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# Hookah, Cigarette, and Marijuana Use: A Prospective Study of Smoking Behaviors among First-Year College Women

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## Abstract

Better understanding of the temporal sequence of hookah, cigarette, and marijuana use will help to inform smoking prevention efforts. To address this gap in the literature, we assessed all three of these smoking behaviors in a sample of 424 first-year college women. Using a longitudinal design, we investigated whether hookah use predicts initiating/resuming cigarette and/or initiating marijuana use, and whether cigarette and/or marijuana use predict initiating hookah use. Participants (67% White, *M* age = 18.1 years) completed nine monthly surveys. The initial (i.e., baseline) survey assessed demographics, sensation-seeking, impulsivity, and pre-college substance use. Follow-up surveys assessed past-month substance use; outcomes were initiating/resuming cigarette use, initiating marijuana use, and initiating hookah use during the first year of college. We controlled for sensation-seeking, impulsivity, binge drinking, and other smoking behaviors in our multivariate logistic regression models. The results showed that (a) pre-college hookah use predicted initiating/resuming cigarette use; (b) pre-college marijuana use predicted initiation of hookah tobacco smoking; and (c) pre-college cigarette use predicted neither hookah nor marijuana initiation. The findings highlight the co-occurrence of smoking behaviors as well as the need for bundling preventive interventions so that they address hookah, cigarette, and marijuana use.

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**Contributors**

Robyn L. Fielder, Kate B. Carey, and Michael P. Carey designed the study. Robyn L. Fielder collected and analyzed the data, reviewed the literature, and wrote the first draft of the manuscript. All authors contributed to and critically reviewed the manuscript, and all have approved the final manuscript.

**Conflict of Interest**

All authors declare that they have no conflicts of interest.

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**Keywords**

hookah; waterpipe; tobacco; marijuana; college students

## 1. Introduction

Smoking behaviors, including cigarette, marijuana, and hookah use, all undermine the health of young people. Cigarette smoking and marijuana use have been well-characterized in the United States. For example, 15% of college students report current (past 30 day) cigarette smoking, and 19% report current marijuana use (Johnston, O'Malley, Bachman, & Schulenberg, 2012). Much is known about the antecedents of both cigarette smoking (U.S. Department of Health and Human Services, 2012) and marijuana use (Hall & Degenhardt, 2007). However, less is known about hookah use in the U. S., especially with regard to the co-occurrence of hookah, cigarette, and marijuana use, and the temporal pattern of initiation among these three smoking behaviors. Given that all three behaviors involve smoking, it is reasonable to consider whether initiation of one might predispose to initiation of another. The current study provides a preliminary investigation into these relationships with a special emphasis on the role of hookah tobacco smoking, a growing trend among young adults (Cobb, Ward, Maziak, Shihadeh, & Eissenberg, 2010).

### 1.1. Prevalence of Hookah Use

Hookah use has been increasing worldwide (Akl et al., 2011), especially among adolescents and college students (Cobb et al., 2010). In representative samples of American high school students, 10% report past month or lifetime hookah tobacco use (Barnett, Curbow, Weitz, Johnson, & Smith-Simone, 2009; Jordan & Delnevo, 2010; Manderski, Hrywna, & Delnevo, 2012; Primack, Walsh, Bryce, & Eissenberg, 2009). Among American college students, lifetime prevalence ranges from 15% to 48% (Braun, Glassman, Wohlwend, Whewell, & Reindl, 2012; Eissenberg, Ward, Smith-Simone, & Maziak, 2008; Fielder, Carey, & Carey, 2012; Jarrett, Blosnich, Tworek, & Horn, 2012; Primack et al., 2008; Sutfin et al., 2011). Hookah use is now almost as common, if not as common or more common, as cigarette smoking among American college students (Grekin & Ayna, 2012; Nuzzo et al., 2013). Hookah lounges, now ubiquitous in college towns (Sutfin et al., 2011), may be especially appealing to students under age 21, who cannot legally enter traditional bars. Hookah smoking is less common among Americans beyond traditional college age (i.e., 18–24 years old); in the 2009–2010 National Adult Tobacco Survey of over 118,000 adults aged 18 years or older, the prevalence of current waterpipe use was 7.8% among 18–24 year olds, 1.2% among 25–44 year olds, and 0.3% among 45–64 year olds, for an overall prevalence of 1.5% (King, Dube, & Tynan, 2012). Thus, the college years appear to be a particularly high risk period for hookah experimentation.

