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# Testing the Feasibility of a Positive Psychology Mobile Health App for College Electronic Cigarette Users

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

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Professor Laura Holt, PhD

Fall 2022- Spring 2023

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## Table of Contents

**Abstract**

Electronic cigarette (EC) use is common among college students, with over 50% endorsing lifetime use. Recent research shows Mobile Health (mHealth) technology is a promising tool to help address EC use in young adults. Yet only 3% of cessation apps were designed to facilitate quitting ECs and the majority lack empirical support of their effectiveness. The Smiling Instead of Smoking (SiS) app is a positive psychology-based smartphone app for nondaily smokers. Due to previous success with brief, self-administered positive psychology exercises for cigarette cessation, this study examined the SiS App's feasibility and effectiveness for EC cessation. Sixteen undergraduates used the SiS app for 3 weeks: one week before their quit date and 2 weeks after. As hypothesized, participants had significant declines in their craving and maintained pre-cessation levels of positive affect. There were no significant changes in dependency or self-efficacy. At the one-month follow-up survey, 38% of participants reported being abstinent. The app had an almost 4-star rating for its features (e.g., functionality, aesthetics, information, etc.) and participants reported moderate satisfaction with its use. Participants used the app, on average, 10 out of the 21 days of the prescribed app use. This study highlights the promise of mHealth support and positive psychology for EC cessation, adding to the understanding of possible ways to support EC quit attempts.

# Testing the Feasibility of a Positive Psychology Mobile Health App for College Electronic Cigarette Users

Since 2014, the National Youth Tobacco Survey (NYTS) has determined that electronic cigarettes are the most widely used tobacco product among US youth (U.S. Department of Health and Human Services [USDHHS], 2020). Two years later, the US Surgeon General characterized electronic cigarette use among adolescents and young adults as a major public health crisis, and in 2018 they declared youth electronic cigarette use an epidemic (USDHHS, 2020; Walley et al., 2019). Despite recognition of the potential for adverse consequences associated with e-cigarette use, a national outbreak of electronic-cigarette or vaping-associated lung injury (EVALI) occurred in 2019. Although the majority of the cases have since been linked to electronic cigarette products containing tetrahydrocannabinol (THC), testing revealed many of the patients were also using nicotine devices (Blount et al., 2020). The EVALI outbreak, therefore, helps to demonstrate the potential harmfulness and potential for fatalities with electronic cigarette use (CDC, 2021; Park et al., 2022). This emergence of health-related problems is of particular note due to the uncertainty of electronic cigarettes' long-term health implications as these products are relevantly new.

The population most affected by this public health crisis, accounting for most hospitalizations and fatalities, were young adults aged 18-24 years old (CDC, 2021). Since a large portion of emerging adults in the US (69.1%) are enrolled in college institutions, college students are an important population to focus on in small-scale, pilot studies of electronic cigarette interventions, as these individuals may be a representative population of young adults in the US (Lanza et al., 2020). The importance of introducing interventions to this subpopulation is

further emphasized when considering the high rate of electronic cigarette use among college students.

Previous research on college campuses has reported various prevalence estimates of e-cigarette use. A large-scale study ($N$ = 3,572) in 2016 estimated 9.2% of college students used electronic cigarettes within the past 12 months (Grant et al., 2019). Another smaller-scale study from 2015-2016 ($N$ = 452) reported that almost 40% of college students had a lifetime use of electronic cigarettes (Lanza & Teeter, 2018). The latter study is consistent with other research estimating that around 40-50% of college students have tried electronic cigarettes (Holt et al., 2022; Wallace and Roche, 2018). Not only are prevalence estimates high, but they have increased over a relatively short period of time. From 2017 to 2019, Monitoring the Future (MFS), a national, longitudinal survey, reported a significant increase (6% to 22%) in past 30-day electronic cigarette use among college students (Schulenberg et al., 2020). In the general population of 19-30-year-olds, the lifetime prevalence of electronic cigarettes was 39% (Schulenberg et al., 2020). Despite varying estimates, emerging adulthood is associated with a high-risk period for addictive symptoms to appear (Grant et al., 2019). Therefore, it should be a research priority to implement and evaluate electronic cigarette cessation programs on college campuses. Accordingly, the current study seeks to understand the extent to which novel interventions such as mobile health technologies and positive psychology can help promote electronic cigarette cessation on a college campus.

Recent literature has highlighted the potential for, and interest in, offering electronic cigarette cessation interventions in the form of smartphone apps (Berg et al., 2021; Etter, 2019; Garey et al., 2021; Graham et al., 2020; Huma et al., 2022, Palmer et al., 2022). Although there are a number of currently available electronic cigarette cessation apps, many of them lack two

key elements: 1) behavioral change techniques and 2) research-based information content (Berg et al., 2021; Meacham et al., 2020; Sanchez et al., 2022).

To address this lack of evidence-informed interventions, the current study seeks to investigate the feasibility and acceptability of the Smiling Instead of Smoking (SiS) App with college students who wish to quit or reduce their electronic cigarette use. The SiS App is a positive psychology-based smartphone app originally built for nondaily cigarette smokers (Hoeppner et al., 2017; 2019). Examining SiS's functionality to support electronic cigarette cessation would broaden the research on potentially useful and accessible interventions for college electronic cigarette users. As such, research suggests tobacco-cessation programs often offer useful frameworks for electronic cigarette interventions (Sanchez, 2021). Additionally, investigating the SiS App's feasibility and acceptability will also contribute to understanding how positive psychology and the Social Cognitive Theory approach may be resourceful in modifying intermediate behaviors that sustain nicotine dependence.

In the next section, I will first outline the initial development and components of e-cigarettes (ECs), why ECs have become popular and used widely among young adults, current regulations for ECs, and health complications associated with EC use. Various barriers will be noted from previous research that highlights the challenges and obstacles in addressing the pervasive problem of EC use on college campuses, as well as theoretical models to understand such behavior. Next, I will review of existing EC cessation interventions and discuss the potential for mobile health technology to facilitate EC cessation. Finally, I will describe the behavioral conceptual framework of the SiS app based on positive psychotherapy and Social Cognitive Theory and my research questions and hypotheses about the effects of the SiS app with college students in this preliminary feasibility study.

# Background

## History and Overview of E-Cigarettes

In 2007, ECs were introduced into the US market (Grana et al., 2013; Park et al., 2022; USDHHS, 2020). These battery-powered, hand-held devices go by many different names such as Electronic Nicotine Delivery Systems (ENDS), vapes, e-cigs, e-hookah, etc. (CDC, 2022; Grana et al., 2013; USDHHS, 2020). The variety of names alludes to the diversity of EC designs and generations available. Across devices, EC devices consist of four main components: a mouthpiece, a liquid reservoir, a battery, and a heating element (CDC, 2021; Park et al., 2022). For consistency reasons, these devices will be referred to as EC throughout this paper, and using one of these devices will be referred to as vaping.

When the US patented ECs from the Chinese pharmacist Hon Lik, who invented the first model in 2003, ECs were characterized and marketed as a substitute or alternative to combustible cigarettes, primarily to facilitate cigarette smoking cessation (Grana et al., 2013; Park et al., 2022). Accordingly, first-generation EC models were similar to cigarettes (Grana et al., 2013; Grana et al., 2014; Park et al., 2022; USDHHS, 2020). As new modifications developed and transitioned into second, third, and fourth-generation categories (CDC, 2021; Walley et al., 2019), these devices were further distinguished as ‘vapes’ instead of cigarette substitutes. The original use of ECs to act as an alternative to cigarette smoking was further redirected as new flavor profiles were offered throughout the evolution of EC generations.

## Electronic-liquid (E-Liquid) Composition, Additives, and Puffing Behaviors

Around 7,000 - 15, 000 EC flavor profiles have been reported as available to the public (Lichtenberg, 2017; Walley et al., 2019). Notably, flavors consisted of ‘kid-friendly’ flavors of candies, fruit, and desserts (Lichtenberg, 2017). The flavor profiles of ECs are an important

aspect of these devices as they attract the attention of younger populations. Indeed, research on youth EC usage suggests that a large contributor to initiating EC was flavor curiosity (CDC, 2022), which will be discussed in a later section.

The ingredients and additives used in EC liquid (e-liquid) concentrate vary among different brands and types. Most commonly, the composition of e-liquid is a nicotine-based aerosol or EC vapor composed of flavoring agents, synthetic liquid substances, vegetable glycerin, and propylene glycol (Grana et al., 2013; Grana et al., 2014; USDHHS, 2020; Woodall et al., 2020). All these components have been linked to damaging the respiratory system (Woodall et al., 2020). Among the harmful additives in EC aerosol that have been identified, the most frequently reported are heavy metals (e.g., lead), ultrafine particles, volatile organic compounds, formaldehyde, and acetaldehyde (CDC, 2022, Grana et al., 2014; Seiler-Ramadas et al., 2021). Additionally, vitamin E acetate (VEA) is an e-liquid additive most associated with the outbreak of EVALI cases in 2019 (CDC, 2021).

Although research suggests that VEA is most commonly found in marijuana vapes (CDC, 2021), devices with just nicotine were not ruled out as contributors to EVALI, and other sources identify VEA in all ‘vape’ devices (CDC, 2021; Park et al., 2022). The distinction between cannabis and nicotine vapes is important to note since these are two different drugs that operate on different mechanisms of action within the body, affecting users in different ways. The CDC (2022) reports that 99% of ECs on the market contain nicotine. For this paper and the current study, ECs will only be referred to as devices that administer nicotine.

Devices vary in the amount of nicotine they deliver, possibly impacting the risk they pose for addiction (Grana et al., 2013). Often expressed in mg/ml, the amount of nicotine concentration in EC ranges from 0- 24-35 mg nicotine/mL (Grana et al., 2014; Walley et al.,

2019). Among hundreds of brand companies, the EC brand name JUUL was identified as delivering one of the highest nicotine concentrations to its consumers, having a nicotine concentration of 59 mg nicotine/mL (Hajek et al., 2020; Walley et al., 2019). This helps to explain its popularity among young adults, as JUUL accounted for around 75% of the US EC market in 2015 (CDC, 2022; Gaiha et al., 2022). Using nicotine salts vs free- base nicotine, JUUL products allow for more nicotine administration with less irritation and harshness (CDC, 2022; Gaiha et al., 2022; USDHHS, 2020). Other confounds that affect nicotine administration are users' puffing behavior or "topography" (St. Helen et al., 2018; Lee et al., 2019). Depending on users' topography, ECs may function differently and therefore affect users differently. For example, depending on the depth, duration, and frequency of inhalations, the composition of chemicals and metals found in the EC aerosol may vary based on these variables (Lee et al., 2019; Park et al., 2022). Thus, the user's puff topography has important implications for nicotine consumption, dependence, and possible health consequences.

Beyond different EC devices and user puff topography differences, levels of nicotine administration between ECs and combustible cigarettes have been researched and reveal conflicting results. For example, St. Helen et al. (2020) determined that ECs administer lower levels of nicotine while Wagener et al. (2017) found similar levels of nicotine delivered between third-generation ECs and combustible cigarettes. This may be attributed to different EC devices administering different levels of nicotine. Notably, newer generations of ECs tend to deliver more nicotine than past generations (Wagener et al., 2017). After examining prior research, Prochaska et al. (2022) found that one pod, specifically JUUL pod, is approximately equal to one pack or 20 combustible cigarettes. Overall, there is more potential for variability in nicotine consumption with ECs as compared to combustible cigarettes.

Additionally, another variable that seems to affect the comparability between ECs and combustible cigarettes is whether experienced or naive users are using ECs (Prochaska et al., 2022). This is because experienced users may inhale for longer leading to more nicotine administration and therefore more comparable amounts of nicotine being delivered as to combustible cigarettes (Prochaska et al., 2022). Determining whether users are naive or experienced users may therefore an important factor in understanding users' level of addiction.

**E-Cigarette Pharmacokinetics**

E-liquid is heated by the device and converted into an aerosol, administering nicotine quickly and efficiently into the lungs before being absorbed into the bloodstream and delivered to the brain (Park et al., 2022; USDHHS, 2020). Once in the bloodstream, nicotine attaches to nicotinic acetylcholine receptors (nAChRs) (Siqueira et al., 2017; USDHHS, 2020). The desensitization of these receptors in response to chronic stimulation/use may be responsible for the reinforcement and development of tolerance to nicotine (Siqueira et al., 2017; USDHHS, 2020). As these receptors are activated and subsequent ion channels are affected, nicotine is able to facilitate the release of other neurotransmitters including noradrenaline, serotonin, glutamate, and opioids (Siqueira et al., 2017; USDHHS, 2020). Most notably, dopamine is a key neurotransmitter released and plays an important role in reward-seeking behaviors and the risk of developing addictions (Siqueira et al., 2017).

As nicotine activates the mesocorticolimbic dopamine system, it subsequently transmits dopamine to other brain areas (Siqueira et al., 2017; USDHHS, 2020). Two important areas related to drug dependence and reward are a cortical area, the prefrontal cortex, and a limbic brain area, the nucleus accumbens (USDHHS, 2020). By targeting the mesolimbic dopamine system and increasing dopamine, nicotine elicits a drug-induced reward, thereby increasing the

risk of addiction (Siqueira et al., 2017; USDHHS, 2020). Finally, around two hours after the initial administration of nicotine is when it will reach its elimination half-life, or the time it takes for concentrations of nicotine to be reduced to half of its original dosage (USDHHS, 2020). This helps to explain why individuals dependent on nicotine seek more out relatively soon after just using it (USDHHS, 2020).

**Tobacco Companies' Influence, Regulations, and User 'Loopholes'**

Alongside many approaches and models, *the socioecological approach* has been offered as a way to interpret how EC use begins and why it is sustained (Berg et al., 2021; Bennett et al., 2022). The socioecological approach understands a person's behavior as a result of the dynamic reciprocity between individuals and their surrounding environment (Bennett et al., 2022). The factors outlined below, both external and internal factors, have important implications for understanding EC use within the context of young adults, helping to give insight and background into EC use behavior.

In 2015, the estimated amount of EC sales within the US was figured at 304.2 million dollars (Federal Trade Commission, 2022). In 2018, this estimate jumped to about 2.06 billion dollars (Federal Trade Commission, 2022). The drastic increase in sales within just these three years helps to demonstrate and emphasize the swift onset of the 'vaping epidemic'. Contributing to the rise in sales, advertisements from ECs have employed strategies similar to traditional tobacco companies such as utilizing social media and other social influences such as celebrities to attract younger populations (Grana et al., 2013; Grana et al., 2014; Lichtenberg, 2017; O'Connell & Kephart, 2022). ECs have helped to sustain tobacco companies' longevity, especially considering that popular EC brands are produced by tobacco companies (Walley et al., 2019).

