ABSTRACT

Factors Influencing E-cigarette Use Among College Students at Baylor University

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In 2016 the Surgeon General declared e-cigarette use among United States young adults a major public health concern. Between 17.7% to 40% of college students have tried or are currently using e-cigarettes. For this study, a survey with questions pertaining to e-cigarette use, knowledge, mental distress, academic performance, and self-efficacy was distributed among Baylor University undergraduates. Bivariate analysis and hierarchical multiple regression was used. A significant association between gender and frequency of e-cigarette use was found ($\chi^2 = 22.94$, $p < .001$). Additionally, significant relationships were found between knowledge ($F = 9.01$, $p < .001$), self-efficacy ($F = 4.85$, $p < .05$), depression ($F = 8.31$, $p < .05$), and GPA ($F = 5.49$, $p < .001$) and e-cigarette use. Knowledge was the greatest predictor of e-cigarette use ($R^2 = .029$) followed by GPA ($\Delta R^2 = .016$) and gender ($\Delta R^2 = .009$). Limitations include the use of a convenience sample.

Factors Influencing E-Cigarette Use Among College Students at Baylor University

by

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CHAPTER ONE

Introduction

Background

Tobacco use has been a source of concern for years, however, with combustible cigarette use on the decline, a new concern has arisen in the form of e-cigarettes. With 4.9% of middle school students, 20.8% of high school students, 17.7% - 40% of college students, and 16.2% - 28.4% of the general population having used or currently using electronic cigarettes it is clear that e-cigarette use is high (Gentzke, 2019; Grant, 2019; Lanza, 2018; Delnevo, 2016; Hu, 2019). E-cigarette use is linked to many negative health outcomes including nicotine addiction, chronic respiratory diseases, cancer, and cardiovascular disease (The National Center on Addiction and Substance Abuse, 2008). The high prevalence, combined with a lack of regulating policy and severity of potential health outcomes, has contributed to e-cigarette use becoming a major public health concern.

Rates of e-cigarette use are higher among youth and young adults than the general population which could be due to various market strategies that are specifically geared towards a younger demographic. The misinformation spread by these marketing strategies have led to the incorrect belief by young adults and college students that e-cigarette use is a healthier or less addictive alternative to smoking combustible cigarettes (Case et al., 2016; Luo, Zheng, and Zeng, 2014).

Correlations between e-cigarette use and mental illness have also been found, primarily between depression symptomology and e-cigarette use (Lechner et al., 2017; Bandiera et al, 2017; Ĩiguez et al., 2009). In addition, a recent study showed that mild to severe mental distress, as seen in individuals suffering from anxiety and depression, can produce a negative impact on academic performance (Begdache, Kianhehr, Sabounchi, Marszalek, & Doman, 2019).

Purpose

The purpose of this study is to explore the relationship between five measures of interest - knowledge of potential negative health effects surrounding e-cigarette use, self-efficacy, depression symptomology, anxiety symptomology, and academic performance and e-cigarette use behavior.

Knowledge and depression were selected as measures of interest due to previous research implicating these as influential on e-cigarette use. While previous studies have looked at high self-efficacy and intention to quit e-cigarette use (Chan et al., 2019; Pokhrel et al., 2013), this study is designed to assess the relationship between low self-efficacy and initiation of e-cigarette use. Previous studies have found a relationship between smoking combustible cigarettes and anxiety symptoms (Mykletun, Overland, Aarø, Liabø, & Stewart, 2008) however, studies assessing the relationship between e-cigarette use and anxiety are lacking. Additionally, it has been shown that mental distress, as seen in individua's suffering from depression or anxiety symptoms, can have a negative impact on academic performance (Begdache et al., 2019). In addition, this study aims to assess the relationship between academic performance and e-cigarette use.

Hypotheses

Hypothesis 1: There will be a negative association between knowledge and e-cigarette use.

Hypothesis 2: There will be a negative association between self-efficacy and e-cigarette use.

Hypothesis 3: There will be a positive association between mental distress (anxiety and depression symptomology) and e-cigarette use.

Hypothesis 4: There will be a negative association between academic performance and e-cigarette use.

CHAPTER TWO

Literature Review

What is Vaping?

In 2016 the Surgeon General officially declared e-cigarette use among United States (U.S.) youth and young adults to be a major public health concern (U.S. Department of Health and Human Services, 2016). E-cigarettes come in many different varieties, sizes, and flavors (U.S. Department of Health and Human Services, 2016). E-cigarette devices are commonly referred to as "e-cigs", "e-hookahs", "mods", "vape pens", "vapes", and "tank systems" (U.S. Department of Health and Human Services, 2016). However, hereafter the term "e-cigarette" will be used to represent all electronic tobacco devices. E-cigarette devises are composed of a battery, a reservoir for holding a solution that typically contains nicotine, a heating element or an atomizer, and a mouthpiece through which the user puffs (U.S. Department of Health and Human Services, 2016). The device heats a liquid solution called e-juice or e-liquid which usually contains propylene glycol or glycerin as a solvent for the nicotine and flavoring chemicals (U.S. Department of Health and Human Services, 2016). Once heated, the liquid solution is converted into an aerosol that is inhaled by the user (U.S. Department of Health and Human Services, 2016). One of the defining characteristics of the more recent generation of devices is that they contain larger batteries and are capable of heating the liquid to a higher temperature. This allows the device to release more nicotine, form additional toxicants, and create larger clouds of particulate matter (Kosmider et al. 2014).

Prevalence

The U.S. Centers for Disease Control and Prevention (CDC) and the Food and Drug Administration (FDA) showed in a National Youth Tobacco Survey (NYTS) that the e-cigarettes have been the most commonly used tobacco product among U.S. youth since 2014. The 2018 results from the NYTS reported that 27.1 % of high school students (4.04 million) and 7.2% of middle school students (840,000) use tobacco products, with electronic cigarettes being the most commonly used product among both high school and middle school students; 20.8% and 4.9% reporting e-cigarette use respectively (Gentzke, 2019). Electronic cigarette use among high school students increased by 77.8%, , from 11.7% in 2017 to 20.8% in 2018 and 48.5% for middle school students from 3.3% in 2017 to 4.9% in the same period (Gentzke, 2019).

Middle and high school students are not the only population at high risk of e-cigarette use. The Behavioral Risk Factor Surveillance System (BRFFSS) study in 2016 found that ever use of e-cigarettes ranged from 16.2% to 28.4%, and current use ranged from 2.4% to 6.7% across the United States (Hu, 2019). E-cigarette use among adults was found to be associated with current subsequent use of combustible cigarettes across all states, with states possessing a higher prevalence of combustible cigarette use also having high prevalence of current e-cigarette use (Hu, 2019).

Other studies have shown that anywhere between 17.7% to 40% of college students have tried or are currently using e-cigarettes (Grant, 2019; Lanza, 2018; Delnevo, 2016) and 60% of college students have been offered an e-cigarette at least once (Copeland, Peltier, & Waldo, 2017; Wallace & Roache, 2018). Additionally, 40% of college e-cigarette users had never previously smoked combustible cigarettes

(Schoenborn & Gindi, 2016) and e-cigarette use among young adults is positively associated with being open to trying combustible cigarettes (Coleman et al., 2015). These findings indicate that e-cigarette use is creating a new population of individuals vulnerable to developing nicotine addiction.

Negative Health Effects

There are many negative health effects associated with youth tobacco consumption, the most predominant of which is a high risk of addiction. According to the National Center on Addiction and Substance Abuse, the risk of addiction to nicotine increases with earlier age of first use (2008). Currently 3.8% of middle and high school students meet the criteria for tobacco addiction, however, this number may be lower than the true rate due to the amount of time it takes for addiction to develop (The National Center on Addiction and Substance Abuse, 2008). Nicotine addiction in young adults was reported to be 8.4% for those who smoked cigarettes and 4.3% for those who smoked e-cigarettes (The National Center on Addiction and Substance Abuse, 2008). Additionally, nicotine exposure during brain development, which continues until the mid-twenties, is associated with decreased attention span later in life (Counotte et al., 2008) and learning disabilities in adulthood (Fountain, Rowan, Kellye, Wiley, & Nolley, 2008).

The health ramifications from e-cigarette use are related to the chemical components within e-liquids, cartridges, and aerosols. Detectable levels of more than 115 volatile organic compounds and semi-volatile organic compounds have been found in a single puff of an e-cigarette, and many of the potentially toxic chemicals found in the aerosol were not present in the e-liquid solution (The National Center on Addiction and Substance Abuse, 2008). This suggests that the aerosolization process itself might

increase the risks associated with e-cigarette use (The National Center on Addiction and Substance Abuse, 2008). The documented acute effects of e-cigarette use include increased plasma nicotine, heart rate, and carbon monoxide concentration (The National Center on Addiction and Substance Abuse, 2008). Other short-term adverse effects include respiratory distress, bronchitis, impaired vascular function, and cell damage that can lead to oral disease. (The National Center on Addiction and Substance Abuse, 2008; McConnel et al., 2017). Research also suggests an increased risk of chronic respiratory symptoms in adolescents who report using e-cigarettes as well as a link to cardiovascular disease and cancer (The National Center on Addiction and Substance Abuse, 2008).

Covid-19

Covid-19 is a respiratory disease caused by the virus severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Brake, Barnsley, McAlinden, Eapen, & Sohal, 2020). Due to the lung damage caused by sustained e-cigarette use, smokers could be at a higher risk of infection and severe presentation of Covid-19. Research has shown that smoking, including e-cigarette use, can lead to an upregulation of the angiotensin-converting enzyme-2 (ACE2) receptor, the known receptor for the coronavirus family, including SARS-CoV-2 (Brake et al., 2020). Attachment of the virus to ACE2 receptors on the cell surface protects the virus from immune surveillance mechanisms, allowing the virus to remain unbothered in the host for longer periods of times thus making the host susceptible to future infections as well as increased spreading of the virus (Brake et al., 2020). This upregulation of ACE2 receptors may put smokers at an increased risk for Covid-19.