Hookah tobacco smoking is a growing public health concern (Cobb et al., 2010; Knishkowy & Amitai, 2005). Hookah smokers inhale nicotine, carbon monoxide, and large volumes of smoke, including toxicants and carcinogens (Cobb, Shihadeh, Weaver, & Eissenberg, 2011; Daher et al., 2010). Research on the health effects of hookah smoking indicates a harmful impact on lung function (Raad et al., 2011) and increased odds of lung cancer, respiratory illness, and periodontal disease (Akl et al., 2010).

### 1.2. Gender Differences in Hookah Use

Research suggests there may be gender differences in patterns of hookah use. Several studies with adolescent samples have found that boys are more likely to report lifetime use of hookah compared to girls (Barnett et al., 2009; Primack et al., 2009; Sterling &

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Mermelstein, 2011). Moreover, a review of seven studies on hookah use among college students found that all but one showed a higher rate of hookah use among males compared to females (Grekin & Ayna, 2012). Nonetheless, many college women experiment with hookah use; we have reported previously that 34% of female college students used hookah during their first year on campus (Fielder et al., 2012), and 8% of women surveyed through the National College Health Assessment II reported hookah use in the past 30 days (Jarrett et al., 2012). Because tobacco use patterns (Rigotti, Lee, & Wechsler, 2000), psychosocial correlates, and reasons for smoking (Branstetter, Blosnich, Dino, Nolan, & Horn, 2012) differ by gender, it is important to examine hookah smoking behavior specifically among women.

### 1.3. Hookah and Cigarette Use

Hookah smoking has been associated with cigarette smoking (Barnett et al., 2009; Braun et al., 2012; Eissenberg et al., 2008; Jordan & Delnevo, 2010; Manderski et al., 2012; Sutfin et al., 2011). Because almost all studies of hookah use have been cross-sectional (Grekin & Ayna, 2012), it remains unclear whether hookah use may spur cigarette smoking, cigarette smoking may spur hookah use, or the two smoking behaviors simply co-occur. Hookah tobacco use may lead to uptake of cigarette smoking. Indeed, hookah, with its flavored tobacco and smoother smoke, may introduce non-smokers to nicotine in a manner that is less harsh than cigarettes. Over time, because hookah smoking requires an apparatus and is time-consuming (Braun et al., 2012), and because cigarettes are portable and obtained more easily, hookah users may supplement their hookah use with cigarette smoking or switch to cigarettes (Rastam et al., 2011). Hookah use may also re-introduce those who have already quit smoking to tobacco, triggering relapse (Maziak, 2011). Because hookah smoking delivers nicotine, it confers risk for tobacco dependence (Cobb et al., 2011). Alternatively, cigarette smokers who try hookah may favor the latter given the flavored tobacco and less harsh smoke, leading them to substitute hookah smoking for cigarette use. At the same time, hookah and cigarette smoking may both result from shared genetic predispositions (Agrawal, Budney, & Lynskey, 2012) and underlying personality traits, such as sensation-seeking or impulsivity, which have been linked to tobacco use (Granö, Virtanen, Vahtera, Elovainio, & Kivimäki, 2004; Spillane, Smith, & Kahler, 2010).

### 1.4. Hookah and Marijuana Use

Hookah smoking is also associated with marijuana use (Braun et al., 2012; Jarrett et al., 2012; Sterling & Mermelstein, 2011; Sutfin et al., 2011). Hookah and marijuana use reflect similar motives, such as social enhancement, relaxation, and experimentation (Braun et al., 2012; Lee, Neighbors, & Woods, 2007; Smith-Simone, Maziak, Ward, & Eissenberg, 2008). The social context is important for hookah use, as nearly all (96%) college students smoke hookah with their friends (Braun et al., 2012). Peer influence can create availability and exposure opportunity (Pinchevsky et al., 2012) as well as an environment in which use of both hookah and marijuana is encouraged (Agrawal et al., 2012). Also, the route of administration may be a factor, as some hookah users smoke marijuana out of the same waterpipe they use for tobacco (Smith-Simone et al., 2008). As with cigarette use, hookah and marijuana use may both be related to a shared genetic predisposition to disinhibition, general problem behavior, and substance use (Agrawal et al., 2012).

