n = 2137), % or Mean (SD)	Wave 4, Spring 2016 (n = 2190), % or Mean (SD)	Wave 5, Fall 2016 (n = 2094), % or Mean (SD)	Wave 6, Spring 2017 (n = 2167), % or Mean (SD)
Cigarettes	38.9	32.4	32.5	31.8	30.1	30.5
Electronic nicotine delivery systems	32.5	28.6	23.9	21.3	18.2	17.8
Hookah	32.7	27.9	25.4	22.4	19.8	18.6
Cigars	18.1	13.4	11.6	11.8	9.7	10.3
Smokeless tobacco	5.7	4.4	4.2	4.7	4.4	4.5
No. of products	1.27 (1.17)	1.06 (1.10)	0.98 (1.06)	0.92 (1.03)	0.82 (0.98)	0.82 (0.98)

TABLE 2—Model Estimates from Conditional Growth Curve Models for Number of Tobacco and Nicotine Products Used in the Past 30 Days and for Current Use of Cigarettes, ENDS, Cigars, Hookah, and Smokeless Tobacco: Texas, 2014–2017

		OR[b] (95% CI)				
Variable	No. Products, B[a] (95% CI)	Cigarettes	ENDS	Hookah	Cigars	Smokeless
Intercept	1.45 (1.30, 1.60)	0.57 (0.42, 0.79)	0.85 (0.62, 1.15)	0.44 (0.32, 0.59)	0.16 (0.11, 0.23)	0.01 (0.01, 0.03)
Age[c]	−0.35 (−0.40, −0.30)	1.03 (0.92, 1.16)	0.55 (0.49, 0.62)	0.56 (0.50, 0.63)	0.73 (0.63, 0.85)	1.17 (0.90, 1.52)
Male	0.34 (0.27, 0.40)	1.53 (1.34, 1.73)	1.30 (1.15, 1.47)	1.04 (0.93, 1.18)	2.66 (2.29, 3.10)	6.24 (4.73, 8.22)
Hispanic	−0.04 (−0.12, 0.03)	0.89 (0.77, 1.04)	0.91 (0.79, 1.04)	1.35 (1.17, 1.56)	0.87 (0.72, 1.04)	0.79 (0.57, 1.10)
Black/African American	−0.10 (−0.23, 0.02)	0.39 (0.30, 0.51)	0.69 (0.54, 0.88)	1.64 (1.31, 2.07)	1.74 (1.32, 2.30)	1.21 (0.70, 2.07)
Asian	−0.07 (−0.16, 0.03)	0.65 (0.53, 0.79)	0.78 (0.64, 0.93)	2.04 (1.71, 2.44)	0.71 (0.56, 0.90)	1.25 (0.85, 1.84)
Other race/ethnicity	0.04 (−0.07, 0.16)	0.87 (0.69, 1.11)	1.03 (0.82, 1.29)	1.77 (1.42, 2.20)	1.08 (0.82, 1.44)	0.65 (0.37, 1.13)
4-y college	−0.00 (−0.13, 0.12)	0.85 (0.66, 1.10)	0.90 (0.71, 1.15)	1.33 (1.03, 1.70)	0.99 (0.73, 1.34)	1.16 (0.65, 2.08)

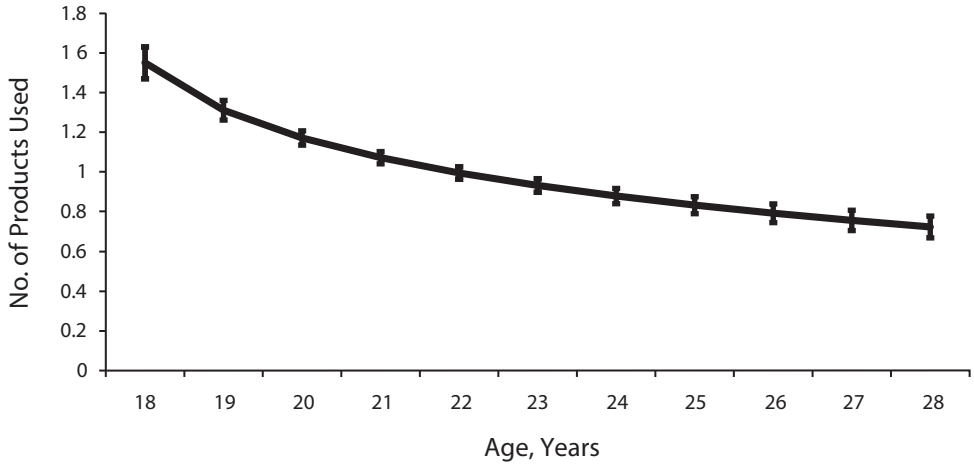
Note. CI = confidence interval; ENDS = electronic nicotine delivery systems; OR = odds ratio. The sample size was n = 2711.
[a]Results from SAS MIXED, regressing number of products used on age and sociodemographics.
[b]Results from SAS GLIMMIX with a logit link for dichotomous distributions, regressing current use on age and sociodemographics.
[c]Log-transformed value of age.

hookah use was slightly greater or similar to cigarette use at younger ages, but differences between ENDS and hookah use versus cigarette use became more pronounced across increasing age, with only ENDS and hookah showing statistically significant developmental declines in use.