Mental Illness and E-cigarette Use

High rates of e-cigarette use have been linked to an increase in depressive symptoms among young adults (Lechner, Janssen, Kahler, Audrain-McGovern, & Leventhal, 2017). One study found that former e-cigarette users had a 1.6 times higher odds of reporting a history of clinical diagnosis of depression than never users and current e-cigarette users had a 2.10 times higher odds (Obisesan et al., 2019). Additionally, the study found higher odds of reporting depression were observed with increased frequency of use among current e-cigarette users compared with never users (Obisesan et al., 2019). Reports indicate that a single day of nicotine exposure during adolescence is sufficient to precipitate a negative emotional state rendering the individual increasingly vulnerable to the adverse effects of stress and subsequently depression in adulthood (Ĩiguez et al., 2009). Furthermore, Bandiera, Loukas, Wilkinson, and Perry (2017) found that elevated depression symptoms predicted e-cigarette use up to 6 months. A bi-directional relationship between depression symptoms and e-cigarette use has been suggested, implying that depressed individuals may smoke as a form of self-medication and that smoking may lead to increased depressive symptoms (Chan, 2019; Bandiera 2017). The bi-directionality of the relationship between e-cigarette use and depression is further supported by Chiaton et. Al. (2015), whose study suggest that the pathways from depressive symptoms to smoking differ from the pathways that relate smoking to depressive symptom onset.

While previous studies have indicated a relationship between depression and vaping (Lechner et al., 2017; Bandiera et al, 2017; Ĩiguez et al., 2009), few studies have focused on anxiety and vaping. A previous study regarding combustible cigarette use

showed a higher correlation between individuals suffering from both depression and anxiety or individuals suffering solely from anxiety and smoking combustible cigarettes then those suffering from depression alone (Mykletun, Overland, Aarø, Liabø, & Stewart, 2008). Smoking combustible cigarettes has also been associated with an increased risk of new onset of mood and anxiety disorders (Mojtabai & Crum, 2013). From these results, it stands to reason that vaping may also be used as a form of self-medication for those suffering from anxiety. Additionally, a recent study showed that mild to severe mental distress, as seen in individuals suffering from anxiety and depression, can produce a negative impact on academic performance (Begdache, Kianhehr, Sabounchi, Marszalek, & Doman, 2019).

Marketing Strategies

E-cigarette companies target younger adults, specifically high school and college students, through various marketing strategies. One such strategy is the production of flavored e-liquids. The e-liquids used in e-cigarettes come in a variety of flavors, with the most prominent flavors available being mint, coffee, and fruit flavors (Grana and Ling 2014). One study found that approximately 7,764 unique e-liquid flavors exist (Zhu et al. 2014) not including the custom flavors available to consumers in retail shops, commonly referred to as “vape shops”. The widespread popularity of flavored e-cigarettes is a public health concern due to youth and young adults being more likely than adults to choose flavored cigarettes (The National Center on Addiction and Substance Abuse, 2008). These concerns led to Congress banning flavored combustible cigarettes, other than tobacco or menthol, in the Tobacco Control Act (The National Center on Addiction and Substance Abuse, 2008). However, e-cigarette devices do not fall under this Act, a cause

of concern as 81.5% of youth e-cigarette users admitted to using e-cigarettes because they came in appetizing flavors (Ambrose et al., 2015). Additionally, a study conducted by Dai and Hao (2017) found that 66.5% of colleges in the United States have at least one vape shop within a 3-mile radius of campus and that prevalence of vape shops increases as the student population of the campus increases (Dia & Hao, 2017).

Social Media

E-cigarette manufacturers also target young adults and college students through the use of social media platforms and the internet as their primary outlet for e-cigarette advertisements. While 87.6% of college students reported getting information about e-cigarette use from social connections, such as friends or family who use e-cigarettes, the second most common source cited was social media platforms and internet searches (Dobbs, Clawson, Gowin, & Cheney, 2018). From 2010 to 2015 a 450% increase in google searches for e-cigarette terminology was seen (Ayers et al., 2016). As well, 90% of young adults use social media in some capacity (Perrin, 2015) with 63% of Facebook and Twitter users relying on social media as their primary source of information and news outside of friends and family members (Pew Research Center, 2015). It has also been found that college students perceive any information found online, from YouTube, reddit, or the result of a google search, as credible information without verifying the source and that personal experiences are considered to be sufficiently credible sources (Dobbs et al., 2018).

An analysis of e-cigarette videos on YouTube found that 85% of e-cigarette promotional videos were produced directly by e-cigarette manufactures and that 94% of e-cigarette videos and advertisements on YouTube were “pro” e-cigarette use while only

2% of videos found were “anti” use, showing the negative ramifications of using e-cigarettes (Luo, Zheng, and Zeng, 2014). Of the “pro” videos, 84.3% presented a website link directly connecting the consumer to an e-cigarette vendor website (Luo, Zheng, and Zeng, 2014). The main promotional strategy used by e-cigarette manufacturers was presenting e-cigarette use as a healthier alternative to smoking combustible cigarettes, with 74.6% of “pro” videos using this promotional tool (Luo, Zheng, and Zeng, 2014). Other promotional strategies included emphasizing the ability to use e-cigarettes in social situations where smoking combustible cigarettes is unacceptable (40% of videos) and highlighting the many flavor options available (43.2 % of videos) (Luo, Zheng, and Zeng, 2014). When analyzing e-cigarette retailer websites, it was found that 95% of websites make explicit or implicit health-related claims, 64% had smoking cessation-related claims, and 22% featured doctors (Grana & Ling, 2014). Vendor sites catered to a youth-oriented audience through claims of modernity (73% of sites) and enhanced social status (44%) (Grana & Ling, 2014). Appeal of advertisements is correlated with the belief that e-cigarette are less addictive alternative to smoking combustible cigarettes and intention to use e-cigarettes (Trumbo, 2015).

Knowledge, Perceptions, and Motivation to Use E-cigarettes

As the primary focus of many advertisement efforts, college students are often the first adopters of new products. However, in a study which sought to understand the knowledge and perceptions of college students in regard to e-cigarette use, the majority of participants were unsure how to define an e-cigarette and unable to identify the contents of an e-cigarette, specifically whether or not e-cigarettes contain tobacco and/or nicotine (Case, Crook, Lazard, & Mackert, 2016). Additionally, users and nonusers alike

cited e-cigarette use as a healthier alternative to smoking combustible cigarettes reposting that e-cigarettes contain fewer chemicals, less nicotine, and less smoke than their combustible counterparts (Case et al., 2016). Throughout the study, another theme that emerged was the belief that e-cigarettes can be used as a cessation method for smoking combustible cigarettes (Case et al., 2016). One study found that people who believed e-cigarettes were less addictive than combusted cigarettes had 2.49 times the odds of trying e-cigarettes than those who believed that e-cigarettes were just as or more addictive than combusted cigarettes (Wiseman, Margolis, Bernat, & Grana, 2019).

Other than these central beliefs among college students surrounding e-cigarette use as a safer alternative to combustible cigarettes, college students have reported family and friend support to be of significant influence on their e-cigarette use (Cheney, Gowin, & Clawson, 2018). Another study found that the top reason for college students to experiment with e-cigarette use was curiosity with 54.4% of participants citing this as their main reason for using e-cigarettes, followed by appealing flavors and peer influence with 43.8% and 31.6% of students reporting these reasons as their main reason for using e-cigarettes respectively (Kong, Morean, Cavallo, Camenga, & Krishman-Sarin, 2014). A recent study identified five overarching themes for college student initiation of e-cigarette use: feeling buzzed, feeling relaxed/less stressed, taste better than tobacco flavor and the high variety of flavor options, e-cigarettes are seen as a healthier alternative, and it is fun or cool (Lanza & Teeter, 2018) Other reasons for using e-cigarettes have also included the belief that vapor is less harmful to others than tobacco smoke, to save money, that e-cigarettes are better for one's health and, the ability to use e-cigarettes in non-smoking areas (Hefner et al., 2019).

Secondhand Exposure

With the increase in popularity of e-cigarette use, an environmental public health concern has arisen regarding the potential negative health effects of passive or secondhand exposure to the vapor exhaled by e-cigarette users, especially in indoor places (Balbè et al, 2014). Various means have been used to determine secondhand exposure including measurements of air quality and biochemical markers of cotinine, the predominant metabolite of nicotine. However, the health effects of secondhand exposure to e-cigarette vapors can be hard to determine as long-term exposure studies have yet to be conducted. Additionally, the multitude of various types of e-cigarette systems as well as varying levels of nicotine concertation found in e-liquid can lead to variability in the quantities of biproduct created by different brands, systems, and e-liquids.

Nicotine

Of primary concern among environmental public health specialist is the amount of nicotine individuals will be exposed to through secondhand, or passive, inhalation of vapor from e-cigarette users. A study conducted by Balbè et al, (2014) reported significantly lower rates of secondhand nicotine exposure for e-cigarette use than combustible cigarette exposure, but secondhand exposure from e-cigarette use was still significantly higher than non-smoker baseline rates. This indicates that while e-cigarettes use may reduce the harm of secondhand nicotine exposure, it is still significantly higher exposure than non-smoking households.

Czogala et al, 2014 found that e-cigarettes are a source of secondhand exposure to nicotine with the average air concentration of nicotine emitted by different brands of e-cigarettes ranging from 0.82 to 6.23 μg/m3. The different results on nicotine levels found

indicate that although there is clearly secondhand exposure to nicotine from the vapors of e-cigarettes, quantifying amount and therefore risk can be hard to accomplish due to the variability across types of e-cigarette devise.

Lui et al. (2017) compared different types of e-cigarette devises for presence of varying chemical compounds in the secondhand vapors. The study compared first generation e-cigarettes, which often mimic the structure of conventional cigarettes and come with a disposable cartridge, to that of second-generation e-cigarette devices that are composed of a large tank system. The study found the highest levels of nicotine were found for combustible cigarettes which reached a mean level of 40.65 $\mu g/m^{3.}$ The mean nicotine levels for first generation e-cigarettes ranged from 0.38 $\mu g/m^3$ to 0.96 $\mu g/m^3$ and second-generation e-cigarettes produced a mean of 2.83 $\mu g/m^3$ nicotine biproduct (Lui et al., 2017). While combustible cigarettes clearly create higher nicotine levels than their e-cigarette counterparts, the secondhand nicotine levels recorded for e-cigarettes are still significantly greater than baseline. Additionally, e-cigarettes produce secondhand exposure to other potentially volatile constituents. This indicates that while e-cigarettes may be a safer option than combustible cigarettes when it comes to secondhand exposure to vapor biproduct, they are not completely without risk.

