Spring 2021

Nicotine and Cannabis Vaping Among College Students: Factors Associated with Initiation, Patterns of Use, and Dependency

Asa Wint
asa.wint@trincoll.edu

Nicotine and Cannabis Vaping Among College Students:

Factors Associated with Initiation, Patterns of Use, and Dependency

A thesis submitted in partial fulfillment for the Bachelor of Science Degree in Psychology

Asa Wint

Trinity College

Fall 2020 – Spring 2021

Table of Contents

Acknowledgements

I would like to thank all the individuals who helped make this thesis achievable. This project would not have been possible without the support and guidance I received every step of the way.

I would first like to thank my roommates, friends, and family who offered their support throughout the entire yearlong process. I truly appreciate their kinds words of encouragement and their belief in me.

I would also like to thank the Trinity College Psychology Department. I am very fortunate to be a part of a major that encourages students to pursue and take on research, as well as challenge students academically through their coursework. I would also like to thank Professor Senland and my peers in the Senior Thesis Colloquium for offering their insightful comments and suggestions.

Finally, I would like to express my sincere gratitude to my outstanding thesis advisor, Professor Holt, for her tireless support and assistance at every stage of this research project. I am extremely grateful to have had the opportunity to work with her, and the invaluable advice, continuous support, and patience she provided me during the process. Without Professor Holt's motivation and guidance, this would not have been possible. I am extremely grateful for the impact that Professor Holt has had on me both personally and academically.

Abstract

Vaping has become a common method to consume nicotine and cannabis on college campuses across the United States. Between 2017 and 2019 there was a significant increase in the prevalence of both nicotine (6% to 22%) and cannabis vaping (5% to 14%) among college students. As of 2019, there were over 2,000 vaping-associated lung injuries or deaths and recent data suggest nicotine vaping was associated with greater risk of contracting COVID-19. In the present study, I examined data from an online survey of seven colleges and universities across the US (*N*=2160) to determine the prevalence of nicotine vaping, cannabis vaping, and dual use (i.e., nicotine and cannabis). A second aim was to determine whether these user groups differed by demographic characteristics and other characteristics such as impulsivity, depression, anxiety, and family history of substance use. As hypothesized, males were more likely to endorse dual use and Whites were less likely to identify as nonusers. Contrary to my hypothesis, there was no difference in socioeconomic scores by user group. Dual users were higher in impulsivity, had a higher family history density, and had greater depressive and anxious symptoms than all other user groups, which was somewhat consistent with my hypothesis, although I expected single users to score higher than nonusers on these variables as well. These findings may help to inform the development of brief interventions that target dual users and take into account characteristics and vulnerabilities that are more likely in this group.

Nicotine and Cannabis Vaping Among College Students:

Factors Associated with Initiation, Patterns of Use, and Dependency

In recent decades, cigarette smoking has become unattractive and distasteful in the eyes of modern society, swaying young adults away from smoking combustible products (Civiletto & Hutchison, 2020). However, as traditional cigarette use has decreased, vaping has become far more common (Ksinan et al., 2020). ‘Vaping’ has gained immense popularity in recent years in the vocabulary of both adolescents and adults. Oxford Dictionary chose ‘vape’ as the 2014 word of the year, signifying the universal acceptance of this substance trend (Budney et al., 2015). Vaping is a relatively novel method of substance administration, referring to the process of heating liquid, oil/concentrate or plant material at a certain temperature. A high enough temperature causes the release of aerosol vapors and a psychoactive substance (e-cigarettes commonly contain nicotine, and cannabis vapes contain THC), which is then consumed by inhaling the mixture via a battery-operated electronic device (Budney et al., 2015; Giroud et al., 2015). Vaping devices differ in design, shape, and size (i.e., small pen-style to large table units) and the devices being used to vape have become increasingly innovative as the result of technological advancement. For example, devices now have the capability of LED displays, puff counts, settings for power/voltage/wattage, temperature control, etc. (Giroud et al., 2015).

In fact, there are over 450 distinctive brands of vaping devices marketed for global use, each attempting to earn a piece of the approximate $3 billion spent in 2013 within the electronic cigarette (e-cig) industry. A separate trend shows that the legal cannabis industry had similar revenue: in 2014 alone, the industry generated over 2.7 billion dollars. On the basis of these statistics, the vaping industry quickly evolved to maximize their profits, particularly within the e-cigarette and legal cannabis markets (Budney et al., 2015). Indeed, the primary consumers (ages

18-24) are now three times more likely to initiate e-cig usage than combustible cigarettes (Jones et al., 2016). E-cig products have been available on the U.S. market for well-over a decade now. Nearly all e-cigarette companies are owned in part by other major tobacco companies. These large companies view younger, wealthier e-cig users as a way to increase their lifetime consumer base and, ultimately to gain market control as these vulnerable populations may be more prone to long-term use and addiction (Civiletto & Hutchison, 2020).

Vaping has quickly become well-liked and a common way to consume nicotine and THC on college campuses across the United States. Data from the Monitoring the Future (MTF) study conducted among college students showed a significant increase in the 30-day prevalence of vaping nicotine from 6.1% in 2017 to 22% in 2019. Similarly, an increase in prevalence was found in non-college attending young adults: 7.9% in 2017 to 18% in 2019. Following the rise of the cannabis industry, vaping cannabis also showed significant growth between 2017 to 2019. Among college students, the 30-day prevalence of vaping cannabis increased significantly from 5.2% to 14%, nearly equivalent to the increase among non-college young adults (7.8% to 17%). These increases are among the highest levels for any substance since the MTF survey began forty-five years ago. Similarly, the rate of marijuana use in the last year among college aged adults has held consistent at 43%, the highest percentage over the past thirty-five years (Schulenberg et al., 2020).

Along with the substantial rise in prevalence of vaping nicotine and cannabis among young adults comes multiple concerns about the potential ramifications if ‘vaping culture’ continues to predominate. Currently, there is limited information about the health consequences of e-cigarette use; little is known about the negative effects of vaping cannabis. A vaping culture has the potential to contribute to mix and match usage (single and/or poly-product within one substance), coadministration usage (dual substance), or experimental use of new substances through vaporization. The rapid expansion of this ‘vaping culture’ could lead to initiation, increase of repeated use, or chronic use of one or both substances. In turn, these devices may potentially promote more frequent or sustained use, which may increase vulnerability to psychopathology and a greater likelihood of addiction to the substances vaped (Budney et al., 2015). A study by Dobbs et al. (2020) showed that participants who reported poly-tobacco use were more dependent on nicotine. Yet, because many e-cig users are poly-tobacco users, their nicotine dependence was not of inordinate concern.

Given the current trends of increased vaping in conjunction with the legalization of recreational cannabis use across the United States (Budney et al., 2015), it is important to enhance our understanding of the profiles of users who vape, especially those containing a cannabis byproduct. Lee et al. (2016) concluded that those who vaped cannabis in their lifetime were also more likely to report e-cigarette use: 75% vs. 49% who had not previously vaped cannabis. Thus, more investigation on the relation between vaping nicotine and cannabis is critical to understanding and ultimately preventing potential harm to the college-aged adult population using these substances (Ksinan et al., 2020). The development of this knowledge also will allow health policymakers to understand the complexities of both single substance and dual substance usage, which will aid in the creation of vaping substance-specific screening, prevention, and intervention programs (Giroud et al., 2015). In addition, further research will allow legislators to make more informed decisions regarding public accessibility (Ksinan et al., 2020).

Given that most of the research to date has focused on demographic predictors of e-cigarette use and polyproduct use, more research on specific aspects of an individual’s functioning and how they relate to e-cigarette use is needed to inform prevention and intervention efforts. Accordingly, the current study examined how impulsivity, family history of addiction, and symptoms of depression and anxiety were associated with single and poly product use. Further investigation is warranted to understand how these predictors are associated with the initiation of use, patterns of use, and dependence on these substances.

Background

New Devices Promote a Shift in Substance Trends

Nicotine and cannabis are the most frequently vaped substances (Kenne et al., 2017), but their effects vary. When an individual inhales from a vaping device, the liquid containing the highly addictive stimulant nicotine is converted to aerosol vapor (Ford et al., 2020). That vapor is readily absorbed from the lungs into the bloodstream. Simultaneously while entering the blood, nicotine will stimulate the adrenal glands to release the hormone epinephrine. Epinephrine, in turn, stimulates the central nervous system and increases blood pressure, breathing, heart rate, and the release of dopamine. As a result of this fast absorption process, nicotine can momentarily create feelings of pleasure and concentration. However, these pleasant sensations are short-lived, subsiding within minutes (NIDA, 2020).

Following similar administration into the body, THC also activates the brain’s reward system. The absorption of THC into the blood signals for a release of dopamine, but at higher levels than typical. This may produce a pleasant euphoria and a sense of relaxation for some individuals (NIDA, 2020).

Vaping devices have evolved considerably over a relatively short period of time to be more user friendly and to deliver higher concentrations of psychoactive substances. Originally, the devices consisted merely of a battery, a vaporization chamber, and a cartridge containing a psychoactive substance (Civiletto & Hutchison, 2020). However, companies quickly recognized that these initial designs delivered substances at lower levels than desired. In acknowledgement of this, vaporizer companies refocused their attention to improve upon the performance and rate of substance delivery to the user (Giroud et al., 2015). For example, companies such as Pax Labs, Inc. began to substitute nicotine salts for free-base nicotine in liquid while also developing innovative hardware. These products often have easily interchangeable cartridges/pods (Giroud et al., 2015). While they saw great success with the development of these products, Pax Labs, Inc. continued to expand. Pax Labs, Inc. vaporizer company successfully launched its subsidiary, JUUL Lab, Inc., causing a great stir in both the vaping industries and public health realms.

The JUUL has become an exceedingly popular device among younger generations and can be categorized as a “pod-mod” device. “Pod-mod” devices, like JUUL, resemble a sleek and modern USB drive. These small and tightly compacted devices can administer highly concentrated puffs. One pod of JUUL contains the same nicotine concentration of about twenty traditional cigarettes (Civiletto & Hutchison, 2020). Cannabis users and companies have applied similar device innovations to their own sector (Giroud et al., 2015). Following these new developments, numerous designs of e-cigs were modified to have the capability to vape liquid, oil/concentrate or plant material containing cannabis. Additional novel features such as temperature control mentioned earlier, notably elevated the attraction of using e-cigs or similar vaporizer devices for vaping psychoactive substances, such as THC (Giroud et al., 2015).

The similarities of the features of e-cig and cannabis vaping devices has made the methods of administration nearly indistinguishable. A special device was recently patented to make e-cigs compatible for vaping nicotine, THC, tobacco and other psychoactive substances. Despite the popularity of these new devices, much debate still remains regarding the factual or theoretical advantages and dangers of administering psychoactive substances via vaporization (Giroud et al., 2015).

Potential Upsides of Vaping

Delivery Efficiency

Similar to previously stated evidence, administration via inhalation allows for the desired substance to go directly into general circulation of the blood. This route bypasses first pass metabolism thus producing a higher toxicity. It is the frequency with which the substance gains entrance to the brain that generally regulates the positive and euphoric effects. In order to attain this optimal blood concentration of either nicotine or cannabis, the individual must be able to consume fewer than a dozen puffs within the shortest amount of viable time. The newer devices previously discussed are able to accomplish this feat, producing the desired effects for the consumers of these substances (Giroud et al., 2015). For example, devices like JUUL, are capable of achieving a blood nicotine absorption level similar to that of a traditional cigarette (Giroud et al., 2015). Further, those that vaped cannabis reported that they gained more of the desired effects even when using less cannabis, emphasizing the increased delivery efficiencies of these devices (Budney et al., 2015). Additionally, vaporizers allow for the ability to self-dose, meaning the user is able to control the concentration of the substance. Since vaping devices can deliver a substantial dose in a marginal amount of time, they may be more successful in fulfilling the psychological dependencies of the user (Ford et al., 2020; Giroud et al., 2015).

Harm Reduction

Vaping has been considered to be a viable alternative for current cigarette smokers, which was the original intent behind the creation of these devices. Vaping has been shown to reward previous cigarette smokers' behavioral needs, more specifically the oral satisfaction of inhalation that is identified in some smokers (Ford et al., 2020). Currently, however, there is minimal evidence available to defend this distinct claim. A study by Hajek et al. (2019) randomized 886 participants into two separate treatment groups: one using nicotine patches and pills and the other using e-cigs. The study revealed that the abstinence rates of e-cig users after one year of treatment were higher (18%) in comparison to the nicotine replacement group (9.9%). Importantly, these results insinuate that with proper support and a suitable environment, patients who are heavy smokers may benefit from switching to e-cigs (Civiletto & Hutchison, 2020). These findings also may hold true for heavy marijuana smokers motivated to quit. Switching to vaping may lessen cannabis use and may be a first step towards reaching abstinence. Interestingly, it has been shown that even vaping raw cannabis or THC alone can reduce exposure to toxicants and lessen the addiction to nicotine (Giroud et al., 2015).

Vapes require lower temperatures (140 °F –374 °F) in comparison to combustion temperatures (1472 °F –1652 °F) (Giroud et al., 2015). Like e-cigs, vaping cannabis produces vapors at low temperatures, yielding smaller amounts of harmful byproducts. Further, vaping reduces inhalation of smoke-related toxins and carcinogens (e.g., carbon monoxide, tar, ammonia, hydrogen cyanide, etc.) that are typically inhaled when using combustibles (Ford et al., 2020; Giroud et al., 2015). Further exploration is still required to better understand the benefits of vaping as a smoking cessation tool for specific populations (Civiletto & Hutchison, 2020).