As advertisements reflected marketing strategies for cigarette smoking, policy initiatives and regulations followed this same approach. In 2016, the U.S. Food and Drug Administration (FDA) initiated the first types of regulations around ECs by regulating them as tobacco products under the Tobacco Control Act (Lichtenberg, 2017; O'Connell & Kephart, 2022; USDHHS, 2020). States and different areas (e.g., localities and territories) may vary in the requirements adopted under this act, ranging from a ban on all tobacco products to very few restrictions on these products (USDHHS, 2020). Although age-limit laws were implemented to prevent young adults from purchasing EC, findings revealed that 70% of younger populations reported using someone else's EC device (O'Connell & Kephart, 2022). In 2020, flavor bans were instituted, restricting the sale of flavored pre-filled or cartridge-based ECs besides tobacco, mint, and menthol flavors (CDC, 2019; Gaiha et al., 2022). Yet, these flavoring restrictions did not pertain to all generations of ECs. Disposable ECs were left out, which partly led to a rise in youth interest in flavored, disposable ECs (Gaiha et al., 2022; O'Connell & Kephart, 2022). Although the FDA targeted companies and brands that were attracting the youths' interest (Gaiha et al., 2022), not extending regulations to all generations of EC likely explains why preferences for disposable ECs have risen recently among young adults. Indeed, a study conducted by the CDC on young adults EC behavior in 2022 found that more than half reported the use of disposable ECs (55.3%) whereas pod based, or refillable pods, were used by 25.2% (CDC, 2022). Thus, disposable ECs are now dominating the EC market, more so than JUUL or pod-based devices.

The national, longitudinal Population Assessment of Tobacco and Health (PATH) Study revealed insightful data on flavored ECs and their impact on young adults. Reporting on data from the 2018 PATH Study, Rostron et al. (2020) found that over 80% of a large sample ($N$ = 5,854) of emerging adults' first tobacco product was flavored compared to only 50% of adults ($N$

= 10,115). This stark difference helps to emphasize the impact flavoring has in appealing to young adults. Indeed, almost 90% of young adults in this study reported flavoring as a reason for using EC (Rostron et al., 2020). In contrast to young adults, research from adult populations illustrates that flavored ECs may be beneficial for combustible cigarette users using ECs to quit smoking (Etter & Eissenberg, 2015). Although the flavoring aspect of ECs impacts populations differently, the link between flavorings and the initiation of EC use among young adults is an important consideration for policy intervention as well as cessation interventions.

Smoke-free venues were set in many states in 2020 as research established EC aerosols may be a source of air pollution by emitting ultrafine particles into the environment, particles which have been linked to inflammation and cardiovascular disease (Grana et al., 2013; O'Connell & Kephart, 2022; Walley et al., 2019). Despite these regulations, around half of adult EC users report using ECs in prohibited areas (O'Connell & Kephart, 2022). Indeed, ECs are known for their concealability and sleekness which may contribute to the appeal of these products among young adults (Grana et al., 2014).

The regulations and policies mentioned above are in addition to retail licensure policies, taxation, and the FDA approval process. Notably, the recency of these regulations and the subsequent underdeveloped research about the policies' effectiveness limits a current and sufficient understanding of EC policies. Educational resources for younger populations about the harmfulness of ECs may be an important area to integrate into policy implementation as most youths may be uninformed about EC health consequences due to limited research and misleading marketing tactics (USDHHS, 2020).

**E-cigarettes: A Harm-Reduction Tool?**

Controversy over the health effects of ECs has been outlined in the literature, centering around whether ECs are 'better' than combustible cigarettes and if they are a valuable harm-reduction tool because they have the potential to reduce cigarette smoking. Despite the carcinogens and toxicants found in ECs, ECs have been proposed as *safer* alternatives when compared to cigarettes. As noted by the Surgeon General: "EC aerosol has been shown to contain markedly lower levels of harmful constituents than conventional cigarette smoke" (USDHHS, 2020, p.23). Additionally, the 2018 report by the National Academies of Sciences, Engineering, and Medicine (NASEM) on the public health implications of ECs determined that toxic substances found in ECs are substantially lower than the aerosol from combustible cigarettes (Stratton et al., 2018). The report weighs both the negative and positives associated with ECs, discussing their potential usefulness as a harm-reduction tool specifically for combustible cigarette smokers who are less willing to quit than their counterparts. Yet, NASEM also highlights the various concerns with promoting ECs as a harm-reduction tool: sustaining the use of nicotine, which has its own health consequences, the possibility of relapse to tobacco products, and continuing engagement with the tobacco industry (Stratton et al., 2018). After an extensive review of research and literature, NASEM determined that depending on the individual, EC use may cause harm for some but provide benefits (e.g., lowering cigarette use) among others.

In reviewing research examining ECs as a cessation intervention for cigarette smokers, Ghosh & Drummond (2017) came to several, non-linear conclusions. Randomized control trials (RCTs) overall showed that in comparison to nicotine replacement therapies (NRTs) as well as placebos, ECs do not fare better, or worse, in helping support smoking cessation (Ghosh & Drummond, 2017). Although they found studies supporting the association between using ECs

and quit attempts among combustible cigarette smokers, research revealed no associations between ECs and smoking cessation (Ghosh & Drummond, 2017). In all, the authors concluded that in the face of individuals attempting ECs for smoking cessation, it would be most beneficial to consider legitimately approved therapies such as NRTs and varenicline (Ghosh & Drummond, 2017).

When focusing on college students who use ECs, research has shown that around 40% of this population has not previously used combustible cigarettes (Jones et al., 2021). Therefore, viewing ECs as a harm-reduction tool may not apply to this population. Indeed, an examination of motivations for using ECs from seven college campuses revealed how ECs were rarely reported as a means for combustible cigarette cessation or reduction (Holt et al., 2020). Most contradictory to ECs' function as a harm reduction tool is the reported association between EC users and future willingness for trying combustible cigarette smoking among college students (Jones et al., 2021).

Within the general population of adult combustible cigarette users, Brouwer et al. (2020) found that adults who just used ECs were more likely to be using combustible cigarettes in the future compared to those who never used ECs (26% vs 1%). This was shown through a sophisticated model estimating the transition of stopping and using tobacco products and predicting future tobacco use called the Markov multistate transition model (Brouwer et al., 2020). Additionally, this study found that EC users were more likely to report a combustible cigarette relapse (Brouwer et al., 2020), which will be discussed more in the section below. Since ECs have been shown to facilitate combustible cigarette initiation and relapse, the FDA has not approved any EC for cigarette cessation (CDC, 2022). Despite this, tobacco companies have still

marketed ECs as such (Wagener et al., 2017) which highlights a consequence of continuing engagement with 'Big Tobacco' and illustrates the harmful role of EC advertisement.

**Perceived Health Threat**

Examining how individuals perceive a certain behavior and the subsequent outcomes of such is widely known to be connected to the likelihood of performing that behavior. For example, the *health belief model* (HBM) and *risk perception theory* are popular theoretical explanations for health-related behaviors, specifically highlighting the influence that people's beliefs, expectations, values, perceptions, and personality traits have on their following actions (Bennett et al., 2022; Glanz et al., 2017). Evaluating individual characteristics (i.e., self-efficacy) and the individual's level of risk and sense of security (Bennett et al., 2022; Glanz et al., 2017), may provide insight into EC initiation. Perceptions of the safety of ECs vary greatly among users and the general population, as mentioned above, further emphasizing why it is important to look at individuals' beliefs about such devices.

A longitudinal study conducted by Cooper et al. (2017) investigated how the perceived harm and addictiveness of ECs contributed to EC initiation. Data from over 5,000 college students showed that lower perceptions of risk and addictiveness of ECs were associated with EC initiation among non-cigarette smoking college students (Cooper et al., 2017). Yet, this population may not be using ECs for combustible cigarette cessation; therefore, the risks of ECs are not offset by the benefits of quitting combustible cigarettes as ECs still contain toxic and carcinogenic chemicals.

Research has also established the other side of this relationship in which both lower and higher perceptions of harm and addiction to ECs can affect EC use. Research has shown a positive and significant effect of knowledge on EC behavior (Cuccia et al., 2021; Jones et al.,

2021). Having a higher awareness of the negative health effects of ECs and a higher level of harm perception has been associated with abstaining and quitting ECs within the past year (Cuccia et al., 2021; Jones et al., 2021). Cuccia et al. (2021) examined factors that impact EC cessation and, using a multivariable regression model, revealed greater harm perceptions increased the odds of individuals' intentions to quit (Cuccia et al., 2021). Therefore, it is important to note that the perceived health threat of ECs may work in either direction; that is, it may be associated with more or less EC use, depending on the study and perceptions of the user.

Notably, the recent COVID-19 pandemic may have influenced perspectives of ECs' health threats. Indeed, research has shown EC users may be at a higher risk of COVID-19 diagnosis (Jones et al., 2021; Park et al., 2022). Bennett et al. (2022) posited that extensive media coverage concerning social distancing may have contributed to changes in EC use (Bennett et al., 2022) (Bennett et al., 2022). EC use may have been affected if, for example, individuals felt threatened by the risk COVID-19 posed to the respiratory system. Additionally, social distancing may have impeded EC use if individuals were more likely to use ECs in social scenarios. Indeed, a multivariable regression analysis model determined that greater perceived risks and general COVID-19 media exposure predicted EC cessation (Bennett et al., 2022). On the contrary, by using bivariate comparisons, Bennett et al. (2022) found that a lower perceived risk of ECs was significantly associated with those who initiated EC use during this time (Bennett et al., 2022). Therefore, media exposure (e.g., COVID news coverage) may be a specific mediating factor for influencing health perceptions.

**Actual Health Threat**

Although research is still evolving about the actual health threat ECs pose, recent studies have determined definite health complications from the toxicants, heavy metals, and carcinogens

found in EC aerosol. The most well-known health consequences of ECs are their impact on the pulmonary system since ECs' route of administration is inhalation. Park et al. (2022) comprehensively reviewed various reports and studies examining the health consequences of EC and found acute lung disease from EC use across various studies (e.g., pneumonia and bronchitis). EC use may lead to stress and inflammation of the lungs, causing other acute pulmonary issues such as shortness of breath, coughing, wheezing, and asthma (Seiler-Ramadas et al., 2021; Walley et al., 2019). Research also reports ECs' impact on the cardiovascular system: specifically, increases in heart rate, blood pressure, and chest pain, and increased risk for cardiovascular disease (Park et al., 2022; Seiler-Ramadas et al., 2021; Siqueira et al., 2017). In addition to the health concerns that the contaminants from ECs cause, nicotine on its own has specific health concerns for young adults compared to adults.

### *Nicotine and the Developing Brain*

Exposure to nicotine among young adults has specific health implications compared to adults. During this period of adolescence and young adulthood, critical brain areas are still undergoing development, and don’t reach maturity until around the mid-20s (CDC, 2022; Grant et al., 2019; Siqueira et al., 2017). Thus, this population is susceptible to developing nicotine addiction, which is often established during this period (Grant et al., 2019; Jones et al., 2021; Schulenberg et al., 2021; Walley et al., 2019). Research has reported that nicotine use during adolescence can affect brain areas, leading to changes in brain structures responsible for executive functioning and attention, learning and memory, motivation, aggression and impulsivity, and sleep (CDC, 2022; Seiler-Ramadas et al., 2021; Siqueira et al., 2017; Walley et al., 2019). Notably, these changes may not be reversible if nicotine use is continuous, leading to

permanent impairments of typical brain functioning (Grant et al., 2019; Schulenberg et al., 2021).

Nicotine's effect on young adults positions ECs on the side of harmful instead of beneficial. ECs' use as a harm-reduction tool for college students is further contradicted by research that shows ECs' strong ties in initiating combustible cigarette use and other drug use, which will be discussed below. As such, the importance of delivering available EC cessation programs to young adults should be a high priority for public health and addiction researchers.

## Nicotine, Poly-Substance Use, and Mental Health Consequences

The time between adolescence and adulthood is a transition often characterized by different life expectancies with increased responsibility and stressful circumstances. As such, this period of young adulthood is the age range when individuals are most vulnerable to developing substance use disorders. Indeed, it is well-known that the developmental period of emerging adulthood is linked to susceptibility to initiating various substance use (Grant et al., 2019; Lanza et al., 2020). Notably, college campuses create environments that increase exposure to substance use and peer influences.

### *Electronic Cigarettes & Polysubstance Use*

Among students who have reported EC, research has shown that this population is more likely to use substances, including a greater likelihood of problematic alcohol and illicit drug use (Grant et al., 2019). Lanza et al. (2020) conducted a more recent study investigating co-occurring substance use patterns by using a latent class analysis and found four classes: binge drinking, cannabis use, cigarette smoking, and EC use. Among these classes, EC users were the class with the most co-occurring substance use (Lanza et al., 2020). Additionally, Walley et al. (2019) determined that EC use was associated with subsequent use of all substances assessed (i.e.,

alcohol, marijuana, non-prescribed Ritalin/Adderall, hallucinogens, and cocaine) from data within the large-scale, longitudinal PATH study. The trajectory of using one drug to multiple is defined within the *Gateway Hypothesis*, proposed by Denise Kandel, and described as "a well-defined developmental sequence of drug use that starts with a legal drug and proceeds to illegal drugs" (Kandel & Kandel, 2014, p. 932). Thus, promoting EC cessation may help to interrupt the progression to other substance use triggered by accessible substances like nicotine.

Notably, and most contradictory to the selling point of ECs that portrays them as a cessation aid, research has reported a significant association between EC use and the initiation of cigarette use (Brouwer et al., 2020; Grana et al., 2014; Lanza et al., 2020). Research that evaluated data from the 2018 PATH Study identified that after a one-year follow-up, youth who had ever used ECs were at 1.87 higher odds (or almost twice as high) of reporting cigarette use within the past 30 days compared to those who were not EC users (Walley et al., 2019). Berry et al. (2019) also examined data from the PATH study, utilizing multivariable logistic regression analyses, and found that prior history of EC use had over 4 times higher odds of cigarette initiation than those who never used an EC or tobacco product. The most drastic association found that exclusive EC users were 20 times more likely to report combustible cigarette use than non-EC users (Brouwer et al., 2020). As research established this association between EC use and cigarette use, it would be ideal to have cessation interventions that address both health behaviors.

### *Electronic Cigarettes & Mental Health*

EC use also may severely and negatively impact young adults' mental health. One of the largest national surveys of the Behavioral Risk Factor Surveillance System with around 900,000 adults in the US found that compared to never-users, current EC users were at 2.10 times higher

odds of having a diagnosis of depression (Obisesan et al., 2019). Furthermore, this same study found higher odds of experiencing depression with a reported increase in the frequency of EC use (Obisesan et al., 2019). Interestingly, Jones et al. (2021) found a significant difference between depression scores among those who have never used ECs and those who use ECs on some days by a one-way between-group ANOVA. Yet, there was no significant difference between the depression scores of everyday users and never users (Jones et al., 2021). Thus, it is important to acknowledge how the frequency of use may not only impact the development of nicotine dependence but may also influence the mental health of EC users. Additional studies have not found significant associations between EC use and depressive symptoms (Lanza et al., 2020; Grant et al., 2019). This may be due to the socialization factor of ECs, as facilitating socialization is identified as a motivator for using ECs (Bennett et al., 2022; Berg et al., 2018**;** Lanza et al., 2020). ECs in some social contexts may be viewed as prosocial behavior, allowing individuals who begin using EC to enter new social scenes endorsing such behavior.

Grant et al. (2019) conducted a study on more than 3,000 college students and found that EC use was significantly associated with a higher probability of being diagnosed with post-traumatic stress disorder (PTSD), attention-deficit/hyperactivity disorder (ADHD), anxiety, and impulsivity. Although there was no significant association between EC use and depression, EC users had significantly lower self-esteem (Grant et al., 2019). Despite mixed results on EC use and depression, EC use has consistently shown associations with displaying or being diagnosed with psychiatric conditions.

