



Published in final edited form as:

Drug Alcohol Depend. 2020 July 01; 212: 108017. doi:10.1016/j.drugalcdep.2020.108017.

Digital Media Use and Subsequent Cannabis and Tobacco Product Use Initiation among Adolescents

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Abstract

Background: Digital media engagement, such as browsing the internet or social media posting, may be associated with cannabis and tobacco product use initiation among adolescents. Whether certain digital media exposure confers greater – or reduced – risk for specific cannabis or tobacco products is unknown.

Methods: Adolescents completed surveys on digital media and substance use every 6 months from 2015–2017 (4 waves). Self-reported digital media use (14 items) was classified into six subcategories (e.g., “social media posting,” “reading news/articles & browsing photos”). Random-effect repeated-measures regression models examined the association of exposure to each digital media subcategory with subsequent cannabis or tobacco product use initiation in the next 6 months, among baseline cannabis and tobacco never-users (n=1841; n=1558, respectively).

Results: High frequency digital media use (multiple times/day) of “social media posting” (vs. no high frequency use; OR=1.95; 95%CI:1.20–3.17) and “checking in” (OR=1.71; 95%CI:1.23–2.38)

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Contributors

Ms. Kelleghan conceptualized and designed the study, conducted the analyses, drafted the initial manuscript, and reviewed and revised the manuscript; Dr. Leventhal conceptualized the study, coordinated and supervised data collection, and reviewed and revised the manuscript; Drs. Cruz, Unger, Kirkpatrick, and McConnell, and Ms. Riehm made contributions to the conception and design of the study and critically reviewed the manuscript for important intellectual content; Ms. Bello conceptualized the study and revised the manuscript for intellectual content; Drs. Liu and Cho made conceptual contributions to the analytical and statistical design of the study and reviewed the Results and Analytic Plan sections for important intellectual content; Dr. Barrington-Trimis conceptualized and designed the study, drafted the initial manuscript, reviewed and revised the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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Conflict of Interest
No conflict declared.

were associated with greater odds of any cannabis product use initiation 6 months later. “Reading news/articles & browsing photos” was associated with decreased odds of initiation (OR=0.52; 95%CI:0.34–0.79). “Checking in” and “reading news/articles & browsing photos” were similarly associated with any tobacco use initiation. “Chatting and shopping” was associated with greater odds (OR=4.63; 95%CI:1.53–14.06) of e-cigarette initiation, but not of other product use initiation.

Conclusions: Some subcategories of digital media use conferred increased odds, others conferred reduced odds, and others were not associated with cannabis and tobacco use initiation. Research exploring mechanisms that put users of specific digital media at greater risk for substance use initiation is warranted.

Keywords

social media use; tobacco; cannabis; adolescence

1. INTRODUCTION

Cannabis and tobacco products (including e-cigarettes), are two of the most commonly used substances among adolescents (Cullen et al., 2018; Johnston, 2019). In 2018, among adolescents in grades 8, 10, and 12, 29.7% of youth reported ever using cannabis, 25.2% reported ever use of e-cigarettes (i.e., vaping nicotine) and 16.1% reported ever use of cigarettes (Johnston, 2019). Use of cannabis and tobacco products pose significant risks to the overall public health of youth (Degenhardt et al., 2016); both substances have been associated with short-term pernicious outcomes, including cognitive impairment, poor academic achievement, and changes in peer and parenting relationships (Broyd et al., 2016; McCaffrey et al., 2010).

Risk factors for substance use initiation have been examined, including school environment (Bond et al., 2007; Costello et al., 2012), peer factors (D’Amico and McCarthy, 2006; Van Ryzin et al., 2012), parental monitoring (Piko and Kovács, 2010; Van Ryzin et al., 2012), family relationship quality (Van Ryzin et al., 2012), and parental attitudes towards substance use and parental substance use (Hemphill et al., 2011). Exposure to digital media may additionally play an important role in adolescent cannabis and tobacco use initiation. Approximately 95% of U.S. adolescents have access to a smartphone (Anderson and Jiang, 2018), and are exposed to various forms of digital media. Other portable electronic devices – including iPads or tablets – increase exposure; youth can use various digital media platforms from almost anywhere. Digital media enables youth to connect with and be influenced by their peers, and to be exposed to direct and indirect marketing, including that of tobacco, cannabis, and other products (Jackson et al., 2018; Romer and Moreno, 2017), all of which may normalize substance use and substance use behaviors (Nesi et al., 2017). Associations between exposure to media and substance use have been identified across both older media (e.g., television, music) and some newer digital media platforms (e.g., smartphones, social media, internet; (Brown and Bobkowsky, 2011; Rücker et al., 2015)). Researchers have examined online engagement with tobacco advertisements and have found cross-sectional evidence that online engagement (Soneji et al., 2017), posting of tobacco-related tweets on Twitter (Unger et al., 2018), and exposure to friends’ risky photos on Facebook or Myspace