Other Particulate Matter

In combustible cigarettes, secondhand smoke is generated from the burning of the tobacco rod between puffs as well as exhaled smoke. However, because the mechanisms of e-cigarettes do not include the burning of tobacco, secondhand exposure to aerosol is solely generated from the user's exhaled breath (Liu, 2017). A study of the measured chemical constituents in exhaled breath of e-cigarette users was found to

average 6% of nicotine, 8% of propylene glycol, and 16% of the glycerin originally inhaled (St. Helen, Havel, Dempsey, Jacob, & Benowitz, 2016). The secondhand exposure rates can vary, however, due to the varying types of e-cigarette devices available for consumption.

Outside of nicotine, the two constituents of primary concern are propylene glycol, and glycerol. The second generation (tank system) e-cigarettes showed the largest changes from baseline in propylene glycol and glycerol, which mean changes from baseline of 317.06 and 242.00 $\mu g/m^3$ respectively (Lui et al., 2017). An additional study, conducted by Schober et al. (2014), measured particulate matter (PM) and particle number concentrations (PNC) in an environmentally controlled room with predetermine occupancy density and air exchange rate that mimicked the real-world environment of a café. The study found that PM of all three diameters, 10 μm, 2.5 μm, and 1 μm, was markedly higher on e-cigarette use days versus control days but that levels were highest for $PM_{2.5}$ with a mean value of 197 g/m3 (Schober et al., 2014).

High $PM_{2.5}$ concentrations are of concern due to the adverse health effects associated with exposure to high concentrations of $PM_{2.5}$. Although the effect of $PM_{2.5}$ exposure depends on physical characteristics, including breathing mode, rate, and volume of the individual, (Brown, Gordon, Price, & Asgharian, 2013) research has shown that the particles that have the most adverse impact on human health are those less than 10μm in diameter (Kim, Kabir, & Kabir, 2015). This is because, due to their small size, they can infiltrate the respiratory tract, penetrating the nasal passage down to the alveoli, deep within the lungs (Lindbom et al, 2006). These particles are eventually deposited into the respiratory bronchioles and alveoli where gas exchange occurs and can even penetrate the

lungs (Lindbom et al., 2006). With time, these particles will escape into the blood stream where they can cause significant health problems (Fu et al., 2011).

Exposure to PM has been identified as the root of many different health effects including increased hospital admissions, emergency room visits, respiratory symptoms, exacerbation of chronic respiratory and cardiovascular diseases, decreased lung function, and premature mortality (Kim, Kabir, & Kabir, 2015). Additionally, research has shown that exposure to high PM levels may lead to diverse symptoms in fetus development including low birth weight in infants, pre-term deliveries, and possibly fetal and infant deaths (Kim, Kabir, & Kabir, 2015). Mild problems associated with inhaling $PM_{2.5}$ include shortness of breath, chest discomfort and pain, and coughing and wheezing (Guaita et al., 2011). A national U.S. epidemiologic study found a consistent and significant association between ambient air pollution $PM_{2.5}$ and diabetes prevalence (Pearson et al., 2010). Additions of behavioral, ethnic, and socioeconomic covariates only modestly reduced the magnitude of impact of $PM_{2.5}$ on adult diabetes (Pearson et al., 2010). Furthermore, removal of highly polluted regions with high diabetes prevalence did not alter the relationship in a significant manner (Pearson et al., 2010). Exposure to $PM_{2.5}$ in children has been shown to affect lung development in children, including reversible deficits, chronically reduced lung growth rate, and a deficit in long-term functioning (Brauer et al., 2012).

PM pollution has been linked to an increased risk of hospital admission for myocardial infarction in the elderly and exacerbation of congestive heart failure (Wellenius, Schwartz, & Mittleman, 2006). However, recent research links increased PM levels with increases in blood plasma viscosity, acute-phase reactants, endothelial

dysfunction, and altered autonomic control of the heart ((Sun, Hong, and Wold, 2010). Additionally, PM exposure has been linked to initiation and promotion of atherosclerotic progression, the main source of cardiovascular disease, as well vulnerability to plaque rupture (Suwa et al., 2002). Moreover, it has been found that even short-term exposure to $PM_{2.5}$ leads to a statistically significant increase in cardiovascular and respiratory hospitalizations (Bell et al., 2008).

Secondhand Exposure for Children

Another environmental public health concern is the possible negative health outcomes for children from exposure to e-cigarettes. The most common exposure that serves as a threat for infants and young adolescents is accidental ingestion of e-liquid solutions containing high concentrations of nicotine. From January 1, 2012 to April 30, 2017, there were 8,269 liquid nicotine exposures reported to the United States Poison Control Center involving children 6 years of age or younger (Govindarajan, Spiller, Casavant, Chounthirath, & Smith, 2018). Of these reported incidents, 83.9% involved children under the age of 3 (Govindarajan et al, 2018). Additionally, 92.5% of these reported incidents involved exposure through ingestion (Govindarajan et al, 2018). Consumption of e-liquid is more dangerous than that of tobacco, as the liquid can be absorbed into the body's systems in less time, even in dilute concentrations (Gill, Sangha, Poonai, & Lim, 2015). The toxic effects of e-liquid ingestion are dose-dependent with mild to moderate toxicity inducing symptoms of nausea, vomiting, dizziness, headache, tremors, diaphoresis, tachycardia, pallor, and hypertension (Gill et al., 2015). Most common of these symptoms are GI distress indicated by nausea and vomiting, in addition to pallor, diaphoresis, and mental confusion (Gill et al., 2015). Severe toxicity can induce

seizures, confusion, weakness, bradycardia, hypotension, and respiratory muscle paralysis (Gill et al., 2015). Death by nicotine overdose is also possible as was seen in the case of a 15-month-old female infant who was mistakenly given 5 ml of e-liquid containing a concentration of 10 mg of nicotine per ml, misidentifying it as cough medicine (Seo, Kim, Yu, & Kang, 2016). Upon consumption the infant vomited but immediately lost consciousness and was unresponsive (Seo et al., 2016). Despite being rushed to the emergency room, the dosage proved to be fatal (Seo et al., 2016).

Policy

FDA Regulation

In May of 2016, the FDA implemented a rule that required e-cigarettes to undergo a "premarket" review process for new tobacco products as well as requiring a warning label stating that the product contains the addictive chemical nicotine (FDA, 2016). However, any e-cigarette device already on the market as of August 8, 2016 was allowed to continue to be sold with the stipulation that manufactures were allotted three-years to complete a pre-market new tobacco product application. In 2017, the time period allowed for such applications was extended from three years to six years. This delay in enforcement has effectively allowed e-cigarettes to remain on the market for years without being reviewed or authorized by the FDA. As a result, e-cigarettes are not currently under any regulatory body.

Preventing Youth Access

A common concern in public health is that e-cigarettes introduce young adults to nicotine at an early age, both increasing the likelihood of nicotine addiction and serving

as a gateway for the use of other tobacco products. Research has shown that not only do young adults consider e-cigarettes to be a safer alternative to conventional cigarettes, but that e-cigarette companies specifically target teens and college-age individuals (Dobbs et al., 2018). These concerns led to the implementation of minimum legal sale age (MLSA) laws on e-cigarettes, with New Jersey being the first state to implement such laws in 2010 (Dave, Feng, & Pesko, 2019). They were quickly followed by four other states later the same year (Dave, Feng, & Pesko, 2019). When the Food and Drug Administration (FDA) enforced federal e-cigarette MLSA laws for those under the age of 18 in August of 2018, all states but two already had e-cigarette MLSA laws in place (Dave, Feng, & Peski, 2019). As of December 20, 2019, the President signed legislation to raise the federal minimum age of sale of tobacco products, including e-cigarettes, from 18 to 21 years old.

However, MLSA laws have had an unexpected impact on tobacco use among minors. It has been found that e-cigarette MLSA laws have led to an increase in minors smoking conventional cigarettes in their place. Studies have shown anywhere from a 0.8% to 1.3% increase in minor use of conventional cigarettes (Pesko, Hughes, & Faisal, 2016; Dave, Feng, & Pesko, 2019). While this regression to conventional cigarettes may seem counterintuitive as minors are also restricted from purchasing conventional cigarettes, studies suggest that the implementation of e-cigarette MLSA laws increase the cost of accessing e-cigarettes compared to the cost of accessing conventional cigarettes (Dave, Feng, & Pekso, 2019). Conventional cigarettes have been on the market for a long time and adults are more likely to smoke conventional cigarettes then they are to use e-cigarettes. Therefore, minors have previously established alternative methods for bypassing such restrictive laws through the use of secondary sources, such as “bumming”

or borrowing from a friend or adult (Hansen, Rees, & Sabia, 2013). As more adults smoke conventional cigarettes, as opposed to vaping, it may be harder for youth to obtain e-cigarettes though these types of secondhand endeavors.

Labeling

As of August 10, 2018, the FDA requires that all e-cigarette devices contain a nicotine warning label that states "**WARNING: This product contains nicotine. Nicotine is an addictive chemical.**" The FDA states that the purpose of the addiction warning is to help consumers understand the consequences and addictiveness of e-cigarettes containing nicotine (Berry, Burton, & Howlett, 2017). However, studies have been done to evaluate the effectiveness of such labels, with varying results. One study looked at the effectiveness of nicotine warning labels when combined with positive health advertisements. In this study, participants were either shown an e-cigarette with only a warning label stating "Warning: E-cigarettes are addictive" or they were shown in the e-cigarette warning label in conjunction with a pro-health advertisement stating that e-cigarettes are "the healthier smoking alternative" (Berry, Burton, & Howlett, 2017). The study found that when the warning label was shown alone, the perceive risks reported by participants increased. However, when the pro-health advertisement was added, it mitigated the warning label resulting in lower levels of perceived risk among participants (Berry, Burton, & Howlett, 2017). These results emphasize the importance of reducing the unsubstantiated health claims that are common among e-cigarette advertisements.