In contrast to negative mental health effects, nicotine users have self-reported fewer negative emotions (e.g., pain and anxiety) and more positive emotions (e.g., euphoria, increased attention and alertness, improved memory and learning) following the administration of nicotine

(Siqueira et al., 2017). Despite these subjective reports from the previous literature and research presented above, there is a clear association between worsening mental health conditions and nicotine use. Thus, EC cessation interventions may help to reduce associated mental health issues as a result of EC use or prevent the exacerbation of pre-existing mental health conditions.

The sections above illustrate the current research on the health effects of ECs as well as perceptions surrounding these devices from both established institutions as well as from users themselves. In the next section, I provide an overview of why combustible cigarette smoking programs may be leveraged for EC cessation as well as promoted through the *Social Cognitive Theory* and mobile health technologies. This will lead to the current study focusing on using the Smiling Instead of Smoking (SiS) App for college students looking to quit or reduce their EC use.

## Attitudes About E-Cigarette Cessation

Although the prevalence rates for EC use are concerning, research examining intentions to quit ECs among young adults reveals that around 50% report plans to stop (Palmer et al., 2022; Cuccia et al., 2021). Additional research has shown approximately 50% of young adults have made one or more serious quit attempts (Garey et al., 2021). These results help to illustrate how students may react to offered support to quit, helping to give insight into the amount of interest for such support.

### *Potential Use of Cigarette Cessation Interventions for E-Cigarette Cessation*

Combustible cigarettes and ECs both sustain users through nicotine dependence by the same method of consumption: smoking. Due to the chemical and behavioral similarities, it is fruitful to explore how transferable tobacco cessation programs are for EC cessation, especially in the face of limited, underdeveloped research on EC interventions. EC cessation programs tend

to encompass a broad framework from tobacco cessation interventions as tobacco cessation programs have been around for longer (Graham et al., 2020; Sanchez et al., 2021). Yet, research on the direct application of tobacco cessation programs for EC cessation is limited despite its potential utility. Notably, there exists research on young adults' perspectives on the similarities and differences between these behaviors, suggesting how tobacco cessation may be leveraged for EC cessation.

Sanchez et al. (2021) conducted small focus groups ($N$ = 41) to better understand how young adults perceive the similarities and differences between combustible cigarettes and ECs. In comparing the two, socialization was a common theme in sustaining both behaviors, facilitating and maintaining connections with other users (Sanchez et al. 2021). Additionally, young adults viewed both behaviors as ways to reduce stress, especially when studying (Sanchez et al. 2021). Finally, individuals reported similar sensation rewards (i.e., “head rush”, burning sensation, calming) and behavioral rewards (i.e., oral fixation) between both ECs and combustible cigarettes, highlighting related “sensory and behavioral gratification” (Sanchez et al. 2021).

In addition to barriers to quitting, similar motivations for quitting among the two behaviors were identified. The most common perceived similarity in motivating quit attempts among both types of users was the perceived level of addiction evoked by feelings of craving, dependence, and withdrawal (Sanchez et al. 2021). Seemingly, young adults did not want to feel trapped by their nicotine dependence and addiction anymore. In line with this, research investigating reasons for quitting just among young adult EC users ($N$ = 1000) found that around 50% wished to quit due to health reasons, wanting to improve their well-being (Amato et al., 2021). Finally, the financial burden and continuing engagement with the tobacco industry were

perceived as similar motivators to quit ECs and combustible cigarettes for young adults (Sanchez et al. 2021). Taking into consideration these similarities, interventions focused on identifying and preparing for craving triggers as well as focusing on how quitting can, overall, improve health outcomes and life goals for combustible cigarettes may also help EC users.

Despite these similarities, research has also identified some key differences in barriers to cessation for ECs and combustible cigarettes. Unique to ECs were 1) the appeal of flavors ECs maintaining use, 2) the concealability and discreteness of using ECs as opposed to cigarettes (i.e., no smell, not having to go outside), and 3) not noticing how often they are using their EC device or how much (Sanchez et al. 2021). Additionally, differences in reasons for quitting were identified as well. One such difference that motivated users to quit ECs, but not cigarettes, is having an insufficient amount of information about, for example, the health effects of ECs as compared to the information available on cigarettes (Sanchez et al. 2021). Another difference in reasons to quit was the higher level of perceived social acceptability of ECs compared to smoking (Sanchez et al. 2021). Indeed, cigarettes seem to have more disapproval among young adults compared to ECs (Sanchez et al. 2021). These distinctive features of ECs in comparison to cigarettes are noteworthy as tobacco interventions may not sufficiently address these aspects of ECs.

Further exploration into the feasibility of adapting tobacco cessation programs for EC cessation is needed to determine if these behaviors can be targeted using similar tools or if there warrants a complete separation of the interventions. If cigarette cessation programs do not show promise as EC cessation tools, there should be more of an impetus for specifically tailored EC cessation programs.

**Gaps in E-Cigarette Cessation Interventions**

Since ECs are relatively new to the market, research is still developing around effective cessation programs. Extant research suggests that the current cessation programs not only are limited in number but also do not use a theoretical framework to ground their treatments (Berg et al., 2021; Liu et al., 2020; Palmer et al., 2022). Research also highlights that specifically tailored EC interventions are often focused on prevention, not treatment (Sanchez et al., 2021).

Another challenge is getting young adults to seek out such interventions. Young adults do not seem to capitalize on the available intervention programs offered, often reporting going "cold turkey" or unassisted (Berg et al., 2021; Sanchez et al., 2021; Kong et al., 2021; Palmer et al., 2022). Therefore, administering interventions in a suitable form for this specific population is instrumental in addressing this gap in accessing resources to quit.

**Mobile-Health Technologies and E-Cigarette Cessation**

In response to the need to support research on EC cessation programs, as outlined in the US Surgeon General's Report (USDHHS, 2020), recent research indicates that Mobile Health (mHealth) technology is a promising tool to help address EC use among young adults (Berg, 2021; Huma et al., 2022; Sanchez et al., 2022). Telehealth and mHealth do not require the available time or resources (e.g., transportation, healthcare, cost) necessary for in-person counseling, offering real-time support (Sanchez et al., 2022). Notably, mobile health phones are ubiquitous among college students and young adults, with 99% of US young adults owning such devices (Graham et al., 2020). Due to their accessibility as well as time and cost-effectiveness, smartphone apps serve as important resources to help bridge the gap between cessation tools and young adult EC users looking to quit. Unfortunately, research has found that apps have not been leveraged productively, promoting EC use instead of cessation. Recent research reviewing the

available EC smartphone apps outlines several shortcomings of the available apps offered for EC cessation.

**Gaps in E-Cigarette mHealth Technology**

Meacham et al. (2020) examined the current 'vaping-related apps" within Google Play Store in December 2019 (keywords: *vape* and *vaping*). 79 out of the first 100 apps from Meacham et al., (2020) search query were related to ECs and were included for further analysis. 15 out of the excluded 21 apps did not apply to ECs but were found to only be specifically related to combustible cigarettes (Meacham et al., 2020). Therefore, EC users looking for apps about ECs are often met with cigarette apps. Of the 79 apps, only 2 (3%) were built for quitting ECs (Meacham et al., 2020). Out of the apps that did pertain to ECs, the majority (87%) were designed to support the use of ECs (i.e., how-tos on creating e-liquids, shopping, etc.) (Meacham et al., 2020; Sanchez et al., 2022). Researching the effectiveness of current combustible cigarette cessation programs for EC cessation can help address this lack of smartphone apps specifically tailored for EC cessation, leveraging resources that are currently available.

Sanchez et al. (2022) also conducted a review of free smartphone apps available during 2020 within both Apple and Google Play Store (keywords: *vaping, vaping cessation, quit vaping, stop vaping,* and *no vaping*). This search also yielded a small number of free and available smartphone apps, 8 out of the initial 186 Apple Store apps and 601 Google Play Store apps, that were specific to EC cessation (Sanchez et al., 2022). Notably, Apple removed 181 apps related to ECs from its store, all directed toward promoting the use of ECs in response to the EVALI outbreak (Fried & Allen, 2019; Meacham et al., 2020) which explains this large difference in EC apps found between Apple and Google. Out of the 8 apps identified, only one was tested through an efficacy trial with a corresponding published paper (Sanchez et al., 2022). This finding is

similar to the research reviewing smartphone apps for combustible cigarette cessation in which out of the top 50 smoking cessation apps identified, only six apps had empirical evidence to support their effectiveness in providing cessation support and only two apps were easily identifiable (Haskins et al., 2017b). The scarcity of EC cessation apps as well as the research on empirically evaluating apps' effectiveness warrants a better understanding of current, evidence-based apps that may offer resourceful tools for EC users looking to quit.

Another well-researched variation of mHealth besides smartphone apps are text-messaging programs. Although smartphone apps offer more engaging and interactive content and activities (Hoeppner et al., 2017), recent research on mHealth for EC cessation is largely focused on this popularized mode for delivering EC cessation programs (Berg et al., 2021; Calabro et al., 2019; Graham al., 2021; Liu et al., 2020). A frequently cited EC cessation program specifically for young adults is a text-messaging program, *This is Quitting*, which uses a well-established theoretical framework: *Social Cognitive Theory (SCT)*.

**Social Cognitive Theory**

SCT was first proposed by Albert Bandura in the 1970s (Luszczynska & Schwarzer, 2015). The primary use of SCT, as described by Bandura (1998), focuses on changing health behaviors and individuals' personal control over their well-being in the context of social and environmental influences: "This approach addresses the social structural determinants of health as well as the personal determinants" (Bandura, 1998, p. 624). To understand the factors that influence health behavior and habits, personal factors (e.g., cognitions, thoughts, and learned experiences), environmental factors (e.g., peers, school, marketing influence, policies), and behavior (e.g., EC initiation) are examined under a reciprocal interaction (Bandura, 1998). Bandura (1998) posits that by taking into account these determinants and not just focusing on

changing the habits of an individual, personal change may be promoted. As such, SCT has been long applied to smoking cessation (Bandura et al., 1998).

Studies ranging from using ecological momentary assessment (EMA) study designs (Van Zundert et al., 2009), cross-sectional analyses (Gottlieb et al. 1990), and follow-up assessments at different time points (Bricker et al., 2010; Dijkstra et al., 1999; Zheng et al., 2007) have investigated the utility of SCT to help combustible cigarette smokers quit. Although each of the studies examined different outcome variables related to SCT such as intention to change, self-efficacy, and outcome expectancies or the perceived pros and cons of smoking (defined below), outcome variables are always centered within the triadic relationship of personal (i.e., cognitive factors; stress levels), environmental (i.e., stimulus triggers), and social factors. Notably, the first specifically tailored and empirically tested EC cessation program for young adults uses this theory (Graham et al. 2020).

Facilitated by the Truth Initiative, Graham et al. (2021) built a text-messaging program for EC cessation utilizing SCT. Graham et al. (2021) describe how one's behavior is positioned within the context of the individual's cognitive thought processes (internal factors such as perceived self-efficacy) and social environment (external factors such as peers) through an SCT lens. These internal and external factors work to influence outcome expectations and motivations for individuals, which are constructs of SCT (Graham et al., 2021). Compared to the control participants who had abstinence rates of 18.6%, participants who used *TIQ* had abstinence rates of 24.1%. Thus, SCT frameworks show promise for not only cigarette cessation, but for EC cessation as well.

*Outcome expectations* or the predicted estimations in which a specific behavior will lead to a specific outcome may be positive (e.g., using ECs will give me an enjoyable buzz) or

negative (e.g., using ECs will be detrimental to my health) (Bandura, 1998; Berg et al., 2021). These perceptions have been shown to influence the performance or likelihood of a behavior to occur (Bandura, 1998; Berg et al., 2021). This aligns with the HBM, mentioned above.

Other personal factors identified to support EC cessation using SCT's model for behavioral change include perceived risks of ECs, or knowledge of such, and the set of skills an individual has to perform a behavior, also known as behavioral capability (Berg et al., 2021). Additionally, a fundamental construct of SCT focuses on individuals' self-efficacy.

### *Self-Efficacy*

Self-efficacy refers to an individual's confidence or belief in their ability to perform a behavior or achieve a goal (Bandura, 1997; Hyde et al., 2008). It differs from outcome expectations as it pertains more to personal control and agency (Schwarzer & Fuchs, 1996). As defined by Bandura (1997), perceived self-efficacy "refers to beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (p. 3). It has been related to the amount of effort one is willing to exert when challenges present themselves (Hyde et al., 2008). Self-efficacy works by influencing one's actions because it is related to "self-related cognitions", which impact an individual's level of motivation for enacting behavioral change (Luszczynska & Schwarzer, 2015, p. 226). From this, Bandura (1997) explains that individuals who believe they can achieve their goals, or those with high self-efficacy, are more successful, effective, and healthier. Thus, those with higher self-efficacy may be more confident, willing to commit, and be successful in changing behavior (e.g., stopping EC use). If there is a high degree of perceived ability to pursue and complete an action, it has been shown that individuals will set higher goals for themselves and be more likely to stick to them (Locke & Latham, 1991). Thus, it is easy to see why self-efficacy's role in impacting health

behaviors has been widely examined and why interventions to change health behaviors often target this construct.

### *Self-Efficacy and Combustible Cigarette Cessation*

The meta-analysis on the role of self-efficacy and smoking cessation reveals research dating back to the 1980s on the strong association between these two variables (Gwaltney et al., 2009). From the self-efficacy theory, Gwaltney et al. (2002) identify how self-efficacy not only predicts relapses but also the specific situations in which individuals may relapse. Methods for cigarette users to cope in high-risk situations become difficult to engage in with low self-efficacy (Gwaltney et al., 2009). Therefore, it would be advantageous for users attempting to quit to identify high-risk situations that are specific and context-based in which they would be attempted to smoke again (Gwaltney et al., 2002).

Additionally, self-efficacy has been described as a dynamic state under the social-learning relapse model (Hoeppner et al., 2014). Internal and external environments change within a relatively short period, impacting self-efficacy and the following behavior (Hoeppner et al., 2014). For example, external situations such as preparing to quit and internal situations such as the feelings of negative or positive affect have been shown to influence momentary self-efficacy (Hoeppner et al., 2014). Since self-efficacy is impacted by such events, the theorized mechanism of change to promote cessation among smokers is therefore to address situations that could lead to changes in self-efficacy before a quit attempt has even began (Hoeppner et al., 2014). Several other studies have also determined that self-efficacy can anticipate engagement and continuation of abstinence from smoking and predict relapse occurrences (DiClemente, 1981; Gwaltney et al., 2002; Hyde et al., 2008). Looking specifically at college students ($N$ = 161), Von Ah et al. (2004) found that self-efficacy significantly predicted smoking behavior.

In addition to relating to behavioral outcomes, self-efficacy in terms of smoking behaviors has been linked to craving levels, with lower self-efficacy being moderately associated with higher cravings (Gwaltney et al., 2002). With lower amounts of perceived control, automatic thoughts and feelings such as cravings would be harder to moderate. Additionally, Hoeppner et al. (2014) found a negative association between nicotine withdrawal and self-efficacy: as self-efficacy increases, withdrawal symptoms decrease. The various meditating variables that influence self-efficacy and the intricate consequences self-efficacy has on behavior and internal factors emphasize its nuanced role in smoking cessation.