Fewer Perceived Negative Health Effects

E-cigarettes are perceived as a safer alternative to cigarette smoking, akin to cannabis vaping as a better alternative to cannabis smoking (Jones et al., 2016). The perceptions of e-cigs among college students are largely positive, with many young adults eager for experimentation.

The inclination to experiment with e-cigs may be attributed to perception that these devices cause less harm than traditional cigarettes (Kenne et al., 2017). Furthermore, studies have found that individuals using cannabis perceive it to be less damaging to their health when it is vaporized compared to combustible smoking (Budney et al., 2015; Kenne et al., 2017). Young adults who have similar perceptions of vapes could result in increased prevalence or frequency of nicotine or cannabis use (Lee et al., 2016).

Limiting Second-Hand Exposure

Vaping still allows for the social connection to smoking to remain (Ford et al., 2020). Distinct from combustible smoking, contamination of second-hand smoke from vaping is far less likely. Traditional combustibles generate endless particles when in use, whereas vapes hardly release any sidestream smoke. Sidestream smoke is the smoke released from the end of an ignited cigarette or joint. And e-cigarettes produce no vapor when the device is turned off. Mainstream e-cigs do release aerosols and organic compounds (propylene glycol, diacetin, flavoring substances). The only time aerosol is emitted into the environment, however, is when the user exhales the vapor (Giroud et al., 2015).

An added benefit of vaping devices is having the ability to control the amount of vapor exhaled; thus, with new devices you can be as discreet or as “cloudy” as you desire. Interestingly, it only takes a brief 11 seconds for the half-life of the exhaled vapor to remain in the air compared to 20 mins for combustible smoke (Giroud et al., 2015). Therefore, the risk of secondhand exposure from vaping e-cigs and cannabis is reduced (Budney et al., 2015; Giroud et al., 2015).

Better Sensory Experiences

One of the most significant advantages of vaping is that the user and their surrounding environment does not smell of smoke and noxious odors. As shown in Budney et al. (2015), those who vaped nicotine and cannabis were able to recognize non-health advantages of vaping as well. The respondents suggested that it tasted better than smoking, was more discreet, and some even reported it provides a more euphoric effect. Vaping not only may lead to a more pleasurable experience, but also allows one to use in more places without directly impacting others.

Further, using flavored liquids may leave a pleasant aroma. There are virtually endless options to choose from (e.g., watermelon, pineapple, citrus, cotton candy, blue razz, cookies, menthol, tobacco, etc.) with new flavors being created all of the time. Respondents of a study who vaped both substances primarily described mixing flavors with nicotine; far less has been reported with cannabis. Flavored cannabis intended for vaping is not as in demand as for nicotine. However, if these substance use trends continue, we may see flavored cannabis mixtures or mixtures of both cannabis and nicotine offered to the public. In the study conducted by Lee et al. (2016), it was reported that 67% vaped flavors and nicotine together the first time they vaped, while 21% vaped a flavor alone and 11% vaped flavors and cannabis the first time they vaped a flavor. The marketing of these products directly targets youth with appealing flavors of candy, fruits, sweets and even desserts, coupled with bright and colorful exteriors. However, most of the ingredients in individual flavorings have not undergone testing for long term safety (Civiletto & Hutchison, 2020).

In summary, consistent with prior research cited by Lee et al., (2016), e-cig users reported that, compared to combustible cigarettes, vaping tastes better (39%; 38%); is healthier

(43%; 40%); is easier to conceal/hide (36%; 47%); does not smell as strong (43%; 40%); is more convenient (43%; 28%); and produces a stronger/better high (58%; 41%) (Morean et al., 2017).

Potential Downside of Vaping

Earlier Initiation

Although there are potential advantages of vaping, the term ‘double-edged sword’ often appears when evaluating the risks. Given what we have learned about other substances, increases in potency and delivery efficiency may lead to a greater potential for misuse and addiction. Multiple studies suggest that reductions in perceived risk of harm may lead to earlier initiation of use, increased frequency or quantity of use, and a decreased motivation to quit or reduce use (Budney et al., 2015). As aforementioned, vaping devices provide more efficient and intense effects, so the use of these devices will most likely influence the frequency of use and ultimately contribute to the development of problematic use or addiction. Moreover, mixing cannabis with tobacco is already a common method of consuming cannabis around the world. Accordingly, vaping devices that encourage inhaling a nicotine/cannabis mixture may lead to more frequent cannabis and nicotine administration (Budney et al., 2015). Another concern is whether vaping cannabis increases the risk for e-cig initiation and whether this leads to use of combustibles (Lee et al., 2016).

Unknown Short- & Long-Term Effects

Although traditional cigarettes are known to cause marked cardiovascular and respiratory harm, more research is needed to reveal the short-term and long-term consequences of vaping devices and e-liquids. Although deemed a healthier alternative, there are still many harmful components in the aerosols and liquid of e-cigarettes. The most common aerosols include: glycerol, propylene glycol, and the psychoactive substance. Other components include: acrolein, formaldehyde, acetone, acetaldehyde. Lastly, heavy metals involving chromium, nickel, and lead have emerged in smaller portions within the vapor. These metals have established carcinogenic effects and are related to inflammation and respiratory damage (Civiletto & Hutchison, 2020). Therefore, it is important for the public and consumers to acknowledge that although these devices reduce the carcinogens and toxins inhaled from traditional combustibles, vaping still has damaging effects to your body and brain, with many still left unknown (Civiletto & Hutchison, 2020).

There is much evidence suggesting e-cigarettes are linked to the development of chronic respiratory symptoms. Further evidence shows that inhaling nicotine liquids leads to higher rates of respiratory infections. In our current times, it is important to acknowledge this study by Gaiha, Cheng, and Halpern-Felsher (2020). They found that both past 30-day use, and ever-use of e-cigarettes and dual (combustible cigarettes) use were associated with a positive COVID-19 test diagnosis. This may be true due the lung damage caused by e-cigarettes, COVID-19 disease transmission (repeated touching of one's hands with the mouth and face), and lastly that sharing devices is a regular practice among youth e-cig users. Previously, in 2019, outbreaks of vaping associated lung injuries began to surface and reported a steady increase of cases throughout the U.S. The notable signs of this type of injury included pulmonary infiltrate, and vaping use within the past 90 days (Civiletto & Hutchison, 2020). Although the identifying cause of lung injury still remains undetermined, Blount et al. (2020) found evidence that Vitamin E acetate was in the supply of THC-containing products and used among patients in the 2019 outbreak of lung injuries.

Physiologically, studies indicate that vaping nicotine can cause a short-term increase in vital signs (e.g., blood pressure and heart rate). Other short-term side effects include gastrointestinal distress, palpitations, and headache. However, if consumed in large enough amounts, nicotine can cause seizures, respiratory depression, and severe bradycardia (Civiletto & Hutchison, 2020). Furthermore, exposure to nicotine impairs the development of the brain and may even lead to a long-lasting impairment of neurochemical and behavioral functioning. This is especially important for adolescents and young adults, as the human brain does not finish developing until around the mid-twenties (Civiletto & Hutchison, 2020).

Similarly, with exposure to cannabis, studies have indicated that early initiation followed by chronic use can be linked to a lower volume of brain's grey matter, cognitive decline, and performance impairments. These abnormalities become more well-defined when the user begins use prior to 18 years of age (Giroud et al., 2015). Overall, far more research is needed on the unknown effects, but there is still enough support regarding the negative health consequences for people who vape, especially adolescents (Civiletto & Hutchison, 2020).

Observational Learning May Lead to Use

Although it was previously concluded that the risks posed by second-hand vapor are modest, other research has shown that e-cigs are indeed a source of "third-hand exposure" to nicotine. It is not the inhalation of secondhand vapor, but rather that children learn by modeling others, especially their peers and adults. Therefore, it is reasonable to assume that recurrent passive exposure to e-cigs could considerably increase a young child's desire and urge to vape nicotine (Giroud et al., 2015). Also, it is important to note that doses that may be tolerable to adults could be fatal if consumed by a young child (Civiletto & Hutchison, 2020).

Stealth Vaping Appeal to Young Adults

Most certainly, 'advantageous' aspects of vaping devices make them easier to market strategies, and may further drive use. Advertisements and promotions already fill our communities, and many are aimed towards the younger generations (Budney et al., 2015). Vaping's better taste, safer perception, and less inhalation of harsh smoke filled with toxicants, may prompt earlier age of onset and provide a more positive first experience with nicotine or cannabis. Both nicotine and cannabis are associated with the escalation and development of substance use problems (Budney et al., 2015). Indisputably, vaping is less obvious than traditional smoking, and the relative lack of smell coupled the small technological sound devices, allow for the discreet transport of pods and devices. These features facilitate concealed use from authority figures. This concealability allows use without being detected, commonly called "stealth vaping". In recent years, this has become a prominent issue in secondary schools, colleges, and universities that struggle to discourage students from vaping in many spaces (e.g., bathrooms, hallways, locker rooms, classrooms etc.) and also hiding use from parents and teachers (Budney et al., 2015; Giroud et al., 2015; Jones et. al, 2016).

Theories and Models to Explain Vaping and Poly-Product Use

Gateway Theory

The pattern in which a user begins to use substances is known as an initiation sequence. The gateway theory was created to understand the progression of these sequences. It is comprised of three essential components: (1) the progressive sequence of substance use, (2) the increased risk, or subsequent use of other products or substances compared to non-users, and (3) the dose-response relationship between the frequency or intensity of the substance used and related future risks (Etter, 2017). This theory emphasizes the social aspect of substance use, meaning that the pattern in which emerging adults' substance use progresses will depend heavily on their environment. The environment is particularly important in controlling when exposure to substances occurs, availability of the substance(s), and use of the substance in one's peer network(s), regardless of whatever substance is used first (Ford et al., 2020; Mayet & Lavagna, 2018; Mayet et al., 2016).

Applying this theory to the substances under investigation in the current study, it infers that experimentation with a substance (e.g., nicotine) may increase the risk of subsequent use of another substance (e.g., cannabis). According to this theory, cannabis use typically follows licit drug use such as tobacco, whereas other “harder” illicit drugs follow cannabis use (Mayet et al., 2016). In support of this claim, a study conducted by Mayet and Lavagna (2018) found that the tobacco to cannabis sequence was five times more frequent than the reverse sequence. This “string of opportunities” likely occurs since licit substances have legal status and are more easily accessible to young consumers in our societies (Mayet et al., 2016, p. 114).

For example, if college students already frequently consume nicotine on weekend evenings, it is realistic to presume that a college setting coupled with peer influence may lead to an expansion of opportunities for the student to progress their sequence further to engage in cannabis use. Following the traditional gateway pattern, if college student engages in cannabis use overtime their usage may increase and the student may no longer use only in the environment where initiation originated. That is, the student may begin to consume cannabis alone, more frequently, and in higher quantities. Congruent with findings previously mentioned, consuming in higher frequencies may lead to the development of a physiological dependency to either nicotine or cannabis. In addition, this theory would predict that an emerging adult might find themselves in unsafe environments to obtain cannabis, allowing for a greater exposure of “harder” or illicit substances (Mayet et al., 2016).

Nicotine and cannabis act as gateway drugs on the brain. This effect is likely to occur whether the exposure is from traditional tobacco/cannabis smoking, passive smoking, or e-cigarettes/cannabis vaporizers. This is crucial knowledge, as evidence shows that young adults have a high susceptibility to the psychoactive and addictive effects of nicotine (Chapman et al., 2019). The psychoactive effects of cannabis also increase the propensity to use other drugs, essentially priming the brain for further substance use, which helps to explain the sequential relationship of substance use (Etter, 2017).

Recently, the Gateway Theory has been applied to understand e-cigarette and other vaporizer use. An alleged and growing trepidation is that vaping may cause an increase in the use of combustible products in young adults, who previously identified as nonsmokers. This suspected pattern may breach previously well-established patterns of use, providing a new gateway to traditional tobacco or cannabis combustibles. When applied to vaporizers, gateway theory suggests that the use of less harmful forms of substance administration (e.g., e-cigs or cannabis vaporizers) may lead to the use of more harmful modes of delivery (e.g., combustible cigarettes or cannabis smoking). This is a concern particularly for adolescents and emerging adults entering the period of smoking initiation, rather than older and previous smokers who are using vaporizers for cessation and as a harm reduction tool (Chapman et al., 2019; Etter, 2017; Ford et al., 2020).

There is support for the idea that vaping could be a “gateway” to combustible methods. This claim states that e-cigs and cannabis vaporizers are the first choice on substance initiation that may enable a descent into other products and substances. After all, e-cigs and cannabis vaporizers are readily available, have a perceived low risk, and are appealing to young adults. The eventual transition is reasonable to assume since both forms of substances are often sold together (i.e., e-cigs and cigarettes; cannabis vape cartridges and cannabis). Further, young adult will be exposed more often to other forms of products when seeking out the initial vaporizer (Chapman et al., 2019).

Another explanation as to why vaporizer use may lead to combustible use is that vaping leads to an addiction to either nicotine or cannabis that vaping alone can no longer satisfy. This implies that some users shift from vaping to smoking in order to satisfy the physiological dependencies of the addicted user. The logical solution would be to utilize the latest models of vaporizers that deliver substantial amounts of the desired substance in minimal time, instead of switching to smoking combustible products (Etter, 2017). Although most individuals who smoke combustibles did not begin with e-cigs, a primary concern that remains is that individuals who use e-cigs have a higher risk of using combustibles than those who do not use e-cigs. These concerns are exemplified in a study by Soneji et al. (2017) that found evidence that e-cigarette use is associated with an increased probability of subsequent cigarette smoking or current smoking.