An additional study, which also looked at the effect of FDA warning labels on e-cigarettes, found that there was no significant difference in the likelihood of individuals

purchasing e-cigarettes when an FDA regulated warning label is present (Wackoswki et al.,2019). Additionally, no significant difference was found on participants harm and addiction beliefs regarding e-cigarettes with the presence or absence of a warning label (Wackoskwi et al., 2019). These results indicate that text-only warning labels have little to no impact on individuals when placed among otherwise colorful and interesting e-cigarette advertisements (Wackoski et al., 2019).

CHAPTER THREE

Methods

Participants

All full-time undergraduate students at Baylor University between the ages of 18 and 25 and enrolled in a PUBH course were eligible to participate in this study. Students enrolled in public health courses were asked to participate in an online survey pertaining to vaping behavior between August 2019 and January 2020. Prospective participants were assured that their participation was completely voluntary, anonymous, and confidential, as no identifying information was collected and that there would be no penalty for declining to participate, discontinuing at any time, or omitting answer to any questions. After clicking the link for the survey, participants were directed to a consent form, reiterating the above information, as well as the purpose of the study, the risk associated with participation, and contact information for the research team if needed. By clicking "next" to continue, participants indicated their consent to participate and their understanding of the nature of the study. The study was approved by the Baylor Institutional Review Board. An incentive for participation was not provided. Of the eligible students, 873 participated in the survey. Thirty-one responses were eliminated for missing data.

The 20-question, approximately 15-minute survey included questions related to demographics, frequency of e-cigarette use, knowledge and perceptions surrounding e-cigarette use, anxiety and depression symptomology, academic performance, and self-efficacy.

Demographics

Participates were asked to report their age, race/ethnicity, gender, major, and classification.

Outcome Measure

E-cigarette Use

E-cigarette use was assessed using two questions. The first question assessed frequency of use ("How often do you vape?") with possible responses including "everyday", "somedays", "rarely", or "not at all". Additionally, past, current, or never use was assessed using the question "Have you ever used an e-cigarette or vape?" with possible responses of "never", "once or twice", "occasionally but not regularly", "regularly in the past" or "regularly in the present". The categories "once or twice", "occasionally but not regularly" and "regularly in the present" where collapsed into a new category "current use".

Independent Variables

E-cigarette Knowledge and Perceptions

Knowledge and perceptions surrounding E-cigarette use was assessed using 8 Likert scale questions. Questions included "Vaping is harmful for your health", "Vaping may lead to future use of regular cigarettes", "Vaping is a public health concern", "Vaping should be regulated like other tobacco products", "Vaping should be regulated like other tobacco products", and "Vaping should be regulated in work or public places".

Each response was scored with “Strongly Agree” assigned 5 points, “Agree” 4 points, “Neither Agree nor Disagree” 3 points, “Disagree” 2 points, and “Strongly Disagree” 1 point. Three questions were reverse coded including “Vaping is safer than regular cigarette use”, “Vaping is less addictive than regular cigarette use” and “Vaping is a helpful aid for smoking cessation”. A total knowledge score was created for each participant by adding the scores of each individual question.

Self-efficacy and Academic Performance

Self-efficacy was assessed using the General Self-Efficacy Scale (GSE), a ten-question Likert scale survey with a score range between 10-40 (Schwarzer & Jerusalem, 1995). The GSE has a Cronbach’s Alpha between 0.76 and 0.90 (Schwarzer & Jerusalem, 1995). Academic performance was evaluated using self-reported overall GPA. This method of assessment for academic performance was selected because four-year overall GPA reliability is found to be quite high, at .94. (Bacon & Bean, 2006). Additionally, overall reliability of GPA increases over time, from .84 in the first year, to .90 in the second year, .93 in the third year, and finally to .94 at the end of the 4th year (Bacon & Bean, 2006). It has also been shown that overall GPA reliability is higher than a specific sub-set GPA such as a science GPA or business GPA (Bacon & Bean, 2006). Additionally, self-reports of GPA and GPAs reported from the registrar have been found to correlate as high as .97 (Cassady 2001). For these reasons, GPA was selected as the outcome measure for academic performance.

Depression and Anxiety Symptomology

Anxiety symptomology was assessed using the Generalized Anxiety Disorder scale (GAD-7), a seven-question assessment with a score range of 0-21 (Spitzer, Kroenke, Williams, & Lowe, 2006) Cutoff scores of 5,10, and 15 corelate with mild, moderate, and severe anxiety symptoms respectively (Spitzer et al., 2006). The GAD-7has a Cronbach's Alpha of 0.8914 (Spitzer et al., 2006).

Depression symptomology was assessed using the Patient Health Questionnaire (PHQ-9), a nine-item survey that scores to 27(Kroenke, Spitzer, & Williams, 2001) Scores of 5, 10, and 20 correlate to mild, moderate, and severe depression respectively (Kroenke, Spitzer, & Williams, 2001). The PHQ-9 has a Cronbach's Alpha of 0.89 (Kroenke, Spitzer, & Williams, 2001).

Data Analytic Plan

Descriptive statistics summarizing the characteristics of the sample were provided. The extent to which knowledge pertaining to the harms associated with e-cigarette use, self-efficacy, depression, anxiety, GPA, and gender effect e-cigarette use frequency was assessed using multiple regression. Hypothesis testing was achieved using Hierarchical Multiple Regression. All analysis was conducted using IBM SPSS Statistics 26. Significance was set at P-value < 0.05.

CHAPTER FOUR

Results

Descriptive Characteristics

A summary of sample population demographics can be seen in Figures A.1, A.2, and A.3. The sample population was primarily non-Hispanic white females in their senior year of college. Participants were 37.6% male and 61.7% female. The sample population was comprised of Baylor University undergraduate students registered for public health courses with 14.3% of the respondents in their freshman year, 12.9% in their sophomore year, 20.7% in their junior year, and 52.1% in their Senior year. The majority of respondents were non-Hispanic white (62.1%), with 13.5% of respondents identifying as Hispanic/Latino, 6.8% as African American, 0.5 as Native American, 12.1% as Asian or Pacific Islander, and 5% as "other". Descriptive characteristics of e-cigarette frequency are reported in Table A.1. The majority of respondents reported never use of e-cigarettes (74.8%) with 7% reporting everyday e-cigarette use, 6.2% reporting use on somedays, and 11.5% reporting rare use. Table A.2 reports demographic characteristics based on current e-cigarette users, past e-cigarette users, and never users. Over a third of respondents were current users (40.9%) with a higher prevalence among females (24.5%) compared to males (16.4%) and a higher prevalence among non-Hispanic whites (26.7%).

Bivariate Results

As can be seen in Table A.1, chi-squared analysis showed a significant association between gender and frequency of e-cigarette use ($\chi^2 = 22.94$, $p < .001$). Based on the odds ratio, males were 3.16 times more likely to use e-cigarettes somedays compared to females. Use of e-cigarettes every day, rarely, or never were not significantly different in males and females. No significant association between classification or race was seen with e-cigarette use frequency. Table A.2 shows the results of chi-squared analysis for demographic characteristics and current e-cigarette use, past e-cigarette use, and never use. There was a significant association between gender and e-cigarette use ($\chi^2 = 39.99$, $p < .001$).

As can be seen in Table A.3 and Figure A.6, significant relationships were found between knowledge ($F = 9.01$, $p <.001$), self-efficacy ($F = 4.85$, $p < .05$), depression ($F = 8.31$, $p < .05$), and GPA ($F = 5.49$, $p < .001$) and e-cigarette use. No significant relationship was seen between anxiety and e-cigarette use. Post Hoc analysis indicates a significant difference in knowledge scores between never users and everyday users and between never users and somedays users. This indicates that lower levels of knowledge pertaining to the possible negative health outcomes of e-cigarette use significantly correlates to more frequent use of e-cigarettes. For self-efficacy, post hoc analysis revealed a significant difference between self-efficacy scores and all categories of e-cigarette use, indicating that as self-efficacy decreases, frequency of e-cigarette use increases. Depression scores were significantly lower for never users compared to somedays users; however, differences were not significant among other e-cigarette frequency categories. A significant decrease in GPA was seen in everyday users when

compared to never users however, the relationship between GPA and e-cigarette use was not significant for other categories of e-cigarette use frequency.

Multivariate Results

A hierarchical multivariate regression was configured. Results are presented in Table A.4. Knowledge was the greatest indicator of e-cigarette use ($R^2 = .029$) followed by GPA ($\Delta R^2 = .016$) in step 2 and gender ($\Delta R^2 = .009$) in step 3. A significant change in R^2 was not seen for self-efficacy, anxiety, or depression.

Table A.5 shows the correlation matrix for all independent variables. Knowledge was found to be significantly correlated with self-efficacy ($r = .178$, $p < .01$), and GPA ($r = .095$, $p < 01$). Self-efficacy was significantly correlated with depression symptomology ($r = -.222$, $p < .01$), anxiety symptomology ($r = -.206$, $p < .01$), and GPA ($r = .106$, $p < .01$). Depression was significantly correlated with anxiety ($r= .762$, $p < .01$) and GPA ($r = -.140$, $p < .01$).

CHAPTER FIVE

Discussion

The study assessed the independent associations between five outcomes of interest – knowledge of possible negative health effects of e-cigarette use, self-efficacy, anxiety, depression, and academic performance – and e-cigarette use in a sample of undergraduate college students at Baylor University. The mean family income of students at Baylor University is 127,500 (Buchanna, L & Aisch, G, 2017). According to the institute of research and testing, Baylor has a higher ratio of females to males. For the 2019-2020 school year, 41% of the school's population was male and 59% was female. In addition, the institute of research and testing reports the racial demographics of Baylor University to be 61% non-Hispanic white, 20% Hispanic, 5.5% African American, 7% Asian or Pacific Islander, 0.5% American Indian, 0.3% unknown, and 5.7% two or more races. Our sample population closely mirrored the demographics of Baylor University with 37.6% of respondents being male, 61.7% being female, and 0.6% unknown. Additionally, the racial demographics of the sample population closely mirrored that of Baylor University with 62.1% identifying as non-Hispanic White, 13.5% as Hispanic, 12.1% as Asian or Pacific Islander, 6.8% as African American, 0.5% as Native American, and 5% as other.