### 1.5. Longitudinal Associations among Hookah, Cigarette, and Marijuana Use

Little research has addressed the prospective relationship between hookah use and cigarette/marijuana use. Only two longitudinal studies have explored hookah as a predictor of cigarette use. One study sampled Danish adolescent males and found that hookah use increased the odds of transitioning from experimentation to regular cigarette smoking over eight months (Jensen, Cortes, Engholm, Kremers, & Gislum, 2010). The second sampled

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Jordanian adolescents and found that hookah smokers were twice as likely as non-smokers to become cigarette smokers two years later (Mzayek, et al., 2012). Interestingly, in the latter study, the reverse pattern was also true; that is, cigarette smokers were twice as likely as non-smokers to become hookah smokers, but this association was not statistically significant. To our knowledge, no longitudinal studies have sampled Americans or college students or examined hookah as a predictor of marijuana use.

### 1.6. The Current Study

The primary purpose of this study was to examine the relationship between hookah tobacco smoking and (a) cigarette and (b) marijuana use using a prospective design. We focused on college students given the high prevalence of hookah use in this population (Grekin & Ayna, 2012), especially compared to those older than 18–24 years (King et al., 2012). We focused on women because tobacco use patterns differ by gender (Branstetter et al., 2012; Rigotti et al., 2000). Using data from a larger study of women, we examined pre-college hookah use as a predictor of initiating cigarette and marijuana use during the first year of college. The secondary purpose of this study was to examine pre-college cigarette and marijuana use as a predictor of initiating hookah use during the first year of college. To control for a general propensity toward substance use, we controlled for binge drinking as well as two personality constructs that have been linked to smoking behaviors (viz., impulsivity and sensation-seeking; Granö et al., 2004; Spillane et al., 2010) in all analyses.

### 1.7. Hypotheses

We hypothesized that pre-college hookah tobacco smoking would increase women's likelihood of initiating cigarette and marijuana use during the first year of college. We did not make any predictions for the opposite direction of effect.

## 2. Methods

### 2.1. Participants

Eligible participants were first-year female college students ($N = 483$) engaged in a 13-month longitudinal study from August 2009 to August 2010 designed to investigate health behaviors and relationships during the transition to college. The sample size was chosen to reach a large proportion of the population while maintaining feasibility. According to the University's Office of Institutional Research, the sample represented 26% of all incoming female students for the 2009–2010 academic year, with an equivalent racial/ethnic breakdown. The racial distribution was 67% White, 11% Asian, 9% Black, and 13% other or multiple; 9% self-identified as Hispanic. On average, participants were 18.1 years old ($SD = 0.3$, range: 18–21) at baseline.

### 2.2. Study Design

The current study used data from the first nine months of the larger study (see Fielder, Walsh, Carey, & Carey, 2013; Walsh, Fielder, Carey, & Carey, 2013), representing the first academic year of college. We focused this investigation on the academic year given the link between higher rates of hookah smoking and the presence of hookah cafes in college towns (Sutfin et al., 2011). We used a prospective cohort design with a baseline survey and eight monthly follow-up surveys (waves 2–9). Response rates for the eight follow-up surveys were: 97%, 95%, 95%, 91%, 92%, 92%, 89%, and 85%; mean number of surveys completed was 8.8 ($SD = 0.4$, range: 7–9). We included participants with complete data on at least 75% of assessments in both the Fall and Spring semesters ($n = 424$); of these, 85% completed all 9 surveys. There were no differences between included participants and women excluded due to missing data ($n = 59$) on age, race, ethnicity, impulsivity, sensation-seeking, or frequency of pre-college hookah, cigarette, marijuana use, or binge drinking (all $p$s > .05).

