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Hookah use predicts cigarette smoking progression among college smokers

Running Head: COLLEGE HOOKAH AND CIGARETTE USE

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### Abstract

*Aims:* Hookah use is increasingly common among US college students, but little is known regarding the relationship between hookah and cigarette use. The purpose of this study was to test the hypothesis that the added nicotine exposure from hookah use may accelerate the uptake of cigarettes.

*Methods:* An ethnically diverse sample of college students ( $n = 256$ ; 43% female) who had smoked cigarettes in the past month completed two in-person interviews over six months. This study was a secondary analysis of data collected for a longitudinal study of young adult cigarette smoking patterns. Analyses examined 6-month changes in past 30 day cigarettes smoked and number of days smoking, controlling for age, nicotine dependence, marijuana use, and the respective baseline variable for each outcome.

*Results:* Current hookah use (any use in past 30 days) was endorsed by 34% of participants at baseline, while 94% reported lifetime use. Change in past 30 day number of cigarettes ( $p = .043$ ) and number of smoking days ( $p = .040$ ) differed significantly between those who did or did not report recent hookah use at baseline. Hookah users reported a greater number of cigarettes smoked at the 6-month follow-up, while non-users decreased their smoking quantity. For number of smoking days in the past 30, hookah users reported a smaller decrease than non-users.

*Conclusions:* Recent hookah use predicted increased cigarette smoking over 6 months in a college sample. These are the first prospective data demonstrating this relationship, indicating the value of developing strategies to prevent hookah use among college students.

## Introduction

Hookah or waterpipe tobacco use is common among college students and young adults in the US with reported prevalence ranging from 15-48% lifetime, 12-31% past year, and 5-22% past month<sup>1-10</sup>. **Data from the Monitoring the Future study suggest increasing past year use among 12<sup>th</sup> graders, from 17% in 2010 to 21% in 2013<sup>11</sup>.** In some college samples, rates of lifetime and past year hookah use surpass those of cigarette use, but current or past month cigarette use is higher than hookah use<sup>7,12</sup>. These data underlie concerns about increasing hookah use among college students in the US. Hookah tobacco use is addictive<sup>13,14</sup> and has comparable health consequences to cigarettes because hookah smoke contains similar toxicants<sup>15</sup>. In addition, potential public health risks are exacerbated by common misperceptions that hookah has few health risks<sup>6,9,16</sup> **as well as by the increasing prevalence of hookah use among adolescents and young adults<sup>7,17</sup>.** Further, properties of hookah use such as prolonged sessions, inhaling at high volume, less irritating smoke, and flavors to enhance taste compound potential risks<sup>15,18</sup>. Overall, hookah smoking appears to have limited barriers for initiation and high risk for addiction and negative health consequences.

Despite evidence to the contrary, college students perceive hookah to be less harmful and less addictive than smoking cigarettes, beliefs that are stronger in hookah users<sup>5,9,10,19</sup>. **In fact, compared with smoking one cigarette, single episodes of hookah use tend to be substantially longer and to involve intake of greater amounts of smoke, nicotine, tar, and carbon monoxide<sup>20</sup>.** Thirty-five percent of college hookah users report never having smoked cigarettes, highlighting that hookah may be a more acceptable form of tobacco use in this population<sup>9,12</sup>. Previous research has documented characteristics associated with college student hookah use, including younger age, being a male undergraduate student, having Arab, Hispanic,

or Caucasian ethnicity, participation in club or intramural sports, living on campus, and membership in a fraternity or sorority<sup>2,3,6-9,21</sup>. Social and peer influences play an important role in hookah use as indicated by findings that college hookah users are more likely to report having friends who have tried hookah and are supportive of hookah use<sup>6,10</sup>. Accordingly, college hookah users **commonly** introduce friends to smoking hookah and often use with friends<sup>5</sup>. In addition, hookah use is related to other health-risk behaviors such as problem drinking and **illicit** drug use, a relationship that may be influenced by social factors, coping skills, impulsivity, or physiological effects<sup>5,10</sup>. Of particular concern, hookah use may be associated with future cigarette use, as 17-35% of non-cigarette smoking students who use hookah express intentions or interest in trying cigarettes<sup>10,22</sup>, and prospective studies of college freshman women find hookah use predictive of cigarette smoking initiation or resumption<sup>23</sup>.