Approximately a fourth of respondents (24.8%%) reported e-cigarette use which alines with previous research regarding e-cigarette prevalence among college students (Grant, 2019; Lanza, 2018; Delnevo, 2016). Of the variables assessed in this study,

significant relationships were seen between knowledge, self-efficacy, depression, and academic performance with e-cigarette use. No significant relationship between anxiety and e-cigarette use was seen.

Previous research has indicated a relationship between knowledge or perceptions surrounding the safety of e-cigarettes to be an indicator of likeliness to use e-cigarettes (S Wiseman, Margolis, Bernat, & Grana, 2019; Case et al., 2016) which the results of this study support, as knowledge was found to be the largest indicator of e-cigarette use. Significant differences were seen in knowledge scores for everyday users when compared to never users and someday users compared to never users. No significant difference was seen between rare users and never users indicating that knowledge may not decrease the likelihood of an individual trying e-cigarettes but does influence continued, habitual e-cigarette use behaviors.

High self-efficacy has been seen in previous research as an influence of indication to quit e-cigarette use (Chan, 2019; Pokhre et al., 2013) however, the influence of low self-efficacy on initiating e-cigarette use has not been previously explored. This study showed a significant relationship between self-efficacy and all categories of e-cigarette use frequency, implying that low self-efficacy can lead to more frequent use e-cigarette devices.

Previous research has shown a bi-directional relationship between depression and e-cigarette use (Chan, 2019; Bandiera 2017; Chiaton et al., 2015). Due to the nature of this study being a cross-sectional survey, temporality of the relationship between depression and e-cigarette use could not be observed. However, the results did indicate a significant difference between depression scores for never users when compared to

somedays users, indicating rates of depression symptoms tend to be higher among somedays users. A significant difference was not seen between depression scores of everyday users when compared to never users which could be due to the relatively small number of everyday users present in the sample.

While previous studies have found a relationship between anxiety symptoms and use of combustible cigarettes, (Mykletun, Overland, Aarø, Liabø, & Stewart, 2008; Mojtabai & Crum, 2013) no research has been conducted assessing the relationship between anxiety and e-cigarettes. While no significant difference between anxiety and e-cigarette use was found, anxiety scores were slightly lower for never users (mean = 10.90, SD = 4.37) than for everyday users (mean = 11.39, SD = 4.43). The lack of significance could be due to a small number of individuals in the sample reaching criteria for generalized anxiety disorder. It is possible that participants still use e-cigarettes as coping mechanism for dealing with feelings of stress and anxiety without reaching full criteria for an anxiety disorder. As research into e-cigarette use progresses, a relationship between anxiety and e-cigarette use may emerge. It is important to understand any possible underlying motivations for e-cigarette use, especially those pertaining to self-medication of mental illness, in order to effectively reduce e-cigarette use.

In addition, this study found a significant relationship between academic performance, as assessed using self-reported cumulative GPA, and e-cigarette use. Specifically, a significantly lower GPA was seen in everyday users when compared to never users. Again, due to the nature of the cross-sectional survey, causality of this relationship could not be determined therefore it cannot be discerned whether those with

lower academic performance are more likely to use e-cigarettes or if using e-cigarettes in some way leads to a decrease an academic performance.

Lastly, multivariate analysis indicated that the strongest predictor of e-cigarette use was knowledge ($R^2 = .029$). While results indicated gender and GPA play a smaller role in e-cigarette use, self-efficacy, depression, and anxiety symptomology did not have a significant impact on e-cigarette use in multivariate analysis. The lack of significance within the hierarchical regression model could be due to the high levels of correlation between independent variables as seen in Table A.5.

Implications

The results of this study indicate that community health workers in public health should focus on education as a tool to reduce the prevalence of e-cigarette use among college students. Lack of knowledge or misinformation regarding the possible long-term negative health effects of e-cigarette use was found to be the greatest predictor of e-cigarette use. Additionally, a relationship between low self-efficacy and increased frequency of e-cigarette use was found, indicating that along with providing accurate information, public health workers should focus on increasing self-efficacy. Lastly, emphasizing the importance of healthy outlets for managing stress, anxiety, and depression symptoms could help reduce the number of students using e-cigarettes for symptom management.

Recommendations

Future research pertaining to e-cigarette use among college students is needed. Replicating this study at other colleges, specifically colleges without religious affiliations

or tobacco-free, smoke-free campuses, could help further illuminate the relationships between e-cigarette use and the target variables. Additionally, future research on the relationship between anxiety and e-cigarette use is needed. Lastly, research focusing on the relationship between sustained e-cigarette use and susceptibility to respiratory diseases would be beneficial.

Limitations

The main limitation of this study was the use of a convenience sample of Baylor University undergraduates enrolled in PUBH classes between Fall 2019 and Spring 2020. Cross-sectional surveys are inherently prone to bias, including response bias, selection bias, and sample bias. Response bias may have been present as students were enrolled in a health-based class and may have felt uncomfortable providing information regarding e-cigarette use frequency in such an environment. Selection bias is seen in the use of a convince sample. Although the demographic characteristics of the sample population closely mirror the demographic characteristics of the Baylor University population, sample bias may still be present due to the high proportion of Business students present in the sample population (see Figure A.1). Furthermore, temporality cannot be determined with the use of a cross-sectional survey.

As Baylor University is a Tobacco-free, smoke-free campus, it is possible that e-cigarette use is lower among Baylor University students than students at colleges that lack these stipulations. In addition, as Baylor University is a religiously affiliated in university, it is possible that the general population at Baylor University is less likely to use e-cigarettes when compared to non-religious institutions.

APPENDIX

APPENDIX

Table A.1

Frequency of E-cigarette use by demographic characteristics

Characteristic	n	Everyday	Somedays	Rarely	Never	P-Value
Gender						< .001
Male	305(37.6%)	25 (3.1%)	32 (3.9%)	41 (5.1%)	207 (25.5%)	
Female	501 (61.8%)	32 (3.9%)	18 (2.2%)	51 (6.3%)	400 (49.3%)	
Rather not say	5 (0.6%)	0 (0.0%)	1 (0.1%)	1 (0.1%)	3 (0.4%)	
Classification						.521
Freshmen	116 (14.3%)	4 (0.5%)	9 (1.1%)	10 (1.2%)	93 (11.5%)	
Sophomore	105 (12.9%)	8 (1.0%)	4 (0.5%)	14 (1.7%)	79 (9.7%)	
Junior	168 (20.7%)	13 (1.6%)	15 (1.8%)	18 (2.2%)	122 (15%)	
Senior	423 (52.1%)	32 (3.9%)	23 (2.8%)	51 (6.3%)	317 (39%)	
Race/Ethnicity						.278
Hispanic/Latino	110 (13.5%)	7 (0.9%)	9 (1.1%)	14 (1.7%)	80 (9.9%)	
African American	55 (6.8%)	4 (0.5%)	4 (0.5%)	2 (0.2%)	45 (5.5%)	
Native American	4 (0.5%)	1 (0.1%)	0 (0.0%)	1 (0.1%)	2 (0.2%)	
Asian/Pacific Islander	98 (12.1%)	12 (1.5%)	7 (0.9%)	12 (1.5%)	67 (8.3%)	
Non-Hispanic White	504 (62.1%)	31 (3.8%)	29 (3.6%)	55 (6.8%)	389 (47.9%)	
Other	41 (5%)	2 (0.2%)	2 (0.2%)	9 (1.1%)	28 (3.4%)	

Note: Chi-square tests of association for group comparisons

Table A.2

Current, never, and past e-cigarette use by demographic characteristics

Characteristic	n	Current users	Never users	Past Users	P-Value
Gender					< .001
Male	305(37.6%)	133 (16.4%)	131 (16.2%)	41 (5.1%)	
Female	501 (61.8%)	199(24.5%)	287 (34.6%)	21 (2.6%)	
Would rather not say	5 (0.6%)	2 (0.2%)	3 (0.4%)	0 (0.0%)	
Classification					.176
Freshmen	116 (14.3%)	45 (5.5%)	64 (7.9%)	7 (0.9%)	
Sophomore	105 (12.9%)	39 (4.8%)	63 (7.8%)	3 (0.4%)	
Junior	168 (20.7%)	76 (9.4%)	79 (9.7%)	13 (1.6%)	
Senior	423 (52.1%)	175 (21.6%)	209 (25.7%)	39 (4.8%)	
Race/Ethnicity					.004
Hispanic/Latino	110 (13.5%)	39 (4.8%)	60 (7.4%)	11 (1.4%)	
African American	55 (6.8%)	14 (1.7%)	38(4.7%)	3 (0.4%)	
Native American	4 (0.5%)	3 (0.4%)	1 (0.1%)	0 (0.0%)	
Asian/Pacific	98 (12.1%)	47 (5.8%)	51 (6.3%)	0 (0.0%)	
Islander					
Non-Hispanic White	504 (62.1%)	217 (26.7%)	246 (30.3%)	41 (5%)	
Other	41 (5%)	15 (1.8%)	19 (2.3%)	7 (0.9%)	

Note: Chi-square tests of association for group comparisons

Table A.3

Mean, standard deviation, and bivariate results for knowledge, GSE, PHQ, GAD, and GPA compared to e-cigarette use frequency

Characteristic	Every day (n=57)	Somedays (n=51)	Rarely (n=93)	Never (n=611)	P-Value
Knowledge (mean, SD)	27.56 (5.42)	26.20 (4.08)	28.86 (5.25)	31.82 (4.47)	> .001
Self-Efficacy (mean, SD)	29.02 (8.87)	32.18 (4.66)	31.67 (5.73)	31.85 (5.04)	.002
Depression (mean, SD)	13.63 (5.03)	14.12 (4.69)	13.87 (5.40)	13.01 (4.66)	.040*
Anxiety (mean, SD)	11.39 (4.43)	11.67 (4.69)	11.60 (4.39)	10.90 (4.37)	.319
GPA (mean, SD)	3.30 (0.38)	3.41 (0.33)	3.43 (0.33)	3.50 (0.36)	.001