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### 2.3. Procedures

All procedures were approved by the university's Institutional Review Board. The study was conducted at a private university in upstate New York. Participants were recruited for the larger study via a mass mailing sent to incoming first-year female students supplemented with campus flyers, word of mouth, and the psychology department research pool. Most participants (61%) were recruited from the mass mailing, 28% from the participant pool, and 11% from word of mouth or flyers. Eligibility criteria were: at least 18 years of age, first-year student, and not a scholarship athlete (excluded due to National Collegiate Athletic Association policies). Interested women signed up on a website, were screened to ensure eligibility, and attended an orientation, at which time research staff explained study procedures and obtained written informed consent, and participants completed the baseline survey on lab computers.

Follow-up surveys were administered online using a secure survey website. On the last day of each month, participants received emails containing an embedded link to a confidential survey. Follow-up surveys required 10–20 minutes to complete, and participants had one week to respond. Survey responses were linked over time by unique identification codes, and identifying information was stored separately to protect privacy. Participants who missed surveys could resume participation with the next available survey. Participants received monetary compensation ($10–20 per survey, depending on length) and/or course credit for participating. To encourage prompt responding, participants were entered into monthly raffles (two $50 cash prizes per month) with the number of raffle entries inversely related to response time.

### 2.4. Measures

**2.4.1. Demographics and personality—**At baseline, participants provided their age, race, ethnicity, and two personality variables. Impulsivity ($\alpha$ = .81) was measured using six items (e.g., "I often throw myself too hastily into things"; Magid, MacLean, & Colder, 2007) from the Impulsiveness Monotony Avoidance Scale (Schalling, 1978). Sensation-seeking ($\alpha$= .82) was also measured using six items (e.g., "I like doing things just for the thrill of it"; Magid et al., 2007) from this scale (Schalling, 1978). Participants indicated how well each statement applied to them using a 4-point scale (1 = not at all like me to 4 = very much like me); scores were summed to create a total score ranging from 6 to 24. We included sensation-seeking and impulsivity in our models as covariates.

**2.4.2. Substance use—**For all substance use measures, specific anchor dates (e.g., August 1–31) were provided to facilitate recall.

At baseline, participants indicated the number of times they "ever smoked ***hookah*** before starting college"; this frequency variable served as the pre-college hookah use predictor. At each follow-up, participants indicated on how many days in the last month they "used hookah to smoke tobacco." Due to low rates of initiation within any given month (e.g., 1–3%) and low variability in frequency of hookah use during college, we created a dichotomous indicator of hookah initiation (collapsing across waves 2–9) during the first year of college for our outcome variable; we also created a dichotomous indicator of pre-college hookah use for classification purposes.

At every assessment, participants indicated whether they had smoked a ***cigarette*** (even one puff) in the last month; if so, they were asked the number of cigarettes they smoked each day in a typical week in the last month. Due to the low frequency of smoking in our sample, we used number of days of cigarette smoking per typical week for pre-college cigarette use as a predictor. Due to low levels of cigarette smoking during college, we created a

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dichotomous indicator of cigarette use (initiation/resumption, collapsing across waves 2–9) during the first year of college for our outcome variable; the threshold for inclusion was reporting smoking an average of at least one cigarette per typical week during one or more months. We also created a dichotomous indicator of pre-college cigarette use for classification purposes.

At baseline, participants indicated the number of times they had ever used ***marijuana*** in their entire lives; this frequency variable served as the pre-college marijuana use predictor. At each follow-up, participants indicated on how many days in the last month they used marijuana. To be consistent with the other outcomes, we created a dichotomous indicator of marijuana initiation during the first year of college (collapsing across waves 2–9) for our outcome variable; we also created a dichotomous indicator of pre-college marijuana use for classification purposes.

At baseline, participants indicated on how many days in the last month they had four or more standard drinks of ***alcohol*** on one occasion (i.e., a binge episode for women). We used this variable as a covariate.

### 2.5. Analyses

We tested demographics as potential covariates of hookah, cigarette, and marijuana initiation using logistic regression. Alpha was set (*a priori*) at .05. No demographic variables were associated with any of the three outcomes (all *p*s > .05). Based on prior research and theory, we controlled for impulsivity, sensation-seeking, and binge drinking in all analyses.