### *Self-Efficacy and Electronic Cigarette Cessation*

Research on self-efficacy has been studied under the context of many addictive behaviors due to its role in affecting individuals' perceived control and subsequent behavior (Hyde et al., 2008). Now, the function of self-efficacy is being studied and incorporated into EC cessation programs (Graham et al., 2020; Krishnan et al., 2022). Krishnan et al. (2022) evaluated specific constructs of SCT and their relationship with EC quit attempts. Through a binary logistic regression model, the study found that greater self-efficacy was a predictor of quit attempts among a relatively large sample size (Krishnan et al., 2022). Additionally, Jones et al. (2021) found a significant association between both low and high self-efficacy and subsequent EC use in a population of more than 800 college students. A one-way between-group ANOVA analysis confirmed an association between high self-efficacy, as measured by the General Self-Efficacy (GSE) Scale, and less frequent EC use (Jones et al., 2021). Additionally, the inverse was found in which low self-efficacy with increased frequency of EC use (Jones et al., 2021). Targeting self-efficacy should therefore be further explored in the context of helping EC users quit.

### *Self-Efficacy and Positive Affect in E-Cigarette Cessation*

An important component to understanding how self-efficacy can be leveraged in smoking cessation is positive affect: “Positive mood enhances self-efficacy” (Bandura, 1998, p. 626). Indeed, mood has been identified as a possible mediating variable between cognitions related to self-efficacy and behavioral change (Hyde et al., 2008). Research that examined correlates of smoking cessation self-efficacy found that low affect had significantly impacted participants' self-efficacy (Martinez et al., 2010). Similarly, in a sample of adolescents, Hoeppner et al. (2014) showed that positive affect, or more specifically ‘low activation positive states’ such as calm and relaxed mood states were significantly related to self-efficacy for quitting smoking. This research also provided evidence of the relationship between self-efficacy and negative affect: self-efficacy decreases, and negative affect, as well as craving, increases (Hoeppner et al. 2014).

Although Bandura (1997) suggests a causal relationship between self-efficacy and behavioral change, focusing on the broader context of positive affect’s role in influencing self-efficacy and behavioral change can be more advantageous than just focusing on improving self-efficacy. This can be attributed to research showing how self-efficacy is highly context-specific to individuals and their specific challenges, as mentioned above (Gwaltney et al., 2002). Thus, for intervention programs, bolstering positive mood can offer a broader model to effect self-efficacy and ultimately cessation.

**Positive Psychology: History and Research**

Positive psychology was first outlined by Seligman and Csikszentmihalyi (2000) as a science motivated to understand factors that allow individuals and communities to prosper, increasing the quality of life. Seligman advocated for going beyond the focus of alleviating suffering and pathology to looking at how individuals may flourish (Krentzman, 2013). Positive psychotherapy, as described by Seligman et al. (2006), differs from other interventions that

primarily focus on addressing depressive symptoms. Positive psychotherapy focuses on bolstering positive emotions, feeling of meaning and enhancing motivation and engagement instead of just returning to a normal state (Seligman et al., 2006). Notably, positive psychology did not come up with the idea of promoting resilience, growth, and personal strengths, but was the first field to comprehensively put these ideas together (Krentzman, 2013). Despite critiques surrounding positive psychology's rigor as a legitimate science and neglect of complex, harsh life experiences, examining how one can facilitate health, happiness, and wellness is important to research (Krentzman, 2013).

Positive psychology interventions typically look to measure improvements in positive feelings, behaviors, and/or cognitions (Krentzman, 2013). Self-administered, and brief, exercises that focus on improving such areas have been defined as a type of intervention under positive psychology called 'positive activity interventions' (Krentzman, 2013). These exercises may also endorse practicing kindness and mindfulness to promote positive feelings (Krentzman, 2013).

To test the theoretical approach, Seligman et al. (2006) delivered positive psychotherapy via different types of positive activity interventions. For example, an activity called *Three Good Things/Blessings* instructed participants to list three good things that happened to them, and an activity called *Savoring* asked participants to pause for a moment to enjoy the activity they were doing and reflect on it (write it down) (Seligman et al., 2006). Compared to the control group, these exercises had drastically decreased depression symptoms over a relatively short period of time, and effects were seen throughout a one-year follow-up (Seligman et al., 2006). In addition to their effectiveness, such exercises are time and resource efficient as they are self-administered (Seligman et al., 2006). The *Counting Blessings* exercise has also shown significant results for early adolescents in increasing well-being and gratitude and in decreasing negative affect (Froh

et al., 2008). This is a notable observation as the appropriateness of asking adolescents to engage in such introspective activities has been criticized since they may have fewer experiences and cognitive capacity to recount such moments (Krentzman, 2013).

Sin and Lyubomirsky (2009) later conducted an analysis of positive psychology interventions, including 51 studies and over 4,000 participants. Within this paper, positive psychology interventions were defined as "treatment methods or intentional activities that aim to cultivate positive feelings, behaviors, or cognitions" (Sin & Lyubomirsky, 2009, p. 468). The meta-analysis found that positive psychology interventions (i.e., gratitude exercise, kindness exercises, mindfulness, etc.) administered to both depressed and healthy individuals significantly increased well-being ($r$ = .29) and decreased depression symptoms ($r$ = .31) vs comparison groups.

**Positive Psychology for Smoking Cessation**

Applying positive psychotherapy to smoking cessation, Kahler et al. (2014) had demonstrated its usefulness in helping combustible cigarette smokers stay abstinent. The study had also empirically tested a set of positive psychotherapy exercises specifically tailored to smoking cessation. Although this study had a small sample size ($n$ = 19), around one-third of participants were smoke-free through six months of follow-up (Kahler et al., 2014). Additional research with a larger sample size and a comparison group of 'standard smoking cessation treatment' further validated positive psychotherapy for smoking cessation's usefulness (Kahler et al., 2015). Participants were taught exercises such as *Three Good Things, and Savoring*, as well as exercises around gratitude, exercises that draw upon participants' personal strengths, and using individualized strategies (Kahler et al., 2015). Compared to standard treatment, positive psychotherapy yielded higher smoking abstinence rates (Kahler et al., 2015).

Improvements in abstinence rates from positive psychology interventions can be illustrated by describing past research that investigates the role of positive emotions in influencing cognitions. Indeed, affect has been widely studied within the context of influencing individuals' cognitions and behaviors (Aspinwall, 1998). Specifically, Das et al. (2012) demonstrated the role of positive mood in helping smokers process and accept relevant health information and recommendations. Das et al. (2012) mention factors such as self-regulation and attention (e.g., focus on long-term goals) in which positive mood has been shown to improve, helping to explain this interaction in decreasing defensiveness in hearing health-threatening information. Another explanation for how positive affect can impact individuals' thought processes and behavior outcomes is partly demonstrated by the research showing that with increased positive mood, more creative and adaptive judgments can be facilitated (Aspinwall, 1998). Positive affect can thus help elicit broader cognitions about one's environment (Aspinwall, 1998).

***Broaden-and-Build Theory***

Positive emotions' influence on cognition has been researched by a highly cited article by Fredrickson (2001) who posited a theory called the *broaden-and-build theory*. This theory explains how positive emotions promote individuals to capitalize on their personal resources or strengths, and "broaden people's momentary thought-action repertoires" (Fredrickson, 2001, p. 11). Fredrickson (2001) describes the process of how negative emotions mainstream thoughts and decisions in order to make quick judgments, which is an adaptive behavior. This juxtaposes with how positive emotions are often elicited in non-life-threatening circumstances allowing individuals to expend more time, attention, and energy to think of new ideas and a broader array of actions (Fredrickson, 2001). Fredrickson (2001) gives examples of emotions that elicit such

movement to broader thought-action repertoires: interest, a type of positive emotion, for example, promotes more ability to explore and expand knowledge and action. Fredrickson (2001) accounts for research validating the relationship between positive affect broadening cognitions/attention and negative affect limiting such. Once acquiring unique, creative thoughts and ideas elicited by positive emotions, individuals can utilize such newfound resources later in life, continuing to build upon new repertoires (Fredrickson, 2001). Taken together, positive psychology interventions would seem to hold promise for promoting EC cessation and have already shown preliminary efficacy in promoting combustible cessation.

**Smiling Instead of Smoking (SiS) App**

Inspired by the previous work on positive psychotherapy for smoking cessation, Hoeppner et al. (2017) created an app compatible with younger adults who are non-daily smokers, centering around bolstering positive mood: “The pursuit of happiness is generally appealing and non-stigmatizing and thus might overcome treatment resistance” (Hoeppner et al., 2019, p. 2). Additionally, tobacco cessation programs are largely founded on preventing daily smoking habits, which differ from non-daily smoking, a behavior that is becoming more and more prevalent (Hoeppner et al., 2017).

During the development phase of the SiS app, a pilot study ($N$ = 38) was conducted to assess challenges and perceptions of smoking cessation among young adult non-daily smokers (Hoeppner et al., 2017). Notably, almost all the participants (97%) could note specific times that they may struggle to remain abstinent (Hoeppner et al., 2017). Another 87% of participants were able to come up with context-related strategies for themselves (Hoeppner et al., 2017). Thus, notifying smokers during challenging times of their personalized strategies was a feature developed within the app (Hoeppner et al., 2017). Since participants did seem to not capitalize on

social support (57%) in comparison to the extent they reported it to be helpful (84%), the app offered suggestions on how to seek and receive such support (Hoeppner et al., 2017). In addition to other tools within the app (scheduling a quit day, entering personal reasons, identifying challenging times and helpful strategies, etc.), the app assigns one of three positive psychology exercises every day: *Three Good Things, Savoring,* and *Experiencing Kindness* (Hoeppner et al., 2017); these exercises have been empirically tested by Seligman et al. (2006), Lyubomirsky et al. (2005), and Otake et al. (2006) to promote happiness. In all, the SiS1 app was centered around interactive, behavioral coaching and happiness features, exercises, and benefits of quitting information.

### *Version One of the SiS App*

A single-group pilot study was later conducted to test the feasibility of the first version of the SiS app among nondaily smokers ($n$ = 30), where participants were instructed to use the app for three weeks (Hoeppner et al., 2019). As shown by Strong et al. (2009) and Strong et al. (2011), positive affect declines prior to quit days. Therefore, Hoeppner et al. (2019) proposed that by engaging in positive psychology exercise one week before participants' quit date, this effect would be counteracted. Based on the research summarizing the positive affect's effect on self-efficacy, as described above (Hoeppner et al., 2014), they also hypothesized that self-efficacy would increase when engaging in the exercises, thereby reducing the temptation to smoke. Lastly, based on results from Fredrickson (2001), as described above, Hoeppner et al. (2019) hypothesized that engaging in positive psychology exercises would increase participants' reservoir of thoughts and behaviors or their 'thought-action repertoire'. Version one of the SiS app showed positive results: participants reported greater confidence to quit and to stay quit and less temptation to use cigarettes (e.g., having fewer positive expectancies if they were to smoke)

(Hoeppner et al. 2019). Almost all (90%) of the participants stated the app helped them during their quit attempt and their confidence (80%) to quit (Hoeppner et al. 2019). Importantly, the positive-psychology exercises were rated favorably and were easy to use (Hoeppner et al. 2019). After the prescribed app usage, 30% of participants were biochemically confirmed to be smoke-free, and at the 6-month follow-up, 53% of participants self-reported abstinence (Hoeppner et al. 2019).

***Version Two of the SiS App***

In developing a second version of the app, a larger single-group study ($N$ = 100) asked participants to use the SiS app for 7 weeks (Hoeppner et al. 2021) while attempting to quit smoking. In refining the app from the results of study one, design features as well as different cessation tools were incorporated into the app. For example, two happiness exercises were added called *Rose, Thorn, and Bud* and *Reliving Happy Moments* in addition to *3 Good Things, Savoring, and Experiencing Kindness*. Similar hypotheses to study one were examined (i.e., within-person changes in self-efficacy, desire to smoke, etc.) (Hoeppner et al. 2021). Such exercises were assigned every day in addition to behavioral tasks (tracking the number of cigarettes smoked, logging reasons as to why smoking occurred, smoke alarms to remind users not to smoke, listing personal reasons to not smoke, etc.) (Hoeppner et al. 2021). Additionally, push notifications were used to remind participants to complete behavioral challenges and look at *Owl Wisdoms,* which are scientifically supported information about how happiness can improve health and well-being and help with smoking cessation (Hoeppner et al. 2021). A game feature called *Magma Bear* and a reward system in which points were given to users for completing certain tasks were also incorporated (Hoeppner et al. 2021). Finally, the recruitment process differed in that participants were onboarded remotely instead of in-person (Hoeppner et

al. 2021). Similar hypotheses and objectives were examined in the first study on SiS as in this one; within in-person changes were hypothesized to show an increase in abstinence self-efficacy, a decrease in the temptation to smoke, an increased ability to process self-relevant health information, and no observed changes in positive affect (Hoeppner et al. 2021). Additionally, measures assessing the app's acceptability among participants were included. Expected changes were partially observed; a significant increase in self-efficacy, a significant decrease in desire to smoke, and perceived pros of smoking were found, and positive affect levels remained consistent throughout participants' quit attempts (Hoeppner et al. 2021). Yet, motivation to be abstinent and participants perceived importance of the positives of quitting decreased from baseline levels. In terms of acceptability, participants reported that app features were very easy to use and scored its usability within an A range (Hoeppner et al. 2021). At the end of treatment, or 6 weeks after participants quit day, 40% of participants self-reported abstinence.

### *Version Three of the SiS App*

The third version of the SiS app is currently being evaluated in a randomized control trial, with participants using either the SiS app, the National Cancer Institute app called *QuitGuide*, or the National Cancer Institute smoking cessation pamphlet called *Clearing the Air* (Hoeppner et al., 2023). The same treatment length was used as in the second version of the SiS app, but with a larger sample size ($N$ = 225), 75 of which were assigned to the SiS app (Hoeppner et al., 2023). Additionally, the app's way of organizing and assigning happiness and behavioral challenges was adjusted to promote more engagement and variety within the app (Hoeppner et al., 2023). Main outcomes of this study are forthcoming (Hoeppner et al., 2023).

## Current Study and Hypotheses

In order to advance research on understanding the usability of cigarette cessation programs centered around positive psychology and mHealth technology interventions, this current study recruited college EC users to use the SiS app for three weeks: one week before their quit day, and two weeks after. Based on previous research on SCT, positive psychology, and studies on the SiS app before and after a quit attempt, I proposed the following hypotheses:

1. Participants will report decreases in their vaping, vaping dependence symptoms, and craving for vaping from pre- to post-assessments.
2. Positive affect will be maintained throughout participants' quit attempts
3. Self-efficacy will increase after using the SiS app.

To evaluate the SiS app as a resourceful tool to help with EC cessation, the following research questions were developed:

1. To what extent are participants engaging with the SiS app daily?
2. What is the perceived quality, usability, and satisfaction with the SiS app?
3. What are participants' primary reasons for vaping? How many times have participants tried to quit previously? What perceived barriers do they face in quitting?

## Method

### Participants

Participants (*N*=16) included undergraduates from a small liberal arts college in the Northeast US. The age range of participants was from 21-23 years old, with many participants being 21 (56.3%, *n* = 9). Three participants (18.8%) did not report their age. Most participants identified as female (81.3%, *n* = 13), were predominately white (87.5%, *n* = 14), were in their Senior year of college (93.8%, n = 15), not involved in NCAA (93.8%, 15). Just under half were involved in Greek life (43.7%, *n* = 7). (See Table 1).