On the contrary, recent data from the US show that one third of young adults who initiate substance use via e-cigarettes have risk profiles that make them unlikely to start with cigarettes (Chapman et al., 2019). Therefore, it is more compelling to identify those that vape and are already dependent upon nicotine or cannabis based on society's perception of vaping to be less harmful and more socially accepted method to administer their desired substance. This proposed explanation supports the observation that the pattern of first smoking then vaping is more common, further helping to discredit the more recent adaptation of the Gateway Theory (Etter, 2017).

The Gateway Theory's two competing interpretations swing in opposite directions: First, the traditional gateway begins a sequence with one substance such as e-cigarettes, where each new substance used (e.g., combustible cigarettes and/or cannabis) is more harmful than the last. Secondly, a separate explanation stemming from the new vaping industry may be heading to a new direction of harm reduction for previous smokers while concurrently introducing other products that younger consumers view as being comparable to e-cigarettes (Ford et al., 2020).

Route of Administration (RAM)

Inhalation is the most common route of administration for consuming nicotine and cannabis. For the cigarette industry, altering the traditional method but keeping the same route may have been a necessary strategy to appeal to young adults (as most major companies now sell e-cigs). Regular smokers typically began with a single puff as a young adult and progress to more regular or daily use (Chapman et al., 2019). After all, vaping replicates the gestures and feelings of cigarette inhalation; therefore, it is possible that RAM contributes to either gateway sequence between vaporizers and traditional combustibles (Mayet & Lavagna, 2018). As previously described, the new devices used to administer both substances are extremely similar. In concordance with the traditional gateway theory, when an individual begins using one inhaled substance (e.g., e-cigs containing nicotine), it may be a motivation to try other substances (e.g., vaporizers containing cannabis). This may be true if inhalation is the preferred route and/or can be used with a similar device (Ksinan et al., 2020).

The RAM theory was proposed to better understand use in the reverse sequence (i.e., cannabis to nicotine). The shared route of inhalation may account for the later initiation of other types of substance use, explaining why nicotine and cannabis use commonly co-exist (Mayet et al., 2016). Likewise, if the gateway theory previously mentioned holds true (i.e., tobacco initiation increases the likelihood of subsequent cannabis use), we would also expect to observe a reverse cannabis gateway effect; that is, initiating tobacco use after cannabis use would be more likely than the likelihood of initiating tobacco use with no prior cannabis experience. Therefore, vaping nicotine and cannabis are consistent with the RAM since they share the same route of administration. Indeed, previous research indicates that users already consume mixtures of tobacco and cannabis (Mayet et al., 2016).

Familial Transmission

Numerous studies have shown that substance use and misuse results, in part, from one's family history of substance use. Familial aggregation of substance use and misuse can be traced to both genetic and environmental factors. Shared genetic factors between members may influence susceptibility to the substance alone (e.g., metabolism, sensitivity, tolerance, cognitive/psychological effects, alteration of emotional, or cognitive states, such as depression or anxiety). The second dimension of environment can be observed in both specific (e.g., increasing environmental exposure or enabling access to substances) and nonspecific ways (e.g., impaired parenting, chronic stress, negative life events, and physical, sexual, or emotional abuse) (Merikangas et al., 1998).

A study by Merikangas et al. (1998) had 231 probands with dependence to various substances (e.g., nicotine, cannabis, alcohol, etc.) and 1267 adult first-degree relatives participating. The researchers interestingly found that rates of nicotine dependence were elevated among relatives of all the substance use disorder proband groups when compared to those of controls. In fact, an estimated two thirds of the relatives reported a history of nicotine dependence. Another important finding was that rates of dependence on “harder” and illicit drugs were moderately elevated among relatives of probands with cannabis use disorder (Merikangas et al., 1998).

In contrast to the Gateway Theory, within familial transmission, the Common Liability Model (CLM) proposes that using both licit and illicit drugs could indicate a common liability, particularly among individuals with substance use disorders. This liability could include genetic and individual vulnerabilities, such as proneness to deviance from norms and familial liability to addiction (Mayet et al., 2016). The CLM also is in line with the findings that people who use substances gravitate towards poly-substance use, an example of how individual liability can intersect with environmental influences. Individuals with specific characteristics may be more likely to wind up in environments that enable easier access to drugs (e.g., peers that use substances, behaviors increasing substance use opportunities, etc.) (Mayet et al., 2016). It is important to continue to identify ways in which families impact substance use (Merkingas et al., 1998), especially for substances like e-cigarettes, whose onset may be influenced by family history, but for which we have limited understanding.

Onset (Chicken or the Egg?)

Across the globe, consuming a nicotine/cannabis mixture is already a previously established substance trend. Interestingly, dual users of nicotine and cannabis have noted that these two substances can have interactive effects. For example, inhaling a nicotine/tobacco mixture may theoretically strengthen and prolong the euphoric effects of cannabis (Ksinan et al., 2020). Yet, findings from Lee et al. (2016) show that only 5% of respondents reported ever mixing nicotine and cannabis in a vaporizer. Given the patterns of co-use, this finding may be rather unanticipated. However, a more directly related concern of vaping is determining the sequence of product or substance initiation, and whether that product led to the initiation of subsequent poly-product or substance use.

Thus far, there has been an abundance of research reporting that prior e-cigarette and cannabis use are both linked with vaping cannabis (Cassidy et al., 2018; Lee et al., 2016; Morean et al., 2015). Consistent with this finding, Ksinan et al. (2020) further showed that young adults who use tobacco products, including e-cigs, are far more likely to use cannabis when compared to their non-tobacco counterparts. Given this evidence, it may be speculated that individuals began with one substance (e-cigarettes or cannabis) and later transitioned to the other substance in order to experience the interactive effects mentioned above. An additional justification may be merely that young adults have an increased propensity to experiment with substances, different than simply progressing through the initiation sequence (Ksinan et al., 2020).

Yet, the presumption of transitioning substances is supported by evidence from Lee et al. (2016). As aforementioned, Lee and colleagues showed that those who ever vaped cannabis were more likely to report e-cig use (75% vs. 49%). Further, the mean age of initial e-cig use was younger for those who had vaped cannabis (23.9 vs. 32.5). These data show that those who had vaped cannabis in their lifetime were younger, and initiated cannabis use at a younger age than their non-vaping counterparts. Similar findings were reported in a study by Morean et al. (2017). Morean et al. (2017) found that those who initiated e-cigarette use at an earlier age showed greater use of vaporizer devices to vape cannabis. Again, other evidence indicated that 90% of a sample of adult cannabis vapers also used nicotine e-cigarettes (Morean et al., 2017).

Cassidy et al. (2018) found that lifetime e-cigarette use was a strong predictor of cannabis vaping initiation. They also reported that lifetime cannabis use was a robust predictor of cannabis vaping initiation at the beginning of college. These data show that students who have prior experience with e-cigarettes and other cannabis products are more likely to participate in the novel trend of cannabis vaping (Cassidy et al., 2018). These results also align with findings from

Morean et al.'s (2015) high school sample. Separately, Cassidy et al. (2018) found that using cannabis was a predictor of initiation of e-cigarette use. Finally, it was reported that cannabis vapers increased their frequency of cannabis use as time progressed, suggesting that vaping is not an effective harm reduction or replacement method, and in turn may increase the overall dependence in young adults (Cassidy et al., 2018). These findings from Cassidy et al. (2018) may be applicable to the Gateway theory by suggesting that using cannabis will increase the risk of subsequent use, more specifically the initiation of e-cigarettes.

These findings were replicated by Ksinan et al. (2020), who found that e-cigarette use predicted more cannabis use at later time points. Cannabis use also predicted greater e-cig use in the future. This study provided support for a bi-directional relationship between cannabis use and e-cigarette use over time in young adults. That is, cannabis use increased future e-cigarette use and e-cigarette use increased future cannabis use (Ksinan et al., 2020). Despite all of these findings indicating that prior e-cigarette and cannabis use are indeed a risk factor for either vaping nicotine or cannabis, more research is needed to understand the sequence of substance use, in addition to other risk factors for vaping (Morean et al., 2017).

Intrapersonal Predictors of Vaping

Demographic characteristics

Researchers have found associations between vaping and demographic characteristics such as gender, socioeconomic status, and race/ethnicity. Regarding gender, Jones et al. (2016) provided evidence that younger individuals (high school to college aged students), specifically males, tend to vape more often. Similarly, Lee found that males were more likely to report vaping compared to females: 63% vs. 50% (Lee et al., 2016). Researchers have speculated that this difference is due to males' greater propensity for risky behavior and willingness to experiment (Morean et al., 2017). The finding that males were also more likely to use poly-substances (e.g., nicotine and THC) is consistent with these explanations as well (Morean et al, 2015).

Regarding financial resources, a recent study showed that an individual's likelihood of dual or poly-substance use dramatically rose in relation to their weekly spending money. That is, for each dollar amount spent, the likelihood of poly-substance use rose. This finding suggests that access to, and higher amounts of spending money is associated with substance use (Zuckermann et al., 2020). Similar results were found in multiple other studies, showing that individuals from higher socioeconomic families and more years of education vape more often (Jones et al., 2016; Morean et al., 2017). These findings may be attributed to the ability to purchase the costly substances, vaping devices, and accessories (Jones et al., 2016). Of note, not all research has shown a positive relation between socioeconomic status and vaping. Lee et al. (2016) reported no differences in income or educational achievement detected between an adult sample (over 18 years of age), when comparing those that had vaped in their lifetime to those reported never vaping.

Lastly, Lee et al. (2016) found that African Americans were less likely to approve of vaping in comparison to other racial or ethnic groups, a likely explanation for why this and numerous other studies found that those who vape are predominately White. These findings may also hold true since the respective samples were predominantly White (59% and 93.5%) (Jones et al., 2016; Kenne et al., 2017).

Impulsivity

Thus far, there is substantial evidence that impulsivity is positively associated with e-cigarette use. Important to note, the onset mentioned above may be one factor that accounts for this association (Bold et al., 2017). Bold et al. (2017) showed that younger e-cigarette users who had both greater impaired self-regulation and impulsivity had an increased likelihood of trying e-cigarettes at an earlier age. Earlier initiation was found to be connected to greater frequency of use in the past month. High school aged adolescents were at greater risk for recurring e-cig use since they initiated use at an earlier age when compared to their less impulsive peers. This finding signifies that impulsivity is an important risk factor for early e-cig use. Importantly, the novelty of e-cig use may be especially appealing to highly impulsive high school students who tend to act without regard for possible negative consequences. However, it is probable that early e-cig use is primarily driven by a pre-existing vulnerability of poor self-regulation of impulsivity. Still, it is possible that this relationship is bidirectional, meaning e-cig use influences impulse control and the rewards that adolescents experience from initial uses of e-cigs motivate continued use (Bold et al., 2017).

The relation between impulsivity and e-cig use was replicated with college students. In a study by Grant et al. (2019), students who reported e-cigarette use also had significantly higher impulsivity scores. Although these findings are consistent with prior research, it remains unknown whether e-cigarettes lead to subsequent substance use, or if e-cigs share a common liability with other behaviors such as cannabis vaping (Grant et al., 2019).

Moreover, it may be the case that constructs like impulsivity or sensation-seeking are more likely to predict use of a more novel substance but become less predictive of use as the substance becomes more commonplace. Spillane et al. (2010) found that smokers had significantly higher scores of impulsivity-like traits. In fact, sensation seeking, a component of impulsivity, was shown to accurately predict smoker status. However, Spillane and colleagues emphasized that experimenting with a novel trend differs from becoming dependent. They noted that over time, a substance trend may lose its uniqueness, and in turn the high sensation seeking individual may need to switch to another new substance to satisfy their need for stimulation (Spillane et al., 2010).

Ksinan et al. (2020) replicated the sensation seeking and e-cigarette association and also found that sensation seeking was associated with a greater likelihood of all cannabis use in a college sample. These results were consistent with Morean et al. (2017), who showed that higher impulsivity was associated with more frequent vaping of cannabis using an e-cigarette or vape-pen. Bidwell et al. (2013) similarly found that that with 151 participants, aged 18-30, who endorse greater impulsivity are typically more likely to try or be willing to try cannabis. However, there is much that remains unknown, more specifically how greater impulsivity differentiates mono and dual users who vape.

Family History of Addiction

The information provided by familial aggregation studies has been advantageous in better understanding the heritability of psychological disorders. Indeed, this research has provided insights into which families produce greater genetic or familial environmental risk. For example, Niu et al. (2000) looked at current smokers and their nuclear families. The results of this study indicated that both the initiation and maintenance of smoking were influenced by heredity. According to Niu and collaborators, heritability estimates were 47-76% for smoking initiation, and 62% for continued smoking. Interestingly, smoking was found to be as heritable as alcohol consumption. Yet, this study had a few limitations. First, the study only focused on male-male current smoker sibling pairs in a sample of a Chinese population. So, these results may not be applicable to other ethnic groups with different characteristics. Also, the familial aggregation findings by this study may have emerged from both shared genetics and a shared family living space. Living environments may have a serious impact on nicotine dependence for both siblings (e.g., parental smoking or negative life events). Nonetheless, the results provide compelling evidence that nicotine dependence has a substantial familial component (Niu et al., 2000).

