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ELECTRONIC NICOTINE DEVICES AND ALCOHOL USE AMONG YOUNG ADULTS: FINDINGS FROM THE 2015-2016 NATIONAL HEALTH AND NUTRITION EXAMINATION SURVEY (NHANES)

by

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of the
Requirements for the Degree

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30303

APPROVAL PAGE

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by

Lucinda Ackah-Toffey

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July 20th 2020
Date

Abstract

Introduction

Young adults have high rates of alcohol and tobacco use relative to any other age group. However, levels of use vary by race and education. This study aimed to examine the association between alcohol use and Electronic Nicotine Devices (ENDS) in a representative sample of young adults and to determine if any associations vary by race or education.

Methods

Data utilized in this study originated from the 2015-2016 National Health and Nutrition Examination Survey (NHANES). Records were restricted to those aged 18–35 years (n = 1145), with the primary outcome, ENDS use in the past 12 months. Multivariable logistic regression was performed to assess the association between the primary outcome, and alcohol use and socio-demographic variables. Further assessment was completed to determine if the association between the primary outcome and alcohol use while controlling for cigarette use varied by race or educational level.

Results

The overall prevalence of ever ENDS use was 38.29%. Prevalence was highest among young adults 26-30 (31.01%), those reporting heavy alcohol use (44.93%), Non-Hispanic Whites (58.53%), those with some college or Associate of Arts degree (34.04%) and income range of $25,000 to $54,999 (35.59%). Traditional cigarette use (aOR=12.62; 95% CI 12.60 - 12.64), Income $25,000 to $54,999 (aOR=1.60; 95% CI 1.59 – 1.60), higher collegiate education (aOR=0.41; 95% CI 0.41 – 0.41), moderate and high alcohol use (aOR=1.76; 95% CI 1.76 – 1.77, aOR=1.89; 95% CI 1.88 – 1.89 respectfully) was associated with ENDS. The association between alcohol usage level and ENDS use also varied by education when adjusting for traditional cigarette use. The effect that alcohol usage has in predicting ENDS use is different for various education status when controlled for traditional cigarette use (p-vale: <0.0001).

Conclusions

ENDS use is common among young adults in the U.S. and is associated with socioeconomic status as well as alcohol use. Prevention efforts need to factor in these demographic characteristics when targeting interventions, and also factor in that moderate and heavy alcohol use are associated with ENDS use, which likely will exacerbate health concerns among ENDS users.

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I would like to first and foremost thank the almighty God. Although I chose my path, God rendered my steps.

I dedicate this thesis to my late Grandmother, Nana Ngoama, for instilling in me the importance of education. To my parents, siblings, and the rest of my family, thank you for all the love and support.

I would also like to express my sincere gratitude to my advisor, Dr. Swahn, for the continuous support of my MPH studies and writing of this thesis and Dr. Culbreth for the insightful recommendations and encouragement.

Author's Statement Page

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Chapter I: Introduction

1.1 Background

One of the leading causes of preventable diseases and deaths in the United States is Tobacco use (National Center for Chronic Disease Prevention & Health Promotion Office on Smoking and Health, 2014). The Surgeon General has reported that smoking cigarettes were responsible for over 480,000 deaths per year in the United States, about one in five deaths annually in 2014 (National Center for Chronic Disease Prevention & Health Promotion Office on Smoking and Health, 2014).

Although the prevalence of smokers using combustible cigarettes has decreased, the prevalence of electronic cigarette users continues to increase among adults in the United States (Jamal et al., 2016). Generally, 15-30% of young adults who smoke are most likely to use more than one tobacco product (Le et al., 2019; Lee et al., 2014). Since emerging in 2007, Electronic Nicotine Delivery Systems (ENDS), also called electronic cigarettes, have been used and considered by users as a safe alternative to traditional combustion cigarettes (Adkison et al., 2013). The increasing use of ENDS in the United States has raised many concerns over its potential health effects. Expanding legislation continues to affect the prevalence of ENDS usage. Current federal laws regulate ENDS as tobacco products and restrict consumers from purchasing ENDS unless 21 years and older.

Previous literature has reported an association between alcohol use and smoking traditional combustion cigarettes (Drobes, 2002; Jiang & Ling, 2011). Alcohol and tobacco use are relatively high among young age groups. Individuals who smoke may also drink alcohol and vice versa. Tobacco companies continue to use promotional strategies linking cigarettes and alcohol

(Jiang & Ling, 2011). Various approaches include but are not limited to, sponsoring events with alcohol companies to increase interest and generate increased revenues.

Various studies related to ENDS research have found that individuals young in age (less than 50 years old), (Arnold, 2014; Delnevo et al., 2015; Du et al., 2019; B. A. King et al., 2015; Schoenborn & Gindi, 2015; Wilson & Wang, 2017), those with some form of college/ higher education (Du et al., 2019; Hartwell et al., 2017; B. A. King et al., 2015; Levy et al., 2017), and those who consumed alcohol (Arnold, 2014; Du et al., 2019; Grant et al., 2019) were more likely to have ever used ENDS. Epidemiologists have further investigated the estimated prevalence of individual, concurrent consumption, and dependence of tobacco-related products and alcohol (Anthony & Echeagaray-Wagner, 2000).

An assortment of human biological mechanisms shows the codependency of alcohol and tobacco. Genes involved in regulating brain chemical systems, neurobiological mechanisms, conditioning mechanisms, and psychosocial factors are some mechanisms involved in the concurrent use of Alcohol and ENDS (Drobes, 2002). Alcohol consumption increases the cravings to smoke. In addition, Nicotine increases the urge to consume alcohol (Glautier et al., 1996; A. C. King & Epstein, 2005). In fact, it seems as alcohol increase the desire and enjoyment for smoking cigarettes providing a “double buzz” (Jiang & Ling, 2011; Stromberg et al., 2007). It is therefore of interest to understand alcohol use and its association with ENDS, particularly among young adults who are at high risk for both ENDS and alcohol use.