## Measures

### *Electronic Cigarette Related Variables*

**Age of EC Initiation.** Participants were asked to report the age at which they first used ECs, even one or two puffs.

**EC Type**. To identify the type of EC participants were using, pictures of four common types of ECs were provided for participants to self-report: disposable e-cigarettes, vape pens, JUUL/PHIX pod devices, and Mods/Advanced Personal Vaporizers (Hinds et al., 2016).

**Frequency of Use.** Participants were asked if they had used each of these four products during the past 30 days and, if yes, on how many of these days they used the product (Hinds et al., 2016).

**Flavor Preference.** Participants were asked what their most common flavor preference was (*Tobacco, Menthol, or mint, Some other flavor like fruit, candy, alcohol, coffee, vanilla, etc., No flavor, Don't know*).

**Previous Quit Attempts.** Participants were asked whether they have ever tried to quit or stop using ECs. If they have, they were asked to specify the number of quit attempts made. Additionally, participants were asked to identify the type of resources or services used (i.e., quitlines, group support, "cold turkey", etc.) (Camenga et al., 2021). This measure was adapted from Camenga et al. (2021), who assessed the resources used by college students who attempted to quit combustible cigarettes.

**Reasons for Recent E-Cigarette Use.** Participants were asked about the primary reasons for using in the pre-and post-survey interventions as well as a breakdown of the reasons for why they used ECs within the past week (Hoeppner et al., 2014). Examples of response choices include "To reduce stress", "To take a break", "To socialize/hang out with other vapers", "Habit

(e.g., when waking up, with coffee or meals)", "While drinking alcohol", etc. The option of putting in "other" was given where participants may write a reason not listed.

**Barriers to Cessation.** The Electronic Cigarette Barriers to Cessation Scale (E-BCS; Garey et al., 2017) assessed perceived barriers and related stressors to quitting ECs (Mayorga et al., 2021). It was adapted from the Barriers to Cessation Scale (BCS; Macnee & Talsma, 1995) for combustible cigarettes (Mayorga et al., 2021). E-BCS incorporates specific constructs that may impede successful quit attempts for users including internal triggers (emotional state and control over such), external cues (friends and people), and the impact of an individual's level of addiction (Mayorga et al., 2021). Additionally, E-BCS was found to be positively associated with EC withdrawal symptoms, EC expectancies and perceived consequences of ECs, emotion dysregulation, frequency of use, etc. (Mayorga et al., 2021). The scale includes 18 items in which participants respond on a 4-point Likert scale (Not a barrier - A large barrier) and has been shown to have excellent internal consistency ($\alpha = 0.96$) (Mayorga et al., 2021). The total score of E-BCS has been positively associated with multiple key aspects relating to characteristics of EC dependence, EC behavior (i.e., previous failed quit attempts and withdrawal symptoms), perceived cognitions (i.e., positive and negative expectancies for use), as well as psychopathology concerns (i.e., emotion dysregulation, anxiety sensitivity, and depression) (see Mayorga et al., 2021 for a review).

### *Mechanisms Theorized to Impact Cessation*

**EC Dependency Level.** The E-Cigarette Fagerström Test of E-Cigarette Dependence (e-FTCD), a 6-item scale adapted from the Fagerström Test of Cigarette Dependence (FTCD; Fagerström, 2011; Heatherton et al., 1991), was used to assess participants' level of dependence on ECs (Piper et al., 2020). e-FTCD is a valid measure of EC dependence as supported by a

single-factor structure, and correlates with important EC dependence measures (e.g., self-report level of addiction and heaviness of vaping, and predictive on continued use) (Piper et al., 2020). By summing the items together, lower self-reported scores correlate to lower EC dependence (i.e., total scores of 0-2 = low dependence, 3-4 = low to moderate dependence) while higher scores indicate higher EC dependence (i.e., 5-7 = moderate dependence and 8+ = high dependence) (Piper et al., 2020).

**EC Craving Level.** The Questionnaire on Vaping Craving (QVU; Dowd et al., 2019) evaluates EC cravings and includes 10 items on a 7-point scale (strongly disagree - strongly agree). The measure was originally adapted from the Questionnaire on Smoking Urges (QSU; Tiffany & Drobes, 1991) and uses similar constructs that, for example, assess the desire and intention to use, positive expectations, use in easing withdrawal symptoms (Dowd et al., 2019). The Cocaine Craving Questionnaire (CCQ; Tiffany et al., 1993) was also examined for relevancy, informing the addition of assessing the lack of control in using (Dowd et al., 2019). Using items from the QSU and CCQ as well as adding two specific, unique items relevant to the smell and taste of flavored ECs. The measure was found to have a high internal consistency ($\alpha$ = 0.96), strongly associated with using ECs more often, lower confidence in quitting, greater negative mood, and greater EC dependence (Dowd et al., 2019).

**Self-Efficacy.** The Smoking Self-Efficacy Questionnaire (SEQ; 12-items; 0 = *not at all confident* to 100 = *extremely confident*) assesses participants' confidence to abstain from smoking in risky situations regarding internal (i.e., low mood) and external stimuli (i.e., being with other smokers) (Etter et al., 2000). The scale lists specific situations in which smokers may have a hard time staying abstinent (e.g., “When I feel nervous”) and has been shown to be a valid and reliable scale among cigarette smokers (Etter et al., 2000). Research shows high internal

consistency in assessing both internal stimuli, items 1-6, ($\alpha = 0.95$) and external stimuli, items 7-12 ($\alpha = 0.94$) (Etter et al., 2000). To adapt this scale for people who use EC, the words and phrases 'smoke cigarettes' were replaced with 'vaping'. An open-ended question was also included, asking what other times it would be difficult to refrain from vaping. Additionally, a single-item measure of confidence from 0 (not at all) to 100 (extremely confident) was used asking how confident participants are to be able to quit and stay quit (Hoeppner et al., 2011; Gwaltney et al., 2009).

**Positive Affect.** The Positive and Negative Affect Schedule (PANAS) is a brief, self-report scale that measures both negative and positive affect consisting of two 10-item mood scales, which are reported separately (Watson et al., 1988; Crawford & Henry, 2004). Participants are asked to what extent they felt each emotion within the past week using a 5-point Likert scale (*very slightly - not at all* to *extremely*) (Crawford & Henry, 2004). Negative affect includes subjective feelings of "anger, contempt, disgust, guilt, fear, and nervousness" while low negative affect is characterized by feelings of "calmness and serenity" (Watson et al., 1988, p. 1063). In turn, positive affect is a state of feeling that includes "enthusiastic, active, and alert" while low positive affect includes "sadness and lethargy" (Watson et al., 1988, p. 1063). Despite the various dimensions of positive and negative affect states, research reports high internal consistency and quality construct validity (Watson et al., 1988; Crawford & Henry, 2004).

**Cessation Outcome: One-month follow-up.** One month after their quit date, participants received a brief survey inquiring about their current EC use status.

### *Quality, Perceived Impact, and Satisfaction with mHealth*

The User Mobile Application Rating Scale (uMARS) is a 26-item measure to evaluate the quality of mHealth apps and, overall, has high internal consistency ($\alpha = 0.90$) (Stoyanov et

al., 2016). The measure consists of various subscales. The first set of subscales measure the objective qualities of apps such as engagement (α = 0.80), functionality (α = 0.70), aesthetics (α = 0.71), and information quality (α = 0.78) as well as subjective qualities relating to satisfaction (α = 0.78) (Stoyanov et al., 2016, p. 1). The final subscale of the measure assesses participants' perceived impact of the app (i.e., 'The app has changed my attitudes toward improving this health behavior') (Stoyanov et al., 2016). Research reports that this measure has high interrater reliability among apps that promote well-being and mindfulness (Stoyanov et al., 2016).

The System Usability Scale (SUS) developed by Brooke (1996), is a 10-item measure using a 5-point Likert scale (*strongly disagree - strongly agree)* to assess the perceived or subjective view of how useable a product is on the dimensions of effectiveness, efficiency, and satisfaction (Brooke, 1996). The measure was adapted for this study by replacing 'System' with the 'SiS App'. Final SUS scores range from 0 - 100 with higher scores indicating a higher rating of useability (Bangor et al., 2008). This measure has been shown to be highly reliable (α = 0.91) and a robust scale for reporting a single score assessing usability (Bangor et al., 2008). An adjective rating scale, item 11, about an overall rating for how user-friendly the app was added on 7-point Likert scale from (*worst imaginable - best imaginable*) (Bangor et al., 2009).

The Client Satisfaction Questionnaire (CSQ-8) measures how satisfied clients are with the useability and outcome of a health service, originally adapted from the longer version, the CSQ-18 (Attkisson & Zwick, 1982; Larsen et al., 1979). The CSQ-8 has shown high internal consistency (α = 0.93) (Attkisson & Zwick, 1982). Questions included positively worded items such as "I thought the SiS app was easy to use" as well as negatively worded items such as "I thought there was too much inconsistency in the SiS app. To specifically tailor the measure to this study, "this system" was replaced with "the SiS App".

**App Usage Data.** App usage data was passively recorded to determine how often participants engaged in the app during the prescribed 3-week period.

### *Correlates and Predictors of Electronic Cigarette Use*

**Other Substance Use.** Past cigarette use was recorded by asking participants if they have ever smoked a cigarette. If yes, they were asked how often they used a cigarette, cigar, or cigarillo (*every day, some days, not at all*) and how often in the past 30 days (*less than half a pack per day, half to a pack per day, one to two packs per day, two packs per day, more than two packs per day, I didn't smoke in the past 30 days*).

Several other constructs, not reported on in the current study, were assessed. Specifically, alcohol and cannabis use were assessed through the Alcohol Misuse Screening (AUDIT-C; 3-items; Bush et al., 1998) (Higgins-Biddle & Babor, 2018) and the Cannabis Use Disorder Identification Test (CUDIT-SF; 3-items; Bonn-Miller et al., 2016). The AUDIT-C was adapted from the 10-item AUDIT and assesses the amount of drinking as well as alcohol-related problems and dependency symptoms (Higgins-Biddle & Babor, 2018). Total scores less than 3 indicate normal alcohol consumption (Higgins-Biddle & Babor, 2018). Like the AUDIT, the CUDIT-SF is a shortened version of the CUDIT-R (Adamson & Sellman, 2003; 8-items) and demonstrates high sensitivity and specificity in detecting problematic cannabis use with a total score of 2 or higher screening positive (Bonn-Miller et al., 2016). Symptoms of depression and anxiety also were assessed with the Center of Epidemiologic Studies Depression Scale (CES-D-10; Andresen et al., 1994) and the Generalized Anxiety Disorder Screener (GAD-7; Spitzer et al., 2006).

## Design and Procedure

Participants were recruited through paper and digital recruitment flyers/ business cards posted around campus and circulated through social media (e.g., Instagram), email, and snowball sampling. Additionally, an e-mail with information about the study was distributed to a random sample of around 400 students on a small private college campus. A QR code on the flier directed interested candidates to the eligibility survey. If candidates expressed interest and met the eligibility criteria, they received a link to the informed consent and the first, pre-intervention survey. Once completed, participants were asked to identify a day they would like to quit and participate in a Zoom call one week before this date to onboard to the study with the Principal Investigator (Futter), download, and explain the functionality of the SiS App. Participants had the ability to change their quit date on the app after the onboarding.

Two weeks after the quit date, participants received a link to a post-intervention, 2-week follow-up survey link that assessed changes in individual characteristics (perceptions of barriers to quitting, mental health status, etc.) and outcome variables (EC dependence and craving, level of positive affect, and self-efficacy), and their perceived impact of SiS as a mHealth tool.

One month after their quit date, participants received a brief survey asking if they were currently using ECs (if so, how frequently) and if they were still engaging in the SiS App. All survey answers were administered and recorded through the research electronic data capture (REDCap) which is a secure website, password protected, and HIPAA-compliant. The data collected were exported and analyzed on IBM SPSS 28 software.

To participate in the study, individuals had to be at least 18 years old, use Electronic Nicotine Delivery System (ENDS) products (i.e.-cigarettes, vape pens, or e-hookah) at least once a week, and be interested in quitting or reducing their ENDS use. Participants who were trying to quit before enrolling in the study were excluded since participation includes using the SiS App at

least one week before this date. Participants who did not successfully onboard to the study were excluded as well. Enrollment was open from December 2022 to March 2023 and this study was approved by the college's Institutional Review Board.

## Results

### Participant Flow

Of 42 individuals who completed the eligibility survey, 17 completed the pre-intervention survey, and 16 successfully completed an onboarding zoom call and downloaded the App. Post-intervention and one-month follow-up surveys were completed by all 16 participants. Figure 1 depicts how participants moved through the study, from the recruitment phase to the final follow-up.

### Electronic Cigarette Related Variables

**Age of EC Initiation.** The average age students first used an EC product, even one or two puffs, was 16.47 years ($n$ = 15; $SD$ = 1.46), with a minimum of 14 and maximum of 20 years old. Over one-third (38%) of participants ($n$ = 6) reported that 16 years old was the age they first initiated EC use.

**EC Type and Frequency of Use.** During the past 30 days, all participants ($n$ = 16) reported using disposables (i.e., PuffBar) or an EC with a disposable nicotine cartridge. Frequency of use within those 30 days averaged 15.06 days ($SD$ = 8.39). Three participants reported using the device within the range of 25-28 days during the last 30 days, five participants used the device between 19-20 days, four reported somewhere between 9-15 days, and the final four said they used the device somewhere between 4-5 days during the last 30 days. Most participants (81%; $n$ = 13) typically used less than one disposable e-cigarette or disposable nicotine cartridge per day, and 18.8% (n = 3) participants used one disposable e-cigarette or

cartridge per day. No participants used more than one disposable e-cigarette or disposable nicotine cartridge. A breakdown of the different types of EC devices and the estimated number of days (out of the past 30) participants reported using such device(s) is illustrated in Figure 2.

Many participants (63%; *n* = 10) had used JUUL or ECs that use pods during the past 30 days. On average, participants used this device 11.20 days (*SD* = 9.10) out of the past 30 days. Five participants used these devices 2-5 days out of the past 30, 2 reported using them 10 and 15 days during the past 30, and 2 reported using this device 20 and 24 days. One participant did not report how frequently they used such devices. Of the 10 participants who reported using JUUL, 80% (*n* = 8) of participants used fewer than one pod a day and two participants (13%) used one pod per day.

Only 2 participants had used a vape pen, hookah pen, or EGO (i.e., a device with a battery and a tank, or a refillable tank for e-liquids) as intended (i.e., with nicotine e-liquid/e-juice) (*M* = 11 days, *SD* = 7.07) out of the past 30 days.

**Flavor Preference.** The most common flavor preference reported was menthol or mint (*n* = 10); next was some other flavor (e.g., fruit, candy, alcohol, coffee, vanilla, etc.) (*n* = 5). One participant reported not knowing what flavor they used the most.

**Previous Quit Attempts.** Ten participants reported past attempts to quit. Most participants had 1, 2, or 5 previous quit attempts (*M* = 4.50, *SD* = 5.68). The highest number of quit attempts reported was 20.