Note: ANOVA one-way analysis used to compare means

* Kruskal-Wallis Test for Independent samples used due to violation of normalcy

Table A.4

Hierarchal regression results for independent variables and e-cigarette use

Characteristic	B	SE B	β
Step 1			
Constant	2.33	.26	
Knowledge	0.04	.01	.17*
Step 2			
Constant	1.33	.38	
Knowledge	0.04	.01	.16*
GPA	0.31	.09	.13*
Step 3			
Constant	1.20	.38	
Knowledge	0.04	.01	.15*
GPA	0.29	.09	.12*
Gender	0.17	.06	.10*
Step 4			
Constant	1.03	.34	
Knowledge	0.04	.01	.14*
GPA	0.28	.09	.11*
Gender	0.18	.06	.10*
Self-Efficacy	0.01	.01	.05
Step 5			
Constant	1.20	.42	
Knowledge	0.04	.01	.14*
GPA	0.27	.09	.11*
Gender	0.18	.06	.10*
Self-Efficacy	0.01	.01	.04
Depression	-.01	.01	-.04
Step 6			
Constant	1.20	.42	
Knowledge	0.04	.01	.14*
GPA	0.27	.09	.11*
Gender	0.18	.06	.10*
Self-Efficacy	0.01	.01	.04
Depression	-0.00	.01	-.00
Anxiety	-0.01	.01	-.05

Note: $R^2 = .029$ for Step 1, $\Delta R^2 = .016$ for Step 2 ($p < .001$), $\Delta R^2 = .009$ for Step 3 ($p = .008$), $\Delta R^2 = .003$ for Step 4 ($p = .155$), $\Delta R^2 = .001$ for Step 5 ($p = .291$), $\Delta R^2 = .001$ for Step 6 ($p = .389$). * $p < .05$.

Table A.5

Correlation matrix for independent variables

Characteristic	Correlation	Knowledge	Self-Efficacy	Depression	Anxiety	GPA
Knowledge	Pearson Correlation	1	.178**	.008	.027	.095
	P-value		.000	.835	.447	.008
Self-Efficacy	Pearson Correlation	.178**	1	-.222**	-.206**	.106**
	P-value	.000		.000	.000	.003
Depression	Pearson Correlation	.008	-.222**	1	.762**	-.140**
	P-value	.835	.000		.000	.000
Anxiety	Pearson Correlation	.027	-.206**	.762**	1	-.070
	P-value	.447	.000	.000		.053
GPA	Pearson Correlation	.095**	.106**	-.140**	-.070	1
	P-value	.008	.003	.000	.053	