The college years form a transition from adolescence to adulthood, a period during which tobacco use and other health behaviors are still being formed. Accordingly, this is a period of instability in cigarette use patterns, with smoking persisting throughout college and beyond for some, but not all students<sup>24,25</sup>. The formative nature of this period is further evidenced by the heterogeneity of smoking patterns observed among college students, the majority of whom are non-daily smokers and who report a broad range of cigarette use quantity and frequency<sup>26,27</sup>. A substantial concern is that increased nicotine exposure via other forms of tobacco in this unstable context may accelerate the trajectory of cigarette smoking and hasten progression toward nicotine dependence<sup>28,29</sup>. Although limited data are available to address this issue, recent findings from studies of college students indicate that approximately one-third of current cigarette users also used hookah in the past month<sup>6,12</sup>, highlighting the substantial concordance of these behaviors. Currently, the effect of concurrent hookah and cigarette use on future

smoking patterns is unknown. However, hookah use, possibly through increased exposure to nicotine, may serve to escalate cigarette consumption and accelerate the development of nicotine dependence, a relationship which may have significant public health implications.

Increased hookah use in the US and its high concordance with cigarette smoking, especially among college students and young adults<sup>15</sup>, accentuates the need for research examining the consequences of this behavior on cigarette use trajectories. However, there is little research on this question to date. One recent study among Danish youth found that, in a sample of irregular smokers, hookah use predicted increased cigarette smoking eight months later<sup>30</sup>. The present study is the first to our knowledge to prospectively examine the influence of hookah use on progression of cigarette smoking among young adults. We predicted that recent hookah use reported at baseline would be significantly associated with cigarette smoking progression six months later, as indicated by greater increases in quantity and frequency of cigarette consumption when compared with non-hookah users.

## **Methods**

### *Participants*

Participants ( $N = 323$ ; 39.9% female) were students from two universities in the Southwestern United States taking part in a longitudinal study of cigarette smoking self-change. The present study was a secondary analysis of these data. Participants were on average 19.8 years of age ( $SD = 1.50$ ), and the sample consisted of 41.5% Asian, 32.2% Non-Hispanic White, 7.4% Hispanic/Latino, and 9.6% mixed ethnicity students. Data were drawn from two studies of smoking self-change in college students ( $ns = 111$  and 212, respectively) with identical inclusion criteria: 1) having smoked at least one cigarette in each of the four weeks prior to the initial interview, 2) between 18 and 24 years of age, and 3) enrolled as an undergraduate student for the

duration of study participation (six months). There were no differences between participants from the two universities in terms of age, sex, nicotine dependence, or hookah or cigarette use at baseline or follow-up ( $p$ 's > .10). Participants from one university were more likely to identify as Asian American [ $\chi^2(3) = 50.59, p < .001$ ]. Participants completed in-person interviews at baseline and 3- and 6-months post-baseline. Two hundred and fifty-six participants (78.9%) completed the six month follow-up and were included in predictive analyses for the present study. Those who completed the follow-up assessment did not differ from participants lost to follow-up with regard to ethnicity, age, baseline hookah use, daily smoking status, nicotine dependence, or baseline alcohol and other drug use ( $p$ 's > .05). Participants lost to follow-up were more likely to be male (70.6% versus 57.3% of those retained;  $p = .046$ ).

### *Procedure*

The studies were approved by the Institutional Review Boards of the participating universities. Potential participants were recruited through flyers posted on college campuses. Those who contacted the study staff were screened for eligibility. Trained research assistants explained study participation and obtained informed written consent from eligible students. Participants individually completed in-person interviews at baseline and six months later; interviews lasted 60 to 90 minutes, and participants were compensated. Participant enrollment was ongoing throughout the calendar year.