DISCUSSION

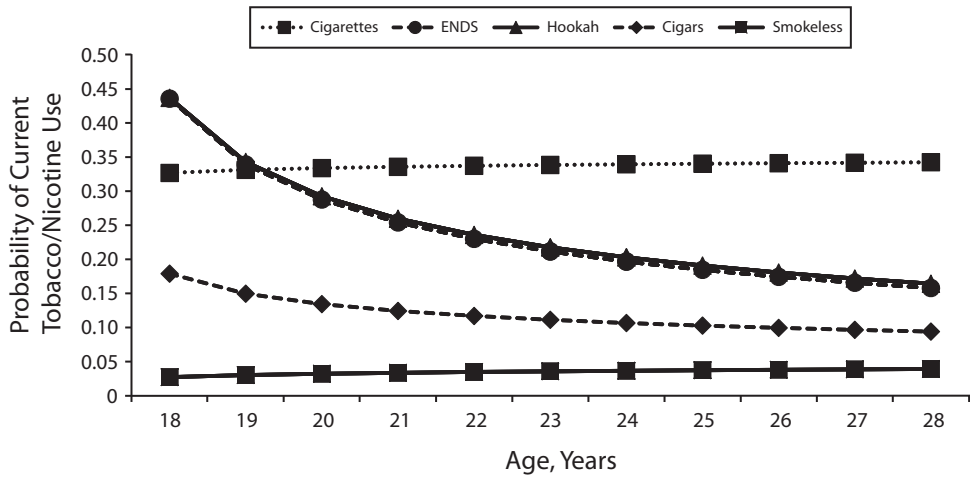
Polytobacco use is increasingly prevalent in the contemporary tobacco and nicotine landscape, particularly among young adults.[2] To date, few studies have examined intraindividual change or trajectories of polytobacco use across multiple periods. Our findings extend existing research by showing that polytobacco use declined across young adulthood. Our findings also showed statistically significant developmental declines in the use of ENDS, hookah, and cigars but not in the use of smokeless tobacco or cigarettes. It is noteworthy that cigarette use was not only stable across young adulthood but also consistently the most used product at all study waves and virtually all ages. Results indicate that young adults may mature out[13,14] of polytobacco use and the use of ENDS, hookah, and cigars as they age, but they may continue to use some products, most notably cigarettes, which are considered the most toxic and addictive tobacco and nicotine product.[16]

Our findings are consistent with the maturing out hypothesis,[13,14] indicating that polytobacco use becomes less prevalent across young adulthood. Thus, young adults may experiment with multiple tobacco and nicotine products but eventually quit using at least some of these products as they age. The maturing out hypothesis proposes that these



Note. Model adjusted for participant sex, race/ethnicity, and college type (2-y vs 4-y).

FIGURE 1—Growth Curve Model Showing Change in Number of Tobacco and Nicotine Products Used Across Young Adulthood (n = 2711): Texas, 2014–2017



Note. ENDS = electronic nicotine delivery systems. Model adjusted for participant sex, race/ethnicity, and college type (2-y vs 4-y).

FIGURE 2—Growth Curve Models Showing Change in Probability of Current (Past 30-Day) Use of Each of the 5 Tobacco and Nicotine Products Across Young Adulthood (n = 2711): Texas, 2014–2017

developmental declines occur because substance use is not compatible with adult roles, such as marriage and full-time employment. However, tobacco and nicotine product use may not necessarily be incompatible with adult roles, considering that it is legal for adults and that unlike psychoactive substances, these products likely do not interfere with the fulfillment of adult roles.

An alternative explanation for the developmental decline may be young adults' changing interpersonal needs and social contexts.[13] Research shows that young adults may initiate use of tobacco and nicotine products because of peer influence and socialization needs.[27] As young adults age and transition to adulthood, peer influences decline,[28] as might the opportunities and contexts for using varying products.[13] Because there is limited longitudinal research on polytobacco use, the factors associated with the declining trajectory are not known. Additional studies are therefore needed to determine why there are developmental changes in polytobacco use and to identify transitions in patterns of use.

Similar to polytobacco use, and consistent with a maturing out hypothesis,[14] ENDS, hookah, and cigar use also declined across young adulthood. The declining use of these 3 products likely accounts for, or explains, the developmental decline in polytobacco use. ENDS, hookah, and cigar use may be initiated by young adults because they are perceived to be less harmful, less addictive, and more socially acceptable than are traditional cigarettes.[9,10] Yet, the use of these products is intermittent or nondaily during young adulthood,[29–31] and according to findings from this study, use may be transient or experimental for at least a portion of young adult users.