(Huang et al., 2014) were positively associated with tobacco product use. Understanding whether certain digital media use activities are differentially linked with substance use risk is important as it can inform intervention and prevention efforts to reduce youth substance use. It is possible that not all digital media use confers increased odds of substance use initiation, and that some forms may be more strongly associated with substance use than others. Digital media use that has the potential to expose youth to peer social environments or to direct or indirect marketing (e.g., via social media) – known risk factors for substance use initiation – would be more strongly associated with substance use initiation than digital media use that does not result in such exposure (e.g., reading news or blogs). There is limited research that simultaneously examines multiple categories of digital media use as risk (or protective) factors for initiation of use of new and different types of cannabis or tobacco products, such as e-cigarettes. In the current study, we examined associations of frequent use (i.e., multiple times per day) of different digital media activities with subsequent cannabis and tobacco product use initiation over 18 months of follow-up from 2015–2017 in a prospective cohort of youth recruited from the greater Los Angeles, CA metropolitan area.

2. METHODS

2.1. Participants and Procedures

The present study is a secondary analysis of data collected as part of the Happiness & Health Study, a prospective cohort study of adolescents recruited from 10 Los Angeles area high schools (Leventhal et al., 2015). Data collection occurred in classrooms each semester from 9th to 12th grade (2013–2017). The current study includes data obtained at four time points across two years of follow-up beginning in Fall 2015 when participants in 11th grade completed the survey (N=3,232). Data on digital media use were collected in Fall 2015, Spring 2016 (second semester of 11th grade), Fall 2016 (first semester of 12th grade), and Spring 2017 (second semester of 12th grade; see Supplemental Figure 1). The analytic samples were restricted to (A) participants who reported no history of cannabis at the exposure wave (N=1841; analytic sample for the association of digital media with cannabis initiation) or (B) participants who reported no tobacco use at the exposure wave (N=1558; analytic sample for the association of digital media with tobacco initiation), had digital media data for at least one exposure wave, and had product use data available at the following 6-month wave for one or more follow-up waves. A total of 1,978 participants (61.2%) were included in at least one analytic sample (see Table 1).

2.2. Ethics Statement

This study was approved by the University of Southern California Institutional Review Board. Written or verbal parental consent and written student assent was obtained prior to data collection.

2.3. Measures

2.3.1. Cannabis Product Use—At each wave of data collection, participants reported whether they had ever used the following cannabis products in their lifetime: combustible, blunts, edible, vaporized, or synthetic cannabis. Cannabis initiation was defined as new onset

of (1) any cannabis use, (2) combustible cannabis use, or (3) other cannabis use (blunts, edible, vaporized, or synthetic cannabis) at the subsequent 6-month follow-up wave.

2.3.2. Tobacco Product Use—Participants reported their lifetime use of tobacco products (cigarettes, cigars, e-cigarettes, smokeless tobacco, hookah water pipes, or other tobacco) at each wave of data collection. Tobacco initiation was defined as new onset of (1) any tobacco use, (2) combustible cigarette use, or (3) e-cigarette use containing tobacco at the subsequent 6-month follow-up wave. Initiation of products other than combustible cigarettes or e-cigarettes with tobacco was too low to analyze as a separate outcome.

2.3.3. Digital Media Use—Students reported their frequency of digital media use during each wave of data collection using an author-constructed questionnaire (Ra et al., 2018). Youth were asked how often they engaged in 14 different digital media activities, including “checking social media sites”, “playing games by yourself on a console, computer, or smartphone”, and “posting own photographs, images, videos, status updates, or blogs” (see Table 2 for a complete list of all digital media activities assessed) over the past week (0 times; 1–2 times per week; 1–2 times per day; many times per day). Digital media items were dichotomized into high-frequency use (multiple times per day) compared to less frequent use (0 times, 1–2 times per week, 1–2 times per day), consistent with prior research analyzing the same digital media data (Ra et al., 2018). Exploratory factor analysis was used as a data reduction technique to identify digital media subcategories.

2.3.4. Covariates—Covariates included self-reported gender (male/female), race/ethnicity (Hispanic, Asian, white, other), eligibility for subsidized lunch (free lunch, reduced cost, no subsidized lunch, don’t know or missing), number of friends’ using cannabis or tobacco (no friends, 1–2 friends, 3–5 friends), and highest level of parental education (some high school or less, high school graduate, some college, college graduate, advanced degree, don’t know or missing), a proxy for family socioeconomic status.