### *Measures*

*Demographics and Student Characteristics.* Age, gender, ethnicity, campus residence status and Greek society membership were ascertained as part of an interviewer-administered baseline questionnaire. Smoking history, including whether the student had smoked 100 cigarettes or had



ever smoked hookah, was also assessed as part of the questionnaire, **as were parental, roommate, and significant other smoking statuses.**

*Alcohol, Tobacco and Other Drug Use.* Hookah, cigarette, alcohol and other drug use were assessed for the 90 days preceding each interview using the Timeline Followback procedure (TLFB)<sup>31,32</sup>. Frequency of use (i.e., days on which use occurred) was recorded for all substances. Quantity of alcoholic drinks and cigarettes consumed was recorded for each day on which participants reported use. The TLFB has been shown to have good psychometric properties when assessing alcohol, drug and tobacco use, including nondaily tobacco use<sup>33</sup>, with college students. Past 30-day data from the TLFB were summarized to compute variables employed in the analyses: hookah use; total number of cigarettes, change in total number of cigarettes (calculated as total past 30-day cigarettes at six months minus total past 30-day cigarettes at baseline), and days smoking; total drinks of alcohol and number of drinking days; number of days using marijuana; and number of days using illicit drugs other than marijuana.

*Nicotine dependence.* The Hooked on Nicotine Checklist (HONC) was used to assess nicotine dependence<sup>34</sup>. The HONC is a 10-item self-report measure rated on a dichotomous scale (i.e. yes or no). The HONC has been found to have good reliability and predictive validity among college student smokers<sup>35</sup>. In addition, the HONC items have been found sensitive to lower levels of smoking, such as are commonly found in youth samples<sup>36</sup>. **HONC scores range from 0 to 10; scores > 0 are thought to reflect decreased autonomy over smoking behavior (i.e., dependence), with each additional point reflecting greater reduction in control over one's smoking behavior<sup>37</sup>. Wellman and colleagues<sup>34</sup> reported HONC means of 1.2 for college students who smoked 1-4 of the past 30 days, 2.6 for those smoking 5-19 of the past 30 days, and 5.8 for those smoking at least 20 of the past 30 days.**

*Analytic Plan*

**Initially, univariate t-tests and chi-squares were used to test for differences between hookah users and non-users on demographic characteristics and on smoking and other substance use variables.** Ordinary least squares regression models were used to test the hypothesis that having used hookah in the 30 days before baseline would be associated with greater increases six months later in a) number of cigarettes smoked in the prior 30 days and b) days smoked in the past 30. To account for the possibility that change would be influenced by baseline consumption, the respective baseline variable was included as a covariate. Demographic or student characteristic variables that were associated with hookah use in bivariate analyses were also included as model covariates. All analyses were conducted using Intercooled Stata 12.0 (StataCorp LLP, College Station, TX) and  $\alpha = .05$ .

## Results

*Hookah use in baseline sample*

Examination of lifetime hookah use revealed that virtually all participants reported having ever used hookah (94.7%). Of the baseline sample, 34.0 percent reported past 30 day hookah use. A comparison of those who had and had not used hookah recently was conducted for variables previously identified with college hookah use. As shown in Table 1, recent hookah users tended to be younger, have lower levels of nicotine dependence, and reported less cigarette smoking and more marijuana use over the past 30 days at baseline. No differences emerged for gender, ethnicity, **parent, roommate, or significant other smoking**, or alcohol use. Baseline nicotine dependence, frequency of marijuana use, and age were included as covariates in subsequent analyses.

*<Insert Table 1 about here>*

*Hookah and cigarette quantity at 6 month follow-up.*

The regression model is shown in Table 2. Age, nicotine dependence, and frequency of marijuana use were unrelated to change in total cigarettes from baseline to 6 months.