Note: ** significance at the p < .01 level

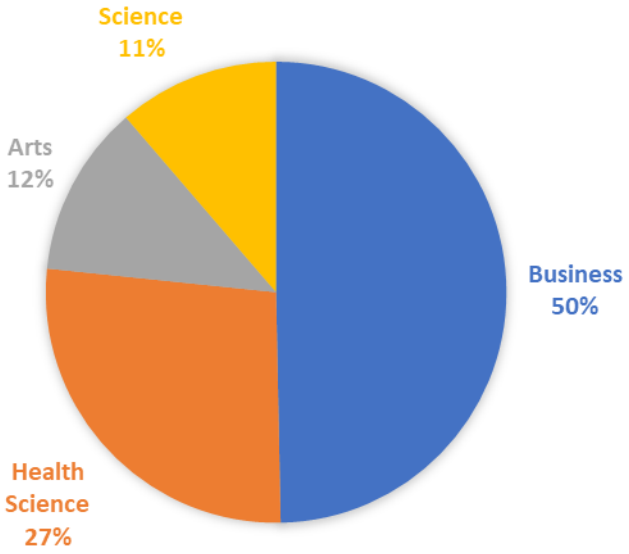

Figure A.1. Participant majors

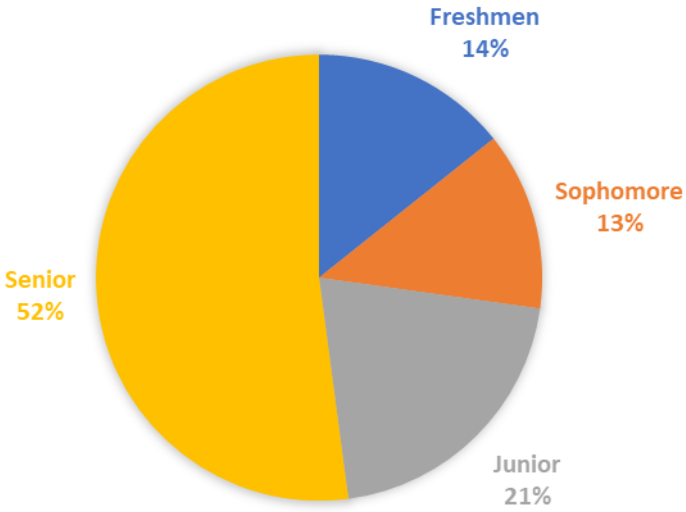

Figure A.2. Participant Classification

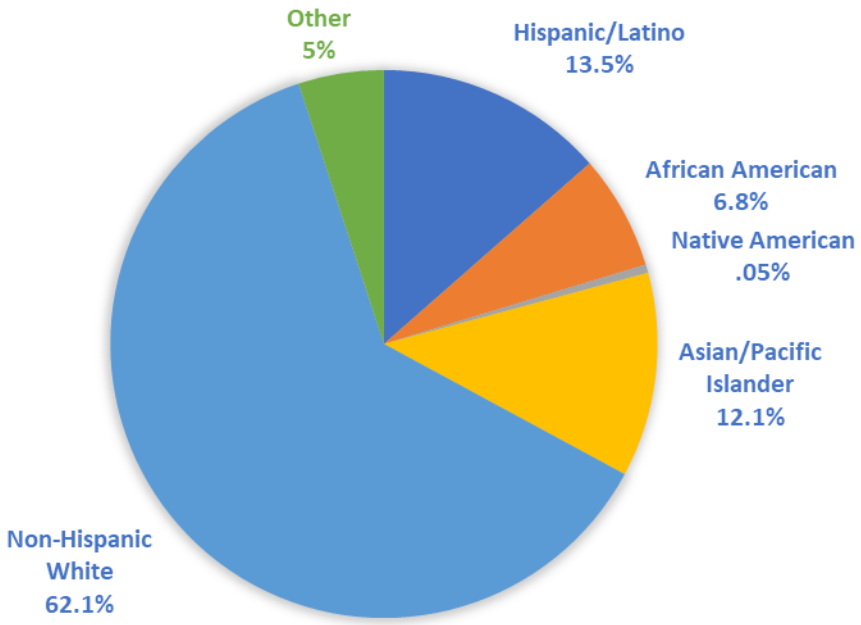

Figure A.3. Participant Race

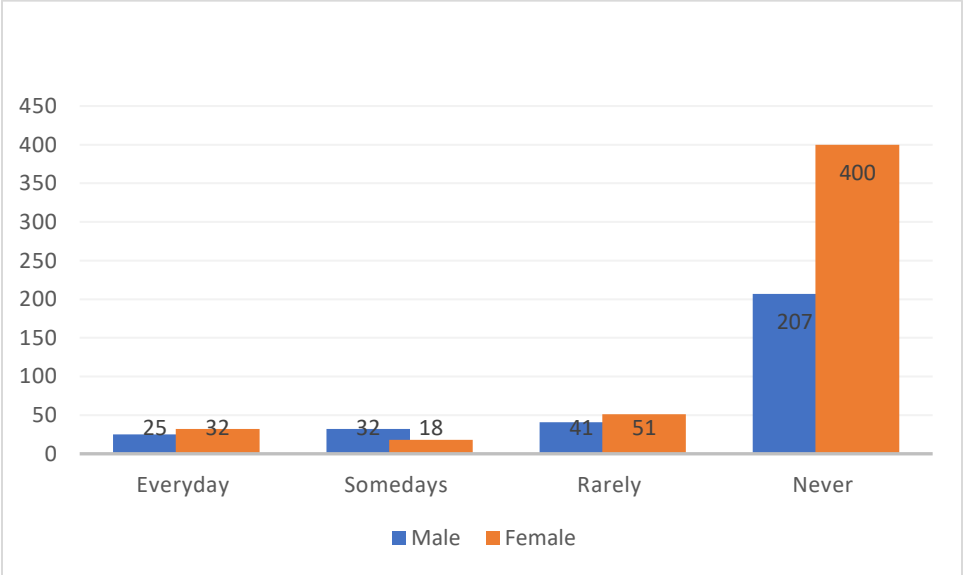

Figure A.4. E-cigarette behavior by gender

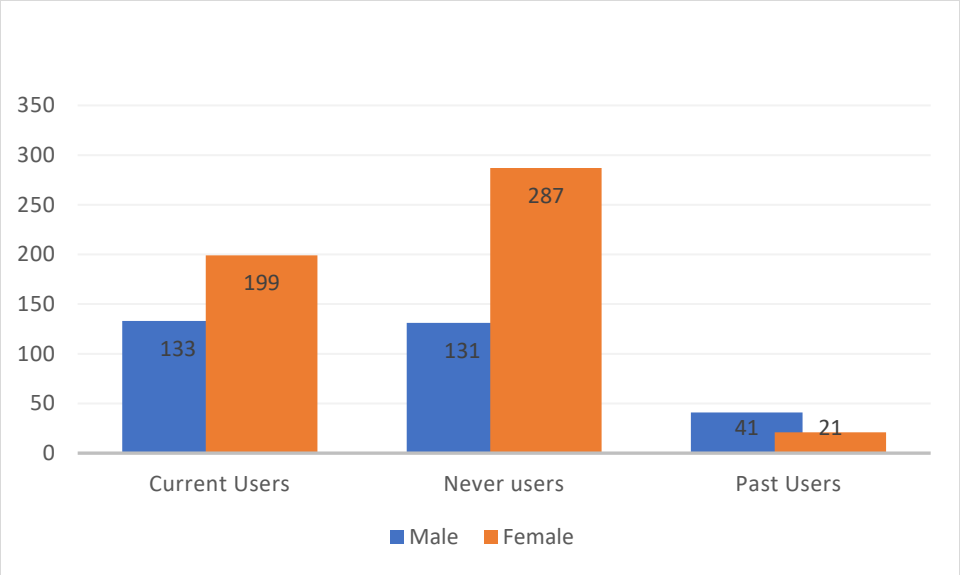

Figure A.5. E-cigarette current users, never users, and past users by gender

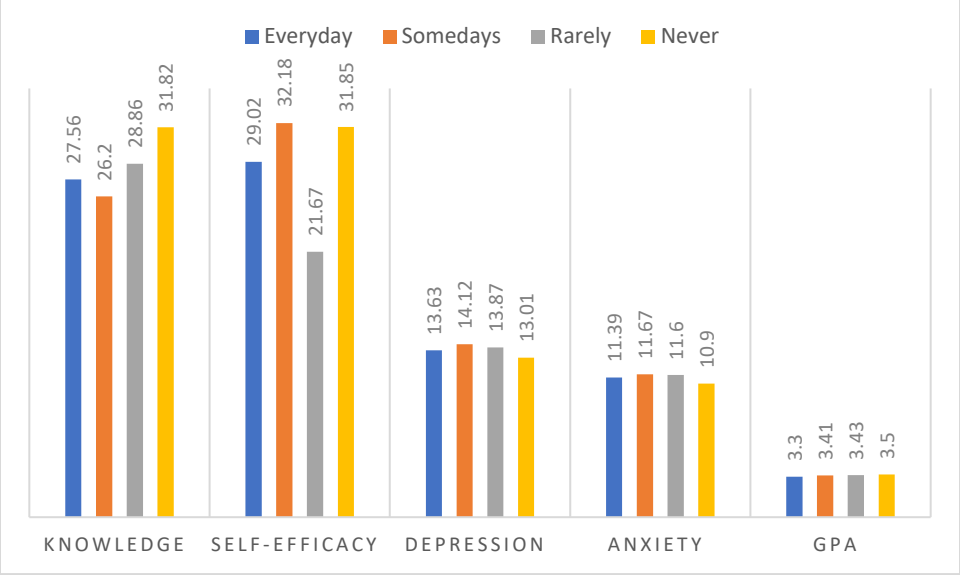

Figure A.6. Mean scores for knowledge, self-efficacy, depression, anxiety, and GPA by e-cigarette use frequency

BIBLIOGRAPHY

Ambrose, B. K., Day, H. R., Rostron, B., Conway, K. P., Borek, N., Hyland, A., & Villanti, A. C. (2015). Flavored tobacco product use among US youth aged 12-17 years, 2013-2014. *Jama*, *314*(17), 1871-1873.

American Association of Poison Control Centers (AAPCC) (2018). E-cigarettes and liquid nicotine. *AAPCC.* Retrieved from https://www.aapcc.org/track/ecigarettes-liquid-nicotine

Ayers, John W., PhD, MA, Althouse, Benjamin M., PhD, ScM, Allem, Jon-Patrick, PhD, MA, Leas, E. C., MPH, Dredze, M., PhD, & Williams, Rebecca S., PhD, MHS. (2016). Revisiting the rise of electronic nicotine delivery systems using search query surveillance. *American Journal of Preventive Medicine*, 50(6), 173-181.

Bacon, D. R., & Bean, B. (2006). GPA in research studies: An invaluable but neglected opportunity. *Journal of Marketing Education*, *28*(1), 35-42.

Ballbè, M., Martínez-Sánchez, J. M., Sureda, X., Fu, M., Pérez-Ortuño, R., Pascual, J. A., . . . Fernández, E. (2014). Cigarettes vs. e-cigarettes: Passive exposure at home measured by means of airborne marker and biomarkers. *Environmental Research, 135*, 76-80.

Bandiera, F. C., Loukas, A., Li, X., Wilkinson, A. V., & Perry, C. L. (2017). Depressive symptoms predict current e-cigarette use among college students in Texas. *Nicotine & Tobacco Research*, 19(9), 1102-1106.

Bell, M. L., Ebisu, K., Peng, R. D., Walker, J., Samet, J. M., Zeger, S. L., & Dominici, F. (2008). Seasonal and regional short-term effects of fine particles on hospital admissions in 202 US counties, 1999–2005. *American journal of epidemiology*, *168*(11), 1301-1310.

Begdache, L., Kianhehr, H., Sabounchi, N., Marszalek, A., & Doman, N. (2019). Principal component regression of academic performance, substance use, and sleep quality in relation to risk of anxiety and depression in young adults. *Trends in Neuroscience and Education.*

Buchanan, L., Aisch, G.(2017). Economic diversity and student outcomes at Baylor University. Retrieved from https://www.nytimes.com

Brake, S. J., Barnsley, K., Lu, W., McAlinden, K. D., Eapen, M. S., & Sohal, S. S. Smoking Upregulates Angiotensin-Converting Enzyme-2 Receptor: A Potential Adhesion Site for Novel Coronavirus SARS-CoV-2 (Covid-19).

Brauer, M., Amann, M., Burnett, R. T., Cohen, A., Dentener, F., Ezzati, M., ... & Van Donkelaar, A. (2012). Exposure assessment for estimation of the global burden of disease attributable to outdoor air pollution. *Environmental science & technology*, *46*(2), 652-660.

Brown, J. S., Gordon, T., Price, O., & Asgharian, B. (2013). Thoracic and respirable particle definitions for human health risk assessment. *Particle and Fibre Toxicology, 10*(1), 12-12. doi:10.1186/1743-8977-10-12

Case, K., Crook, B., Lazard, A., & Mackert, M. (2016). Formative research to identify perceptions of e-cigarettes in college students: Implications for future health communication campaigns. *Journal of American College Health*, 64(5), 380-389.

Cassady, Jerrell C. 2001. Self-reported GPA and SAT: A methodological note. *Practical Assessment, Research & Evaluation.* 7 (12).

Chan, G., Morphett, K., Gartner, C., Leung, J., Yong, H. H., Hall, W., & Borland, R. (2019). Predicting vaping uptake, vaping frequency and ongoing vaping among daily smokers using longitudinal data from the International Tobacco Control (ITC) Four Country Surveys. *Addiction*, *114*, 61-70.

Cheney, M. K., Gowin, M., & Clawson, A. H. (2018). Using the Ecological Model to understand influences on college student vaping. *Journal of American College Health*, 66(7), 597-607.

Chaiton, M., Cohen, J. E., Rehm, J., Abdulle, M., & O'Loughlin, J. (2015). Confounders or intermediate variables? Testing mechanisms for the relationship between depression and smoking in a longitudinal cohort study. *Addictive behaviors*, *42*, 154-161.

Coleman, B. N., Apelberg, B. J., Ambrose, B. K., Green, K. M., Choiniere, C. J., Bunnell, R., & King, B. A. (2015). Association between electronic cigarette use and openness to cigarette smoking among US young adults. *Nicotine and Tobacco Research*, 17(2), 212- 218.

Copeland, A. L., Peltier, M. R., & Waldo, K. (2017). Perceived risk and benefits of e-cigarette use among college students. *Addictive behaviors*, 71, 31-37.

Counotte, D. S., Spijker, S., van de Burgwal, Linda H, Hogenboom, F., Schoffelmeer, A. N. M., de Vries, T. J., . . . Pattij, T. (2009). Long-lasting cognitive deficits resulting from adolescent nicotine exposure in rats *Neuropsychopharmacology*, 34(2), 299-306.

Czogala, J., Goniewicz, M. L., Fidelus, B., Zielinska-Danch, W., Travers, M. J., & Sobczak, A. (2014). Secondhand exposure to vapors from electronic cigarettes. *Nicotine & Tobacco Research, 16*(6), 655-662.

Dai, H., & Hao, J. (2017). Geographic density and proximity of vape shops to colleges in the USA. *Tobacco control*, 26(4), 379-385.

Delnevo, C. D., Giovenco, D. P., Steinberg,M. B., Villanti, A. C., Pearson, J. L.,Niaura, R. S.,&Abrams,D. B. (2016). Patterns of electronic cigarette use among adults in the United States. *Nicotine & Tobacco Research*, *18*, 715–719.

Dobbs, P. D., Clawson, A. H., Gowin, M., & Cheney, M. K. (2018). Where college students look for vaping information and what information they believe. *Journal of American College Health*, 1-10.

Farber HJ, Nelson KE, Groner JA, Walley SC; Section on Tobacco Control. Public policy to protect children from tobacco, nicotine, and tobacco smoke. Pediatrics. 2015;136(5):998-1007

Flouris, A. D., Chorti, M. S., Poulianiti, K. P., Jamurtas, A. Z., Kostikas, K., Tzatzarakis, M. N., . . . Koutedakis, Y. (2013). Acute impact of active and passive electronic cigarette smoking on serum cotinine and lung function. *Inhalation Toxicology, 25*(2), 91-101.

Fountain, S. B., Rowan, J. D., Kelley, B. M., Willey, A. R., & Nolley, E. P. (2008). Adolescent exposure to nicotine impairs adult serial pattern learning in rats. *Experimental Brain Research*, 187(4), 651-656.

Fuoco FC, Buonanno G, Stabile L, et al. Influential parameters on particle concentration and size distribution in the mainstream of e-cigarettes. Environ Pollut. 2014;184:523–9.

Genikomsakis, K. N., Galatoulas, N., Dallas, P. I., Ibarra, L. M. C., Margaritis, D., & Ioakimidis, C. S. (2018). Development and on-field testing of low-cost portable system for monitoring PM2.5 concentrations. *Sensors (Switzerland), 18*(4), 1056.

Gentzke, A. S. (2019). Vital signs: Tobacco product use among middle and high school students—United States, 2011–2018. MMWR. *Morbidity and Mortality Weekly Report*, 68.