2.4. Statistical Analysis

2.4.1. Digital Media Subcategories Using Exploratory Factor Analysis—Digital media subcategories were developed using exploratory factor analysis (iterated principal factors) with promax factor rotation. Consistent with prior work, rotated factor structures were investigated to identify items with weak factor loadings (<0.4) or cross loadings (<0.1 difference in loading on 2 or more factors), which were removed from the analysis iteratively (Reio and Shuck, 2015). Three items were removed from the factor analysis through this process. The model was determined to be finalized when all remaining items had a strong factor loading (>0.4) on at least one factor and no cross loading (>0.1) on 2 or more factors. Once the list of items was finalized, the number of factors was determined based on eigenvalues (>1.0) and evaluation of scree plots (Williams et al., 2010). Six digital media subcategories were identified based on these criteria. Eleven items were included in the six subcategories (Table 2); the first five subcategories each had two items, consistent with literature on factor analysis (Henson and Roberts, 2006), and the sixth subcategory was comprised of one item.

2.4.2. Associations between Digital Media Subcategories and Substance Use Initiation—Random-effect repeated-measures regression models were used to test the association of each digital media subcategory at the exposure wave (as a time-varying and time-lagged regressor) with initiation of cannabis or tobacco product use (in separate models) at the immediately subsequent 6-month outcome wave. Analyses were conducted to examine initiation of any cannabis product, or tobacco product (in separate models), as well as product-specific initiation (e.g., initiation of e-cigarettes, combustible cannabis). Models were restricted to never cannabis or never tobacco product users at the exposure wave. All models were adjusted for time-invariant and time-varying covariates including wave, gender, race/ethnicity, friends' substance use, and socioeconomic status (i.e., reduced or free lunch and parent education), and included a random effect of participant ID. Covariate-adjusted models were subsequently adjusted for all other social media subcategories. Missing data were managed with listwise deletion. Odds ratios with 95% confidence intervals are reported (SAS 9.4(Institute., 2017) was used to run analyses.

3. RESULTS

3.1. Descriptive Analyses

There were two analytic samples for this report, one for cannabis analyses and one for tobacco analyses (Table 1). A total of 1,841 students ($M_{age}=16.5$ years, $SD=0.01$) who reported no prior use of any cannabis products at baseline were included in the current cannabis analyses. Of these students, 54.3% were female, and 40.1% were Hispanic, 25.5% Asian, 16.7% White, and 17.7% of another race. Over 18 months of follow-up, a total of 421 students (22.87%) initiated cannabis use. Analyses assessing tobacco use initiation included 1,558 students ($M_{age}=16.5$ years, $SD=0.01$) who reported no prior use of any tobacco products at baseline. Of these students, 54.8% were female, and 41.1% were Hispanic, 25.7% Asian, 16.1% White, and 17.1% of another race. Over 18 months of follow-up, a total of 180 students (11.6%) initiated tobacco use.

3.2. Digital Media Subcategories

The exploratory factor analysis identified a 6-factor solution that accounted for 97.7% of the variance (Table 3), considering the Kaiser criterion (eigenvalue >1) and evaluating the scree plots. This solution was used to inform the development of six digital media subcategories: “social media posting” (posting photos, video, or statuses; sharing others' content), “reading news/articles & browsing photos” (browsing photos or videos online; reading blogs, articles, and news), “chatting & shopping” (video chatting; online shopping), “gaming” (video gaming alone or with others), “checking in” (checking social media sites; texting), and “music” (streaming or downloading music). We created a unique variable for each digital media subcategory. For each of the first 5 subcategories, use of one or both of the items was reported using three levels (0= no high frequency use of either item, 1= high frequency use of 1 of the items, 2= high frequency use of both items). The final subcategory, “music”, was dichotomized (0= no high frequency use of music, 1= high frequency use of music).

3.3. Exposure to Digital Media Subcategories

High-frequency digital media use varied across digital media subcategories (Table 3). For example, at baseline, 37.9% of respondents reported high frequency use of both “checking in” items, while only 3.3% of youth reported high frequency report of both “chatting and shopping” items.

3.4. Association of digital media use with initiation of cannabis or tobacco products

3.4.1. Cannabis—Higher frequency use of both “social media posting” items (vs. no high frequency use) was associated with greater odds of any cannabis product use initiation, after accounting for all covariates and other digital media variables (OR=1.95; 95%CI: 1.20–3.17) (Table 4). Higher frequency use of both “checking in” items was significantly associated with greater odds of cannabis initiation in fully adjusted models (OR=1.71; 95%CI: 1.23–2.38). Report of high frequency use for both “reading news/articles & browsing photos” items was associated with lower odds of any cannabis initiation (OR=0.52; 95%CI, 0.34–0.79). Similar associations were found between the digital media variables and initiation of combustible cannabis, specifically, and for initiation of other cannabis products. No significant associations were found for the “chatting and shopping”, “gaming” or “music” subcategories with cannabis product use initiation in fully adjusted models.