Since ENDS is a relatively new product, research is still underway. Still, there has been a growing interest in examining the correlates of ENDS use and its potential health consequences and future public health implications. The purpose of this work is to evaluate and further

contribute to current research on various associations with ENDS usage amongst U.S. adults aged 18-35 based on the National Health and Nutrition Examination Survey 2015-2016 with a focus on alcohol usage levels.

1.2 Research Questions

There are three research questions that guided this work.

1. What is the prevalence of ENDS use among young adults in the U.S.?
2. What are the demographics correlated of smoking ENDS among young adults in the U.S.?
3. What is the association between alcohol use and ENDS among young adults in the U.S.? If there is an association, does it vary by race or education when controlled for traditional cigarette usage?

1.3 Purpose of Study

This study aims to provide information that may assist in future interventional programs and research, such as prevention programs and campaigns. The research reported in this thesis is organized in the form of a manuscript thesis, which includes an introduction, literature review and a manuscript. The manuscript covers the association of ENDS use with alcohol use and various covariates with ENDS use in a national representative sample of US young adults age 18-35. It also examines the effects of race or education on alcohol use and ENDS, intended to be submitted for consideration for publication.

Chapter II: Review of The Literature

2.1 Definition and Mechanism

Electronic Cigarettes are battery-operated products that distribute an aerosol (vapor) to users; the vapor is generated by heating a liquid solution called e-liquid (Grana et al., 2014). E-liquids constitute a base liquid such as propylene glycol or glycerin; also, other additives like Nicotine, and flavorings. There is a wide variety of flavoring available on the market, such as menthol, tobacco, coffee, fruit, candy, desserts, and drink flavors. There is a multitude of names used interchangeably for electronic cigarettes such as "Electronic Nicotine Delivery Systems (ENDS)," "e-cigs," "vape pens," or "mods." In the state of Georgia, ENDS is a vapor product, which is defined as follows:

> *"any noncombustible product containing Nicotine that employs a heating element, power source, … that can be used to produce vapor from Nicotine in a solution or other form. The term 'vapor product' shall include any electronic cigarette, electronic cigar, electronic cigarillo, electronic pipe, or similar product or device and any vapor cartridge or other container of Nicotine in a solution or other form that is intended to be used with or in an electronic cigarette, electronic cigar, electronic cigarillo, electronic pipe, or similar product or device." (Georgia, 2014)*

By 2013, the majority of international tobacco companies entered into ENDS production (DeVito & Krishnan-Sarin, 2018; Glasser et al., 2017; Grana et al., 2014). Although ENDS technology is continuously developing, the various designs of ENDS primarily operate similarly and are made up of comparable components (National Institute of Drug Abuse, 2020). Based on the U.S. Patent (No. 8,490,628 B2) awarded to Lik Hon (2013), ENDS includes a shell and a

mouthpiece. This shell has an external wall with an air inlet, an atomizer (heating element), and a cartridge containing e-liquid. The air inlet, atomizer, aerosol passage, and mouthpiece are then interconnected. Aerosol production begins during the initiation of inhalation by the user on the mouthpiece. Inhalation activates the atomizer, which then vaporizes the e-liquid in the shell. The vaporization of e-liquids replaces combustion in traditional cigarettes.

2.2 Regulation and Marketing

In the United States, companies that develop or sell ENDS devices must follow the Food and Drug Administration (F.D.A.) regulations. This rule was established in 2016 for ENDS and e-liquids because ENDS contains Nicotine originating from tobacco therefore, they are subject to government regulation similar to tobacco products. Initially, the F.D.A. attempted to suspend the sale and importation of ENDS, asserting that ENDS was an unauthorized drug delivery device. It was not until the F.D.A. was sued that the U.S. Court of Appeals ruled to establish ENDS as regulated similar to tobacco products, with exceptions for devices advertised for therapeutic purposes (Circuit DC, 2010; Grana & Ling, 2014). In December 2019, the U.S federal government raised the age of purchasing tobacco products from 18 to 21 years. Due to public pressure and the attributable health effects produced by flavored e-liquids, in January 2020, the F.D.A. issued a policy prohibiting the sale of flavored vaping liquids except for menthol and tobacco.

The Internet has been the main channel for ENDS marketing and sales. Analysis of newspaper and online media coverage in the United Kingdom and Scotland over five years documented a total of five overarching themes related to ENDS advertisement (Rooke & Amos, 2014); healthier choice, smoke-free restrictions, celebrity use, risk and uncertainty, and price. Similarly, Grana and Ling (2014), conducted a study to describe the main advertising statements

made by branded ENDS retail websites. Sixty-two sites met all inclusion criteria in the June–July 2011 period. Roughly, 95% made unambiguous and ambiguous health-related claims, and 64% made smoking cessation-related claims. In addition, 76% claimed that ENDS does not produce secondhand smoke, with 88% stating that ENDS can be smoked anywhere and 71% saying that it can be used to bypass clean air policies.

In comparison to traditional combustible cigarettes, 95% advertised ENDS as cleaner, and 93% showing ENDS as cheaper. Numerous websites targeted more impressionable audiences, such as youth and young adults. Websites promoted an increase to social status (44%), romance (31%), and use by celebrities (22%). In a workshop conducted by the F.D.A. (Electronic Cigarettes and the Public Health; March 9–10, 2015), it was explained that ENDS manufacturers had developed explicit marketing strategies to draw the attention of young consumers (Kaisar et al., 2016).

Many tobacco and cigarette companies are to date unable to market their commodities on television/ radio since the 1970s; ENDS, on the other hand, has bypassed such -limitation (Grana et al., 2014). Celebrity backing has been continuously used in the United States. To advertise tobacco and glamorize smoking for years (Grana et al., 2011; Grana & Ling, 2014). Youths are more influenced to initiate ENDS usage when their favorite celebrities promote their use. Further regulation is essential to prevent marketing deceptions to consumers and the enticing of a new generation of tobacco-related users.