Because of our research question (i.e., investigating hookah, cigarette, and marijuana *initiation*), we excluded participants who reported pre-college/baseline use of that substance. For example, 117 participants (28%) reported pre-college hookah use, so they were excluded from analyses predicting hookah initiation. Baseline cigarette use was reported by 38 participants (9%), so they were excluded from analyses predicting cigarette initiation/resumption. Pre-college marijuana use was reported by 171 participants (40%), so they were excluded from analyses predicting marijuana initiation. By excluding these participants, within each predictive analysis, we had a true prospective design with pre-college or baseline use of the predictor substance occurring before initiation of the predicted substance.

We used binary logistic regression for the primary analyses, with continuous indicators of pre-college substance use: pre-college (lifetime) number of instances of hookah and marijuana use and baseline (typical week in the last month) number of days of cigarette smoking. We ran three separate multivariate logistic regression models with dichotomous outcomes of initiation of substance use during the first year of college. For hookah and marijuana use, the outcome of interest was initiation, or the first ever use of the substance. However, because we did not assess lifetime cigarette use at baseline, the outcomes of interest for cigarette smoking were initiation or resumption (after at least one month of non-use). Multivariate models controlled for personality (i.e., impulsivity and sensation-seeking) and binge drinking as well as use of the other substances that were not the focus of the model (e.g., for the model predicting cigarette initiation, we controlled for marijuana use). Predictors were mean-centered to facilitate interpretation. Alpha was set (*a priori*) at .05. We report adjusted odds ratios (AOR) and 95% confidence intervals (CIs).

## 3. Results

### 3.1. Substance Use Initiation

Table 1 displays the prevalence of initiation of each smoking behavior during the first year of college among women who reported no pre-college use of each substance. For example,

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51 of the 307 women reporting no pre-college hookah use (17%) initiated hookah tobacco use during the first year of college.

### 3.2. Pre-College Hookah Use as a Predictor of Cigarette Initiation/Resumption during the First Year of College

The model predicted initiation/resumption of cigarette use, LR $\chi^2$ ($df = 5$, $N = 386$) = 30.03, $p < .0001$. Controlling for covariates, pre-college hookah use significantly predicted initiating/resuming cigarette use during the first year of college (see Table 2). Pre-college marijuana use was also a significant predictor. Holding impulsivity, sensation-seeking, baseline binge drinking, and pre-college marijuana use constant at their means, with each additional instance of pre-college hookah use, the odds of initiating/resuming cigarette smoking increased by 8%.

### 3.3. Pre-College Hookah Use as a Predictor of Marijuana Initiation during the First Year of College

The model predicted initiation of marijuana use, LR $\chi^2$ ($df = 5$, $N = 253$) = 12.38, $p = .03$. Controlling for covariates, pre-college hookah use did not predict initiation of marijuana use during the first year of college (see Table 3). Only impulsivity and pre-college binge drinking predicted initiation of marijuana use.

### 3.4. Pre-College Cigarette and Marijuana Use as Predictors of Hookah Initiation during the First Year of College

The model predicted initiation of hookah tobacco use, LR $\chi^2$ ($df = 5$, $N = 307$) = 43.28, $p < .0001$. Controlling for covariates, pre-college marijuana use, but not baseline cigarette use, significantly predicted initiation of hookah tobacco use during the first year of college (see Table 4). Pre-college binge drinking was also predictive of hookah initiation. Holding impulsivity, sensation-seeking, and baseline binge drinking and cigarette smoking constant at their means, with each additional instance of pre-college marijuana use, the odds of initiating hookah tobacco smoking increased by 3%.

## 4. Discussion

This study—the first prospective study to test the association between hookah and cigarette use among American students and to test the association between hookah and marijuana use—produced three main findings. First, in our sample of first-year women, 28% used hookah before college, and 17% of those with no previous hookah use tried it during their first year of college. Thus, by the end of their first year of college, 45% of female students had tried hookah tobacco smoking (see Fielder et al., 2012), which is consistent with prior research (Sutfin et al., 2011). Factors contributing to hookah's growing popularity include social acceptance, novelty, low cost, marketing, and flavored tobacco (Martinasek, McDermott, & Martini, 2011).

Second, we found evidence to support the hypothesis that hookah tobacco smoking increases the likelihood of initiating/resuming cigarette use during the first year of college. In contrast, tests of the reverse relationship did not support the idea that pre-college cigarette use predicts initiation of hookah tobacco smoking. Our results corroborate findings from two previous studies of hookah predicting later cigarette smoking (Jensen et al., 2010; Mzayek et al., 2012). Collectively, these three studies provide some evidence that hookah tobacco use may precede initiating or resuming cigarette smoking.