3.4.2. Tobacco—High frequency use of both “checking in” items was associated with greater odds of any tobacco product use initiation (OR=2.69, 95%CI: 1.62, 4.48) in fully adjusted models. In models evaluating initiation of specific tobacco product use, reported use of both high frequency items (vs. no high frequency) for “reading news/articles & browsing photos” was associated with significantly lower odds (OR=0.26; 95%CI, 0.09–0.75) of e-cigarette initiation (Table 5), while report of high frequency use for both “chatting and shopping” items was associated with significantly greater odds (OR=4.63; 95%CI, 1.53–14.06) of e-cigarette initiation.

4. DISCUSSION

Exposure to various digital media use subcategories was differentially associated with cannabis and tobacco product use initiation; some forms of digital media use conferred greater odds of initiation while others were associated with decreased odds or were not associated with substance use initiation. “Social media posting” conferred greater odds of cannabis use initiation for all products, and “checking in” was associated with greater odds of cannabis use initiation for all products and any tobacco product. “Chatting and shopping” conferred greater odds of only e-cigarette use initiation. High frequency ““reading news/ articles & browsing photos”” was associated with decreased odds of initiating all cannabis and all tobacco product use.

This initial descriptive analysis of subcategories of digital media use provides evidence that is one layer deeper than previous work examining digital media use as a unitary entity. Given that the content of adolescents’ online activity was not assessed in this study, it can only point towards potential mechanisms that future research should focus on to explore the

underlying link between digital media use and cannabis/tobacco product use. To guide this work, we offer four speculative explanations that warrant further study: 1) tobacco and cannabis marketing and advertising, 2) engagement with the peer group, 3) difficulties with impulse control, or 4) confounding by unmeasured variables.

Digital media has revolutionized marketing industries that now have broader access to adolescents through newer, less regulated marketing venues (e.g., social networking sites, online advertising; (Bierut et al., 2017; Soneji et al., 2016)). High frequency use of “chatting and shopping” was associated with greater odds of e-cigarette use initiation, but was not significantly associated with cannabis use initiation or initiation of any other tobacco products. While we did not assess what adolescents were shopping for in this study, it is possible that youth are exposed to advertisements or product placement while video chatting or shopping online. Although marketing of cigarette products is regulated, similar restrictions are not in place for e-cigarette marketing (Fallin-Bennett et al., 2019). Existing research has found that exposure and engagement with online tobacco marketing is associated with greater odds of tobacco product use initiation and increased frequency of use, compared to adolescents not exposed or engaging with it online (Cruz et al., 2019; Soneji et al., 2018). Similar results were identified for online alcohol marketing to European adolescents such that greater exposure to online marketing was associated with increased odds of initiation and past 30 day problematic use (de Bruijn et al., 2016). If future research can confirm that direct exposure to online advertising accounts for links between digital media use and subsequent substance use initiation, efforts to strengthen age verification checks to limit youth access to online tobacco and cannabis sales, along with stricter regulations on e-cigarette marketing, warrant consideration as a substance use prevention tactic (Soneji et al., 2016).

Engagement in digital media activities that involve reciprocal communication and engagement with peers (i.e., “social media posting” or “checking in”) was associated with greater odds of subsequent cannabis and tobacco product use initiation. Social media platforms provide an opportunity for youth, social media influencers, and advertisers to interact with one another, allowing for reposts and shares to their own peer social media networks. Social media use provides adolescents with largely unsupervised access to their peer network. Youth who use more social media and text more frequently are also more likely to be embedded in a popular peer group (Schwartz et al., 2019) and to display digital status-seeking behavior, a known risk factors for substance use (Nesi and Prinstein, 2019). Although we did not assess the content of postings in this study, it is possible that some youth view substance-related social media content, such as peer posts of themselves engaging in tobacco or cannabis use or come into contact with direct or indirect marketing of these substances while on social media sites. This could normalize substance use perceptions in teens, which could explain the association with increased odds of initiation (Chang et al., 2016; Wu et al., 2015). The current findings fit well with prior research from alcohol use literature suggesting that exposure to social media posts with substance use content is associated with subsequent onset of substance use (Nesi et al., 2017).

Reported high frequency use of “reading news/articles & browsing photos” (including “browsing photos or videos online” and “reading blogs, articles, or news”) was associated

with decreased odds of cannabis and tobacco use initiation. These activities differ from social media activities that spur inter-youth conversational interactions and increased tobacco and cannabis use risk in this study. Instead, reading blogs or news, browsing the internet, or listening to music focus more on information acquisition and less so on engaging with the peer social environment. Blogging is not a common sphere for youth to engage with peers (Lenhart et al., 2010). This delineation between interactive social activities and those involving digital information acquisition could somehow differentiate resultant risks of substance use.