The transient nature of ENDS use is supported by very limited longitudinal research showing that those aged 15 to 21 years who use ENDS only were more likely to transition to nonuse 6 months later than were their combustible-only and polytobacco user peers.[19] Hookah use may also be transient in young adulthood, as reflected in research showing that hookah use declines across the first year of college.[32] Hookah is often used with peers in groups at lounges and bars and serves as an alternative to drinking alcohol to enhance social interaction.[33] However, hookah use may decline in the transition to adulthood when alcohol can be legally purchased and consumed. Our findings suggest that ENDS, hookah, and cigar use are developmentally limited, whereby young adults may experiment with these products at younger ages but eventually stop their use.

Contrary to the maturing out hypothesis and to the declining ENDS, hookah, and cigar use trajectories, smokeless tobacco and cigarette use did not change across increasing age. Use of these 2 products appears to be less experimental or transient than is use of ENDS, hookah, and cigars. Sustained use and addiction, therefore, may be more likely for smokeless tobacco and cigarettes than for other tobacco and nicotine products during young adulthood. It is important to note that the likelihood of using smokeless tobacco was relatively low at each age across young adulthood, but cigarette use was consistently high and the most used product at virtually every age. Moreover, although ENDS and hookah use were more prevalent or similarly prevalent as was cigarette use at younger ages, the ENDS and hookah use trajectories increasingly diverged from the high and stable cigarette use trajectory. The stability of cigarette use is consistent with retrospective research indicating that cigarette use is one of the most persistent types of substance use across young adulthood[14] and with prospective research showing a nonstatistically significant decline in cigarette use from the mid- to late 20s.[34]

The high and stable use of cigarettes is particularly concerning, considering that cigarettes are high on the tobacco risk continuum and potentially the most toxic tobacco and nicotine product.[16] Furthermore, the high and stable use of cigarettes, especially compared with the declining use of ENDS, hookah, and cigars, may indicate that polytobacco use consolidates into cigarette use, at

least for a portion of tobacco and nicotine users. Although young adults use fewer tobacco and nicotine products as they age, some may continue to use cigarettes, the product that has caused the most concern among public health advocates.

One group of young adults who may consolidate their use into fewer products, particularly cigarettes, is those who smoke cigarettes when they enter young adulthood. Noncigarette product use is more prevalent among cigarette users than noncigarette users.[35] Cigarette users may use other products as substitutes for cigarettes in places where smoking is not allowed[11] and to reduce or quit cigarette use.[12] Perhaps young adult cigarette users stop using noncigarette products as they age because they find them to be less satisfying or enjoyable than cigarettes.[27] Because of limited longitudinal studies, additional research is needed that tracks young adult polytobacco users across increasing age to identify who is at risk for the sustained use of 1 or more products.

Limitations

Our study extends existing research by examining intraindividual change in polytobacco and individual product use from ages 18 to 28 years, but there are some limitations. First, because the study was limited to young adults recruited from 24 colleges in Texas, our findings cannot be generalized to the young adult population. Second, we examined intraindividual change in the current use of tobacco and nicotine products; consequently, we could not determine whether, when, and who became consistent or regular users of these products. Subsequent research that continues to follow the present cohort of young adults beyond the 2.5-year study period, as they transition into adult roles, will be crucial for mapping trajectories of use to identify who continues to use tobacco and nicotine products and what products they continue to use.

Public Health Implications

Despite the aforementioned limitations, our study extends existing research by examining trajectories of polytobacco and individual product use across young adulthood. Our findings have implications for public health. First, although there were statistically significant developmental declines in polytobacco use, a portion of young adults continued to be current users of at least 1 product, underscoring the importance of targeting this population with prevention and intervention efforts. Prevention efforts targeted at young adults are particularly important, considering recent evidence that tobacco and nicotine product initiation is now more prevalent during young adulthood than during adolescence.[6] Although all types of tobacco and nicotine products should be included in targeted efforts, a continued focus on preventing and reducing cigarette use is vital, as cigarette use was high and stable across young adulthood, and cigarettes are likely the product with the greatest potential for long-term negative health outcomes.[16] AJPH

CONTRIBUTORS

A. Loukas conceptualized the study and contributed to all sections of the article. C. N. Marti conducted the analyses and contributed to the methods and results sections. C. N. Marti and C. L. Perry edited the article. C. L. Perry contributed to the study conceptualization. All authors reviewed and approved the final version of the article.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

HUMAN PARTICIPANT PROTECTION

Approval to conduct this research was provided by the University of Texas at Austin institutional review board (protocol no. 2013-06-0034). All participants provided electronic informed consent before participation.

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