Comparable findings have emerged for familial transmission of cannabis use. Kosty et al. (2015) investigated the parental transmission risk of cannabis use disorder (CUD) among probands. This study utilized data from the Oregon Adolescent Depression Project (OADP). Prior work with the OADP indicated that 19% of probands developed a CUD by age 30. The results show that there is a greater risk of CUD among children with parental histories of CUD, and hard substance use disorders. These findings are consistent with previous studies showing that adolescent cannabis users had greater family vulnerability to externalizing disorders than non-cannabis users. Further, these findings align with the common liability to addiction theory mentioned earlier; specifically, that individuals have a pre-existing liability operating within themselves or their families that increases risk for substance use and dependence (Kosty et al., 2015).

Another study exploring the transmission from parent to offspring was conducted by Sonon et al. (2015). However, this study explored the effects of prenatal marijuana exposure (PME) on different outcome for offspring. The mothers were initially interviewed at an average age of 23 years old, and the offspring were interviewed at 22 years old. The results show that over 80% of the offspring had initiated cigarette and marijuana use. The study showed that 43% of offspring reported smoking cigarettes in the past year, 50% used marijuana in the past year, and 47% reported a first degree relative had substance use problems. Further results show that PME was a significant predictor of offspring marijuana use as a young adult. Contrary to some studies, family history of substance use problems was not found to be a significant predictor of cannabis use. A possible explanation may be that cannabis use is a common behavior and the genetic factors vastly differ in individuals when progressing from use to misuse. The past studies that have found significant family association were mainly conducted on individuals with cannabis use disorders, like the study done by Kosty et al. (2015).

Depression

Depression is another common predictor of vulnerability to substance use. To date, however, there has been limited research conducted on the relation between depression and vaping. A study conducted by Wiernik et al. (2019) examined the link between depressive symptoms and e-cig use in a large population-based sample and found that current e-cig use was positively associated with depressive symptoms. They also showed that among smokers, depressive symptoms were linked to the dual consumption of tobacco and e-cigarettes, and negatively associated with quitting tobacco without e-cigarette use.

A study by Saeed et al. (2020) yielded similar findings. Their results showed that there was a positive association between e-cigarette use and self-reported depression. However, this association was only found significant for certain subgroups, including those who were never married, widowed/divorced or separated, unemployed, and for cannabis users. It may be that external stressors (e.g., unemployment or divorce) have more of an impact when coupled with the use of nicotine. Specifically, the dysregulating effects of nicotine on mood may impair previously effective coping strategies used to battle depression. Another potential reason is that excessive nicotine exposure can lead to the release of abnormally high levels of dopamine, further dysregulating the neural circuits involved in emotional regulation, and increasing sensitivity to stress. This is particularly concerning in young adults, as their brains are still in development (Saeed et al., 2020).

Saeed et al. (2020) also noted that cannabis use can impair neural transmission, and this effect may be intensified by the presence of nicotine. Since the study found a significant association between e-cig use and depression among individuals who reported cannabis use, one explanation may be that heavy cannabis use can impair serotonin transmission, which has been shown to result in depressive symptoms. This explanation assumes that heavy cannabis use may lead to further impaired decision-making and ultimately depression (Saeed et al., 2020).

Another promising study was conducted by Beck et al. (2009), yet this study differed from those above as they looked at the social context of cannabis use and depressive symptoms. They found partial evidence for depressed students being more likely to use cannabis in a context of sex seeking and peer acceptance. However, using cannabis in the context of emotional pain was most consistently related to both CUD and depression. This may be true since depressed cannabis users may rely heavily on cannabis to alleviate their depression. Although this study did not find significant differences in depression between cannabis users who did and did not meet the criteria for CUD, the authors cannot rule out the possibility that some symptoms of depression may be attributable to the effects of cannabis use, as noted previously by Saeed et al. (2020).

Anxiety

There has been far less research exploring the possible connection between anxiety and vaping. One study by Grant et al. (2019) found that the use of e-cigarettes was significantly associated with symptoms of anxiety and PTSD. Further, those with PTSD were noted to have a much lower cigarette cessation rate than many other mental health disorders. This may be true since it is thought to reflect the vulnerability to anxiety and distress tolerance. Aside from PTSD, anxiety appears to be a risk factor for the maintenance and relapse of traditional smoking. This may stem from the higher intensity of cravings experienced during times of anxiety. This suggests that anxiety may contribute to e-cigarette use in some individuals, and this risk appears to be more distinctive in younger populations (Grant et al., 2019).

Another study conducted by Frohe et al. (2018) investigated the association between vaping and anxiety. However, this study focused on social anxiety, and surprisingly found that there was a negative association between social anxiety and cannabis vaping. This finding was in contrast to Frohe et al. (2018), who reported that social anxiety may increase the desire to use cannabis while in stressful situations. These conflicting findings underscore the need for further research on the association between anxiety and nicotine and cannabis vaping.

Hypotheses and Research Questions

The current study will address major gaps in vaping literature. This study will attempt to replicate demographic characteristics that were associated with vaping in past studies. Additionally, it will address the intrapersonal variables mentioned in prior literature above, in hope to see how these characteristics may be associated with a greater likelihood of nicotine and cannabis vaping.

1. Participants who report any vaping, whether single or dual use, are expected to show similar or substantial characteristics
2. Participants who score higher in impulsivity will distinguish users from nonusers
3. Participants who report higher rates of family history of addiction will be more pronounced from people who use a single substance or dual substances to vape
4. Participants who score higher in depression and anxiety will have higher scores among any user group

RQ: What are the distinctions between the age of initiation of e-cigarettes and the age of combustible initiation?

Method

Participants

A total of 2160 students participated in an online survey. For two of the study measures, the Barratt Impulsiveness Scale (BIS-11) and Family History of Addiction Scale, approximately half of the overall sample completed these measures since participants were randomized to one of two survey batteries, only one of which contained these two measures. Participants were recruited from 7 different colleges and universities across the United States located in the following regions: 33.1% (n = 716) Northeast and Mid-Atlantic, 25.6% (n = 552) Southeast, 24.4% (n = 528) Midwest, and 16.9% (n = 364) Southwest. The average age of participants was 19.25 years (SD = 1.34), with 26.8% (n = 579) identifying as male and 73.2% (n = 1,581) as female. Race/ethnicity was self-reported as the following: 75% (n = 1619) White, 8.8% (n = 190) Black or African American, 6.7% (n = 144) Asian or Asian American, 4.7% (n = 101) Mixed Race, and 4.9% (n = 106) Other. For further information on participants' demographics, see Table 1.

Measures

History of combustible cigarette and ENDS use. Participants were asked to report (Yes/No) on the question: "In your lifetime, have you smoked a cigarette, cigar, or cigarillo (even just a few puffs)?" If participants responded "Yes", they were prompted with several follow-up questions: "How old were you the first time you used a tobacco product, even one or two puffs?" (under 10, 11, 12, etc.) and "In the past 30 days, how often did you use a cigarette, cigar, or cigarillo?" (*every day, some days, not at all*).

Participants were asked to report (Yes/No) on the question: “In your lifetime, have you ever used an Electronic Nicotine Delivery System (ENDS) product, even just a few puffs, as intended (i.e., with nicotine cartridges and/or e-liquid/e-juice)?” If participants responded “Yes”, they were prompted with several follow-up questions: “How old were you the first time you used an ENDS product, even one or two puffs?” (under 10, 11, 12, etc.) and “During the past 30 days, have you used any ENDS product (i.e., an e-cigarette, vape pen, pod device, e-hookah), even one or two puffs, as intended (i.e., with nicotine cartridges and/or e-liquid/e-juice)?” Participants who answered affirmatively also indicated the frequency with which they used one or more specific devices (0-4, 5-9, 10-14, 15-19, 20-29, or 30 or more times per day) including disposable e-cigarettes, vape pens, pod devices, and advanced personal vaporizers (Morean et al., 2017).

E-cigarette dependence. We assessed e-cigarette dependence by averaging the four items on the E-Cigarette Dependence Scale (Hefner et al., 2019; Morean et al., 2018). The measure uses a five-point response scale (1=*never*, 5=*almost always*) and its reliability was excellent (α=.93). A sample item from the scale is: “I vape more before going into a situation where vaping is not allowed.”

History of cannabis vaping. Participants’ history of cannabis vaping was assessed through the question, “Which of the following substances have you vaped in your lifetime?” Participants were given a list of twelve different substances as response options, and directed to check all that applied. Response options included cannabis, MDMA, cocaine powder, crack cocaine, etc. (Blundell et al., 2018).

Impulsivity. To assess participants’ levels of impulsivity, we administered the 30-item Barratt Impulsiveness Scale (BIS-11) (Patton et al., 1995). Participants (n = 1079) selected their level of agreement with 30 statements regarding ways in which they act and think. Students were instructed to respond to each statement using a 4-point Likert scale (1 = *Rarely/Never*, 2 = *Occasionally*, 3 = *Often*, 4 = *Almost Always*). This assessment included statements such as: “I do things without thinking”, “I make up my mind quickly”, and “I act ‘on impulse’”. We calculated a mean impulsivity score from all 30 items. Specific items were reverse scored when a higher score implied less impulsiveness such as: “I plan tasks carefully”, and “I am self-controlled”. Reliability of the scale was good: α=.84.

Family history of addiction. To determine the biological and environmental impact of a familial history of addiction, approximately half (*n* = 1039) of participants received the family history measure. Participants were asked to “Select all family members that have had alcohol or drug addiction.” The response options varied from their nuclear families (mother, father, siblings) to extended family (grandparents, aunts/uncles, cousins). Consistent with scoring recommendations provided by Stoltenberg et al. (1998), the first six items from the survey inquiring about parents and maternal and paternal grandparents were utilized to score this measure and were weighted accordingly: .5 for each parent, .25 for each grandparent. We summed the values to create an overall family history density score, which could range from 0-2.

Negative affect. To examine the severity of depression and anxiety, participants completed the Depression, Anxiety, and Stress Scale (DASS-21) (Lovibond & Lovibond, 1995). This 21-item measure asked participants to read each statement and select a number (0 = *Did not apply to me at all*, 1 = *Applied to me to some degree*, 2 = *Applied to me to a considerable degree, or a good part of time*, 3 = *Applied to me very much or most of the time*) that indicated how much the statement applied to them over the past week. To assess depression specifically, participants responded to seven statements such as: “I was unable to become enthusiastic about anything", "I felt I wasn't worth much as a person", and "I felt that life was meaningless." The internal consistent reliability of the depression subscale was excellent (α=.91).

To evaluate the severity of anxiety, we utilized 7 of the 21 items from the DASS-21 (Lovibond & Lovibond, 1995). Statements related to anxiety included: "I found it hard to wind down", "I was aware of dryness of my mouth", and "I experienced trembling (e.g., in the hands)." The internal consistent reliability of the anxiety subscale was good (α=.81). To ensure equivalence with the original DASS 42-item scale, the responses to the depression and anxiety subscales were multiplied by two, and then summed for a total subscale score. We did not analyze the third subscale focused on stress.

Design and Procedure

Participants were recruited for the College Health and Substance Use Experience (CHASE) survey through classroom presentations, social media and through SONA systems at some institutions. To be eligible, survey participants must have been enrolled undergraduates and between the ages of 18-24. The CHASE survey was administered via Qualtrics and was designed to take between 60 and 90 minutes. Participants provided informed consent prior to beginning the survey. Individuals who completed the survey were granted course or extra credit or were entered into a drawing for a gift card to an online merchant. Those who wished to receive credit were provided a separate link though an additional survey that had no link to their previous responses to maintain anonymity.

Results

Based on the participants' responses to questions pertaining to lifetime use of e-cigarettes and vaping cannabis, I created four different groups. Participants who reported no lifetime use of e-cigarettes or cannabis vaping were identified as *nonusers* (n = 841, 39%), which was the largest group; participants who reported a lifetime history of e-cigarette use only were classified in the *e-cigarette only* (*n* = 562, 26%) group; those reporting both e-cigarette and cannabis vaping in their lifetime were in the *e-cigarette and cannabis vape* (*n* = 645, 30%) group; finally, a small subset of participants reported vaping cannabis, but not nicotine, and thus were in the *cannabis vape only* (*n* = 112, 5%) group (see Table 1).

An examination of the intercorrelations among the study variables revealed several significant associations (see Table 2). Regarding impulsivity, two variables that were significantly and positively correlated were impulsivity and the age of initiation of e-cigarettes, $r(414) = .14$, $p < .004$, and combustible tobacco, $r(590) = .13$, $p < .001$. Further, impulsivity was significantly and positively correlated with both depression $r(1078) = .34$, $p < .000$ and anxiety $r(1078) = .29$, $p < .000$.

Family history density was positively correlated with several variables, including depression $r(1037) = .07$, $p < .026$; anxiety $r(1038) = .16$, $p < .000$; and e-cigarette frequency $r(1038) = .07$, $p < .025$. Family history density was negatively correlated with age of initiation of combustible tobacco $r(404) = -.16$, $p < .002$, but showed no correlation with age of initiation for e-cigarettes $r(587) = .03$, $p < .448$. Age of initiation for e-cigarettes was not significantly correlated with depression $r(1199) = -.02$, $p = .418$ or anxiety, $r(1200) = -.02$, $p = .415$. However, age of initiation for combustibles showed a significant, inverse correlation with both depression $r(836) = -.14$, $p < .000$, and anxiety $r(837) = -.15$, $p < .000$.