A third possible explanation for an association between digital media use and substance use could be that the instantaneous nature of digital media inhibits normative development of impulse control among youth. Repeated distractions, such as those associated with notifications and messages on social media, text messaging, and other digital media mediums, are associated with difficulties in impulse control, sustained attention (Chen and Yan, 2016), and poorer ability to delay gratification (Wilmer and Chein, 2016). Deficits in these areas are also implicated in problematic substance use (Hicks et al., 2011; Rabin and George, 2015), which could account for an association between digital media use and cannabis and tobacco use initiation. However, our data suggest little support for this mechanism, which we would expect to generalize to all digital media subcategories and all substances, given that we did not see these consistent associations. The pattern of results that emerged in this study indicates unique associations between specific subcategories of digital media use and initiation of cannabis or tobacco.

Finally, the observed associations between some digital media subcategories and cannabis and tobacco use initiation could be due to residual confounding. Although the current analyses controlled for ethnicity, socioeconomic status, friends' substance use, and gender, other variables not measured in this study could account for these findings. Further research is needed to examine the possible mechanisms that underlie the association between high frequency "reading news/articles & browsing photos" and lower odds of cannabis and tobacco use initiation.

The current study has several limitations. First, these analyses did not include additional measures of digital media use such as amount of substance use exposure on social media profiles or reports of what youth saw online. This limited our ability to explore potential mechanisms (e.g., exposure to peers' substance-related posts, substance-related marketing or product placement) that may underlie the associations we found in our study. Future research exploring the specific content of adolescents' online behavior is needed to more fully understand the implications of digital media use on adolescents' substance use initiation. Second, these data were self-reported and may be subject to reporting biases. Finally, all data were collected in a diverse, urban area of southern California and may not be generalizable to dissimilar populations. Findings from the current study demonstrate the need to investigate digital media technologies and patterns of use independently in order to understand the effect that exposure to digital media may have on adolescent initiation of substance use. Future research would benefit from assessing multiple indices of youths' digital media experience, including what they view and post online.

This study provides initial evidence of differential associations of digital media use with subsequent tobacco and cannabis use initiation across type of digital media activity. Subsequent studies could examine mechanisms underlying these associations, with a particular focus on substance-related exposures on digital media. Interventions targeting substance use prevention or reduction could harness social media platforms as a potential mode of intervention dissemination.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Role of Funding Source

Research reported in this publication was supported by grant numbers P50CA180905 and U54CA180905 from the National Cancer Institute at the National Institutes of Health (NIH) and the Food and Drug Administration (FDA) Center for Tobacco Products (CTP), grant numbers K01DA042950 and R01DA033296 from the National Institute for Drug Abuse at NIH, grant number 27-IR-0034 from the Tobacco Related Disease Research Program (TRDRP), and grant number DGE-1418060 from the National Science Foundation Graduate Research Fellowship. The funders had no role in the design and conduct of the study; collection, management, analysis, or interpretation of the data; or preparation, review, or approval of the manuscript.

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Highlights:

- Checking social media/texts confer greater odds of tobacco and cannabis initiation.
- Browsing articles/photos confers lower odds of cannabis and tobacco initiation.
- Video chatting and online shopping confers greater odds of e-cigarette initiation.

Table 1.

Descriptive characteristics of analytic sample

	Tobacco Sample^a (n=1,558)	Cannabis Sample^b (n=1,841)
	N (col %)	N (col %)
Female	853 (54.8%)	1,000 (54.3%)
Race/ethnicity		
Hispanic	641 (41.1%)	739 (40.1%)
Asian	400 (25.7%)	470 (25.5%)
White	250 (16.1%)	307 (16.7%)
Other/Missing ^c	267 (17.1%)	325 (17.7%)
Free or Subsidized lunch (at baseline)		
No	823 (52.8%)	966 (52.5%)
Reduced cost	110 (7.1%)	127 (6.9%)
Free lunch	498 (32.0%)	605 (32.9%)
Don't know/Missing ^d	127 (8.2%)	143 (7.8%)
Highest Parental Education		
Some high school or less	135 (8.7%)	171 (9.3%)
High school graduate	190 (12.2%)	224 (12.2%)
Some college	233 (15.0%)	280 (15.2%)
College graduate	475 (30.5%)	548 (29.8%)
Advanced degree	319 (20.5%)	364 (19.8%)
Don't know/Missing ^e	206 (13.2%)	254 (13.8%)
Friends' Cannabis Product Use^f		
0 friends	1,098 (73.2%)	1,275 (71.6%)
1–2 friends	261 (17.4%)	325 (18.2%)
3–5 friends	141 (9.4%)	182 (10.2%)
Friends' Tobacco Product Use^g		
0 friends	1,191 (80.0%)	1,349 (76.3%)
1–2 friends	220 (14.8%)	285 (16.1%)
3–5 friends	78 (5.2%)	133 (7.5%)

^aTobacco sample includes youth who reported no use of any tobacco products (i.e., few puffs of a cigarette, a whole cigarette, e-cigarettes with tobacco, smokeless tobacco, big cigars, little cigars/cigarillos, and hookah water pipe) at baseline.