2.3 Epidemiology of E-cigarettes

Prevalence of E-cigarette use

Tobacco use is one of the leading causes of preventable disease and death in the United States (National Center for Chronic Disease Prevention & Health Promotion Office on Smoking and Health, 2014). The prevalence of ENDS users is continuously rising among adults in the United States, while the prevalence of smoking traditional combustible cigarettes decreases (Jamal et al., 2016). Since ENDS is a relatively new product, there is minimal data on usage patterns available before 2011 (US Department of Health & Human Services, 2016). Roughly, 15-30% of young adults who smoke are most likely to use more than one tobacco product (Le et al., 2019; Lee et al., 2014). The prevalence of ENDS past use was 35.8%, and current use was 13.6% in young U.S. adults 18–24 years in 2013-2014 (US Department of Health & Human Services, 2016). In comparison, adults over 25 have a significantly lower prevalence in the same measures (16.4% and 5.7%, respectively). The prevalence of ENDS usage often decreases steadily as age increases (Delnevo et al., 2015).

Factors Related to E-cigarette Initiation and Use

In 2016, the Surgeon General's report disclosed that past and current use were higher -among Non-Hispanic Whites than other racial/ethnic groups and higher among males than females (US Department of Health & Human Services, 2016). In the 18-24 age group, the appeal of various flavors and tastes become a contributing factor in the initiation of ENDS (Le et al., 2019). Perceived low harm in comparison to other tobacco products, and curiosity are the factors that contribute to the beginning of ENDS use among youth and young adults. (US Department of Health & Human Services, 2016). Data from the National Health Interview Survey (NHIS) indicated, in 2014, 12.6% of adults had -in the past tried ENDS, with use varying by sex, age, and

race (Schoenborn & Gindi, 2015). Amongst these adults, about 3.7% currently uses- ENDS, and 1.1% reported using ENDS daily.

Delnevo et al. (2015), analyzed data from the 2014 NHIS to investigate patterns of ENDS use among adults in the United States. Using multivariable logistic regression, age group, race, cigarette smoking status, and geographical region, all significantly related to -past and current ENDS use. Young white adults who smoked daily and lived in the West had higher odds of ENDS experimentation and current use than comparable groups. It is critical to examine various socio-demographic variables to draw accurate conclusions about patterns of ENDS use at the population level and to estimate potential benefits or harms.

Similarly, Du et al. (2019) examined independent factors associated with past ENDS use using logistic regression with adults 18 years and older, living in Los Angeles (L.A.) County. Variables considered were gender, age, race, disability, alcohol consumption in the past month, and cigarette smoking status. Prevalence of -past ENDS use was the highest among whites (12.8%) than -comparable groups. Males with some college or higher education level were at increased odds to have used ENDS compared to users with less than a high school degree [Odds Ratio (OR) = 1.52; 95% CI = 1.02 - 2.26]. Using non-alcohol consumers as a reference, heavy/binge male drinkers had increased odds of -past ENDS use than non-heavy/non-binge drinkers [OR = 1.80; 95% CI = 1.33 - 2.42, OR = 1.38; 95% CI = 1.03 - 1.85 respectively]. Females had similar patterns as males. Individuals younger than 50 years in both genders, who had some college/higher education, utilized marijuana, consumed alcohol, and were former/current smokers were significantly more likely to have ever used ENDS. Similarly, the findings of Bluestein

et al. (2019), indicated that young adult users of marijuana and alcohol had increased odds of ENDS use.

In the same way, Wilson and Wang (2017), used data from the 2014 NHIS to estimate ENDS use among adults and their relationship with various demographic, socioeconomic, and health behavior measures. Univariate and multivariable logistic regression analysis was performed, adjusting for sex, age, education, race, poverty, marital status, and smoking status. In comparison to those who had never tried ENDS, ENDS users were more likely to be young in age, male, non-Hispanic white, not married, poorer, and current smokers. Additionally, income was positively associated with -past use of ENDS. Individuals with high school or some college education had higher adjusted odds of -having used ENDS in contrast to those with less than high school education and individuals with masters or doctoral level education. Based on literature reported, various social and demographic factors have been associated with -past ENDS use and should be incorporated into evidence-based interventions.

Various studies have reported the association between alcohol use and smoking traditional combustible cigarettes, especially among young adults (Drobes, 2002; Jiang & Ling, 2011; Weitzman & Chen, 2005). In comparison to non-smokers, people who smoke more likely consume alcohol frequently, and in high quantities (Batel et al., 1995; Harrison et al., 2008; Jiang & Ling, 2011). Alcohol consumption increases the cravings to smoke, in addition, Nicotine increases the urge to consume alcohol (Glautier et al., 1996; A. C. King & Epstein, 2005). Amongst those who smoke, they report alcohol increasing their desire/ enjoyment for cigarettes providing a “double buzz” (Jiang & Ling, 2011; Stromberg et al., 2007).

Jiang and Ling (2011) investigated tobacco companies about their knowledge on concurrent use of tobacco and alcohol, in addition marketing strategies linking cigarettes with alcohol. From this study, Tobacco companies confirmed the association between tobacco use and alcohol use in addition, these companies used promotional strategies to link cigarettes and alcohol, reinforcing the use of both substances. The concurrent use of tobacco and alcohol provides difficulty for the user to quit.

Additionally, Weitzman and Chen (2005), studied concurrent use of smoking and drinking among young adults in US college from the 2001 Harvard School of Public Health (HSPH) College Alcohol Study. The HSPH study concluded that over 98% of current smokers drink and smoking risks is greatest among youth who reported high alcohol (total) consumption (adjusted OR 4.21, $p < 0.0001$). Understanding the link between ENDS use, and alcohol usage and various socio-demographic factors can be useful in developing intervention programs in addition, targeting behaviors to develop interventions tailored to the population is essential for successful programs.

2.4 Harms and Benefits

Health Implications

Over the years, the prevalence of cigarette smoking has risen and fallen; additionally, it has fluctuated from being widely accepted to socially unacceptable. Smoking cigarettes has led to diseases and disability, along with substantial harm to the human body (National Center for Chronic Disease Prevention & Health Promotion Office on Smoking and Health, 2014). In 2014, the Surgeon General report over the years 1964-2014 concluded that the overall prevalence of U.S. adult smoking was approximately 20%, less than one-half of what it was in 1964 (National Center for Chronic Disease Prevention & Health Promotion Office on Smoking and Health, 2014).