Hookah smoking may increase risk for initiating cigarette smoking by introducing non-smokers to nicotine. Because users inhale nicotine, hookah tobacco smoking presents

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potential for nicotine dependence (Cobb et al., 2011). Hookah users may supplement their use with cigarette smoking, or switch methods, in an attempt avoid withdrawal symptoms or cravings (Rastam et al., 2011). Cigarettes are more convenient than hookah; they are easily accessible, highly portable, and less time-consuming. In contrast, for some, hookah smoking may only be accessed at a hookah lounge, and it requires a waterpipe apparatus and, on average, 45 minutes (Braun et al., 2012). Hookah use may also re-expose those who have previously quit smoking cigarettes to nicotine, perhaps resulting in resumed cigarette smoking (Maziak, 2011). For infrequent hookah users, who are unlikely to develop nicotine dependence, hookah use may simply increase comfort with smoking as a route of administration (Agrawal & Lynskey, 2009). Furthermore, being in settings where friends are partying may present more opportunities to try cigarettes. Future research should explore the influence of peers' attitudes and behaviors.

Third, the hypothesis that hookah tobacco smoking increases the likelihood of marijuana initiation was not supported. Tests of the reverse direction of effect showed that pre-college marijuana use increased women's likelihood of initiating hookah tobacco use during the first year of college. Marijuana use may lead to more positive attitudes towards substances and greater access (through peers) to substance use opportunities, including hookah. This is the first study to examine hookah as a predictor of marijuana initiation, so these results need to be replicated. The absence of a link from hookah to marijuana use may be related to the context and legality of use. Many youth smoke hookah at hookah lounges (Sutfin et al., 2011; Sterling & Mermelstein, 2011), a setting that does not incur risk for legal or campus sanctions. Exposure to hookah culture may not be sufficient to reduce barriers to illicit drug use for most youth, so they are unlikely to transition from hookah to marijuana.

### 4.1. Theoretical Perspectives to Guide Future Research

The associations among hookah, cigarettes, and marijuana, have led some scholars to hypothesize that hookah smoking may serve as a "gateway" to initiation of cigarette or marijuana use, especially when these behaviors originate in late adolescence or emerging adulthood (Braun et al., 2012; Cobb et al., 2010; Eissenberg et al., 2008; Manderski et al., 2012; Maziak, 2011; Primack et al., 2008; Sterling & Mermelstein, 2011; Sutfin et al., 2011). The gateway theory (Kandel, 1975; Kandel, 2003) suggests developmental stages and a causal sequence of drug use, namely, legal and "softer" drugs before illegal and "harder" drugs. A gateway drug is hypothesized to be causally linked to subsequent drug use, perhaps through access, pharmacological effects, or exposure to social networks in which other drugs are available (Patton, Coffey, Carlin, Sawyer, & Lynskey, 2005). However, in practice it is challenging to test the gateway theory empirically. Longitudinal studies that enrolled participants prior to hookah, cigarette, and marijuana initiation would be necessary to evaluate this hypothesis in a methodologically rigorous way. Given that smoking behaviors can begin very young, researchers would need to recruit youth early (e.g., at 8–9 years old) and then follow them (ideally) through the transition to college, which appears to be a vulnerable time for the initiation of smoking behaviors (Fielder et al., 2012; Pinchevsky et al., 2012). Retaining samples and obtaining funding for such long-term and large-scale studies would be difficult.

Research designed to test competing theories will benefit prevention science. In this regard, it will be worthwhile to reduce the focus on hookah as a potential "gateway" and instead test alternative theories that may offer better explanations for the associations among hookah, cigarette, and marijuana use. For example, the common liability model posits an underlying propensity for drug use or problem behavior as well as shared common risk factors for different substances (Lynskey, Fergusson, & Horwood, 1998). This view posits that the so-called gateway pattern of substance use reflects, at least in part, unmeasured common causes rather than causal effects of specific drugs on subsequent use of others. For instance,

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tobacco and marijuana use may result from individual differences (e.g., personality, neurobehavioral, or genetic vulnerabilities) and/or social risk factors (e.g., familial substance use, peer networks). The common liability model has received some empirical support and appears to be more parsimonious than the gateway model (Lynskey et al., 1998; Morral, McCaffrey, & Paddock, 2002; van Leeuwen et al., 2011).