Demographic Characteristics of User Groups

I hypothesized that participants who reported e-cigarette use and/or cannabis vaping would be more likely to be male, White, and/or of higher socioeconomic status. The chi-square test for gender was significant ($\chi^2 = 9.263$, $df = 3$, $p = .026$), such that males were overrepresented in the *e-cig and cannabis vape* group, providing partial support for my hypothesis (Table 1).

As can be seen by the frequencies in Table 1, a chi-square analysis also showed differences in group membership by race ($\chi^2 = 82.911$, $df = 12$, $p = .000$). White participants were represented less often than expected in the *nonuser* group and *cannabis vape only*, but significantly more often within the *e-cig only* user group. Black/African American participants were overrepresented in the *non-user* and *cannabis vape only* groups, and underrepresented in the *e-cig only* user group. Further, there were significantly more Asian participants in the *nonuser* group than expected. Lastly, those who identified as Mixed race were overrepresented in the *cannabis vape only* user group. Thus, I found partial support for my hypothesis, since Whites were underrepresented in the nonusers group, but also were underrepresented in the cannabis vape only group.

Finally, to analyze whether the user groups differed on socioeconomic status, I conducted a one-way ANOVA. There were no significant differences in mean socioeconomic scores among the four user groups, $F(3, 2016) = 2.33$, $p = .073$; thus, my hypothesis was not supported.

Impulsivity by User Groups

I found support for my second hypothesis that participants who reported any nicotine or cannabis vaping would have higher impulsivity scores compared to nonusers. A one-way ANOVA showed a significant difference among user groups, $F(3, 1075) = 18.20$, $p = .000$. A Tukey post-hoc test showed that *nonusers*' mean BIS-11 score ($M = 1.94$, $SD = .325$) was significantly lower than the mean for all other user groups (see Figure 1). *E-cig and cannabis vape* users ($M = 2.13$, $SD = .357$) reported higher impulsivity than *e-cig only* users ($M = 2.039$, *SD* = .357). *Cannabis vape* users (*M* = 2.10, *SD* = .34) were only distinct from nonusers (see Figure 1).

Family History of Addiction by User Groups

I conducted a one-way ANOVA to test the third hypothesis, namely that *e-cig only*, *cannabis vape*, and *e-cig and cannabis vape* users would report higher family history density (parents/grandparents) addiction scores. The ANOVA showed that the groups differed significantly, $F(3, 1035) = 4.65$, $p = .003$. In order to determine more specifically how the groups differed from each other on this measure, we ran a Games-Howell post-hoc test because the Levene's test for equal variances was significant, indicating that the group variances were not equal. The *e-cig and cannabis vape* users differed significantly ($p = .002$) from the three other groups: they had a higher family history density (*M* = .201, *SD* = .329), compared to the *nonusers* (*M* =.120, *SD* = .258), *e-cig only* (*M* = .147, *SD* = .267), and *cannabis vape only* (*M* =. 171, *SD* = .410) (see Figure 2).

Depression and Anxiety

I found mixed support for my fourth hypothesis, namely that participants reporting any nicotine or cannabis vaping would have more symptoms of depression and/or anxiety compared to nonusers. A one-way ANOVA showed a significant difference among user groups for depression, $F(3, 2155) = 6.84$, $p = .000$, and anxiety, $F(3, 2156) = 4.20$, $p = .006$. Specifically, post-hoc tests showed that those in the *e-cig and cannabis vape* group reported higher mean depression (*M* = 24.41, *SD* = 9.71) and anxiety (*M* = 22.51, *SD* = 7.85) scores when compared to all other user groups (see Figure 3).

Age of E-cigarette and Combustible Cigarette Initiation

To investigate my research question on whether the age of initiation of e-cigarettes was distinctive from age of combustible initiation, I conducted a paired t-test comparing mean ages of initiation for both substances, respectively. The two means differed significantly: $t(706) = 6.66$, $p = .000$. Specifically, age of combustible initiation ($M = 16.59$, $SD = 2.02$) was significantly lower than the age for e-cigarettes ($M = 17.09$, $SD = 1.71$). Further, a chi-square analysis showed that participants who reported lifetime use of e-cigarettes were much more likely to also report lifetime use of combustible tobacco (85%) compared to participants with no history of e-cigarette use (15%) ($\chi^2 = 461.26$ $df = 1$, $p = .000$).

Comparing Single and Dual Users on ENDS Frequency and Dependence

Further, I conducted an exploratory analysis examining the differences between frequency and dependency among single and dual users. I conducted an independent sample t-test comparing the two users groups, *e-cig only* and *e-cig and cannabis vape.* The two means for frequency differed significantly, $t(1205) = -8.07$, $p = .000$ (see Figure 4). The *e-cig and cannabis vape* group ($M = 2.68$, $SD = 3.71$) reported a significantly higher mean e-cigarette use frequency score when compared to the *e-cig only* user group ($M = 1.22$, $SD = 2.49$).

Secondly, similar findings emerged when examining e-cigarette dependency between the two user groups (see Figure 5). The two means for dependency differed significantly, $t(588) = -4.11$, $p = .000$. Specifically, the dual user group ($M = 1.65$, $SD = 1.01$) reported significantly higher means than the single use group ($M = 1.35$, $SD = .78$).

Discussion

The current study aimed to explore the factors associated with the initiation of nicotine and/or cannabis vaping, patterns of use, and dependency. I examined potential intrapersonal predictors of vaping including demographics, impulsivity, family history of addiction, and negative affect by gathering data from college students at college campuses across the United States using an online survey. To my understanding, this is the first study to report on these specific intrapersonal variables simultaneously in the nicotine and cannabis vaping literature.

Demographic Predictors of Vaping

I expected to replicate the previous literature regarding demographic characteristics associated with vaping; specifically, those that report any vaping would be more likely to be male, White, and of higher socioeconomic status (Jones et al., 2016; Kenne et al., 2017; Lee et al., 2016; Morean et al., 2017; Zuckermann et al., 2020). The results of this study are partially consistent with that of previous research and my hypotheses. This study provided partial support for my hypothesis, since males were overrepresented in the *e-cig and cannabis vape* group. One interpretation of these findings may be that males tend to engage in risky behavior and are more willing to experiment with novel trends (Morean et al., 2017). Another plausible explanation for the gender discrepancy is that males are consistently more likely to seek out an intense nicotine rush (Al-Hamdani et al., 2021). A recent study by Yimsaard et al. (2021) found that males were more likely than females to report using larger devices and to use e-liquids with higher concentrations of nicotine. In comparison, females have been shown to like the positive social aspects of vaping, therefore the negative effects of nicotine may resonate more strongly within younger females (Al-Hamdani et al., 2021). Further, these results are consistent with the claim that males were more likely to use e-cigarettes to vaporize cannabis (Morean et al., 2015).

I found partial support for my hypothesis pertaining to race. Previous findings by Lee et al. (2016) showed that African Americans were less likely to approve of vaping when compared to other ethnic groups. Results from this study are consistent with Lee et al. (2016) as African

American participants were more likely to be in the *non-user* group and less likely to be in the *e-cig only* user group compared to other racial groups, which suggests that they are less likely to approve of e-cigarette use. On the other hand, Black participants were more likely to endorse *cannabis* vaping compared to other racial groups, suggesting that they might hold more positive perceptions of cannabis compared to nicotine. One possible explanation for the higher rates of cannabis vaping in Black participants comes from Fahey et al. (2021), who showed that individuals who experience frequent discrimination may be more vulnerable to vaping. Particularly in our current social climate, where high profile cases of discrimination against Black Americans are abundant, these individuals may be at a greater risk for initiating vaping to cope, although my data were only consistent with this idea for cannabis, not nicotine.

Finally, I found partial support for my hypothesis that Whites would be more likely to endorse any vaping. Whites were less likely to identify as nonusers, which was consistent with my hypothesis, but they were also less likely to endorse cannabis vaping, which was in contrast to my prediction. The reasons for the distinction I observed between these substances are not clear, but at a minimum suggest that there may be racial differences in the substances that college students vape.

Additionally, I found no support for differences in mean socioeconomic status (SES) scores across the user groups. My hypothesis that any vaping would be associated with higher SES was based on research suggesting that having access to, and higher quantities of spending money may enable more substance use. Specifically, individuals from families of a higher socioeconomic status would be expected to vape more often, since they have more financial means to purchase both the substance(s) and devices (Jones et al., 2016; Morean et al., 2017). However, my results indicated no such differences between user groups. One possible explanation may be that the measure we used in our survey assessed perceived social status, which encompasses economic resources, but also one's subjective evaluation of their social standing as compared to others. A more objective scale inquiring about family income, education, family size, and occupation might have yielded a more accurate metric of socioeconomic status that is comparable among our study participants. It also is possible that there is no relation between socioeconomic status and vaping – if students are motivated to use these products, they may prioritize their purchase even if they have limited financial resources.

Impulsivity

My hypothesis that participants who reported any nicotine or cannabis vaping would have higher impulsivity scores when compared to nonusers was supported. This hypothesis was based upon extensive past evidence showing that impulsivity was positively associated with e-cigarette and cannabis vaping (Bidwell et al., 2013; Bold et al., 2017; Grant et al., 2019; Ksinan et al., 2020; Morean et al., 2017; Spillane et al., 2010). Not surprisingly, this study showed that *nonusers* had significantly lower impulsivity scores compared to all other user groups. In addition, individuals who displayed more impulsive traits also had an increased likelihood of initiating nicotine or combustible cigarette use earlier, using in greater frequencies, and vaping both nicotine and cannabis, perhaps to satisfy their needs for stimulation. These findings may be best explained through the Gateway and Route of Administration theories. In essence, those that are more impulsive may progress through the sequence of substances faster than their less impulsive peers. Further, impulsive individuals may be quick to experiment, or willing to try different substances. Therefore, since vaping nicotine and cannabis share their route of inhalation, individuals may negate the possible consequences of vaping a different substance since they believe their use will be at the same cost. Essentially, since inhaling vapors is perceived as less harmful to the lungs than inhaling smoke (Budney et al., 2015), the individual who already vapes nicotine will determine the psychological and physiological risk to be less, and therefore, might be more likely to initiate cannabis through the same route of administration and at an earlier age. Ksinan et al., (2020) found this to be true when inhalation was deemed the preferred route of administration. These findings are supported as nicotine and cannabis have been previously established to be co-used, or mixed together (Mayet et al., 2016). These speculations are congruent with our findings as e-*cig and cannabis vape* users reported higher impulsivity scores than *e-cig only* users.

Family History of Addiction

I hypothesized that participants in the *e-cig only, cannabis vape,* and *e-cig and cannabis vape* users would report higher family history density addiction scores. This hypothesis was partially supported, as I found that the dual user group differed significantly from the three other user groups. This hypothesis was based on previous research conducted by Niu et al. (2000) that demonstrated that initiation and maintenance of combustible smoking was influenced by heredity. Further, this study showed that genetic factors may substantially increase the vulnerability to nicotine addiction, as it was revealed that if either sibling was nicotine dependent, the latter had a significantly increased risk of nicotine dependence. However, other factors such as age of smoking initiation, number of years cigarettes were smoked, number of cigarettes smoked per day, and total pack-years were all found to be significantly correlated with nicotine dependence, so heredity is just one of many contributing factors (Niu et al., 2000). Additionally, Kosty et al. (2015) found that regarding cannabis, there is a greater risk of cannabis use disorder (CUD) among children with parental histories of CUD, and other hard substance use disorders (Kosty et al., 2015). Our findings were both consistent and inconsistent with Sonon et al. (2015), who found that family history was not a significant predictor of cannabis use. Participants who reported cannabis vaping did not evidence higher family history density in our study; rather, it was only the dual vapers of cannabis and nicotine.

One challenge we faced in looking at the construct of family history is that we had no means of differentiating the influence of hereditary versus environment when investigating how family members' substance use might be associated with the likelihood of vaping nicotine or cannabis. However, since we did find support for our hypothesis when it came to dual users (i.e., nicotine and cannabis), our results may be explained by familial transmission theory (Mayet et al., 2016). Another explanation for our findings may come through the Common Liability Model, which looks at both genetic and individual vulnerabilities and how they intersect with the individual's environment (Mayet et al., 2016). Understanding our results through the lens of the Common Liability Model allows us to understand why the *e-cig and cannabis vape* group was found to have a higher family history density, showing a more powerful gravitation towards poly-substance use (Mayet et al., 2016).

Findings on Negative Affect

My final hypothesis was that participants reporting any nicotine or cannabis vaping would have more symptoms of depression and/or anxiety when compared to nonusers. This hypothesis was found to have mixed support, as I found that those in the *e-cig and cannabis vape* group reported higher mean depression and anxiety scores when compared to other user groups. This hypothesis was based partly on literature exploring the relation between depression and vaping (Saeed et al., 2020; Weirnik et al., 2019). One previous study from Saeed et al. (2020) offers a particularly interesting explanation of our results. The researchers found that excessive nicotine can lead to the release of abnormally high levels of dopamine, further dysregulating the neural circuits involved in emotional regulation, and increasing an individual's sensitivity to stress; ultimately contributing to the individual's depressive symptoms. Regarding cannabis, it was also noted that use can impair serotonin transmission, and this effect may be intensified by the presence of nicotine. Thus, consistent with past research, it has been proven that this disruption contributes to depressive symptoms (Saeed et al., 2020).