Participants who reported more total cigarettes at baseline tended to report significantly less change between baseline and 6 months ( $\beta = -.46, p < .001$ ). Consistent with our hypothesis, there was a significant relationship between baseline hookah use and change in cigarette quantity ( $\beta = .12, p = .043$ ). More specifically, as shown in Figure 1, the 173 non-hookah users reported a mean (*SD*) of 31.77 (112.94) fewer cigarettes at 6 months than they had at baseline. **Post-hoc t-tests indicated that this was a significant reduction [ $t(172) = 3.70, p < .001$ ].** In contrast, the 80 hookah users reported an average of 17.53 (135.88) more cigarettes at 6 months compared with baseline, **a non-significant increase [ $t(79) = -1.15, p = .252$ ].**

*<Insert Table 2 about here>*

*<Insert Figure 1 about here>*

*Hookah and cigarette frequency at 6 month follow-up.*

Age and frequency of marijuana use were also unrelated to change in cigarette smoking frequency (see Table 3). There was a non-significant trend toward those with higher baseline nicotine dependence reporting greater increases in smoking frequency ( $\beta = .13, p = .055$ ). There was an inverse relationship between baseline smoking frequency and change in smoking frequency ( $\beta = -0.43, p < .001$ ). As predicted, baseline hookah use was positively associated with change in cigarette smoking frequency from baseline to 6 months ( $\beta = .13, p = .040$ ). The average hookah user reported a change in smoking days of -2.43 (10.80), compared with -6.79 (11.96) for the average non-user (see Figure 2). **Post-hoc t-tests indicated that these**

reductions in smoking days were significant for both non-users [ $t(172) = 7.47, p < .001$ ] and users [ $t(79) = 2.01, p = .048$ ] of hookah.

*<Insert Table 3 about here>*

*<Insert Figure 2 about here>*

### Discussion

The present study examined the extent to which any past-month hookah use was prospectively associated with quantity and frequency of cigarette smoking 6 months later for young adult smokers. We hypothesized that having used hookah within the past 30 days at baseline would be associated with larger increases in past 30-day quantity and frequency of cigarette smoking 6 months later. Consistent with these expectations, we found significant effects of hookah use on change in both quantity and frequency of cigarette use. Hookah users reported increased quantity of cigarettes at 6 months, while non-users reported a decrease. Both groups reported fewer smoking days at 6 months relative to baseline, but the decrease was significantly larger for non-users of hookah.

To our knowledge, only one previous study has tested the hypothesis that hookah use is associated with increased cigarette smoking<sup>30</sup>. Our findings are consistent with the earlier study in suggesting heavier smoking at follow-up among baseline hookah users. Recent baseline hookah use in the present sample was associated with younger age and lower levels of cigarette involvement, suggesting these were cigarette smokers earlier in the uptake process. Nevertheless, hookah use predicted changes in cigarette smoking quantity and frequency above the influence of baseline smoking rate. **Hookah users had lower nicotine dependence at baseline, suggesting that relatively infrequent hookah use (mean = 3.0 days in the past month) confers lower risk for dependence compared with more frequent cigarette smoking (mean**

**= 21.3 days in the past month for non-hookah users). However, the subsequent increase in cigarette use suggests that using hookah does indeed potentiate the risk of cigarette smoking progression. One potential explanation for this result is that the increased nicotine exposure resulting from hookah tobacco smoking accelerates the development of tolerance and withdrawal, leading to heightened cigarette consumption. Peer and contextual influences may also play a role in the observed phenomenon. Recent studies suggest that for regular hookah smokers social facilitation is an important motive<sup>38</sup>. Given that the majority of college hookah users also smoke cigarettes<sup>39</sup>, it is likely that regular hookah smoking increases exposure to social contexts in which cigarettes are smoked and thus increases the opportunity to use cigarettes. Considering their lower cigarette consumption and nicotine dependence at baseline, it is possible that hookah users tended to perceive hookah as more socially acceptable than cigarettes; to the extent that this was the case, such concerns appear to have faded over time as baseline hookah smokers increased their cigarette consumption. Social aspects of hookah use may be heightened by the legal context. California law exempts tobacco stores from indoor smoking restrictions, as long as they do not serve food or alcohol<sup>40</sup>. This may encourage hookah smokers to gather in tobacco stores and hookah bars where hookah smoking is permitted.**