The Surgeon General reported that smoking cigarettes was responsible for over 480,000 deaths per year in the United States, about one in five deaths annually (National Center for Chronic Disease Prevention & Health Promotion Office on Smoking and Health, 2014). Since the introduction of ENDS, more users are transitioning from traditional cigarettes to ENDS (Sara Kalkhoran et al., 2019).

Assessing the components of ENDS and their effects on health is still developing. ENDS has become increasingly popular over the years because of the perceived notion of having reduced levels of harmful toxicants compared to traditional combustible cigarettes (Arnold, 2014; Cobb et al., 2010; Kaisar et al., 2016). Herrington and Myers (2015), tested and characterized approximately 60-70 compounds in e-liquids. It was found that there was no variation in the constituency of the various e-liquids tested. It was concluded that some of the compounds detected in the e-liquids were detrimental to human health. Similarly, Kucharska et al. (2016) identified 113 chemicals in 50 brands of various e-liquids, some known to cause cancer and other health effects.

Volatile Organic compounds (VOCs) are present in ENDS; VOCs are various toxic organic compounds, such as benzene, toluene, diacetyl, formaldehyde, acetaldehyde, and acrolein, emitted from generated ENDS vapor (Goniewicz et al., 2014; Kaisar et al., 2016). VOCs can be an irritant, carcinogenic, and neurotoxic. Often causing the development of cancer, cardiovascular, and respiratory diseases (Goniewicz et al., 2014; Hecht, 2003; St Helen et al., 2014). Schripp et al. (2013) analyzed chemical and particulate emissions from ENDS via a chamber study. Results indicated that ENDS composed of VOCs such as acetaldehyde, a cariogenic compound. ENDS emissions also had particulate concentrations similar or comparable to combustion cigarettes.

Evidence suggests that inhalation of particulates contributes to the onset of various diseases such as chronic respiratory diseases, cardiovascular diseases, and cancer (Spirić et al., 2012). There has been more interest in ultrafine particles (UFPs), as they are more readily available to travel from the lung to the blood and other parts of the body than larger particles (Pope III & Dockery, 2006). Children are at an increased risk for respiratory conditions from ENDS use because they have relatively underdeveloped lungs and an immune system not capable of filtering out particle exposure (Chen et al., 2019; Gibbs et al., 2016; Peterson & Hecht, 2017).

Consequently, utilizing ENDS has contributed to worldwide outbreaks of EVALI, also known as E-cigarette or Vaping Product Use-Associated Lung Injury (EVALI). A special report in *The New England Journal of Medicine (NEJM)* reported that Emergency Department visits for EVALI abruptly rose in June 2019, climaxing in September 2019 (Hartnett et al., 2019). The EVALI epidemic produced national attention and scrutinizing of e-liquids, generating legislative laws. Laboratory analysis showed that vitamin E acetate, an additive in certain tetrahydrocannabinol (THC) containing ENDS, was strongly linked to the EVALI outbreak (Boudi et al., 2019; Deliwala et al., 2020). ENDS generated emissions continue to be investigated to examine acute and chronic effects.

The use of E-cigarettes in smoking abstinence/cessation

ENDS has become popular among smokers who wish to reduce their tobacco use and quit smoking (Hajek et al., 2019; Notley et al., 2018). Its effectiveness as a cessation aid remains uncertain (Gomajee et al., 2019). Several surveys, such as the National Youth Tobacco Survey (NYTS), and Youth Risk Behavior Surveillance System (YRBSS), provide data for the estimation of smoking behaviors amongst young adults in the United States. Research related to ENDS use as

a method of cessation has shown that ENDS use may increase the probability of cigarette abstinence (Benmarhnia et al., 2018; Ghosh & Drummond, 2017).

Brown et al. (2014) conducted a cross-sectional survey to study the real-world effectiveness of ENDS when used to aid smoking cessation. The study examined the relationship between ENDS use and smoking status of traditional combustion cigarettes. The population consisted of adults in England, surveyed monthly between July 2009 and February 2014. Using self-reported rates, Brown et al. compared subjects who smoked and tried to abstain by using ENDS only against those who used nicotine replacement therapy (NRT) or those who made an unaided attempt to quit. It was found, ENDS users were more likely to report abstinence than either of those who used NRT [OR = 2.23] or those with no aid [OR = 1.38] (Brown et al., 2014).

Additionally, Gomajee et al. (2019) conducted a cohort study of randomly selected adults (N=200,000) coming from France's enforced health insurance scheme. The study used mixed regression models to investigate the association between ENDS use and the number of cigarettes smoked. Outcomes examined were, (1) the number of cigarettes smoked per day, (2) the difference between the number of cigarettes smoked per day at baseline and the number of cigarettes smoked per day at follow-up, (3) smoking cessation among smokers, and (4) cigarette smoking relapse among former smokers. Amongst 5400 daily smokers, regular ENDS use was associated with decreasing the number of cigarettes smoked per day in contrast to daily smokers who did not use ENDS; [–4.4 [95% CI, –4.8 to –3.9], –2.7 [95% CI –3.1 to –2.4], respectively]. Amongst 2025 former smokers, ENDS use was associated with an increase in the rate of smoking relapse. Overall, ENDS use was associated with a reduction in smoking levels and an increased probability of smoking cessation, but still varied by current smoking status.

Similarly, Donny et al. (2015) conducted a double-blind, randomized clinical trial to examine reduced-nicotine standards for cigarettes. A total of 840 subjects underwent randomization, and 780 completed the 6-week study assigned to different exposure groups or nicotine concentration. The primary outcome reported was the number of cigarettes smoked by the individual. This study provides insight into existing literature because, several ENDS chemical characterization studies have measured low nicotine delivery from ENDS (Cheng, 2014; DeVito & Krishnan-Sarin, 2018; Etter et al., 2013). Subjects who were assigned to their usual brand, compared to those assigned to control cigarettes, smoked significantly more than those assigned to low Nicotine cigarettes.