The services/resources participants identified as resources previously utilized to help participants quit included: quitting cold turkey (*n* = 8) and using willpower (*n* = 8). Another common strategy was making ECs less accessible or less desirable (i.e., throwing it away, giving it to someone else to hide, or using desirable flavors) (*n* = 6). Four participants replaced using

ECs with another activity (i.e., chewing gum, drinking tea or water, exercise, entertainment, mindfulness, etc.) to quit; four participants used a positive or progress mindset/self-concept (i.e., resilient attitude, self-care, or rewarding); and 3 participants reported that they used help and support from friends/family to try to quit. Two participants endorsed using nicotine replacement products (i.e., patch, gum, lozenge). Only one participant (6.3%) had used a texting program for vaping cessation (This is Quitting/DitchJUUL). No participants used a quitline/helpline, one-on-one counseling, group support, book/pamphlet/ video support, or hypnosis. Notably, no participants reported using a vaping cessation app (i.e., quitSTART). Table 3 summarizes the reported services and resources participants had previously employed to quit ECs.

Half of the participants responded to an open-ended question regarding the specific activity they employed to try to cease EC use. Half of the participants ($n$ = 4) described that the most common strategy was not having the device accessible or visible to them. Examples included not ‘purchasing the device’, ‘throwing it away’, ‘giving it to a friend or going to my friend's house where I knew I wouldn't want it’, and ‘focusing on something, like food’. The second most common strategy was using a distraction ($n$ = 3), then pursuing exercise ($n$ = 2). A participant had specified that the NRT that had been used was ‘zyns’. Additionally, one participant reported ‘no activity, just quitting’, in line with going cold turkey.

**Reasons for Using.** 3 primary reasons were identified as reasons for using: 75% of participants ($n$ = 12) checked that it is because they enjoy using it, 19% ($n$ = 3) checked that they used ECs out of curiosity/ just wanted to try them, and one participant (6%) checked that their primary reason for using to cut down on smoking.

Almost all the participants reported that a reason for using ECs was while drinking alcohol (94%, $n$ = 15). Another common reason for using ECs during the last week was to reduce

stress (63%, *n* = 10). Half the participants (50%, *n* = 8) used ECs to socialize or hang out with other people who use ECs; 44% (*n* = 7) to just pass time /relax; 44% (*n* = 7) out of habit (i.e., when waking up, with coffee or meals); 31% (*n* = 5) to reduce craving; and 19% (*n* = 3) used ECs to take a break. The reasons reported by participants for using ECs during the past week are depicted in Figure 3.

Post-intervention, more participants reported that a reason for using ECs during the past week was to reduce cravings (*n* = 9; 56%). Additionally, fewer participants reported that their reason for using was just to pass time / relax (*n* = 3; 18%) and while drinking alcohol (*n* = 13; 81%).

**Barriers to Cessation.** Pre-intervention, the most common and highly ranked perceived barrier was seeing things or people that remind participants of using ECs as seven participants had scored this barrier as *a large barrier*. The second most common and highly ranked perceived barrier was being addicted to ECs (*n* = 6). Withdrawal symptoms (i.e., anger, anxiety, depression, difficulty concentrating, eating more, insomnia, restlessness), were highly ranked as *somewhat of a barrier* (*n* = 7). Almost all the participants ranked feeling lost without ECs (*n* = 14) and having strong feelings such as anger or feeling upset when around other people (*n* = 14) as *not a barrier*.

Post-intervention, instead of 7 participants indicating that seeing things or people that reminded individuals of using ECs was a *large barrier,* only one participant ranked this as *a large barrier*. Additionally, fewer participants had indicated having strong feelings such as anger or feeling upset when with other people as *not a barrier.* Fear of failing to quit was also ranked slightly more favorably as less of a barrier post-intervention, with no one indicating this as a *large barrier* compared to pre-intervention where two individuals indicated this as *a large*

*barrier*. Additionally, thinking about ECs all the time was not as frequently ranked as a *large or somewhat of a barrier* post-intervention.

Although participants had initially ranked no encouragement or help from friends as *not a barrier* ($n$ = 12), fewer participants had ranked this item as *not a large barrier* post-intervention ($n$ = 8), with a higher proportion of participants now ranking this item as a *slight barrier* post-intervention vs pre-intervention ($n$ = 6 vs $n$ = 2). Additionally, feeling lost without ECs was, overall, slightly more ranked as *a larger barrier* post-intervention.

Notably, the ranking of withdrawal symptoms remained relatively consistent pre- and post-intervention, with only one more person indicating this barrier as *not a barrier* compared to pre-intervention responses. Feeling less in control of your moods remained relatively consistent as well.

**Mechanisms Theorized to Impact Cessation**

**EC Dependency Level** (Figure 4). A paired samples t-test was conducted to determine if dependency levels, as measured by FTND, changed before and after prescribed SiS App usage. The results showed that there was a non-significant decrease in pre-intervention dependency levels ($M$ = 2.20, $SD$ = 2.46) and post-intervention dependency levels ($M$ = 1.60, $SD$ = 1.88), $t(14) = 1.655$, $p = .120$. One participant did not complete the FTND measure.

**EC Craving Level** (Figure 4). A paired sample t-test was also used to examine how craving levels, as measured by the QVU, differ pre-and post-intervention. There was a significant decrease from pre-intervention craving levels ($M$ = 3.22, $SD$ = 1.24) and post-intervention craving levels ($M$ = 2.43, $SD$ = .93), $t(15) = 2.804$, $p = .013$.

**Self-Efficacy** (Figure 5). Internal and external measures of the SEQ were analyzed separately, using paired samples t-test. Pre-intervention internal self-efficacy ($M$ = 59.25, $SD$ =

17.80) did not differ significantly from post-intervention internal self-efficacy (*M* = 51.80, *SD* = 16.91), *t*(15) = 1.686, *p* = .112. External self-efficacy between pre- (*M* = 46.82, *SD* = 17.18) and post-intervention (*M* = 50.90; *SD* = 14.02) did not differ significantly, although there was a slight increase, *t*(15) = -1.305, p = .211.

When asking participants how confident they are in quitting vaping and staying quit on a scale from 0 - 100, 0 being not at all and 100 being extremely confident, the mean score was 65.3 (*SD* = 17.2; min = 38.0, max = 100). The single-item question measuring confidence in the ability to quit and stay quit did not differ significantly from baseline (*M* = 65.31, *SD* = 12.18) and post-intervention (*M* = 61.75, *SD* = 20.26), *t*(15) = .509, *p* = .618.

An open-ended question was included inquiring about what other times participants would find it difficult to abstain from vaping. Out of the nine participants who provided answers, almost all participants reported some sort of social setting or situation as challenging moments to refrain from using (*n* = 8). Specific situations were parties/ going out (*n* = 3), drinking alcohol (*n* = 2), and being with people who are using EC users (*n* = 3). One participant reported the morning and waking up during the night as challenging times to not use ECs.

**Positive Affect** (Figure 6). A paired samples t-test was used to examine any changes between positive and negative affect before and after using the SiS App. Positive affect scores at baseline (*M* = 37.31, *SD* = 5.31) did not differ significantly from post-intervention scores (*M* = 35.38, *SD* = 4.77), *t*(15) = 1.074, p = .300 as hypothesized.

**EC Cessation.** At one-month follow-up, 38% (*n* = 6) of participants reported that they were not currently using ECs.

**Quality, Perceived Impact, and Satisfaction with mHealth.**

**The User Mobile Application Rating Scale (uMARS).** uMARS score has an overall mean objective score of 3.91 (*SD* = .78) and a subjective mean score of 2.95 (*SD* = 1.0). The subscales of the objective score had the following reported means: Engagement (*M* = 3.24, *SD* = .86), functionality (*M* = 4.24, *SD* = .79), aesthetics (*M* = 4.02, *SD* = .73), information (*M* = 4.35, *SD* = .62), and perceived impact (*M* = 3.71, *SD* = .90). The subjective quality subscale is not included within the overall means (*M* = 2.95, *SD* = .91). Mean scores should be interpreted as similar to a 5-star rating system.

**Client Satisfaction Questionnaire.** The mean score of the CSQ was 24.88 (*SD* = 4.38), with a higher number corresponding to greater satisfaction.

**System Usability Scale.** The final SUS score was 74.84 (*SD* = 17.04). Scores between 74.1 - 77.1 are considered within a B range (Lewis & Sauro, 2018)

**App Usage Data**. The average number of days participants used the app was 10.19 (*n* = 16; *SD* = 5.60, min = 1, max = 20) out of the 21 days of prescribed app use.

**Continued Use of App.** At the one-month follow-up survey, three participants reported that they had used the SiS App since the study ended (after the prescribed 3-week period).

## Discussion

The current study explored the feasibility and acceptability of a positive psychology mHealth app, Smiling Instead of Smoking (SiS), that was originally built for nondaily combustible cigarette smokers. The aim of the study was to understand the app's ability to support EC cessation and the extent to which it was a useful mHealth intervention for college students with an interest in quitting ECs. As evidenced by the post-intervention and one-month follow-up assessments, individuals benefited from this approach to smoking cessation. That is, there was a significant reduction in craving levels from pre- to post-intervention and 38% of

participants reported that they were not currently using ECs at one-month follow-up. Unlike other interventions that focus on improving depressive states, positive psychology helps bring awareness to personal strengths. Additionally, positive psychology exercises have been shown to increase self-efficacy and decrease cravings, which are two fundamental constructs related to stopping nicotine use. To my knowledge, this is the first study to examine how a positive psychology app with a tobacco cessation framework may assist in EC cessation. These findings help to establish the usefulness and perceived impact, satisfaction, and quality of service of an empirically tested mHealth app with a positive psychology framework for EC cessation. These findings also broaden the scope of possible resources for EC users looking to quit, with the ultimate goal of supporting a greater number of quit attempts in EC users.

**Craving**

In line with Shiffman et al. (2013), who showed that presenting positive affect cues to daily and nondaily combustible cigarette smokers could lead to decreased levels of craving, the results of this study suggest that engaging in exercises that focus on increasing levels of positive affect may help to diminish EC craving. This is demonstrated by participants' significantly lower levels of EC craving after the engagement with the SiS app for three weeks.

Positive affect may influence craving levels by impacting an individual’s perseverance, which is needed in nicotine cessation (Bränström et al., 2010). Bränström et al. (2010) posited that positive affect can support health behaviors by introducing the aforementioned broaden-and-build theory. Specifically, when positive affect is elicited, a broader set of ways to think about how to cope with triggers, cravings, and risky situations may be facilitated. Although thought-action repertoire was not measured in this current study, it provides a possible explanatory mechanism for why cravings may be reduced with an increase in positive affect. Similarly, after

measuring positive affect in combustible cigarette smokers during a quit attempt, Cook et al. (2004) found that a reduced positive mood increased participants' likelihood of experiencing cigarette cravings. Interestingly, an increase in negative mood was not found to be a predictor of cravings. As shown by the results of this current study, focusing on increasing positive affect before and throughout a quit attempt may be an important area to focus on to mitigate increases in cravings.

Shiffman and Waters (2004) outlined the several influences negative affect has on precipitating relapses. One explanation is that smokers may look to smoke in order to manage their affect or manage "withdrawal-induced affect reactivity" (p. 192). Engaging in positive psychology exercises may help assist individuals looking to quit nicotine by providing support in mood-related symptoms of withdrawal cravings through the focus on increasing positive emotions and happiness. Additionally, negative affect can affect smokers' ability to engage in coping strategies (Shiffman and Waters, 2004). This refers to the broaden-and-build theory.

**Dependency**

Although dependency did not significantly decrease, there was an overall trend in dependency levels going down from pre- to post-intervention. Despite these non-significant results, research has previously reported on the significant effects of increasing subjective happiness and positive affect and subsequent decreases in dependency levels in tobacco smokers (Liautaud et al., 2018).

Non-significant dependency findings may be attributed to the small sample size. Additionally, there exists two alternative measures for EC dependence: Penn State Electronic Cigarette Dependence Index (PS-ECDI) (10 items; $\alpha = .74$) and the e-cigarette Wisconsin Inventory of Smoking Dependence Motives (e-WISDM) (11 items; $\alpha = .81$-$.96$) (Piper et al.,

2020). Although the EC dependence scale used in this study, the e-FTCD, had a supported single-factor structure meaning that the items within the scale all correlated to measuring a particular construct (i.e., dependency), the other two measures had higher internal consistency. Since these measures are relatively short, it may have been beneficial to include another dependency scale to determine if other measures of this construct were able to detect change.

Another reason for the lack of substantial change in dependency was that the prescribed app use period may not have been long enough to see such changes. Within the first study of SiS, app usage was prescribed for the same time length as the one used in this current study (Hoeppner et al., 2019). Yet, participants had reported a desire to use the app for a longer period. Indeed, research has suggested that the effectiveness of positive psychology interventions is largely impacted by the length of such interventions (Sin & Lyubomirsky, 2009). Therefore, lengthening the time in which participants are expected to engage with the intervention may be an important consideration for research studies exploring the effects of mHealth technology.

Finally, non-significant findings may be attributed to the relationship between nicotine administration and negative mood. Negative mood states are commonly known to promote nicotine dependency (Lumley et al., 1994). Therefore, if participants had higher depressive symptoms at baseline, this could impact the potential for changes in dependence, especially given the small sample size. Similarly, individuals with more quit attempts have been shown to report higher levels of dependency (Garey et al., 2019). Although previous research reported no relationship between quit attempts and success in quitting smoking (Cohen et al., 1989), it could be beneficial to control for prior quit attempts and/or depressive symptoms when examining the intervention's effect on levels of dependence.

**Self-Efficacy**

Contrary to the theorized mechanism of action, namely that self-efficacy would decrease after engaging in positive psychology exercises, self-efficacy did not change pre- to post-intervention. Using the same measure as in this current study (with the only change being that 'smoking' was changed to 'vaping' in this study), Hoeppner et al. (2019) found a significant increase in self-efficacy after prescribing the SiS app for the same time period. There are several important distinctions from this current study that may explain why I did not find the same results.

One distinction is the small sample size of the current study. Additionally, the time at which self-efficacy is measured may lead to different results regarding how it predicts abstinence (Gwaltney et al., 2009). As described by Hoeppner et al. (2014), self-efficacy is dependent on momentary states and can change drastically during the day. Therefore, measuring self-efficacy at one point in time is complex due to its dynamic nature. This study may have measured self-efficacy on participants' quit date to examine this construct more thoroughly. Research also has suggested that only posttreatment, not pretreatment, self-efficacy predicts relapse (Schwarzer & Fuchs, 1996). Indeed, Bandura et al. (1997) identified a specific attribution in developing self-efficacy called *mastery experiences* as having the greatest influence on someone's overall self-efficacy: "Mastery experiences are the most influential source of efficacy information because they provide the most authentic evidence of whether one can muster whatever it takes to succeed" (p. 80).

Romanowich et al. (2009) help to illustrate contradictory evidence to the directional relationship between pretreatment self-efficacy and later abstinence from smoking. This study reported that declines in smoking behavior, as measured by breath carbon monoxide (CO), were predictive of smoking cessation self-efficacy (Romanowich et al., 2009). Yet, self-efficacy was

not predictive of declines in breath CO or lowering smoking levels (Romanowich et al., 2009). This was established through two multiple regression models in which a significant association was established when abstinence self-efficacy was the dependent variable, but not when breath CO was the dependent variable (Romanowich et al., 2009). Thus, self-efficacy may not play a mediating role in supporting changes in behavioral change as suggested by SCT and previous literature, but instead may be the result of cessation thereafter. Reducing or quitting smoking may drive increasing levels of self-efficacy as individuals prove to themselves they can be successful.