An even more parsimonious perspective focuses on the route of drug administration. It is possible that individuals who have previous experience with inhaled smoke from marijuana joints may be more physiologically adept at inhaling smoke from hookahs (Agrawal & Lynskey, 2009). There have been mixed findings for the route of administration perspective (Agrawal & Lynskey, 2009; van Leeuwen et al., 2011). It will be helpful for future studies to directly compare these different theoretical frameworks to evaluate their relative value.

The co-occurrence of health risk behaviors (Héroux et al., 2012; Walsh, Senn, & Carey, 2013), and especially of substance use behaviors (Dierker et al., 2006; Mohler-Kuo, Lee, & Wechsler, 2003; Primack et al., 2012), is increasingly recognized. This co-occurrence of health compromising behaviors suggests the need for bundling health education, promotion, and prevention interventions (Ickovics, 2008), or identifying a sequence of approaches that aligns with the behavior development process (Prochaska, 2008). Research that identifies the co-occurrence of risk behavior, and the temporal pattern of initiation, can help guide such intervention efforts (Ramo, Liu, & Prochaska, 2012).

### 4.2. Strengths, Limitations, and Directions for Future Research

Several methodological strengths enhance confidence in our results. First, we used a prospective design, which allowed us to identify the temporal ordering of participants' hookah use and cigarette/marijuana use. Second, we followed a large sample of young women during the transition to college, which is an important developmental period that may be a vulnerable time for initiating hookah use (Fielder et al., 2012). Third, we used behaviorally-based measures of smoking, as many college students who smoke cigarettes do not identify as "smokers" (Levinson et al., 2007). Fourth, we used monthly surveys of substance use behavior to reduce recall burden and improve reliability of self-reports. Fifth, in our analyses, we controlled for other forms of substance use, as well as personality characteristics, to rule out alternative explanations.

Limitations of this study suggest directions for future research. First, we recruited only first-year female students from one university, which may limit the generalizability of our findings. To enhance generalizability, future research should sample male and female students from multiple regions of the country, community college students, and non-college attending young adults. Second, although research supports the reliability and validity of self-reported smoking for 18–25 year olds (Ramo, Hall, & Prochaska, 2011), future research might supplement self-report with biological measures of smoking where feasible. Third, owing to our use of data from a broader study, the substance use measures were more general than would be optimal. For example, we did not have a measure of lifetime cigarette use at baseline, and we relied on dichotomous outcomes of smoking initiation. Future studies might assess a wider range of substances and obtain more fine-grained estimates (and counts) of recent and lifetime use. Although hookah smoking has been associated with poor health outcomes (Akl et al., 2010; Raad et al., 2011), it remains unclear whether a small number of lifetime uses has measurable health consequences. Thus, from a public health perspective, it is more important to focus on frequency of use. Future studies spanning longer follow-ups should use count measures. More comprehensive measures of sensation-seeking and impulsivity may also be useful.

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### 4.3. Summary and Implications

Hookah tobacco smoking among college students is increasing and is now almost as common as cigarette smoking (Grekin & Ayna, 2012). Although men are more likely to use hookah than women (Grekin & Ayna, 2012), our findings suggest that hookah use is relatively common among college women, indicating a need for health education efforts targeting women as well as men. Overall, the findings provide mixed support for the notion that hookah tobacco use leads youth to initiate other substance use. In this sample of college women, pre-college hookah smoking increased risk for initiating or resuming cigarette smoking, but not for initiating marijuana use, during the first year of college. In addition, pre-college marijuana use increased risk for initiating hookah tobacco use. If replicated, these findings have public health implications. Many hookah users have never smoked cigarettes (Jordan & Delnevo, 2010; Sutfin et al., 2011), but hookah tobacco use may lower the threshold for cigarette initiation. Identifying risk factors for cigarette initiation is critical because cigarette smoking is responsible for one out of every five deaths in the U. S. (US Department of Health and Human Services, 2010). Even light or intermittent smoking increases risk for health problems (Schane, Ling, & Glantz, 2010). Moreover, the prospective link between different forms of smoking behavior is concerning. Research suggests that co-morbid smoking (e.g., cigarette and marijuana use) may have an additive or synergistic effect in terms of harmful respiratory effects (Moore, Augustson, Moser, & Budney, 2005; Tan et al., 2009).