^bCannabis sample includes youth who reported no use of any cannabis products (i.e., combustible cannabis, blunts, and edible, vaporized, or synthetic cannabis) at baseline.

^cYouth who reported being Black or African-American, American Indian or Alaska Native, multiracial, or “other” were included in this category as was anyone with missing ethnicity data

^dParticipants who endorsed not knowing whether or not they received free/subsidized lunch and those with missing lunch data

^eParticipants who endorsed not knowing their parents' highest education level and those with missing parental education data

^fYouth reported on their friends' cannabis use in the past 30 days. For this item, there were missing data: Tobacco sample N=1500; Cannabis sample N=1782.

^gYouth reported on their friends' tobacco use in the past 30 days. For this item, there were missing data: Tobacco sample N=1489; Cannabis sample N=1767.

^hTobacco use initiation includes use of a few puffs of a cigarette, a whole cigarette, e-cigarettes with tobacco, smokeless tobacco, big cigars, little cigars/cigarillos, and hookah water pipe

ⁱCannabis use initiation includes reported use of combustible cannabis, blunts, and edible, vaporized, or synthetic cannabis

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Table 2 .

Digital media use questionnaire and factor loading of digital media items

Social Media Use Questions ^b	Digital Media Subcategories and Factor Labels ^a					
	Social Media Posting	Reading news/articles & Browsing photos	Chat & Shopping	Gaming	Checking In	Music
Posting your own photos, images, videos, status updates, or blogs	0.7493					
Sharing other people's photos, images, videos, status updates, blogs, articles, news, or websites	0.7178					
Browsing or viewing photos, images, or videos (YouTube, Vine, Pinterest, Imgur, or Reddit, etc.)	0.6593					
Reading blogs, articles, news, online forums, or books on a phone, tablet, or computer	0.5957					
Video-chatting (Skype, Facetime, Omegle, etc.)		0.5269				
Online shopping or viewing products online (clothes, electronics, games, etc.)		0.5144				
Playing games with your friends and family on a console (Xbox, Playstation, Wii), personal computer, or cell phone			0.7833			
Playing games by yourself on a console (Xbox, Playstation, Wii), personal computer, or cell phone			0.8474			
Checking social media sites (Facebook, Twitter, Instagram, etc.)				0.5983		
Texting (Text messaging)				0.6555		
Streaming or downloading music (iTunes, Pandora, YouTube, etc.)						0.5256
Liking or commenting on other people's statuses, wall posts, pictures, etc. ^c						
Watching streamed television shows or movies (Netflix, Hulu, iTunes, etc.) ^c						
Chatting online (instant messaging, Facebook messenger, etc.) ^c						
<i>Eigenvalue</i> ^d	2.3	2.14	2.12	1.96	1.73	1.55

^aDigital media subcategories were developed using exploratory factor analysis (iterated principal factors) with promax factor rotation. Rotated factor structures were investigated to identify items with weak factor loadings (<0.4) or cross loadings (<0.1 difference in loading on 2 or more factors), which were removed from the analysis iteratively. The model was determined to be finalized when all remaining items had a strong factor loading (>0.4) on at least one factor and no cross loading (>0.1) on 2 or more factors. Blanks indicate factor loadings below 0.4.

^bThe digital media questionnaire asked participants to rate, "How often did you do this activity in the past week?" for each item in the list, and answer choices were, "Never; A little (1–2times/week); Every day (1 or 2 times/day); Many times a day".

^cThree items were iteratively removed from the factor analysis due to weak factor loadings (<0.4) or cross loadings (<0.1 difference in loading on 2 or more factors).

^dOnce the list of items was finalized, the number of factors was determined based on eigenvalues (>1.0) and evaluation of scree plots.

Table 3.

Reported high frequency engagement in each digital media activity by subcategory, for each wave

	Endorsement of Activity (%)			
	Baseline	6 month	12 month	
Social Media Posting ^a	No high frequency engagement	85.0	83.6	82.9
	High frequency engagement in 1 activity	9.1	10.3	10.6
	High frequency engagement in 2 activities	6.0	6.1	6.5
Reading news/articles & Browsing photos	No high frequency engagement	49.2	47.5	45.8
	High frequency engagement in 1 activity	33.9	34.8	37.6
	High frequency engagement in 2 activities	16.9	17.7	16.6
Chat & Shopping	No high frequency engagement	84.4	83.0	83.4
	High frequency engagement in 1 activity	12.3	12.1	12.7
	High frequency engagement in 2 activities	3.3	4.9	3.9
Gaming	No high frequency engagement	77.7	74.1	77.8
	High frequency engagement in 1 activity	10.7	12.9	10.6
	High frequency engagement in 2 activities	11.7	13.0	11.6
Checking In	No high frequency engagement	31.1	30.1	26.3
	High frequency engagement in 1 activity	31.1	28.7	27.8
	High frequency engagement in 2 activities	37.9	41.2	45.9
Music ^b	No high frequency engagement	61.1	59.8	57.3
	High frequency engagement in	38.9	40.2	42.7

^a A unique variable for each digital media subcategory was created. For each of the first 5 subcategories, high frequency engagement of one or both of the activities was reported using three levels (0= no high frequency engagement, 1= high frequency engagement in 1 activity, 2= high frequency engagement in 2 activities).