A notable aspect of mastery experiences is highlighted by Warner et al. (2018) who investigated the relationship between mastery experiences and self-efficacy on a day-to-day basis during a quit attempt. They found that the influence of mastery experiences was not sustained for long (Warner et al, 2018). Therefore, consecutive wins, or consistently showing oneself that one can remain abstinent, may be needed to sustain self-efficacy (Warner et al., 2018). Within this study, they provided evidence for a bidirectional or reciprocal relationship between self-efficacy and mastery experiences: both had an influential effect on one another as established by change-predicting-change models (Warner et al., 2018). Although it may be the case that self-efficacy increases when individuals prove to themselves that they can stay abstinent, the inverse may also be true in that self-efficacy can also affect an individual's attempt to stay quit. The latter may be prompted through a longer period of app usage.

Previous research that looked at how combustible cigarette cessation apps support cigarette quit attempts reported that participants had significant increases in self-efficacy after using one of two apps (*Kwit* app or the *Quit Genius* app) for 4 weeks (Rajani et al., 2021).

Therefore, extending the time period for just a week could better support observing these expected changes.

**Positive Affect**

Changes in participants' positive and negative affect were not observed in this study. This result supports my hypothesis that positive affect would be maintained after completing positive psychology exercises during a quit attempt, as research has shown mood declines prior to quit attempts (Strong et al., 2009). This result also aligns with Hoeppner et al. 's (2019) findings on the first version of the SiS app, revealing no significant changes in positive affect one week before quit day and two weeks post-quit while using the SiS app. Yet, at the 12-week follow-up post-quit and after prescribed app use, positive affect was significantly lower among Hoeppner et al.'s (2019) participants suggesting that positive affect may not be sustained without continuing the engagement in positive psychology exercises.

Kahler et al. (2014) also reported no significant changes in mood throughout combustible cigarette quit attempts in which participants were asked to engage in similar positive psychology exercises. This study concluded that because mood did not change drastically during participants' quit attempts, their positive psychotherapy intervention for cigarette cessation was well supported. Thus, this current study contributes to the theorized mechanism of action in which positive psychology exercises can help to mitigate positive affect declines prior to quit attempts. Additionally, there were no significant declines in negative affect throughout participants' quit attempts, highlighting the possible role of the SiS app in supporting individuals' moods during EC quit attempts (Kahler et al., 2014).

One important implication for examining the effects of positive psychology interventions during quit attempts is considering who may be best suited for such programs. Krentzman (2013)

determined that those with initially lower levels of positive affect, as well as high levels of self-criticism, tend to benefit more from gratitude interventions. Therefore, it may be important to consider a participant's baseline high or low positive affect better to understand the potential differential effects of positive psychology exercises.

**Feasibility**

The User Mobile Application Rating Scale (uMARS) demonstrated that the app was rated favorably among participants based on the mean subscale scores: engagement, functionality, aesthetics, information, and impact. The average objective mean score from these scales was an almost a 4-star rating. Yet, the subjective quality score had a lower average of closer to a 3-star rating. In comparison to other freely available vaping cessation apps, Sanchez et al. (2022) examined eight different apps which, overall, had an average MARS score of 3.66 (min = 3.17, max = 4.24). Of note, the MARS and uMARS scales are relatively comparable, in that the uMARS is more user-friendly with less complex wording and three fewer items, but they examine the same constructs of a mobile application (engagement, functionality, aesthetics, and information quality) using the same rating scale (0-5) (Stoyanov et al., 2016). Thus, in comparison to other vaping cessation apps, this study had an above-average score. Notably, the mean score on the information subscale scored the highest with functionality second. Although the information on the SiS app is directed towards non-daily combustible cigarette smokers, it seems as though participants still benefited from the tools provided by the app as evidenced by their favorable ratings for these elements of the app.

The average final System Usability Score (SUS) was 74.8, which is above an average score, within the 'acceptable' range (Bangor et al., 2009), and corresponds to a B letter grade (Lewis & Sauro, 2018). This finding helps to demonstrate the usability of SiS as a supportive

resource for vaping cessation, although the app was originally built for combustible cigarette smokers. Moreover, Bangor et al. (2009) reviewed 2,324 SUS scores from over 200 studies examining the usability rating of various technologies such as computer and phone interfaces. The mean SUS score reported across these studies was 70.14 (*SD* = 21.71). Therefore, this study's SUS score, in comparison to a broad range of technology, is above average.

Palmer et al. (2022) also used the SUS scale to examine the feasibility of a telehealth app for vaping cessation. This study reported a higher mean SUS score, comparatively (*M* = 83.1; *SD* = 15.5), suggesting 'moderately to highly favorable usability' (Palmer et al., 2022). In summary, while the current study's SUS score was not far off from other studies, there may be room for improvement, particularly if the SiS app could be tailored to EC users specifically.

The final scale used to measure the feasibility and acceptability of the SiS app was the Client Satisfaction Questionnaire (CSQ) (*M* = 24.88, *SD* = 4.38). This CSQ score is categorized within the medium level in which CSQ scores are sectioned into three: low levels within the 8 - 20 range, medium levels within the 21 - 26 range, and high levels within the 27 - 32 range (Larsen et al., 1979). Thus, satisfaction with the SiS app was positively viewed.

**Cessation Outcomes**

At one-month follow-up, 38% (*n* = 6) of participants reported that they were not using ECs. Within the first version of the SiS app, the abstinent rate was biochemically confirmed to be 30% (9/30) at the end of the three-week app usage period (Hoeppner et al. 2019). The self-reported abstinent rate at the 30-day follow-up was 41% (12/29). Version 2 of the SiS app evidenced self-reported abstinent rates of 40% at the 6-week follow-up, and 56% at 24 weeks (Hoeppner et al. 2021). In comparison to the previous cessation outcomes of the SiS app, the

one-month follow-up abstinence rate of the current study illustrates the promising ability of the SiS app to support EC cessation.

**Limitations and Future Directions**

There were several notable limitations within this study. Although this study was a feasibility study, the small sample size ($N$ = 16) limits the generalizability of the results. Specifically, the sample small size consisted of an unrepresentative group of students, the majority of whom were white, female, and in their senior year of college, further limiting the ability to compare the results of this study not only to other college students but also to the broader public.

This current study also did not include a control group, which limits the ability to infer that positive psychology exercises impacted positive affect levels in a causal fashion; that is, our participants were not compared to individuals undergoing a quit attempt assisted with an intervention focused on bolstering happiness. Additionally, this limitation extends to justifying that the causation of decrease in cravings was a result of engaging in the SiS app.

Participants were not biochemically confirmed to have been abstinent from nicotine, which has been proposed as the 'gold standard' for verifying abstinence within combustible cigarette populations (West et al., 2005). Although this population is EC users, the same issue of self-report and its potential unreliability remains.

Compared to research examining prevalence rates of college students reporting past 30-day EC use, the low interest in wanting to quit ECs, as indicated by the low number of screening and enrollments, may mean many things. One implication of the low expressed interest may be that current students attending college are simply not interested in quitting. The high proportion of enrolled participants who were seniors may help illustrate that upon leaving college, it will not

be acceptable to continue using ECs. It is well-known that college campuses promote environments that reward 'living your best life', which may include using substances such as nicotine that are reinforced by peers. Yet, senior year is a time to reflect on future goals beyond college, which may or may not include quitting harmful substances.

Although participants were almost all seniors, the level of interest in this subsample of students may point to the fact that this is an opportunistic time in which college students may be more open to incorporating support into their quit attempts. Additionally, future studies should consider broader and more varied recruitment methods: Garey et al. (2020) recommended developing multiple advertisements specifically directed toward the target population, and advertising them on various forms of social media platforms used by the population.

Another limitation concerns the self-efficacy scale used in this study. It may have been beneficial to administer the General Self-Efficacy Scale in the current study to examine self-efficacy more broadly. The Smoking Self-Efficacy Questionnaire (SEQ-12) used in the current study was developed to measure self-efficacy in combustible cigarette smokers, not ECs users. Although previous research has utilized similar techniques for employing a cigarette self-efficacy scale to measure EC self-efficacy by changing 'cigarette' to 'e-cigarette' (Alanazi et al., 2022; Durkin et al., 2021), Mai et al. (2022) developed a scale in which EC self-efficacy was measured by 8-items that had high internal consistency ($\alpha = .95$). Important distinctions between combustible cigarettes and ECs include differences in the perceived benefits and perceived harm of ECs, as ECs are commonly seen as healthier alternatives than combustible cigarettes (Bold et al., 2018). The 'automaticity' at which individuals use or reach for their devices also contrasts greatly with cigarettes as ECs are more discreet (Bold et al., 2018). Finally, ECs vary greatly in 'sensory dependence' compared to cigarettes such as the flavors offered as well as the sensory

"throat hit" that users report (Bold et al., 2018). Such cognitive and behavioral differences may be important constructs to inquire about to understand how individuals feel about their ability to quit.

Finally, although the frequency of vaping was captured in the initial pre-intervention as a quantitative value (e.g., within the past 30 days), the only measure that captured vaping frequency within the post-intervention survey was an item within the e-FTND scale. This item asked participants to report a range of how many times they usually use their EC. Additionally, frequency of use is not as straightforward to measure for ECs as it is for combustible cigarettes due to the fact that puffing behaviors of individuals (e.g., length of inhale, depth of inhale), as well as nicotine concentrations across devices, may vary greatly, which can affect individuals tolerance to nicotine (Bold et al., 2018).

In the future, the effect of using the SiS app and engaging in positive psychology exercises for EC cessation can be further examined more robustly within a randomized control trial. As shown by the results of this study, engaging with an app that promotes positive affect may help to address critical components that sustain smoking behaviors as research indicates positive affect decreases the desire to smoke and relapse (Rabois & Haaga, 2003; Strong et al., 2011) and increases self-efficacy, the ability to process negative health information, and the awareness of one's thoughts and actions (Das et al., 2012; Hoeppner, 2014; Fredrickson, 2001). Therefore, EC cessation interventions may look to incorporate a focus on increasing positive affect and self-efficacy. As mentioned above, it may also be beneficial to prescribe app usage for a longer duration in order to rule this out as a limitation or barrier for unseen but previously expected observations.

Social Cognitive Theory (SCT) purports that a fundamental part of executing a behavior is outcome expectancies. Indeed, as previously discussed, such perceived expectations and individual understandings of EC use are crucial for explaining why individuals use such devices. Therefore, the addition of measures that assess outcome expectations and perceived benefits and drawbacks for engaging in EC use may help to provide more insight into how perceived positive consequences or negative consequences of EC use change after using a positive psychology app.

## Conclusion

The findings of this study add to the understanding of the perceived acceptability and feasibility of a smartphone app originally built for non-daily combustible cigarette users in supporting college EC users' quit attempts. Participants reported favorably on questions inquiring about ease of use and relevance of information. Notably, there were high ratings on increasing knowledge of health behavior and intention to change it. Thus, introducing cessation support that does not directly translate to the exact behavior change may not pose as many barriers or challenges as previously thought. This is especially important to consider as vaping is a relevant new behavior with research still developing on the most promising cessation tools. This study emphasizes the promise of interventions currently available for combustible cigarette smokers which have gone through rigorous, empirical testing. Therefore, advertising this cessation tool to other larger college campuses and recruiting a more diverse population size can help to establish whether a representative population may also view this app favorably.

The current study also helps to illustrate the usefulness of a mHealth app with a positive psychology framework for EC cessation as results showed a significant reduction in EC cravings pre-and post-intervention and because 38% of participants were not using ECs at a one-month follow-up. Therefore, this study brings to light the important target of increasing positive affect

and happiness for EC cessation, especially given the fact the majority of cessation tools focus on improving depressive symptoms and not positive moods. In order to further establish a more robust relationship between administering positive psychology tools to support cessation, a longer duration for engagement with the app should be implemented, as well as incorporating a comparison group not receiving a positive psychology-based intervention.

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## Tables

**Table 1**

*Demographic Characteristics of Sample*

| **Baseline Characteristics** | ***n*** | **%** |
|---|---|---|
| **Gender** | | |
| Female | 13 | 81.3 |
| Male | 3 | 18.7 |
| **Age** | | |
| 21 | 9 | 56.3 |
| 22-23 | 4 | 25.0 |
| Not reported | 3 | 18.7 |
| **Race** | | |
| White | 14 | 87.5 |
| Asian | 1 | 6.2 |
| Other | 1 | 6.2 |
| **Class Year** | | |
| Senior | 15 | 93.8 |
| Junior | 1 | 6.2 |

**Table 2**

*Mechanisms Theorized to Impact Change*

| | Baseline | | Post-Intervention | | *t(15)* | *p* |
|---|---|---|---|---|---|---|
| **Measure** | *M* | *SD* | *M* | *SD* | | |
| Dependency (e-FTND) | 2.20 | 2.46 | 1.60 | 1.88 | 1.655[a] | .120 |
| Craving (QVU) | 3.22 | 1.24 | 2.43 | .93 | 2.804 | .013* |
| Internal Self-Efficacy (SEQ) | 59.25 | 17.80 | 51.80 | 16.91 | 1.686 | .112 |
| External Self-Efficacy (SEQ) | 46.82 | 17.18 | 50.90 | 14.02 | -1.305 | .211 |
| Single-Item Confidence | 65.31 | 12.18 | 61.75 | 20.26 | .509 | .618 |
| PANAS Positive | 37.31 | 5.31 | 35.38 | 4.77 | 1.074 | .300 |
| PANAS Negative | 24.81 | 6.78 | 24.13 | 6.89 | .285 | .780 |

*Note*. e-FTND = The E-Cigarette Fagerström Test of E-Cigarette Dependence. QVU = Questionnaire on Vaping Craving. SEQ = Smoking Self-Efficacy Questionnaire. PANAS = Positive and Negative Affect Schedule.