Another study that may provide insights into our finding was conducted by Beck et al. (2009). This study suggests a different perspective pertaining to the social context of cannabis use and depressive symptoms. Beck et al. found that people are more likely to use cannabis in the context of emotional pain, and this was shown to be highly correlated to both CUD and depression. Therefore, it may be feasible that many users rely on cannabis to alleviate their symptoms of depression (Beck et al., 2009), which provides a plausible explanation to our findings of the current study. However, since the cannabis vape group did not show elevated levels of depression compared to nonusers and e-cig only users, participants with the greatest vulnerability for using cannabis to cope appear to be those who have also vaped nicotine.

The research on anxiety and vaping was far more limited than depression, yet Grant et al. (2019) found that e-cigarettes were significantly associated with symptoms of anxiety. They further argued that higher intensities of cravings are experienced during times of anxiety, which would be interesting to examine in future research. Additionally, a study done by Frohe et al. (2018) cited previous research speculating that social anxiety may increase the desire to use cannabis while in stressful situations. These findings align with the results of the current study, as the dual user group reported higher levels of anxiety than all other user groups. So, it is possible that individuals who were categorized in the *e-cig and cannabis vape* group co-use both substances to effectively self-medicate and relieve themselves of the negative affect symptoms they experience. More in-depth research on motivations for e-cig and cannabis vaping would be needed to confirm this explanation.

Findings on Age of E-cigarette and Combustible Cigarette Initiation

A research question I examined was whether the age of initiation of e-cigarettes was distinctive from age of combustible initiation. I anticipated that e-cigarettes might have a lower age of initiation because of their significant marketing and push towards younger aged individuals. However, our results showed that the mean age of combustible initiation was significantly lower than the age for e-cigarettes. While I initially viewed these results as surprising, since there has been concern recently surrounding a reverse gateway effect (i.e., e-cigarettes to combustibles), especially with those who previously identified themselves as nonsmokers (Chapman et al., 2019), the findings align closely with that of a traditional gateway sequence. This may hold true for several possible reasons. First, combustible cigarettes are often the initial product theorized to begin the substance use sequence. Secondly, it is possible this transition (i.e., combustible to e-cigs) occurs later because users begin searching for products that are more readily available/accessible, perceived as lower risk, and have a greater appeal towards younger populations. For example, when the individual seeks to obtain the original product they prefer (i.e., combustible cigarettes) they are exposed to a variety of other products (i.e., e-cigarettes), since these products are often sold alongside one another. Yet, our findings are somewhat inconsistent with some researchers' claim that e-cigs are the desired first choice of products (Chapman et al., 2019). Of course, it could be the case that even if an individual tries a combustible cigarette first, they might ultimately prefer an e-cig, which would be more consistent with Chapman et al.'s (2019) findings.

Another possible explanation as to why e-cigarettes were found to have a later age of initiation may be that the user had developed a nicotine addiction that combustibles alone can no longer satisfy (Etter, 2017; Spillane et al., 2010). Although Etter (2017) found support for this claim via the reverse sequence, it is still a plausible explanation that may explain why the user may shift products in order to satisfy a physiological dependence on nicotine.

An additional reason may be that children learn by modeling others, especially peers and adults. Therefore, it can be speculated that environmental exposure to combustible cigarettes may explain the difference in age of initiation. This may hold true since e-cigs are a relatively novel product when compared to traditional cigarettes, which have been firmly rooted in society for decades. Therefore, through observational learning, individuals may initiate combustible cigarette use first, merely off the cues or even the accessibility their environment provides to them (Giroud et al., 2015).

Findings also showed that participants who reported lifetime e-cig use were also more likely to report combustible tobacco (85%) when compared to participants with no history of e-cig use (15%). These findings also align with the traditional gateway theory and are consistent with the evidence found in Soneji et al. (2017). These findings may be true since e-cigarette use mimic the gestures and feelings of cigarette inhalation (e.g., hand-to-mouth movement, inhalation of mixture into lungs) (Soneji et al., 2017). Thus, it is possible that the route of administration (RAM) contributes to the gateway sequence between traditional combustibles and vaporizers (Mayet & Lavagna, 2018).

Finally, our findings are of interest in light of research cited by Lee et al. (2016), who reported that e-cigs have better taste, are healthier, easier to conceal, do not smell as strong, are more convenient, and produce a stronger/better high compared to combustible cigarettes

(Morean et al., 2017). Given these data, our findings must be further investigated to understand why the differences in age of initiation remain, especially since research suggests that e-cigarettes are becoming the more preferred product for consuming nicotine among younger individuals.

Single and Dual Users on ENDS Frequency and Dependency

Exploratory analyses revealed that the two user groups, *e-cig only* and *e-cig and cannabis vape* differed significantly on e-cigarette use frequency. More specifically, the dual user group used e-cigarettes more often than the single user group. These findings were consistent with prior research. Lee et al. (2016) found that young adults who have more positive perceptions of vapes were not only more likely to use, but more importantly evidenced an increase of the amount of the substance being consumed. Similar findings were also reported in Budney et al. (2015), stating that vaping devices provide more efficient and intense effects, which would most likely be associated with a greater frequency of use.

Another explanation for why the dual use group reported using e-cigarettes more often might relate to impulsivity. In our study, dual users were found to have significantly higher impulsivity; therefore, it could be the case that the greater impulsivity observed in this group contributes to a greater likelihood of e-cigarette use. Indeed, Morean et al. (2017) found that higher impulsivity was associated with more frequent vaping. Our correlational analysis further supported this idea as impulsivity and e-cig frequency were significantly and positively correlated.

Finally, additional evidence addressing why dual users may report more frequent vaping was found in Cassidy et al. (2018). They showed that cannabis vapers increased their cannabis use as time progressed. This emphasizes that vaping is not an effective replacement method;

instead, it may lead to a concurrent increase in nicotine and/or cannabis use and dependence in young adults (Cassidy et al., 2018).

The second finding of our exploratory analysis showed significant differences in e-cigarette dependence between the two user groups. Similar to frequency, the dual user group reported significantly higher dependence than the e-cig only use group. These findings may be attributed to the notion that these two substances can have interactive effects; that is, as dual users consume both substances to achieve strengthened and prolonged euphoric effects, they ultimately consume nicotine more often, which increases the likelihood of a physiological dependency on nicotine (Ksinan et al., 2020; Mayet et al., 2016). On the basis of this evidence, the results of our exploratory analysis are to be anticipated. It is reasonable to speculate that vaping e-cigarettes makes individuals more accustomed to using a vaping device. Given this, users are at risk for increasing their use and developing dependence symptoms. So, for dual users who also use cannabis, we are more likely to see a higher frequency and, in turn, higher dependence overtime.

Limitations

There are several limitations to the current study. Although we recruited participants from several different colleges and universities across the US, our sample was relatively homogenous with respect to race and gender. This factor may have limited the generalizability of our results to other college campuses with more diverse demographics characteristics. The majority of past research conducted on vaping has involved primarily White samples, so research with more diverse samples would be beneficial, especially since we found that Black/African American participants were overrepresented in the cannabis vape group. Furthermore, the online survey was entirely self-reported. As is the case with any online survey, there is a possibility that a participant may have incorrectly identified or misperceived a question. This accidental or false reporting is likely to occur when participants complete the survey quickly without processing the questions or providing accurate responses. In an attempt to reduce the likelihood of this occurring, we included check questions throughout the survey to ensure participants carefully read and paid attention throughout the whole duration of the survey, but this strategy cannot ensure accurate reporting.

Another limitation of the current study was that the impulsivity and family history density measures were only received by half of our overall sample. These findings likely impacted the accuracy of our findings and possibly skewed the generalizability to our sample. For the family history measure in particular, we choose to only include the response options that referred to parents' and grandparents' addiction, rather than taking into account the possible environmental effects that may arise if siblings, cousins, or other members close to the nuclear family had a history of addiction. It would be interesting to better understand how vaping impacts specific family members, such as siblings, similar to the study conducted by Niu et al. (2000). Future studies that examine family history should consider the specific impact that environments have on vaping both nicotine and cannabis, alongside genetic influences.

Lastly, one limitation of our study was that we did not measure age of cannabis vaping initiation or cannabis vaping frequency. Therefore, we were limited in our ability to understand how cannabis vaping initiation compares to nicotine vaping and combustible smoking. Future studies should aim to assess the frequency of cannabis vaping, and its association with our study variables (e.g., depression, impulsivity, family history density, etc.).

Future Directions

This study aimed to fill several gaps in vaping literature. While vaping is now being studied more widely, there has not yet been sufficient research examining the specific factors associated with the initiation of nicotine and/or cannabis vaping, patterns of use, and dependency. Since this study was among the first to encompass all of these specific factors, it is imperative to expand upon the current findings. With combustible cigarette use decreasing, and nicotine and cannabis vaping rising, it is vital to be able to understand the factors that place individuals at greater risk of using vaping devices to consume nicotine and/or cannabis. While this study pointed to several risk factors associated with vaping including demographics, impulsivity, family history of addiction, and negative affect, these findings need to be replicated so that we can more accurately and confidently describe a user profile that is deemed "at risk" on college campuses. Furthermore, we must also investigate interpersonal variables such as, peer or parental influence, individual/family problems, and academic performance in order to further differentiate single from dual users, as well as nonusers. Additionally, we must continue to educate individuals about the potential risks and consequences of vaping, and it is crucial to research the long-term effects that arise from using these products. Finally, as this field of research continues to rapidly evolve and grow, policy makers must take into account findings that may influence policies regarding the sale and the use of the vaping devices.

Conclusion

The findings of the current study add to the newly evolving research on nicotine and cannabis vaping; specifically, the factors associated with the initiation of nicotine and/or cannabis vaping, patterns of use, and dependency. Additionally, this study contributes to the knowledge of the intrapersonal predictors of vaping on college campuses. The findings of this study have several important implications for future prevention and intervention. The study suggests that individuals who vape dual substances have higher e-cigarette frequency and dependence. Future interventions can utilize screenings to quickly identify those at risk, and also for college students who are dual users it should address higher impulsivity, family history, depression, and anxiety. Informing these students of their increased likelihood towards vaping dual substances may overtime transition their vulnerabilities into protective factors. However, this relies on the students adherence and use of prevention programs, or coping strategies that target these particular factors. Future research should concentrate on replicating and further examining the predictors that make college students more vulnerable to initiate and maintain vaping, as well as investigating potential points where College Administrators, Counseling/Health Centers, parents and peers may effectively intervene to aid the individual in changing their previous patterns of use.

References

Al-Hamdani, M., Hopkins, D. B., Hardardottir, A., & Davidson, M. (2021). Perceptions and experiences of vaping among youth and young adult e-cigarette users: Considering age, gender, and tobacco use. *Journal of Adolescent Health*, *68*(4), 787–793. https://doi.org/10.1016/j.jadohealth.2020.08.004

Beck, K. H., Caldeira, K. M., Vincent, K. B., O'Grady, K. E., Wish, E. D., & Arria, A. M. (2009). The social context of cannabis use: Relationship to cannabis use disorders and depressive symptoms among college students. *Addictive Behaviors*, *34*(9), 764–768. https://doi.org/10.1016/j.addbeh.2009.05.001

Bidwell, L. C., Metrik, J., McGeary, J., Palmer, R. H. C., Francazio, S., & Knopik, V. S. (2013). Impulsivity, variation in the cannabinoid receptor (CNR1) and fatty acid amide hydrolase (FAAH) genes, and marijuana-related problems. *Journal of Studies on Alcohol and Drugs*, *74*(6), 867–878. PubMed. https://doi.org/10.15288/jsad.2013.74.867

Blount, B. C., Karwowski, M. P., Shields, P. G., Morel-Espinosa, M., Valentin-Blasini, L., Gardner, M., Braselton, M., Brosius, C. R., Caron, K. T., Chambers, D., Corstvet, J., Cowan, E., De Jesús, V. R., Espinosa, P., Fernandez, C., Holder, C., Kuklenyik, Z., Kusovschi, J. D., Newman, C., … Pirkle, J. L. (2020). Vitamin E acetate in bronchoalveolar-lavage fluid associated with EVALI. *New England Journal of Medicine*, *382*(8), 697–705. https://doi.org/10.1056/NEJMoa1916433

Blundell, M., Dargan, P., & Wood, D. (2018). A cloud on the horizon–a survey into the use of electronic vaping devices for recreational drug and new psychoactive substance (NPS) administration. *QJM: An International Journal of Medicine*, *111*(1), 9–14. https://doi.org/10.1093/qjmed/hcx178

Bold, K. W., Morean, M. E., Kong, G., Simon, P., Camenga, D. R., Cavallo, D. A., & Krishnan-Sarin, S. (2017). Early age of e-cigarette use onset mediates the association between impulsivity and e-cigarette use frequency in youth. *Drug and Alcohol Dependence*, *181*, 146–151. https://doi.org/10.1016/j.drugalcdep.2017.09.025

Budney, A. J., Sargent, J. D., & Lee, D. C. (2015). Vaping cannabis (marijuana): Parallel concerns to e-cigs? *Addiction (Abingdon, England)*, *110*(11), 1699–1704. PubMed. https://doi.org/10.1111/add.13036

Cassidy, R. N., Meisel, M. K., DiGuiseppi, G., Balestrieri, S., & Barnett, N. P. (2018). Initiation of vaporizing cannabis: Individual and social network predictors in a longitudinal study of young adults. *Drug and Alcohol Dependence*, *188*, 334–340. https://doi.org/10.1016/j.drugalcdep.2018.04.014

Chapman, S., Bareham, D., & Maziak, W. (2019). The gateway effect of e-cigarettes: Reflections on main criticisms. *Nicotine & Tobacco Research : Official Journal of the Society for Research on Nicotine and Tobacco*, *21*(5), 695–698. PubMed. https://doi.org/10.1093/ntr/nty067

Civiletto, C. W., & Hutchison, J. (2020). Electronic vaping delivery of cannabis and nicotine. In *StatPearls*. StatPearls Publishing.