^b The final subcategory, “music”, was dichotomized (0= no high frequency music engagement, 1= high frequency engagement with music).

Table 4. Association of digital media use subcategories with cannabis use initiation across follow-up

	Any Cannabis Use Initiation ^d			Combustible Cannabis Use Initiation			Other Cannabis Use Initiation ^f		
	N ^a (row %)	Adj. OR ^c	P-value	N ^a (row %)	Adj. OR ^c	P-value	N ^a (row %)	Adj. OR ^c	P-value
Social Media Posting	0 ^e 312 (8.0%)	Ref	0.021	244 (6.2%)	Ref	0.024	236 (6.1%)	Ref	0.033
	1 ^e 41 (9.6%)	0.98 (0.66–1.45)		30 (7.1%)	0.86 (0.54–1.36)		31 (7.4%)	1.02 (0.66–1.59)	
	2 ^e 39 (14.8%)	1.95 (1.20–3.17)		31 (11.8%)	1.97 (1.15–3.37)		32 (12.4%)	2.02 (1.18–3.45)	
Reading news/articles & Browsing photos	0 ^e 177 (8.1%)	Ref	0.0064	134 (6.2%)	Ref	0.048	134 (6.3%)	Ref	0.039
	1 ^e 157 (9.6%)	0.93 (0.71–1.21)		124 (7.6%)	1.00 (0.74–1.34)		119 (7.4%)	0.90 (0.67–1.22)	
	2 ^e 55 (7.0%)	0.52 (0.34–0.79)		45 (5.8%)	0.58 (0.36–0.94)		44 (5.8%)	0.55 (0.34–0.88)	
Chatting & Shopping	0 ^e 320 (8.3%)	Ref	0.81	249 (6.5%)	Ref	0.74	241 (6.3%)	Ref	0.96
	1 ^e 45 (8.3%)	0.89 (0.62–1.27)		34 (6.3%)	0.87 (0.58–1.31)		37 (7.0%)	0.96 (0.65–1.43)	
	2 ^e 19 (11.1%)	0.99 (0.52–1.90)		16 (9.3%)	1.10 (0.54–2.22)		15 (8.7%)	0.92 (0.44–1.90)	
Gaming	0 ^e 293 (8.4%)	Ref	0.62	227 (6.5%)	Ref	0.49	221 (6.4%)	Ref	0.45
	1 ^e 41 (7.7%)	0.96 (0.66–1.40)		29 (5.5%)	0.83 (0.53–1.28)		32 (6.1%)	1.03 (0.67–1.56)	
	2 ^e 52 (9.4%)	1.19 (0.81–1.76)		43 (7.7%)	1.15 (0.74–1.77)		42 (7.7%)	1.32 (0.85–2.03)	
Checking In	0 ^e 78 (5.6%)	Ref	0.0065	59 (4.2%)	Ref	0.0072	58 (4.0%)	Ref	0.014
	1 ^e 111 (8.0%)	1.39 (1.00–1.93)		86 (6.2%)	1.48 (1.01–2.15)		85 (6.2%)	1.47 (1.01–2.14)	
	2 ^e 200 (11.0%)	1.71 (1.23–2.38)		157 (8.6%)	1.83 (1.26–2.67)		158 (8.8%)	1.76 (1.20–2.57)	
Music	0 ^e 218 (7.8%)	Ref	0.41	170 (6.1%)	Ref	0.48	168 (6.1%)	Ref	0.85
	1 ^e 174 (9.4%)	1.11 (0.87–1.43)		135 (7.3%)	1.11 (0.83–1.47)		131 (7.2%)	1.03 (0.77–1.37)	

^aThe number of observations with (nonmissing) data available. Each student could contribute multiple observations.

^bThe estimate of the association of the respective regressor with cannabis initiation (vs. no initiation) across follow-up is adjusted for gender, ethnicity, baseline highest parental education, baseline free or reduced lunch, and wave.

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^cThe estimate of the association of the respective regressor with cannabis initiation (vs. no initiation) across follow-up is simultaneously adjusted for gender, ethnicity, baseline highest parental education, baseline free or reduced lunch, wave, and all other social media predictor variables.