**Consistent with previous work<sup>41</sup>, hookah users also reported higher levels of marijuana use and non-significantly higher levels of alcohol use at baseline. This is consistent with problem behavior theory<sup>42</sup>, which suggests that individuals who engage in one problem behavior are more likely to engage in others. Baseline hookah users may have had more risk factors and fewer protective factors and thus greater propensity for experimenting with multiple substances<sup>43</sup>. The theory also suggests that access is an**

**important contributor to problem behavior<sup>4</sup>. Given that hookah users were significantly younger than non-users, they may have had less access to regular bars than non-users, and may have utilized hookah bars as an alternative for social activity.**

Notably, the prevalence of hookah use in the present sample was quite high. More than one-third of the sample had used hookah in the past month, and nearly 95% had used hookah in their lifetimes. In part, this likely reflects the growing popularity of hookah among college students and around college campuses<sup>5,7,12</sup>. It may also reflect regional differences in hookah use and in the number of hookah bars, with previous studies indicating greater prevalence in the Western US<sup>21</sup>. **High rates of hookah use may also be related to the high proportion of Asian Americans in the sample. Some studies have reported higher use among Asian groups<sup>44,45</sup>, though others have not<sup>46</sup>. Higher rates of hookah use in Asian populations may reflect the origins of the practice in Asia as well as the Middle East<sup>47</sup>.** Another limitation of this study was the fact that the sample was comprised of college students who reported high levels of lifetime hookah use, **and recent cigarette smoking**, and may not be representative of young adults generally. Additionally, the great majority of participants classified as past month non-users of hookah at baseline did endorse lifetime hookah use. Because this occurred prior to study entry we were unable to determine recency of hookah use or any impact on cigarette use. The observed declines in cigarette smoking, while unanticipated, do not reflect changes linked to the academic year as participants were enrolled in the study throughout the calendar year. Future research should address these issues by utilizing more comprehensive measurement, **including known predictors of cigarette smoking trajectories (e.g., negative affect, socioeconomic status, social support<sup>48,49</sup>)**, and by including participants from the community.

In addition to the influence of hookah use, the overall patterns observed in cigarette quantity and frequency are worthy of note. Non-hookah users reported fewer cigarettes and fewer smoking days at six months compared with baseline; hookah users reported more cigarettes at six months, but conversely had smoked less frequently relative to baseline. One possible explanation for the apparently contradictory patterns in hookah users is that these individuals smoked cigarettes mainly in social situations, and that they engaged in fewer social activities at the time of follow-up, but smoked cigarettes more heavily on these occasions. Alternatively, the change in cigarette smoking days among hookah users was relatively small ( $M = 2.43$  fewer days) and may simply reflect instability of the behavior among early stage smokers. Overall, these data suggest that smoking behavior among young adults remains malleable, and may therefore be amenable to treatment. They also indicate the importance of further longitudinal research to inform treatment by identifying predictors of smoking escalation and reduction in this population.

Viewed in concert these findings highlight the risk posed by hookah use for cigarette smoking progression. The finding also highlights the potential importance of previous suggestions<sup>50</sup> that prevention and intervention programs designed to reduce cigarette use should address the use of other tobacco products as well. **For example, children and young adults are routinely educated about the dangers of cigarette smoking but not hookah, and frequently perceive the latter as less harmful<sup>6,9</sup>. The inclusion of education regarding the dangers of hookah and other non-cigarette products in prevention programs may reduce uptake. Additionally, many legal restrictions on smoking exempt hookah<sup>18</sup>. In addition to permitting public hookah smoking, such exemptions may convey the message that hookah**

**use is safe. Expanding such restrictions to include hookah smoking may thus reduce its incidence.**

In sum, we found that past-month hookah use was associated with larger increases in cigarette smoking quantity and smaller decreases in smoking days 6 months later in a sample of college smokers. Findings suggest that use of alternative nicotine or tobacco products such as hookah heightens the risk of smoking progression. Additionally, the present study suggests that young adult smoking behavior is unstable over this relatively brief period of observation, and may therefore be responsive to intervention.