Dobbs, P. D., Hodges, E. J., Dunlap, C. M., & Cheney, M. K. (2020). Addiction vs. dependence: A mixed methods analysis of young adult JUUL users. *Addictive Behaviors*, *107*, 106402. https://doi.org/10.1016/j.addbeh.2020.106402

Etter, J.-F. (2018). Gateway effects and electronic cigarettes. *Addiction*, *113*(10), 1776–1783. https://doi.org/10.1111/add.13924

Fahey, M. C., Morris, J. D., Robinson, L. A., & Pebley, K. (2021). Association between perceived discrimination and vaping among college students. *Substance Use & Misuse*, *56*(5), 738–741. https://doi.org/10.1080/10826084.2021.1887250

Ford, E. W., Chan, K. S., Parikh, M., Lowe, K. B., & Huerta, T. R. (2020). E-cigarette and hookah adoption patterns: Is the harm reduction theory just so much smoke? *Addictive Behaviors Reports*, *11*, 100246. https://doi.org/10.1016/j.abrep.2019.100246

Frohe, T., Leeman, R. F., Patock-Peckham, J., Ecker, A., Kraus, S., & Foster, D. W. (2018). Correlates of cannabis vape-pen use and knowledge among U.S. college students. *Addictive Behaviors Reports*, *7*, 32–39. https://doi.org/10.1016/j.abrep.2017.11.004

Gaiha, S. M., Cheng, J., & Halpern-Felsher, B. (2020). Association between youth smoking, electronic cigarette use, and COVID-19. *Journal of Adolescent Health*, *67*(4), 519–523.

Giroud, C., De Cesare, M., Berthet, A., Varlet, V., Concha-Lozano, N., & Favrat, B. (2015). E-cigarettes: A review of new trends in cannabis use. *International Journal of Environmental Research and Public Health*, *12*(8). https://doi.org/10.3390/ijerph120809988

Grant, J. E., Lust, K., Fridberg, D. J., King, A. C., & Chamberlain, S. R. (2019). E-cigarette use (vaping) is associated with illicit drug use, mental health problems, and impulsivity in university students. *Annals of Clinical Psychiatry : Official Journal of the American Academy of Clinical Psychiatrists*, *31*(1), 27–35. PubMed.

Hajek, P., Phillips-Waller, A., Przulj, D., Pesola, F., Myers Smith, K., Bisal, N., Li, J., Parrott, S., Sasieni, P., Dawkins, L., Ross, L., Goniewicz, M., Wu, Q., & McRobbie, H. J. (2019). A randomized trial of e-cigarettes versus nicotine-replacement therapy. *The New England journal of medicine*, *380*(7), 629–637. https://doi.org/10.1056/NEJMoa1808779

Hefner, K. R., Sollazzo, A., Mullaney, S., Coker, K. L., & Sofuoglu, M. (2019). E-cigarettes, alcohol use, and mental health: Use and perceptions of e-cigarettes among college students, by alcohol use and mental health status. *Addictive Behaviors*, *91*, 12–20. https://doi.org/10.1016/j.addbeh.2018.10.040

Jones, C. B., Hill, M. L., Pardini, D. A., & Meier, M. H. (2016). Prevalence and correlates of vaping cannabis in a sample of young adults. *Psychology of Addictive Behaviors*, *30*(8), 915–921. APA PsycInfo. https://doi.org/10.1037/adb0000217

Kenne, D. R., Fischbein, R. L., Tan, A. S., & Banks, M. (2017). The use of substances other than nicotine in electronic cigarettes among college students. *Substance Abuse: Research and Treatment*, *11*, 1178221817733736. https://doi.org/10.1177/1178221817733736

Kosty, D. B., Farmer, R. F., Seeley, J. R., Gau, J. M., Duncan, S. C., & Lewinsohn, P. M. (2015). Parental transmission of risk for cannabis use disorders to offspring. *Addiction (Abingdon, England)*, *110*(7), 1110–1117. PubMed. https://doi.org/10.1111/add.12914

Ksinan, A. J., Spindle, T. R., Thomas, N. S., Eissenberg, T., & Dick, D. M. (2020). E-cigarette use is prospectively associated with initiation of cannabis among college students. *Addictive Behaviors*, *106*, 106312. https://doi.org/10.1016/j.addbeh.2020.106312

Lee, D. C., Crosier, B. S., Borodovsky, J. T., Sargent, J. D., & Budney, A. J. (2016). Online survey characterizing vaporizer use among cannabis users. *Drug and Alcohol Dependence*, *159*, 227–233. PubMed. https://doi.org/10.1016/j.drugalcdep.2015.12.020

Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the depression anxiety stress scales (DASS) with the beck depression and anxiety inventories. *Behaviour Research and Therapy*, *33*(3), 335–343.

Mayet, A., & Lavagna, C. (2018). Electronic cigarettes: Harm reduction tool or new substance use behavior? *Addiction*, *113*(10), 1786–1788. https://doi.org/10.1111/add.14220

Mayet, A., Legleye, S., Beck, F., Falissard, B., & Chau, N. (2016). The gateway hypothesis, common liability to addictions or the route of administration model? A modelling process linking the three theories. *European Addiction Research*, *22*(2), 107–117. JSTOR. https://doi.org/10.2307/26791035

Merikangas, K. R., Stolar, M., Stevens, D. E., Goulet, J., Preisig, M. A., Fenton, B., Zhang, H., O'Malley, S. S., & Rounsaville, B. J. (1998). Familial transmission of substance use disorders. *Archives of General Psychiatry*, *55*(11), 973–979. https://doi.org/10.1001/archpsyc.55.11.973

Morean, M. E., Kong, G., Camenga, D. R., Cavallo, D. A., & Krishnan-Sarin, S. (2015). High school students' use of electronic cigarettes to vaporize cannabis. *Pediatrics*, *136*(4), 611–616.

Morean, M. E., Krishnan-Sarin, S., & S. O'Malley, S. (2018). Assessing nicotine dependence in adolescent E-cigarette users: The 4-item patient-reported outcomes measurement information system (PROMIS) nicotine dependence item bank for electronic cigarettes. *Drug and Alcohol Dependence*, *188*, 60–63. https://doi.org/10.1016/j.drugalcdep.2018.03.029

Morean, M. E., Lipshie, N., Josephson, M., & Foster, D. W. (2017). Predictors of adult e-cigarette users vaporizing cannabis using e-cigarettes and vape-pens. *Substance Use & Misuse*, *52*(8), 974–981. https://doi.org/10.1080/10826084.2016.1268162

NIDA. 2020, January 8. Vaping Devices (Electronic Cigarettes) DrugFacts. Retrieved from https://www.drugabuse.gov/publications/drugfacts/vaping-devices-electronic-cigarettes on 2020, November 28

NIDA. 2020, April 8. How does marijuana produce its effects?. Retrieved from https://www.drugabuse.gov/publications/research-reports/marijuana/how-does-marijuana-produce-its-effects on 2020, November 28

Niu, T., Chen, C., Ni, J., Wang, B., Fang, Z., Shao, H., & Xu, X. (2000). Nicotine dependence and its familial aggregation in Chinese. *International Journal of Epidemiology*, *29*(2), 248–252. https://doi.org/10.1093/ije/29.2.248

Patton, J. H., Stanford, M. S., & Barratt, E. S. (1995). Factor structure of the barratt impulsiveness scale. *Journal of Clinical Psychology*, *51*(6), 768–774.

Saeed, O. B., Chavan, B., & Haile, Z. T. (2020). Association between e-cigarette use and depression in US adults. *Journal of Addiction Medicine*, *14*(5), 393–400. https://doi.org/10.1097/ADM.0000000000000604

Schulenberg, J. E., Johnston, L. D., O'Malley, P. M., Bachman, J. G., Miech, R. A., & Patrick, M. E. (2020). *Monitoring the future national survey results on drug use, 1975-2019: Volume II, college students and adults ages 19-60*. Ann Arbor: Institute for Social Research, The University of Michigan

Soneji, S., Barrington-Trimis, J. L., Wills, T. A., Leventhal, A. M., Unger, J. B., Gibson, L. A., Yang, J., Primack, B. A., Andrews, J. A., Miech, R. A., Spindle, T. R., Dick, D. M., Eissenberg, T., Hornik, R. C., Dang, R., & Sargent, J. D. (2017). Association between initial use of e-cigarettes and subsequent cigarette smoking among adolescents and young adults: A systematic review and meta-analysis. *JAMA Pediatrics*, *171*(8), 788–797. https://doi.org/10.1001/jamapediatrics.2017.1488

Sonon, K. E., Richardson, G. A., Cornelius, J. R., Kim, K. H., & Day, N. L. (2015). Prenatal marijuana exposure predicts marijuana use in young adulthood. *Neurotoxicology and Teratology*, *47*, 10–15. https://doi.org/10.1016/j.ntt.2014.11.003

Spillane, N. S., Smith, G. T., & Kahler, C. W. (2010). Impulsivity-like traits and smoking behavior in college students. *Addictive Behaviors*, *35*(7), 700–705. https://doi.org/10.1016/j.addbeh.2010.03.008

Spindle, T. R., Hiler, M. M., Cooke, M. E., Eissenberg, T., Kendler, K. S., & Dick, D. M. (2017). Electronic cigarette use and uptake of cigarette smoking: A longitudinal examination of U.S. college students. *Addictive Behaviors*, *67*, 66–72. https://doi.org/10.1016/j.addbeh.2016.12.009

Stoltenberg, S. F., Mudd, S. A., Blow, F. C., & Hill, E. M. (1998). Evaluating measures of family history of alcoholism: Density versus dichotomy. *Addiction*, *93*(10), 1511–1520.

Wiernik, E., Airagnes, G., Lequy, E., Gomajee, R., Melchior, M., Le Faou, A.-L., Limosin, F., Goldberg, M., Zins, M., & Lemogne, C. (2019). Electronic cigarette use is associated with depressive symptoms among smokers and former smokers: Cross-sectional and longitudinal findings from the constances cohort. *Addictive Behaviors*, *90*, 85–91. https://doi.org/10.1016/j.addbeh.2018.10.021

Yimsaard, P., McNeill, A., Yong, H.-H., Cummings, K. M., Chung-Hall, J., Hawkins, S. S., Quah, A. C. K., Fong, G. T., O’Connor, R. J., & Hitchman, S. C. (2021). Gender differences in reasons for using electronic cigarettes and product characteristics: Findings from the 2018 ITC four country smoking and vaping Survey. *Nicotine & Tobacco Research*, *23*(4), 678–686. https://doi.org/10.1093/ntr/ntaa196

Zuckermann, A. M. E., Williams, G. C., Battista, K., Jiang, Y., de Groh, M., & Leatherdale, S. T. (2020). Prevalence and correlates of youth poly-substance use in the COMPASS study. *Addictive Behaviors*, *107*, 106400. https://doi.org/10.1016/j.addbeh.2020.106400

Table 1

Demographic and Psychosocial Characteristics for Overall Sample and User Group

Study Variable	Overall sample (N = 2160)	Nonusers (n = 841)	E-cigarette only (n = 562)	E-cigarette and cannabis vape (n = 645)	Cannabis vape only (n = 112)
Age	19.25 (1.34)	19.23 (1.31)	19.20 (1.38)	19.29 (1.33)	19.43 (1.34)
% Male	27%	26%	24%	31%*	24%
Race/ethnicity					
White	75%	70%*	83%*	78%	56%*
Black/African American	9%	11%*	5%*	8%	20%*
Asian	7%	10%*	4%	5%	5%
Mixed race	5%	5%	4%	5%	11%*
Other	5%	4%	5%	6%	8%
School by US Region					
Northeast and Mid-Atlantic	33%	30%	34%	37%	34%
Southeast	26%	26%	31%*	21%*	20%
Midwest	24%	26%	18%*	29%*	21%
Southwest	17%	18%	17%	14%	25%
Socioeconomic Status (SES)	4.97 (1.70)	4.97 (1.68)	4.94 (1.66)	5.07 (1.74)	4.60 (1.82)
Depression (DASS-21)	23.23 (9.39)	22.21 (9.04)[a]	23.34 (9.44)[a,c]	24.41 (9.71)[b,c]	23.52 (9.16)[a,c]
Anxiety (DASS-21)	21.91 (7.67)	21.20 (7.39)[a]	22.22 (7.54)[a,c]	22.51 (7.85)[b,c]	22.32 (8.86)[a,c]
Impulsivity (BIS-11)	2.03 (.352)	1.94 (.325)[a]	2.04 (.357)[b]	2.13 (.357)[c]	2.03 (.352)[b,c]
Family History of Addiction	.16 (.29)	.12 (.26)[a]	.15 (.27)[a,c]	.20 (.33)[b,c]	.17 (.41)[a,c]

Note. *frequency differed from expected frequency after adjusting for multiple comparisons. Means with different superscripts were significantly different. For the impulsivity variable, the sample was as follows: Overall sample (N = 1079), Nonusers (n = 435), E-cigarette only (n = 286), E-cigarette and cannabis vape (n = 308), Cannabis vape only (n = 50). For the family history variable, the sample was as follows: Overall sample (N = 1039), Nonusers (n = 387), E-cigarette only (n = 266), E-cigarette and cannabis vape (n = 326), Cannabis vape only (n = 60).