Likewise, Hajek et al. (2019) performed a randomized Trial of ENDS users versus NRT. Subjects were randomly assigned to either NRT products of their choice (including product combinations) or an ENDS starter pack. ENDS was more effective for smoking cessation than NRT when both products were supplemented by behavioral support. The rate of continuous 1-year abstinence was 18.0% in the ENDS group and 9.9% in the NRT group, supporting the hypothesis that the use of ENDS can aid in tobacco cessation.

Summarizing findings in 2015 based literature, S. Kalkhoran and Glantz (2016) conducted a systematic review and meta-analysis of ENDS and its association with smoking cessation in real-world and clinical settings. Publications from PubMed and Web of Science between April 2015 and June 2015were included in the study. Various data was extracted to include study location, design, population, definitions, the prevalence of ENDS use, comparison group to cigarette consumption, level of nicotine dependence, odds of quitting smoking, and other confounders. Of the studies identified, 38 of 577 studies were included in the systematic review, the odds of

quitting cigarettes was 28% lower in those who used ENDS compared to users who did not use ENDS [OR = 0.72, 95% CI 0.57–0.91], which is inconsistent with previous literature.

To examine the impacts of ENDS, the population size of the studies needs to be a representative sample to translate into different populations of similar backgrounds (Brown et al., 2014; Donny et al., 2015). Interestingly enough, findings are primarily based on exposure treatments, and the number of cigarettes smoked, which can vary across different populations. Smoking abstinence cannot be verified to corroborate subjects claim; as a result, this has led to recall bias and social pressure to report abstinence in many studies (Brown et al., 2014). Providing free materials may also inflate the number of cigarettes smoked per day; this is imperative because consumption decreases with relations to out of pocket spending (Donny et al., 2015).

Although, substantial amount of literature exists, there is limited research on the prevalence, association to, and efficacy of ENDS due to the recent invention of ENDS itself (Chiang et al., 2019). Understanding the association between ENDS use and Alcohol Usage can be useful in developing dual intervention programs such as including policies banning tobacco sales and alcohol promotion and smoking cessation programs addressing the impact alcohol consumption has on tobacco use. The majority of research has been conducted in high-income countries where ENDS and cessation aids are more readily available. It is worthy to note, low- and middle-income countries, where cessation aids are not widely available or rarely used, may be significant in providing more in-depth knowledge of ENDS abstinence/cessation potential in other geographical locations (Lozano et al., 2019). By analyzing data provided by NHANES, this study can provide perspective to the association of alcohol usage level and other covariates with ENDS

use that may provide further background to the design future health and behavioral interventions.

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Chapter III: Manuscript

3.1 Introduction

Young adults have one of the highest rates of alcohol and tobacco use relative to any other age group (Cohn et al., 2015; Pearson et al., 2012; Rath et al., 2012). The potential negative impact of alcohol on future tobacco related-use calls for additional research to understand its association with Electronic Nicotine Devices (ENDS). ENDS are battery-operated products that distribute an aerosol (vapor) to users, with the vapor generated by heating a liquid solution called e-liquid (Grana et al., 2014). In late 2019, the U.S federal government raised the age of purchasing tobacco products from 18 to 21 years partly due to public pressure and the attributable health effects produced by flavored e-liquids. Furthermore, in January 2020, the F.D.A. issued a policy prohibiting the sale of flavored vaping liquids except for menthol and tobacco.

Use of tobacco is one of the leading causes of preventable diseases and deaths in the United States (National Center for Chronic Disease Prevention & Health Promotion Office on Smoking and Health, 2014). The prevalence of smokers using combustible cigarettes has decreased, but the prevalence of ENDS continues to increase among adults in the United States (Jamal et al., 2016). Assessing composition of ENDS and associated health effects is still developing; its increasing popularity has stemmed from the perceived notion of having reduced levels of harmful toxicants compared to traditional cigarettes (combustible) (Arnold, 2014; Cobb et al., 2010; Kaisar et al., 2016). The Surgeon General reported that smoking cigarettes was responsible for over 480,000 deaths per year in the United States, about one in five deaths annually (National Center for Chronic Disease Prevention & Health Promotion Office on Smoking and Health, 2014). Volatile Organic compounds (VOCs), for example, are present in ENDS

generated vapor; these chemicals can be irritant, carcinogenic, and neurotoxic. (Goniewicz et al., 2014; Kaisar et al., 2016). Often causing the development of cancer, cardiovascular, and respiratory diseases (Goniewicz et al., 2014; Hecht, 2003; St Helen et al., 2014). In addition, inhalation of particulates generated by ENDS may contribute to the onset of various diseases similar to exposure to VOCs, chronic respiratory diseases, cardiovascular diseases, and cancer (Spirić et al., 2012).

Documented in the National Health Interview 2014 Survey, 12.6% of adults had in the past tried ENDS, with use varying by sex, age, and race (Schoenborn & Gindi, 2015). Du et al. (2019) examined factors associated with past ENDS use using logistic regression with adults 18 years and older, living in Los Angeles County, males with some college or higher education level were at increased odds to have used ENDS compared to users with less than a high school degree [Odds Ratio (OR) = 1.52; 95% CI = 1.02, 2.26]. Also, using non-alcohol consumers as a reference, heavy/binge male drinkers had increased odds of past ENDS use than non-heavy/non-binge drinkers [OR = 1.80, 1.38, respectively].

Previous studies have reported an association between alcohol use and smoking traditional combustible cigarettes common among young adults (Drobes, 2002; Jiang & Ling, 2011; Weitzman & Chen, 2005). Bobo and Husten (2000), revealed that 37% of adults who consumed alcohol were also smokers, compared to 13 percent of abstainers. The mechanism of neurotransmitters and nicotinic receptors is explored in the literature. It is said that the mechanisms interact with the initiation of alcohol and smoking, causing an increasing sensation from the effects of these substances on the brain, furthermore increasing the amount consumed to sustain these sensational effects (Falk et al., 2006).