^dAny cannabis use initiation includes reported use of combustible cannabis, blunts, and edible, vaporized, or synthetic cannabis.

^eReported frequency of digital media use. 0= no high frequency use of either digital media item; 1= high frequency use of 1 item; 2= high frequency use of both digital media items.

^fOther cannabis use initiation includes reported use of edible, vaporized, or synthetic cannabis.

Table 5. Association of digital media use subcategories with tobacco use initiation across follow-up

	Any Tobacco Use Initiation ^d			Combustible Cigarette Use Initiation ^f			E-cigarette Use Initiation		
	N ^e (row %)	Adj. OR ^c	P-value	N ^e (row %)	Adj. OR ^c	P-value	N ^e (row %)	Adj. OR ^c	P-value
Social Media Posting	0 ^e 135 (3.8%)	Ref	0.43	36 (1.0%)	Ref	0.88	67 (1.9%)	Ref	0.47
	1 ^e 21 (5.9%)	1.12 (0.65–1.93)		7 (2.0%)	0.79 (0.28–2.25)		9 (2.6%)	1.20 (0.55–2.61)	
	2 ^e 11 (4.9%)	0.60 (0.25–1.44)		5 (2.2%)	0.78 (0.19–3.19)		4 (1.8%)	0.46 (0.11–1.94)	
Reading news/articles & Browsing photos	0 ^e 79 (4.0%)	Ref	0.15	20 (1.0%)	Ref	0.98	37 (1.9%)	Ref	0.031
	1 ^e 62 (4.3%)	0.83 (0.55–1.24)		17 (1.2%)	1.08 (0.50–2.36)		35 (2.4%)	0.95 (0.54–1.68)	
	2 ^e 23 (3.3%)	0.55 (0.30–1.00)		11 (1.6%)	1.05 (0.38–2.89)		7 (1.0%)	0.26 (0.09–0.75)	
Chatting & Shopping	0 ^e 129 (3.7%)	Ref	0.35	37 (1.1%)	Ref	0.46	64 (1.9%)	Ref	0.019
	1 ^e 28 (6.0%)	1.32 (0.81–2.16)		9 (1.9%)	1.42 (0.61–3.30)		9 (2.0%)	0.90 (0.41–2.01)	
	2 ^e 8 (5.9%)	1.74 (0.67–4.50)		1 (0.7%)	0.41 (0.04–3.81)		7 (5.2%)	4.63 (1.53–14.06)	
Gaming	0 ^e 125 (4.0%)	Ref	0.53	31 (1.0%)	Ref	0.071	61 (2.0%)	Ref	0.86
	1 ^e 14 (2.9%)	0.72 (0.39–1.36)		2 (0.4%)	0.36 (0.08–1.67)		8 (1.7%)	0.79 (0.33–1.85)	
	2 ^e 20 (4.2%)	1.08 (0.60–1.95)		10 (2.1%)	2.13 (0.85–5.31)		9 (2.1%)	0.97 (0.41–2.29)	
Checking In	0 ^e 30 (2.3%)	Ref	0.0001	10 (0.8%)	Ref	0.15	17 (1.4%)	Ref	0.20
	1 ^e 37 (3.0%)	1.35 (0.79–2.31)		10 (0.8%)	0.84 (0.31–2.30)		20 (1.6%)	1.26 (0.61–2.59)	
	2 ^e 96 (6.1%)	2.69 (1.62–4.48)		27 (1.7%)	1.85 (0.74–4.59)		41 (2.7%)	1.84 (0.90–2.61)	
Music	0 ^e 88 (3.5%)	Ref	0.38	24 (1.0%)	Ref	0.52	39 (1.6%)	Ref	0.09
	1 ^e 78 (4.8%)	1.18 (0.81–1.72)		23 (1.4%)	1.26 (0.63–2.51)		41 (2.6%)	1.54 (0.90–2.61)	

^aThe number of observations with (nonmissing) data available. Each student could contribute multiple observations.

^bThe estimate of the association of the respective regressor with tobacco initiation (vs. no initiation) across follow-up is adjusted for gender, ethnicity, baseline highest parental education, baseline free or reduced lunch, and wave.

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The estimate of the association of the respective regressor with tobacco initiation (vs. no initiation) across follow-up is simultaneously adjusted for gender, ethnicity, baseline highest parental education, baseline free or reduced lunch, wave, and all other social media predictor variables.

^d Any tobacco use initiation includes reported use of a few puffs of a cigarette, a whole cigarette, e-cigarettes with tobacco, smokeless tobacco, big cigars, little cigars/cigarillos, and hookah water pipe.

^e Reported frequency of digital media use. 0= no high frequency use of either digital media item; 1= high frequency use of 1 item; 2= high frequency use of both digital media items.

^f Combustible cigarette use initiation includes reported use of a few puffs of a cigarette or a whole cigarette