These findings have implications for health promotion and disease prevention. For example, they point to the value in educating young people about the potential pathway from hookah to cigarettes. Most college students recognize the health risks of cigarette smoking (Patterson, Lerman, Kaufmann, Neuner, & Audrain-McGovern, 2004), so they may be motivated to avoid substances (i.e., hookah) that might lead them to take up cigarette smoking. In addition, because many youth mistakenly perceive hookah smoking to be less harmful than cigarettes (Nuzzo et al., 2013; Sutfin et al., 2011), prevention efforts should highlight the health risks of hookah smoking. Identifying unique and common pathways to substance use initiation can strengthen prevention and treatment approaches for all addictive substances.

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## Highlights

- Examined hookah, cigarette, and marijuana use among first-year college women
- Used a prospective design and controlled for personality factors and binge drinking
- Pre-college hookah use predicted initiating/resuming cigarette use
- Pre-college marijuana, but not cigarette use, predicted initiation of hookah use
- Pre-college cigarette smoking did not predict initiation of hookah or marijuana use

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**Table 1**

Prevalence of Pre-College Use and Initiation of Cigarette Smoking, Marijuana Use, and Hookah Tobacco Smoking among First-Year College Women

| | **Pre-college use** | | | | **Initiation during first year of college among participants with no pre-college use** | |
|---|---|---|---|---|---|---|
| | **Yes** | | **No** | | | |
| | ***n*** | **%** | ***n*** | **%** | ***n*** | **%** |
| Hookah tobacco use | 117 | 28% | 307 | 72% | 51 | 17% |
| Cigarette smoking | 38 | 9% | 386 | 91% | 36 | 9% |
| Marijuana use | 171 | 40% | 253 | 60% | 43 | 17% |

*N* = 424 participants providing complete data.

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## Table 2

Predictors of Initiating/Resuming Cigarette Use during the First Year of College

| Predictor | AOR | 95% CI |
|---|---|---|
| Impulsivity | 0.99 | 0.88, 1.10 |
| Sensation-seeking | 1.05 | 0.94, 1.17 |
| Binge drinking (last month at baseline) | 1.00 | 0.88, 1.13 |
| Marijuana use (pre-college) | 1.02* | 1.00, 1.03 |
| Hookah use (pre-college) | 1.08* | 1.02, 1.15 |

*Note*. AOR = adjusted odds ratio; CI = confidence interval. $N$ = 386 participants reporting no cigarette smoking in the last month at baseline.

* $p < .01$.

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## Table 3

Predictors of Initiating Marijuana Use during the First Year of College

| Predictor | AOR | 95% CI |
|---|---|---|
| Impulsivity | 1.13* | 1.03, 1.25 |
| Sensation-seeking | 1.01 | 0.91, 1.11 |
| Binge drinking (last month at baseline) | 1.13* | 1.00, 1.27 |
| Cigarette use (last month at baseline) | 0.72 | 0.18, 2.84 |
| Hookah use (pre-college) | 0.98 | 0.85, 1.14 |

*Note*. AOR = adjusted odds ratio; CI = confidence interval. $N = 253$ participants reporting no marijuana use in their lifetime prior to college entry.

* $p < .05$.

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## Table 4

Predictors of Initiating Hookah Tobacco Use during the First Year of College

| Predictor | AOR | 95% CI |
|---|---|---|
| Impulsivity | 1.09 | 0.99, 1.21 |
| Sensation-seeking | 1.04 | 0.94, 1.15 |
| Binge drinking (last month at baseline) | 1.18* | 1.08, 1.30 |
| Cigarette use (last month at baseline) | 1.42 | 0.96, 2.09 |
| Marijuana use (pre-college) | 1.03* | 1.01, 1.05 |

*Note*. AOR = adjusted odds ratio; CI = confidence interval. $N = 307$ participants reporting no hookah tobacco use in their lifetime prior to college entry.

* $p < .01$.