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Table 1. Demographic and tobacco use characteristics at baseline assessment.

Variable	Hookah Users	Non-Hookah Users	Total
	<i>M (SD)</i> or %	<i>M (SD)</i> or %	<i>M (SD)</i> or %
<i>n</i>	110	213	323
Age*	19.5 (1.4)	20.1 (1.6)	19.9 (1.5)
Gender	35% female	42% female	40% female
T1 HONC dependence score*	3.4 (2.7)	5.0 (3.2)	4.5 (3.20)
T1 ≥ 100 lifetime cigarettes	81% yes	86% yes	84% yes
T1 Smoking days past 30 days*	18.5 (9.7)	21.3 (9.6)	20.3 (9.7)
<b>Range, median</b>	<b>2-30, 20</b>	<b>1-30, 25</b>	<b>1-30, 24</b>
T1 Total cigarettes past 30 days*	84.8 (90.0)	119.6 (129.2)	107.8 (118.4)
<b>Range, median</b>	<b>3-426, 55</b>	<b>1-604, 85</b>	<b>1-604, 68</b>
<b>T2 Smoking days past 30 days</b>	<b>16.1 (11.9)</b>	<b>14.5 (12.3)</b>	<b>14.6 (12.2)</b>
<b>Range, median</b>	<b>0-30, 15</b>	<b>0-30, 12</b>	<b>0-30, 13</b>
<b>T2 Total cigarettes past 30 days</b>	<b>102.3 (141.6)</b>	<b>87.8 (111.4)</b>	<b>82.2 (121.8)</b>
<b>Range, median</b>	<b>0-760, 38</b>	<b>0-600, 23</b>	<b>0-760, 29</b>
<b>T1-T2 change in smoking days*</b>	<b>-2.4 (10.8)</b>	<b>-6.8 (12.0)</b>	<b>-5.4 (11.8)</b>
<b>Range, median</b>	<b>-30-27, -1.5</b>	<b>-30-28, -4</b>	<b>-30-28, -3</b>
<b>T1-T2 change in total cigarettes*</b>	<b>17.5 (135.9)</b>	<b>-31.8 (112.9)</b>	<b>-16.2 (122.6)</b>
<b>Range, median</b>	<b>-275-709, -7</b>	<b>-588-482, -17</b>	<b>-588-709, -14</b>
T1 Hookah use days past 30 days*	3.0 (3.9)	0.0 (0.0)	0.9 (2.6)
<b>Range, median</b>	<b>1-24, 2</b>	<b>n/a</b>	<b>0-24, 0</b>
T1 Drinking days past 30 days	6.4 (4.7)	6.1 (5.4)	6.2 (5.2)

	<b>Range, median</b>	<b>0-28, 5</b>	<b>0-26, 5</b>	<b>0-28, 5</b>
T1 Marijuana use days past 30 days*		9.8 (10.5)	7.1 (10.0)	8.0 (10.3)
	<b>Range, median</b>	<b>0-30, 4</b>	<b>0-30, 1</b>	<b>0-30, 2</b>
T1 Other drug use days past 30 days		0.2 (0.6)	0.3 (0.8)	0.3 (0.7)
	<b>Range, median</b>	<b>0-3, 0</b>	<b>0-6, 0</b>	<b>0-6, 0</b>

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\* $p < .05$  for hookah users (**any hookah use in the past 30 days**) vs. non-hookah users (**no hookah use in the past 30 days**). T1 = baseline, T2 = 6 months.

