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The Association Between Depression and E-Cigarette Use in US Adults, 2017-2020: An Analysis of National Survey Data

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An abstract of
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Abstract

The Association Between Depression and E-Cigarette Use in US Adults, 2017-2020:

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By Allison Wynne

Objective: The prevalence of e-cigarette use in the United States is rising, yet risk factors associated with their use are not well known. This research aims to evaluate the association between depression and e-cigarette use among adults age 20 and older in the United States.

Methods: Using the National Health and Nutrition Examination Survey 2017- March 2020 Pre-Pandemic Dataset, we conducted a multiple logistic regression to evaluate the association of depression (primary exposure) and the impact of depressive symptoms (secondary exposure) with e-cigarette use (outcome). The analysis was stratified by use of combustible cigarettes, and restricted to 4,580 participants ages 20 and older with complete data for demographic information and smoking status, as well as complete depression screeners.

Results: Participants were an average of 47.6 years at the time of survey. Among US adults in 2107-2020, the prevalence of e-cigarette use was 3.5% (95% CI: 2.5-4.4), and the prevalence of depression was 12.6% (95% CI: 11.1-14.1). Among combustible cigarette non-users, the odds of using e-cigarettes was 3.2 (95%CI: 1.8-5.7) times higher among those with depression compared to those without depression, after adjusting for demographics. There was not a significant association between the impact of depressive symptoms and e-cigarette use status.

Conclusions: Among combustible cigarette non-smokers, those with depression were 3.2 times more likely to use e-cigarettes than those without depression.

Policy implications: People who suffer from depression but do not smoke conventional cigarettes may be at a higher than average risk for using e-cigarettes. This indicates that depression is a significant risk factor for e-cigarette use. The mental health of e-cigarette users should be considered in developing policies and regulations regarding the production and sale of e-cigarettes. Clinicians should employ techniques to prevent e-cigarette use among their patients who suffer from depression.

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Introduction

Electronic cigarettes (e-cigarettes), originally designed as a tool for combustible (traditional) cigarette cessation, are small, portable devices that deliver a substance via a heated vapor. These devices have gained massive popularity since their invention in 2003.[1] Among young adults (18-24), the prevalence of reported current and daily e-cigarette use increased from 5.1% to 7.6% between 2014 and 2018.[2] Prior studies indicate that people with depressive symptoms are more likely to use e-cigarettes.[3,4] In light of the tripling of depressive symptoms in the United States during the COVID-19 pandemic[5], better understanding the health risks associated with depression has become even more important.

The aims of this thesis are to 1) evaluate if there is an association between depression and e-cigarette use among adults age 20 and older in the United States, and to 2) evaluate if any relationship between depression and e-cigarette use differs between those who smoke combustible cigarettes and those who do not. To generate more context about the relationship between depression and e-cigarette use, this thesis will examine impact (severity) of depressive symptoms in relation to e-cigarette use.

Literature Review

Background

E-cigarettes have become pervasive in recent years. One can find several brands, concentrations, and flavors in gas stations and mall kiosks nationwide. The products and their consumers are rapidly evolving, so it is important to understand what motivates people to use e-cigarettes, and what consequences their use carries.

Though there are recent efforts to determine the health impacts of e-cigarette use, there has not been sufficient research into the risk factors for e-cigarette use. One 2015 study investigated risk and protection variables, including parental support, academic involvement, smoking expectancies, peer smoking, and sensation seeking, and their relationships with e-cigarette use among high school students.[6] Another study of German adolescents evaluated how other social factors and demographic variables like gender and age influence e-cigarette use.[7] A study of working-age adults in the U.S. identified both cognitive and physical disabilities as risk factors for e-cigarette use.[8] A 2019 study broadly identified "mental health symptoms" as a risk factor for both e-cigarette and combustible cigarette use.[9] Yet, there has not been a study that directly assesses current depression as a risk factor for e-cigarette use in the general adult population in the U.S.

The link between mental health and nicotine use has been explored for decades, mostly through research on the effects of combustible cigarette smoking. The relationship between depression and e-cigarettes is an important connection to establish, and an area of study researchers have only begun to explore.