In particular national studies have demonstrated that alcohol and tobacco use heightens during young adulthood (Wagner & Anthony, 2002; Weitzman & Chen, 2005). People who smoke are more likely to consume alcohol, frequently, and in high quantities than non-smokers (Batel et al., 1995; Harrison et al., 2008; Jiang & Ling, 2011). Nicotine, in particular, increases alcohol consumption; in addition, alcohol consumption increases the craving to smoke (Glautier et al., 1996; King & Epstein, 2005). Amongst those who smoke, they report alcohol increasing their desire and enjoyment for cigarettes providing a "double buzz" (Jiang & Ling, 2011; Stromberg et al., 2007).

It is important to explore various socio-demographic variables to draw accurate conclusions about patterns of ENDS use at the population level and to estimate potential benefits or harms. The primary aim of this study was to examine the association of alcohol use and various covariates with ENDS use in a representative sample of young adults age 18-35. Secondary, whether the link between alcohol use and ENDS would be diminished by race or education when controlled for traditional cigarette use.

3.2 Methods

Analysis for this study was based on the 2015-2016 National Health and Nutrition Examination Survey (NHANES). NHANES is a population based series of cross-sectional surveys designed to collect information on the health and nutrition of household population of adults and children in the United States conducted by the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention (CDC) (Fain, 2017).

Study measures that were considered were obtained from the demographic, alcohol use, and smoking-cigarette use files. All contributors aged 12 years and older were eligible for the

smoking survey but not the alcohol use questionnaire. For the analysis, only individuals 18-35 were included. Adults, 18 years and older, responses were collected in the home using the Computer-Assisted Personal Interview (CAPI) system. The CAPI system allows researchers to collect computer-assisted data, to provide a fast turnaround time, in addition improved data quality (Gravlee, 2002).

The smoking-cigarette use data set provided a history of cigarette use, age at initiation, past 30-day use, cigarette brand, sub-brand, and other related details. Questions on past use of cigars, smokeless tobacco, and ENDS were new for the 2015-2016 cycle for adults 18 years and older. Alcohol Use Questionnaire focused on lifetime and current use (past 12 months); questions asked were not specific to the type of alcohol used.

In the interest of this study, self-reported demographic, ENDS, and alcohol usage was determined based on how a person answered the below questions:

- *What is the highest grade or level of school have you completed or the highest degree you have received?*
- *Ever used an e-cigarette? (These are battery-powered devices that usually contain liquid Nicotine, and don't produce smoke. Have you EVER used an e-cigarette EVEN ONE TIME? This hand card shows examples of some e-cigarettes and other devices used to inhale liquid Nicotine; however, there are others not included here).*
- *How often do you drink alcohol over past 12 months? (In the past 12 months, how often did you drink any type of alcoholic beverage? PROBE: How many days per week, per month, or per year did you drink?)*
- *What is the number of days, do you drink alcohol per week, month, year?*

- *Do you now smoke cigarettes?*
- *Have you smoked at least 100 cigarettes in your entire life?*

Any participant who did not have complete information such as refused, missing, and did not know was eliminated from the study. Variables used in this study were age, ethnicity, education, annual family income, alcohol usage level in the past 12 months, traditional cigarette use and past ENDS use.

Age

Age was reported in years at the time of screening. Age was then classified into four categories of 18-20 years, 21 – 25 years, 26–30 years, and 31 -35 years.

Ethnicity/Race

Ethnicity included Hispanic origin with Non-Hispanic Asians included. Ethnicity was classified as Mexican American, Other Hispanic, Non-Hispanic White (NH White), Non-Hispanic Black (NH Black), Non-Hispanic Asian (NH Asian) and Multiracial/ Other races.

Education

Education was classified as less than 9th grade, 9-11th grade (Includes 12th grade with no diploma), High school graduate/GED or equivalent, some college or Associate of Arts (AA) degree and college graduate or above.

Annual Family Income

Total household income was reported as a range value in dollars. Annual family income was classified into categories of $0 - $24999, $25000 - $54999, $55000 - $74999, $75000 - $99999, and $100000 and over.

Alcohol usage level in the past 12 months

Based on NHANES measures of alcohol use in the past year, categories of no, low, moderate and high alcohol use was classified into 4 groups based on data generated percentile ranks as follows: low alcohol usage consisted of participants who drank between 1-12 drinks (mean:7.09, SD:4.33), moderate alcohol usage consisted of those who drank between 14-50 drinks (mean:30.13, SD:9.32), high alcohol usage consisted of individuals who drank between 52-364 drinks (mean:119.49 SD:79.46).

Traditional Cigarette Use

Traditional cigarette usage was classified into two categories no and yes. Participants were reported as using traditional cigarettes if they answered "Yes" to "smoked 100 cigarettes in life" and "do you smoke now." Individuals that answered "no" to "smoked 100 cigarettes in life" and were skipped/missing on "do you smoke now," were coded in the no category.

Sample weights were utilized to ensure the analysis is nationally representative—the weighting procedures adjusted for oversampling of specific population groups and non-responses by way of the sampling weights. Comparisons were made with weighted and unweighted results.

Descriptive statistics of study variables, alcohol usage level in the past 12 months, ENDS use, age, race, ethnicity, education, and income were computed. Univariate and multivariate logistic regression analyses were computed to assess the associations between demographic characteristics, alcohol use and ENDS use. The outcome of interest, analysis for effect modification was computed to determine if race and education modified the association observed between alcohol use and ENDS use when controlled for traditional cigarette use. For

all the analyses, a p-value of 0.05 and a confidence interval (CI) of 95% was used to determine statistical significance. Analyses utilized SAS 9.4 (Cary, NC).

3.3 Results

The complete survey in 2015-2016 comprised of 9971 individuals; of those participants, 1854 where in the age range of 18 – 35 years old. Only 1145 individuals met the eligibility criteria of this study. The average age of study participants was 26.88 years old (standard deviation (SD): 5.06).