Table 2

Intercorrelations among the Study Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. Gender	--									
2. Age	-.03	--								
3. Socioeconomic status	-.08**	-.09**	--							
4. Family history density	.04	.11**	-.13**	--						
5. Impulsivity	-.04	-.06*	-.04	NA	--					
6. Depression	.07**	.02	-.17**	.07*	.34**	--				
7. Anxiety	.14**	-.01	-.12**	.16**	.29**	.66**	--			
8. E-cigarette frequency	-.14**	-.04*	.02	.07*	.22**	.10**	.07**	--		
9. E-cigarette dependence	-.14**	-.01	.03	NA	.25**	.16*	.11**	.73**	--	
10. Age e-cigarette initiation	.08**	.52**	NA	.03	-.13**	-.02	-.02	-.22**	-.18**	--
11. Age combustible initiation	-.01	.16**	NA	-.16**	-.14**	-.14**	-.15**	-.11**	-.10*	.45**

Note. NA=correlation not available because items were on different forms of the survey. Gender was coded as 1=male and 2=female. Socioeconomic status was coded as 1=highest, 9=lowest. $*p < .05$, $**p \leq .01$

Figure 1

Impulsivity Scores for Overall Sample and User Groups

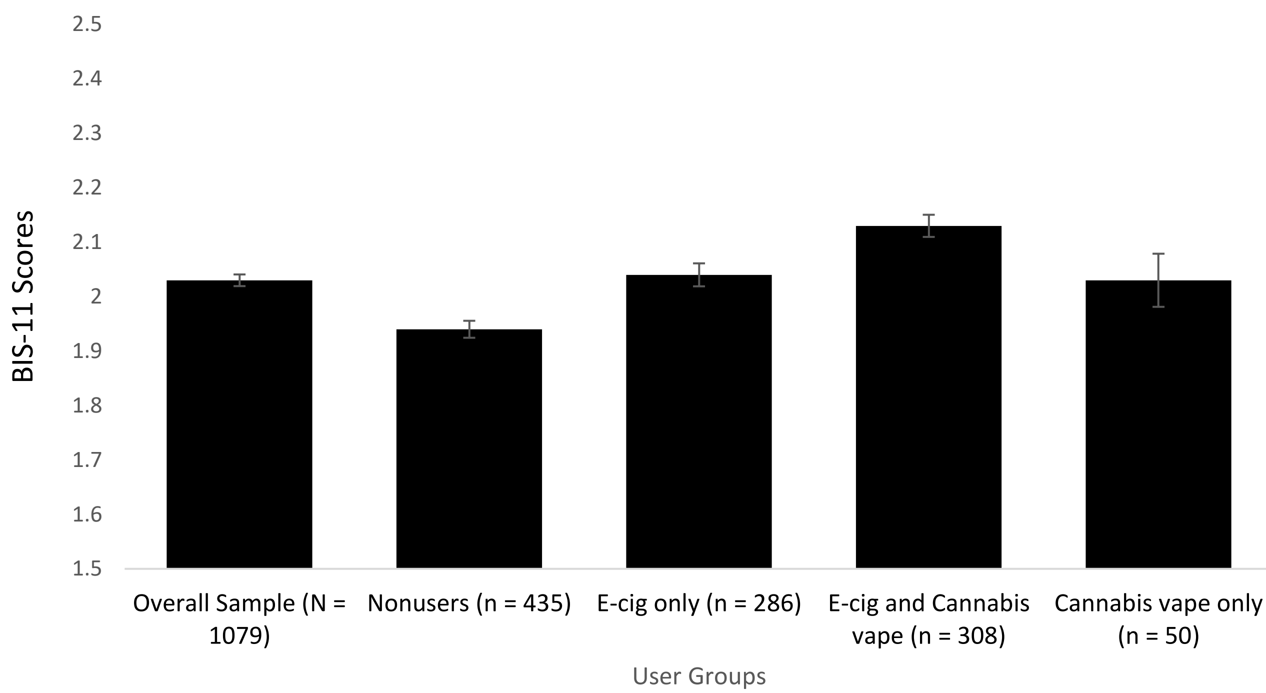

Figure 2

Mean Family History of Addiction Scores for Overall Sample and User Groups

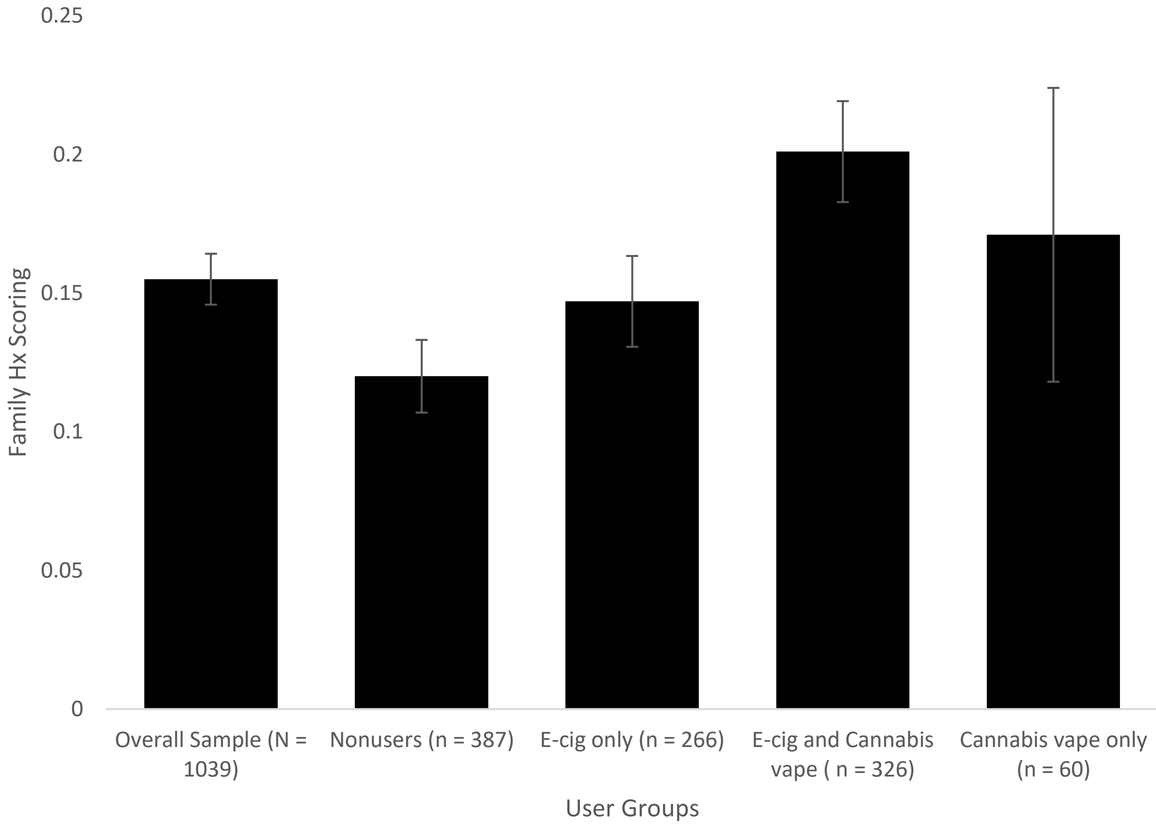

Figure 3

Mean Depression and Anxiety Scores for Overall Sample and User Groups

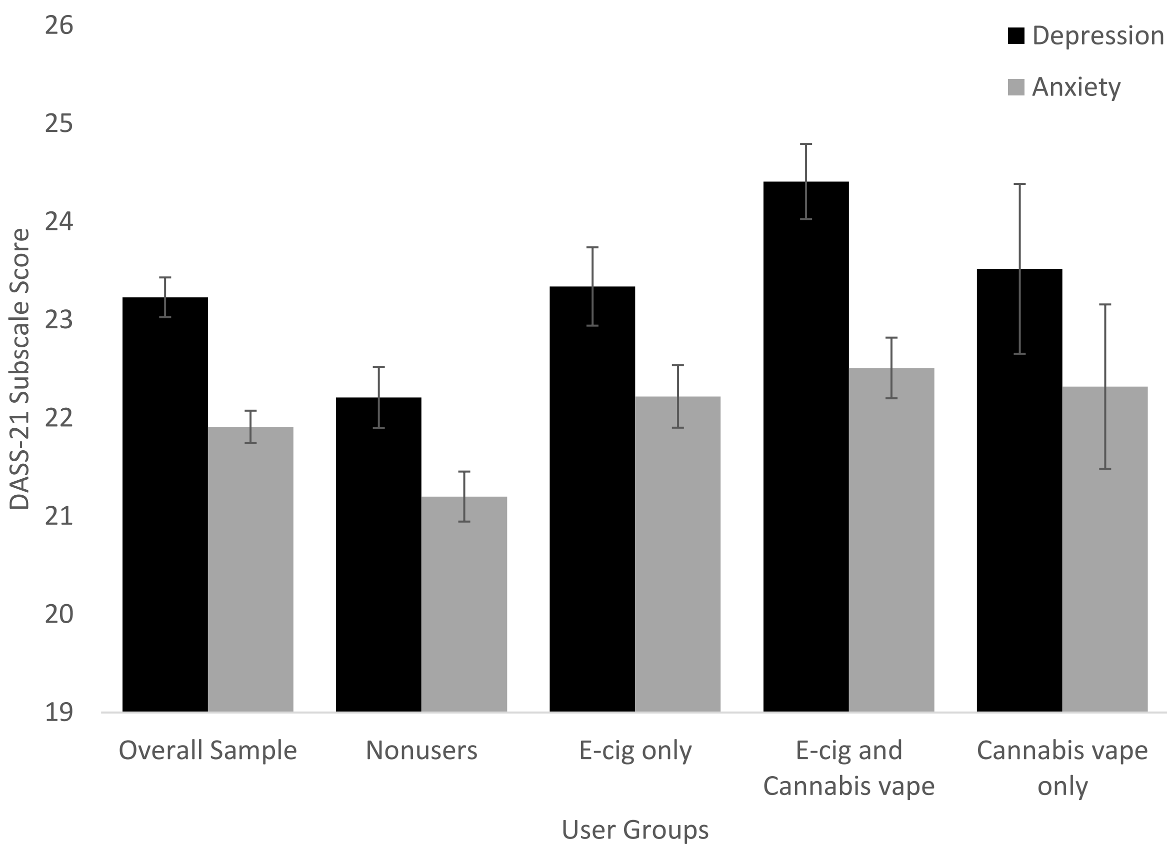

Figure 4

Mean E-Cigarette Frequency Scores for Single and Dual User Groups

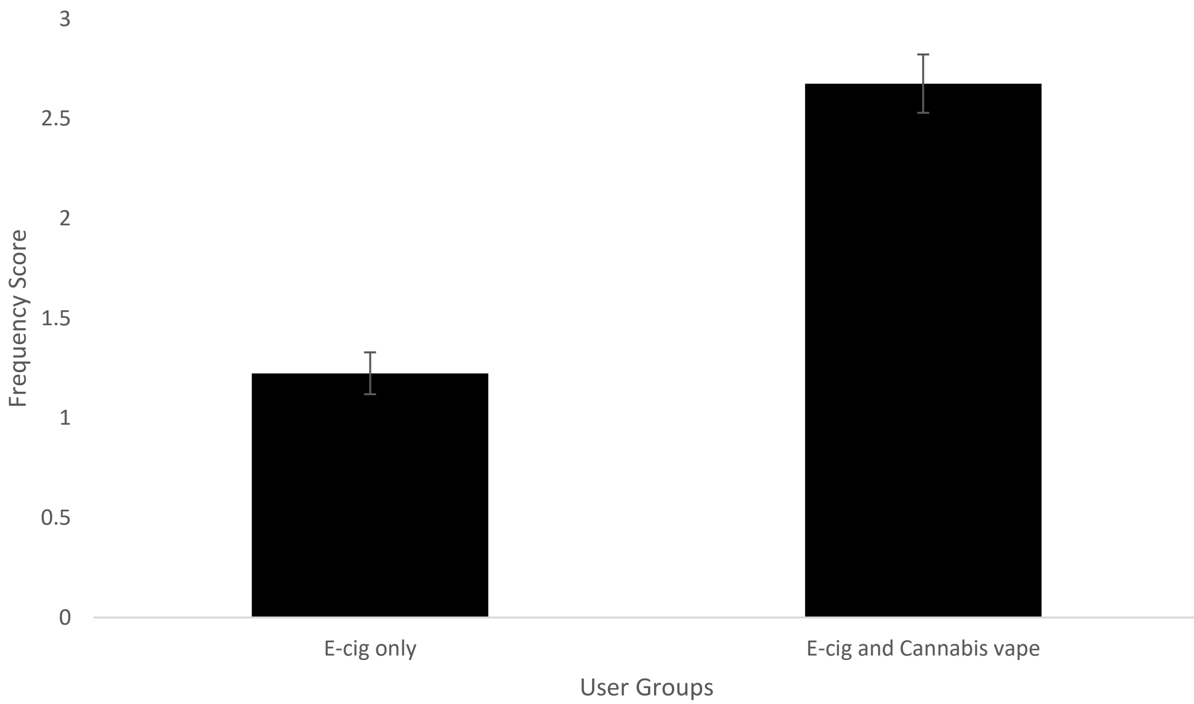

Figure 5

Mean E-Cigarette Dependency Scores for Single and Dual User Groups