Table 2. Regression model of change in total past 30-day cigarettes from baseline to 6 month follow-up.

Effect	$\beta$	Std. Err.	$t$	$p$
Age	0.01	4.90	0.23	.816
Baseline total cigarettes	-0.46	0.08	-6.75	<.001
Nicotine dependence	0.03	2.76	0.41	.683
Baseline marijuana days	0.03	0.71	0.46	.646
Baseline hookah use	0.12	16.17	2.03	.043

Model:  $F(5, 234) = 14.03, p < .001; R^2 = .23$

Table 3. Regression model of change in past 30-day smoking days from baseline to 6 month follow-up.

Effect	$\beta$	Std. Err.	$t$	$p$
Age	0.05	0.47	0.86	.390
Baseline smoking days	-0.43	0.08	-6.38	<.001
Nicotine dependence	0.13	0.26	1.96	.055
Baseline marijuana days	0.08	0.07	1.29	.199
Baseline hookah use	0.13	1.58	2.07	.040

Model:  $F(5, 234) = 9.86, p < .001; R^2 = .17$

Figure 1. Total cigarettes smoked in past 30 days at baseline and 6-month follow-up by baseline hookah use.

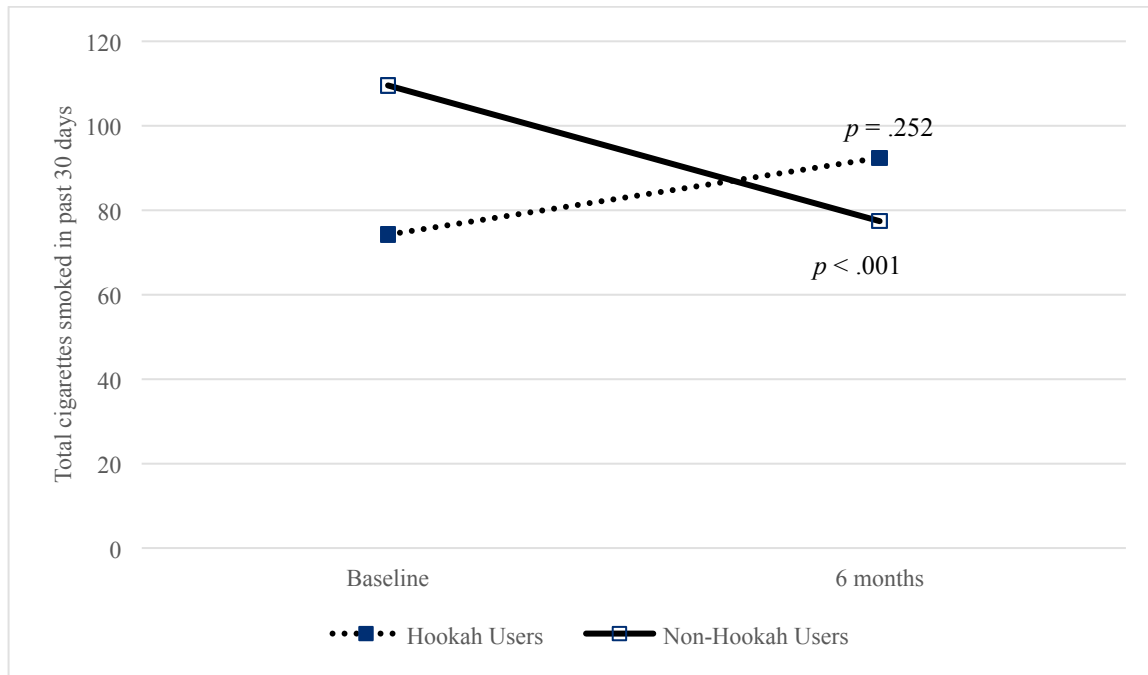


Figure 2. Number of smoking days in past 30 days at baseline and 6-month follow-up by baseline hookah use.