Demographic characteristics of study participants are shown in Table 1. Among them, 38.29% reported ever using ENDS, 37.85% reported ever using traditional cigarettes and 92.36% reported consuming alcohol in the past 12 months (Table 1). Among individuals who reported ever using ENDS (Table 2), 71.80% of participants used traditional cigarettes, 60.09% were NH White, in the ages of 21-25 (35.08%), with some college or AA degree (38.04%) and income between $25000-$54999 (38.20%). Similarly, individuals who did not report using ENDS (Table 2), 16.79% of participants had used traditional cigarettes, 57.56% were NH White in the ages of 31-35 (34.01%), college graduate or above (40.66%) and income between $25000-$54999 (33.97%).

Results from univariate analysis of various covariates, alcohol usage level, age, race, education, and income presented an association to ENDS use, and all variables were seen to be significant (P-value, <0.001) (Table 2). Individuals who reported using traditional cigarettes were 12.62 times more likely than non-traditional cigarette users to use ENDS (95% CI: 12.60 - 12.64). Participants who reported high alcohol usage were 1.89 times more likely than no alcohol users to use ENDS (95% CI: 1.88 - 1.89), followed by moderate alcohol users (adjusted odds ratio (aOR):

1.76, 95% CI: 1.76 - 1.77) and low alcohol were 0.92 times less likely than no alcohol users to use ENDS (95% CI: 0.92 - 0.92). In comparison to individuals age 31 -35, 18-20-year-old participants were 2.29 times less likely to use ENDS (95% CI: 2.28 – 2.29), similarly 21 -25-year-old participants were 1.94 times less likely to use ENDS (95% CI: 1.94 – 1.94) and 26 -30-year-old participants were 1.59 times less likely to use ENDS (95% CI: 1.59 – 1.60). Interestingly, Multiracial / Other Race participants were 1.89 times more likely to use ENDS than NH Whites (95% CI: 1.88 – 1.89), the highest amongst all other racial groups. NH Blacks, NH Asians, Mexican American, and Other Hispanics were less likely that NH Whites to use ENDS (aOR: 0.97; 95% CI: 0.97 – 0.97, aOR: 0.52; 95% CI: 0.52 – 0.52, aOR: 0.85; 95% CI: 0.84 – 0.85 , aOR: 0.76 95% CI: 0.75 – 0.76 respectively). Additionally, High school graduates/GED or equivalent educated individuals were 1.29 times more likely to use ENDS than participants with Some college or AA degree, and individuals who had an income range of $0-$24999 were 2.03 times more likely to use ENDS than participants with income $100,000 and Over.

Assessing whether the association between alcohol usage level and ENDS use varied by a third-factor race, multivariate analysis revealed, alcohol usage level was significant in the model (p-value: 0.0072) and race was not (p-value: 0.7168) when including traditional cigarette use (p-value: <0.0001). Therefore, there is no evidence to suggest effect modification of alcohol usage level by race. Additionally, evaluating the potential change of association between alcohol usage level and ENDS by including education and controlling for traditional cigarette use, multivariate analysis revealed, alcohol usage levels (p-value: 0.0004), education (p-value: 0.0063) and traditional cigarette use (p-value: <.0001) were significant to be used in the final model. Effect modification of alcohol usage levels by education concluded, there is a significant interaction (p-

vale: <0.0001) between alcohol usage level (p-value: 0.0157) and education (p-value: 0.0421) when controlled for traditional cigarette use (p-vale: <0.0001). This indicates that there is evidence that the alcohol usage level effects ENDS use differing by educational status, and evidence that traditional cigarette use outcome is related to ENDS use.

3.4 Discussion

The purpose of this study was to examine the prevalence and demographic characteristics associated with ENDS use in young adults in the U.S. Moreover, the study sought to determine if alcohol use in the past year was associated with ENDS use. The prevalence of ENDS use obtained in this study, 38.3%, is very similar to the prevalence obtained in other surveys. For example, the prevalence of ENDS use was 35.8% among adults ages 18 to 24 years in the National Adult Tobacco Survey (NATS) (Delnevo et al., 2015). In addition, similar to the NATS, ever ENDS use was higher in Non-Hispanic Whites than in other racial/ethnic groups. The demographic characteristics associated with ENDS use reflect mostly mid level socioeconomic status such as some higher education, and middle class low to middle income. Data availability of ENDS use amongst young adults is presently limited with socioeconomic status such as poverty statis and household income (National Center for Chronic Disease Prevention & Health Promotion Office on Smoking and Health, 2014). Examining the socioeconomic determinants of ENDS use may provide important background knowledge because ENDS are potential health risks that are relatively recent and rapidly growing in popularity (Assari et al., 2020; Harlow et al., 2019).

With respect to alcohol use, we found that both moderate and high levels of alcohol use was associated with ENDS use. This is a great concern given that alcohol use may exacerbate other health risks among ENDS users, particularly with low socioeconomic status (SES) individuals

who are less educated and have lower income. The health of low SES groups is disproportionately affected by smoking, low income smokers have an increased protentional to suffer more from diseases caused by smoking than smokers with higher incomes (Centers for Disease Control and Prevention, 2019).

Our analyses also showed that the association between alcohol and ENDS use varied by education. Educational disparities in ENDS use may include different perceptions of health consequences due to smoking (Cowell, 2006; Gilman et al., 2008; Power et al., 2004). In contrast, lack of educational attainment can increase the prevalence of smoking due to financial and occupational status (Gilman et al., 2008; Wills et al., 2002). Higher educational status generally lowers high-risk behaviors such as ENDS use and generates increased economic and health benefits in the United States (Assari et al., 2020). Policies and programs that encourage and aid in high educational attainment may reduce ENDS use. Further assessment can be conducted to include potential racial differences in the interaction between alcohol usage level and educational status in ENDS use as practices may vary.

Few previous studies have examined the association between alcohol and ENDS in young adults (Cohn et al., 2015). As such, it is clear why substance use, such as alcohol, in young adults is a public health problem that continues to be part of the ENDS related prevention and intervention initiatives (Anthony & Echeagaray-Wagner, 2000; Cohn et al., 2015; Degenhardt & Hall, 2012).