Gill, N., Sangha, G., Poonai, N., & Lim, R. (2015). E-cigarette liquid nicotine ingestion in a child: case report and discussion. *Canadian journal of emergency medicine*, *17*(6), 699- 703.

Govindarajan, P., Spiller, H. A., Casavant, M. J., Chounthirath, T., & Smith, G. A. (2018). E-cigarette and liquid nicotine exposures among young children. *Pediatrics*, *141*(5), e20173361.

Grana, R. A., & Ling, P. M. (2014). "Smoking revolution": a content analysis of electronic cigarette retail websites. *American journal of preventive medicine*, *46*(4), 395-403.

Guaita, R., Pichiule, M., Mate, T., Linares, C., & Diaz, J. (2011). Short-term impact of particulate matter (PM2.5) on respiratory mortality in madrid. *International Journal of Environmental Health Research, 21*(4), 260-274.

Hefner, K. R., Sollazzo, A., Mullaney, S., Coker, K. L., & Sofuoglu, M. (2019). E-cigarettes, alcohol use, and mental health: Use and perceptions of e-cigarettes among college students, by alcohol use and mental health status. *Addictive behaviors*, *91*, 12-20.

Hu, S. S. (2019). State-specific patterns of cigarette smoking, smokeless tobacco use, and e-cigarette use among adults—United States, 2016. *Preventing chronic disease*, 16.

Ĩiguez, S. D., Warren, B. L., Parise, E. M., Alcantara, L. F., Schuh, B., Maffeo, M. L., . . . Bolãos-Guzmán, C. A. (2009). Nicotine exposure during adolescence induces a depression-like state in adulthood. *Neuropsychopharmacology*, 34(6), 1609-1624.

Institute of research and testing. Fall 2019 Common Data Set. Retrieved from https://www.baylor.edu/irt/.

Kim, K., Kabir, E., & Kabir, S. (2015). A review on the human health impact of airborne particulate matter. *Environment International, 74*, 136-143.

Kong, G., Morean, M. E., Cavallo, D. A., Camenga, D. R., & Krishnan-Sarin, S. (2014). Reasons for electronic cigarette experimentation and discontinuation among adolescents and young adults. *Nicotine & tobacco research*, 17(7), 847-854

Kosmider, L., Sobczak, A., Fik, M., Knysak, J., Zaciera, M., Kurek, J., & Goniewicz, M. L. (2014). Carbonyl compounds in electronic cigarette vapors: effects of nicotine solvent and battery output voltage. *Nicotine & Tobacco Research*, *16*(10), 1319-1326.

Kroenke, K., Spitzer, R. L., & Williams, J. B. (2001). The PHQ-9: validity of a brief depression severity measure. *Journal of general internal medicine*, *16*(9), 606-613.

Lanza, H. I., & Teeter, H. (2018). Electronic nicotine delivery systems (e-cigarette/vape) use and co-occurring health-risk behaviors among an ethnically diverse sample of young adults. *Substance use & misuse*, *53*(1), 154-161

Lechner, W. V., Janssen, T., Kahler, C. W., Audrain-McGovern, J., & Leventhal, A. M. (2017). Bi-directional associations of electronic and combustible cigarette use onset patterns with depressive symptoms in adolescents. *Preventive Medicine*, 96, 73-78.

Lindbom, J., Gustafsson, M., Blomqvist, G., Dahl, A., Gudmundsson, A., Swietlicki, E., . . . Yrkes- och miljömedicin. (2006). Exposure to wear particles generated from studded tires and pavement induces inflammatory cytokine release from human macrophages. *Chemical Research in Toxicology, 19*(4), 521-530.

Liu, J., Liang, Q., Oldham, M., Rostami, A., Wagner, K., Gillman, I., . . . Sarkar, M. (2017). Determination of selected chemical levels in room air and on surfaces after the use of cartridge- and tank-based E-vapor products or conventional cigarettes. *International Journal of Environmental Research and Public Health, 14*(9), 969.

Lovegrove, M. C., Hon, S., Geller, R. J., Rose, K. O., Hampton, L. M., Bradley, J., & Budnitz, D. S. (2013). Efficacy of flow restrictors in limiting access of liquid medications by young children. *The Journal of pediatrics*, *163*(4), 1134-1139.

Luo, C., Zheng, X., Zeng, D. D., & Leischow, S. (2014). Portrayal of electronic cigarettes on YouTube. *BMC Public Health*, 14(1), 1028-1028.

Mojtabai, R., & Crum, R. M. (2013). Cigarette smoking and onset of mood and anxiety disorders. *American journal of public health*, *103*(9), 1656-1665.

Mykletun, A., Overland, S., Aarø, L. E., Liabø, H. M., & Stewart, R. (2008). Smoking in relation to anxiety and depression: evidence from a large population survey: the HUNT study. *European Psychiatry*, *23*(2), 77-84.

The National Center on Addiction and Substance Abuse. (2008). Beyond Cigarettes: The Risks of Non-Cigarette Nicotine Products and Implications for Tobacco Control. *The National Center on Addiction and Substance Abuse.*

Nelson, B (2016). Text-S.142-114th Congress (2015-2016): Child Nicotine Poisoning Prevention Act of 2015. Retrieved from https://www.congress.gove/bill/114th-congress/senate-bill/142/text

Obisesan, O. H., Mirbolouk, M., Osei, A. D., Orimoloye, O. A., Uddin, S. I., Dzaye, O., ... & Benjamin, E. J. (2019). Association Between e-Cigarette Use and Depression in the Behavioral Risk Factor Surveillance System, 2016-2017. *JAMA network open*, *2*(12), e1916800-e1916800.

Pearson, J. F., Bachireddy, C., Shyamprasad, S., Goldfine, A. B., & Brownstein, J. S. (2010). Association between fine particulate matter and diabetes prevalence in the U.S. *Diabetes Care, 33*(10), 2196-2201.

Perrin A. Social Media Usage: 2005–2015. Washington, DC: Pew Research Center; 2015.

Pew Research Center. The Evolving Role of News on Twitter and Facebook 2015.

Pokhrel, P., Fagan, P., Little, M. A., Kawamoto, C. T., & Herzog, T. A. (2013). Smokers who try e-cigarettes to quit smoking: findings from a multiethnic study in Hawaii. *American journal of public health*, *103*(9), e57-e62.

Protano, C., Manigrasso, M., Avino, P., & Vitali, M. (2017). Second-hand smoke generated by combustion and electronic smoking devices used in real scenarios: Ultrafine particle pollution and age-related dose assessment. *Environment international*, *107*, 190-195.

Schober, W., Szendrei, K., Matzen, W., Osiander-Fuchs, H., Heitmann, D., Schettgen, T., . . . Fromme, H. (2014). Use of electronic cigarettes (e-cigarettes) impairs indoor air quality and increases FeNO levels of e-cigarette consumers. *International Journal of Hygiene and Environmental Health, 217*(6), 628-637.

Schoenborn, C., & Gindi, R. (2016). Cigarette smoking status among current adult E-cigarette users, by age group - national health interview survey, united states, 2015. MMWR-*Morbidity and Mortality Weekly Report*, 65(42), 1177-1177.

Schwarzer, R., & Jerusalem, M. (1995). Generalized Self-Efficacy scale. In J. Weinman, S. Wright, & M. Johnston, Measures in health psychology: A user's portfolio. Causal and control beliefs (pp. 35-37). Windsor, UK: NFER-NELSON.

Shah, A. S., MBChB, Langrish, J. P., MBChB, Nair, H., PhD, McAllister, D. A., MD, Hunter, A. L., MBChB, Donaldson, K., Prof, . . . Mills, N. L., Dr. (2013). Global association of air pollution and heart failure: A systematic review and meta-analysis. *Lancet, the, 382*(9897), 1039-1048.

Seo, A. D., Kim, D. C., Yu, H. J., & Kang, M. J. (2016). Accidental ingestion of E-cigarette liquid nicotine in a 15-month-old child: an infant mortality case of nicotine intoxication. *Korean journal of pediatrics*, *59*(12), 490.

Soule, E. K., Maloney, S. F., Spindle, T. R., Rudy, A. K., Hiler, M. M., & Cobb, C. O. (2017). Electronic cigarette use and indoor air quality in a natural setting. *Tobacco control*, *26*(1), 109-112.

Spitzer, R. L., Kroenke, K., Williams, J. B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: the GAD-7. *Archives of internal medicine*, *166*(10), 1092-1097.

St. Helen, G., Havel, C., Dempsey, D. A., Jacob III, P., & Benowitz, N. L. (2016). Nicotine delivery, retention and pharmacokinetics from various electronic cigarettes. *Addiction*, *111*(3), 535-544.

Suwa, T., Hogg, J. C., Quinlan, K. B., Ohgami, A., Vincent, R., & van Eeden, S. F. (2002). Particulate air pollution induces progression of atherosclerosis. *Journal of the American College of Cardiology, 39*(6), 935-942.

Trumbo, C. W. (2015). The effect of electronic cigarette advertising on intended use among college students. *Addictive Behaviors*, *46*, 77-81.

US Department of Health and Human Services. (2016). E-cigarette use among youth and young adults. A report of the Surgeon General. *Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health*.

Wallace, L.N. & Roache, M.J. (2018). Vaping in context: Links among E-cigarette use, social status, and peer influence for college students. *Journal of Drug Education*, 48(102), 36-53.

Wellenius, G. A., Schwartz, J., & Mittleman, M. A. (2006). Particulate air pollution and hospital admissions for congestive heart failure in seven united states cities. *The American Journal of Cardiology, 97*(3), 404-408.

Wiseman, K. P., Margolis, K. A., Bernat, J. K., & Grana, R. A. (2019). The association between perceived e-cigarette and nicotine addictiveness, information-seeking, and e-cigarette trial among US adults. *Preventive medicine*, *118*, 66-72.

Zhu, S. H., Sun, J. Y., Bonnevie, E., Cummins, S. E., Gamst, A., Yin, L., & Lee, M. (2014). Four hundred and sixty brands of e-cigarettes and counting: implications for product regulation. *Tobacco control*, *23*(suppl 3), iii3-iii9.