[a] $t(14)$

*$p < .05$

**Table 3**

*Previous Services/Resources Employed to Help With Electronic Cigarette Cessation*

| Strategies | Number of Responses | % |
|---|---|---|
| Willpower | 8 | 50.0 |
| Cold turkey (stopped using all at once) | 8 | 50.0 |
| Making vaping less accessible or less desirable (Threw away the device; hide the device; using unpleasant flavors) | 6 | 37.5 |
| Positive mindset (Resilient mindset, noticing winning streaks); self-care, setting rewards | 4 | 25.0 |
| Replacing vaping with another activity (for example, engaging in hobbies, using entertainment, or mindfulness exercises; chewing gum, drinking water or tea; exercise | 4 | 25.0 |
| Help or support from friends or family | 3 | 18.8 |
| Nicotine replacement products (for example, patch gum, lozenge) | 2 | 12.5 |
| A texting program for vaping cessation (for example, This is Quitting/ Ditch JUUL) | 1 | 6.3 |
| A vaping cessation app (for example, quitSTART) | 0 | 0.0 |
| A telephone, quitline, or helpline | 0 | 0.0 |
| Books, pamphlets, videos or other materials | 0 | 0.0 |
| Group support | 0 | 0.0 |
| One-on-one counseling | 0 | 0.0 |

## Figures

**Figure 1**

*CONSORT Flowchart of Participants*

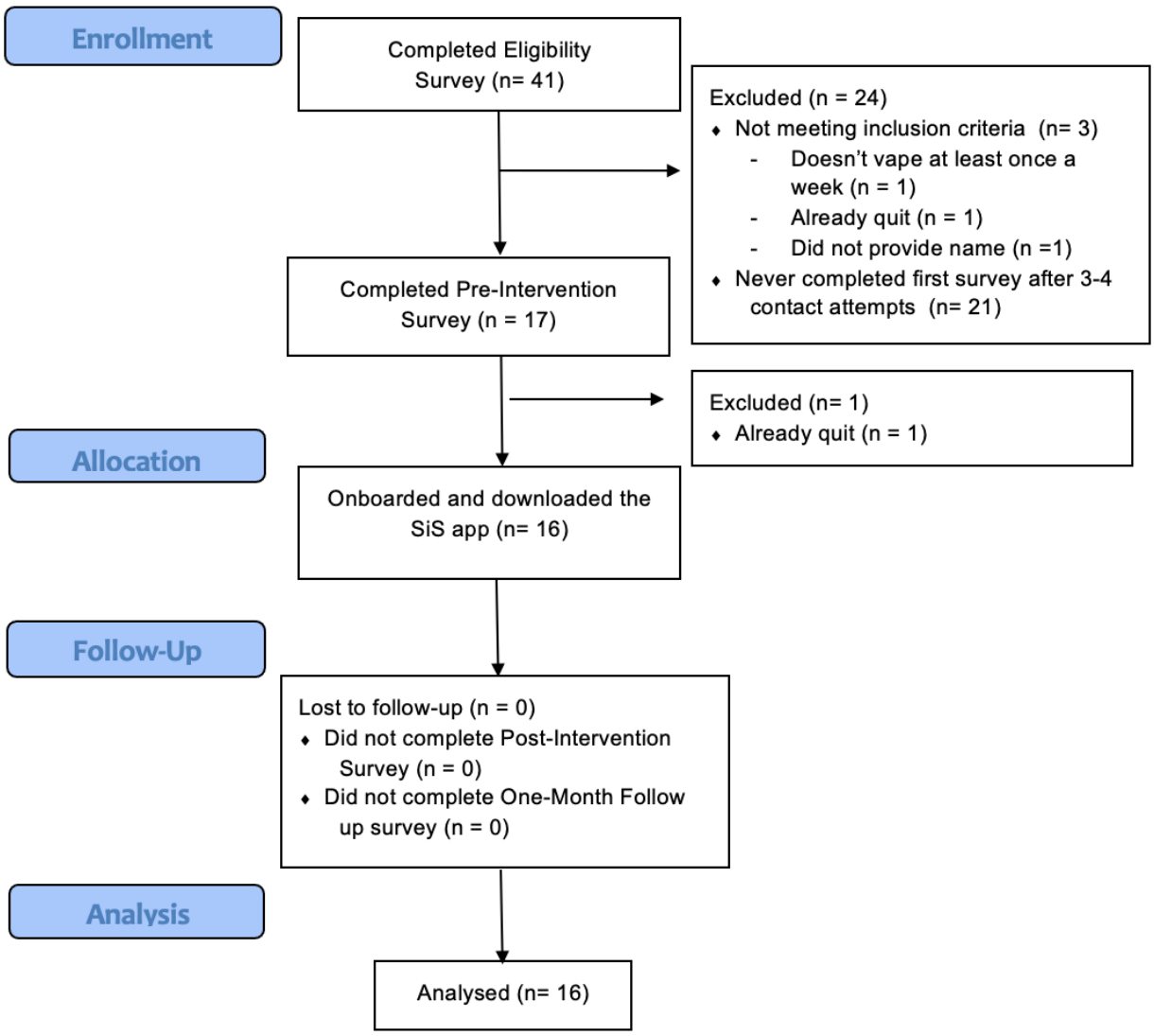


**Figure 2**

*Frequency of Electronic Cigarette Use Per Device During the Past 30 Days*

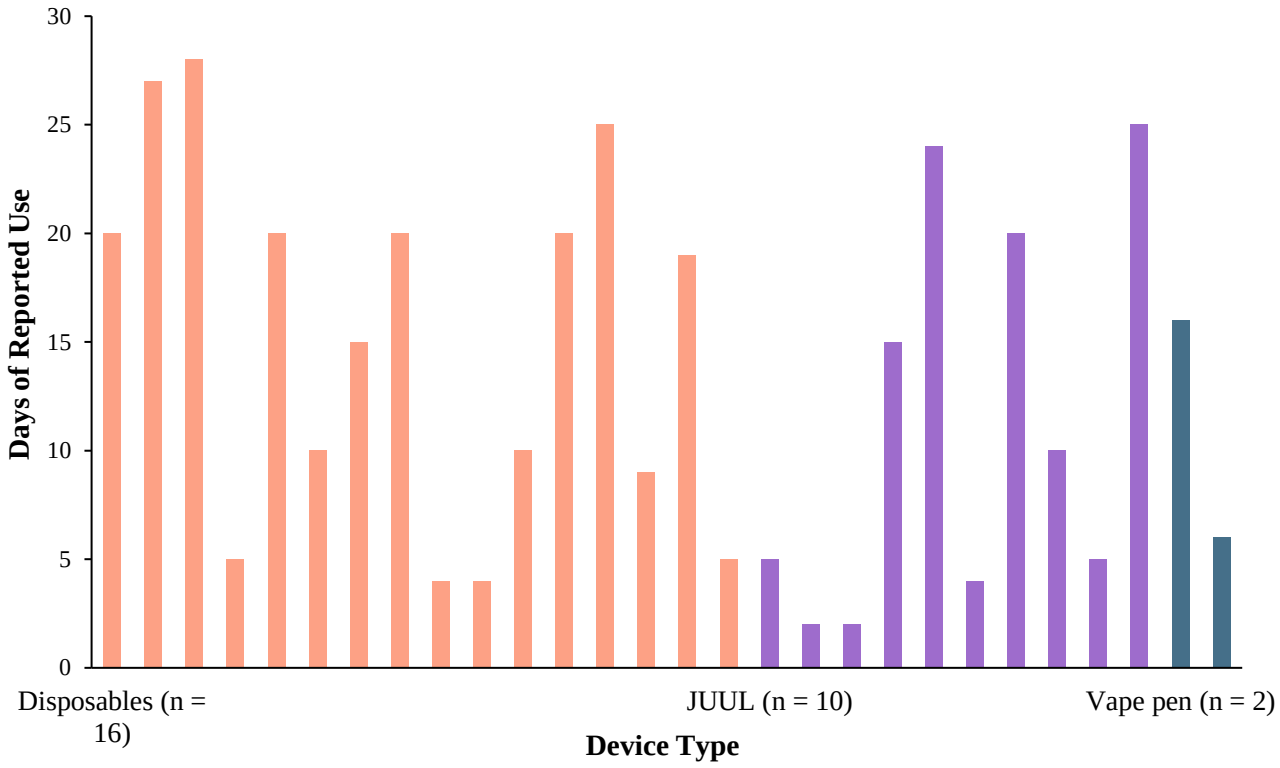


**Figure 3**

*Reasons for Using Electronic Cigarettes During the Past Week*

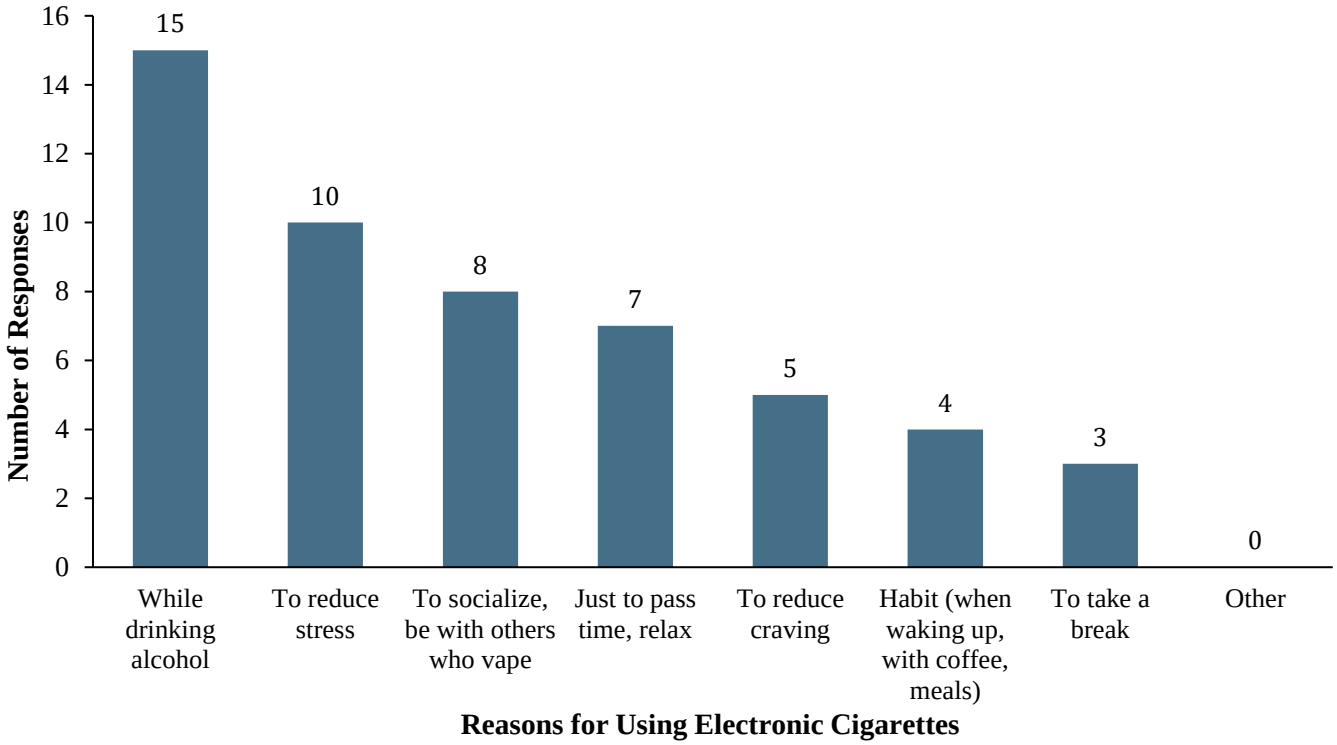
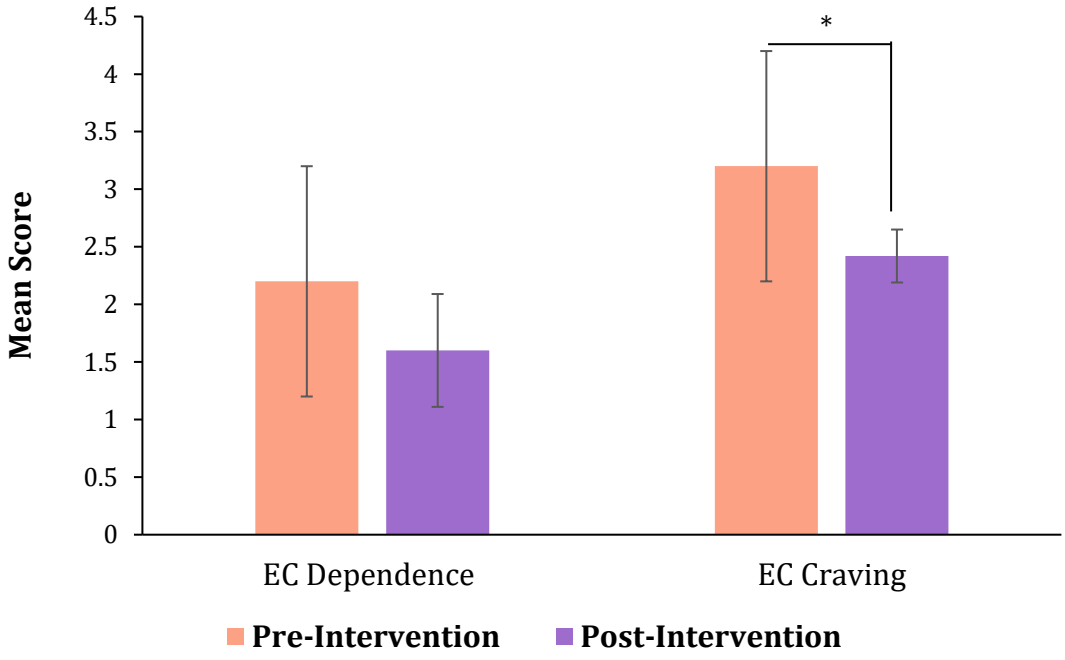


**Figure 4**

*Pre and Post Intervention:Dependency and Craving*

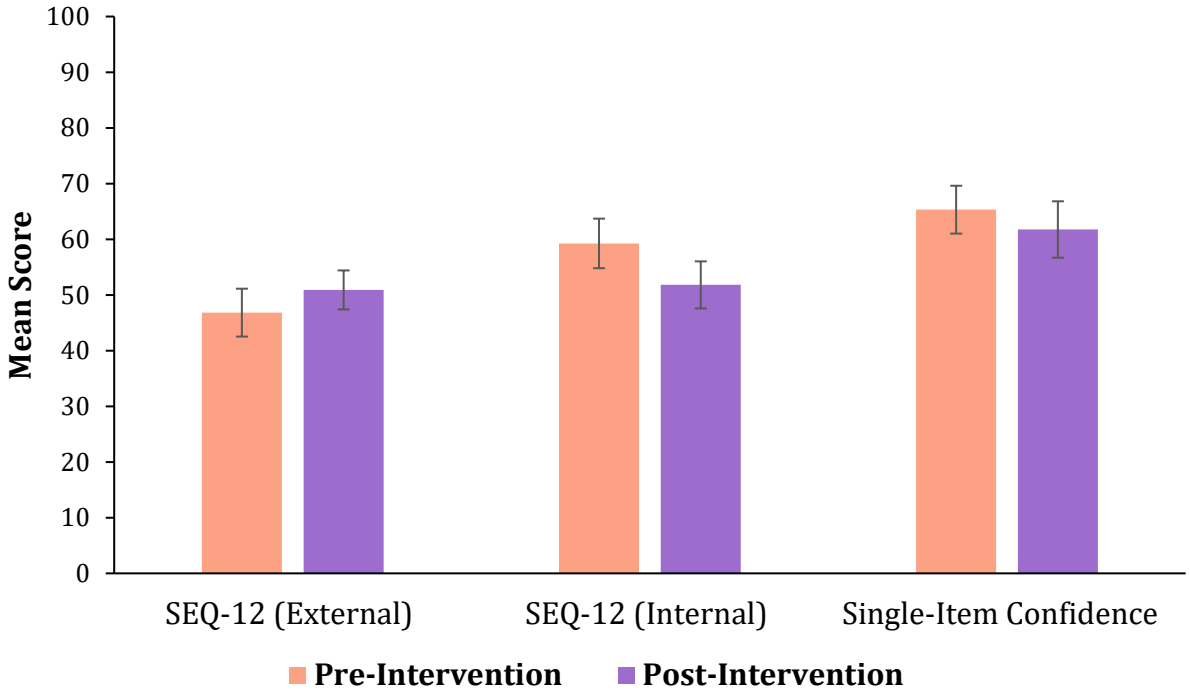



*Note.* EC = Electronic Cigarette.

*$p < .05$.

**Figure 5**

*Pre and Post Intervention: Self-Efficacy and Single Item Confidence Item*




*Note.* SEQ-12 = Self-Efficacy Questionare – 12.

**Figure 6**

*Pre and Post-Intervention: Positive and Negative Affect Scale*