The availability of ENDS and general perceptions of lower harm has led to the increased prevalence of nicotine-addicted users, who would otherwise have been at low risk for tobacco use (Bhatnagar et al., 2019). ENDS use can increase the likelihood that young adults who have

never used any tobacco products could potentially become lifetime users of other tobacco products (Cohn et al., 2015; Delnevo et al., 2015; U.S. Department of Health and Human Services, 2012). For these reasons, it would be prudent to expand current policies of ENDS, which currently focus specifically on young adolescents, to also include young adults.

Several limitations should be considered when interpreting these findings. Our analyses present findings from a cross-sectional study, and as such, causation cannot be determined. Also, the measure on ENDS use was fairly limited. Finally, the self-reported nature of NHANES may introduce social desirability biases to both over and under report certain characteristics of behaviors. However, even with these limitations, this is one of very few studies that have examined the demographic characteristics and alcohol use with respect to ENDS use in a sample of nationally representative young adults.

3.5 Conclusion

ENDS use is common among young adults in the U.S. and is associated with socioeconomic status as well as alcohol use. Prevention efforts need to factor in these demographic characteristics when targeting interventions and also factor in that moderate and heavy alcohol use are associated with ENDS use which likely will exacerbate health concerns among ENDS users.

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Chapter IV: Tables

Table 4.1 Descriptive Statistics of Study Variables NHANES 2015-2016 (N = 1145)

	N	Weighted (%)
Alcohol usage level in the past 12 months		
No Alcohol Use	107	7.64
Low Alcohol Use	405	29.44
Moderate Alcohol Use	220	17.99
High Alcohol Use	413	44.93
Ever used E- Cigarettes		
No	722	61.71
Yes	423	38.29
Traditional Cigarette Use		
No	732	62.15
Yes	413	37.85
Age		
18 - 20	155	8.94
21 - 25	321	30.62
26 - 30	333	31.01
31 - 35	336	29.44
Race		
Non-Hispanic White	372	58.53
Mexican American	217	11.72
Other Hispanic	134	7.61
Non-Hispanic Black	228	11.83
Non-Hispanic Asian	132	5.30
Multiracial / Other Race	62	5.01
Education		
Less than 9th grade	36	2.40
9-11th grade (Includes 12th grade with no diploma)	140	9.20
High school graduate/GED or equivalent	282	21.56
Some college or AA degree	387	34.04
College graduate or above	300	32.79
Income		
$0 to $24,999	310	23.02
$25,000 to $54,999	424	35.59
$55,000 to $74,999	129	11.37
$75,000 to $99,999	118	9.90
$100,000 and Over	164	20.12
Cases who refused, missing, and did not know not were excluded AA = Associate of Arts, N = number		

Table 4.2 Descriptive and Univariate Analysis of Study Variables by Frequency of Ever E-cigarette use NHANES 2015-2016 (N = 1145)

	No (N=744)		Yes (N=437)		Weighted**		
	N	**Weighted (%)**	**N**	**Weighted (%)**	**aOR**	**95 % CI**	**P value**
Alcohol usage level in the past 12 months							
No Alcohol Use	78	8.68	29	5.96	Referent		
Low Alcohol Use	293	34.29	112	21.62	0.92	0.92 - 0.92	**<.0001**
Moderate Alcohol Use	134	16.65	86	20.14	1.76	1.76 - 1.77	**<.0001**
High Alcohol Use	217	40.37	196	52.27	1.89	1.88 - 1.89	**<.0001**
Traditional Cigarette Use							
No	592	83.21	140	28.20	Referent		
Yes	130	16.79	283	71.80	12.62	12.60 - 12.64	**<.0001**
Age							
31-35	235	34.01	101	22.07	Referent		
18 - 20	84	7.54	71	11.19	2.29	2.28 – 2.29	**<.0001**
21 - 25	190	27.85	131	35.08	1.94	1.94 – 1.94	**<.0001**
26 - 30	213	30.60	120	31.66	1.59	1.59 – 1.60	**<.0001**
Race							
Non-Hispanic White	216	57.56	156	60.09	Referent		
Mexican American	144	12.28	73	10.83	0.85	0.84 – 0.85	**<.0001**
Other Hispanic	91	8.29	43	6.53	0.76	0.75 – 0.76	**<.0001**
Non-Hispanic Black	142	11.79	86	11.89	0.97	0.97 – 0.97	**<.0001**
Non-Hispanic Asian	99	6.43	33	3.47	0.52	0.52 – 0.52	**<.0001**
Multiracial / Other Race	30	3.65	32	7.19	1.89	1.88 – 1.89	**<.0001**
Education							
Some college or AA degree	234	31.59	153	38.04	Referent		
Less than 9th grade	24	2.04	12	2.97	1.21	1.20 – 1.22	**<.0001**
9-11th grade (Includes 12th grade with no diploma)	75	7.91	65	11.28	1.19	1.18 – 1.19	**<.0001**
High school graduate/GED or equivalent	160	17.80	122	27.61	1.29	1.29 – 1.29	**<.0001**
College graduate or above	229	40.66	71	20.10	0.41	0.41 – 0.41	**<.0001**
Income							
$100,000 and Over	113	22.68	51	15.99	Referent		
$0 to $24,999	178	19.78	132	28.25	2.03	2.02 – 2.03	**<.0001**
$25,000 to $54,999	263	33.97	161	38.20	1.60	1.59 – 1.60	**<.0001**
$55,000 to $74,999	81	11.37	48	11.37	1.42	1.41 – 1.42	**<.0001**
$75,000 to $99,999	87	12.20	31	6.20	0.72	0.72 – 0.72	**<.0001**

** Based on ENDS use

Cases who refused, missing, and did not know not were excluded from the study and regression analysis

Bold indicates significant findings at α=0.05 (p< .05)

N = number, aOR = adjusted odds ratio, CI = confidence interval, AA = Associate of Arts