Electronic Cigarettes

Electronic cigarettes, or e-cigarettes, have gained massive popularity since their invention in 2003 by Chinese pharmacist Hon Lik. They were designed to be a healthier alternative to smoking combustible (traditional) cigarettes. They function by delivering a heated vapor containing nicotine, a humectant such as glycerin, and often, flavoring agents.[1] E-cigarette use may not have some of the undesirable side effects of combustible cigarette use such as yellowed skin and teeth, halitosis, and skin ageing,[10] but some short-term negative health effects of e-cigarette use have been documented.[11,12]

The nicotine content of e-cigarettes varies both between and within brands significantly,[13] but approximately 99% of electronic cigarettes contain nicotine.[14] Nicotine is an addictive stimulant that leads to an increased risk of adverse cardiovascular, respiratory, and gastrointestinal events. Some research indicates that the use of nicotine contributes to a decreased immune response, negatively impacts reproductive health, and can cause cell proliferation and DNA mutation, which can lead to cancer.[15] The scientific and medical communities have conducted extensive research on traditional cigarette use and have concluded that those with depressive symptoms may be more likely than the average person to use nicotine.[16] The number of additives in different brands and types of e-cigarettes varies wildly, but many of these ingredients have been identified as carcinogens or toxicants.[17]

There are some short-term negative health effects of e-cigarettes that have come to light over the last two decades. Propylene glycol and glycerin, two common ingredients in e-cigarette liquid, are known eye and respiratory irritants. Prolonged exposure to these vapors can affect the central nervous system and spleen. When vaporized, propylene glycol can become propylene oxide, a carcinogen. Vaping e-cigarettes reduces pulmonary function in the short-term, and other

side effects such as nausea, vomiting, mouth irritation and cough have been reported. Serious injuries caused by e-cigarette use involve device explosion.[11] In recent years, at least several hundred cases of acute respiratory distress in the United States have been associated with e-cigarette use. In an in vitro study, e-vapor caused immune cell death. This aligns with early findings that e-cigarette use leads to impaired immune system function. The long-term effects of combustible cigarette use, such as lung cancer, heart disease and chronic obstructive pulmonary disease, were only established after smokers used these products for decades.[12] It may be decades more until the research community can identify the long-term effects of chronic e-cigarette use.

The overall prevalence of e-cigarette use among U.S. adults in 2018 was 3.2%. Among young adults (18-24), e-cigarette use increased significantly among never and former cigarette smokers in nearly every demographic subgroup between 2014-2018.[2] This is indicative that many young adults are not using electronic cigarettes as a smoking cessation tool, but are using nicotine recreationally. Despite the evidence of negative short-term health effects and lack of evidence regarding long-term use, the production and sale of e-cigarettes remain largely unregulated.

Depression as a Public Health Concern

Depression is a mental health condition that has remained a burden on people and health systems around the world for hundreds of years. “Melancholia” was recognized as early as the 4th century BC. Throughout history, depressed moods were attributed to a wide range of causes and defined by a myriad of symptoms.[18] Today, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-V), one qualifies for a diagnosis of depression if they display at least five of eight listed symptoms, including at least one of two listed main symptoms, for a duration of at least two weeks. The two main symptoms of depression in the DSM-V are

depressed mood and anhedonia (loss of interest or pleasure).[19] There are different tools mental health clinicians use to help them assess a patient for depression, including the Hamilton Depression Rating Scale (HAMD),[19] the Occupational Depression Inventory (ODI),[20] and the Patient Health Questionnaire (PHQ-9).[21]

As measured in years lived with disability (YLD), depression is the most prevalent contributor to morbidity worldwide.[22] Prevalence studies estimate that 8.1% of U.S. adults have depression.[23] Regardless of age, depression is almost twice as common among women as among men. Non-Hispanic Asians represent the racial group with the lowest prevalence of depression. Among those living below the federal poverty line, the prevalence of depression is 15.8%.[23] Of all those with depression, 80% reported at least some difficulty with work, home, or social activities due to their depressive symptoms.[23] Since the COVID-19 pandemic began, the prevalence of depression among U.S. adults has increased to 27.8%.[5]

Depression is often comorbid with other diseases, which can compound the severity of one or both illnesses. Patients suffering from depression frequently present with comorbid mental health disorders, including anxiety, obsessive-compulsive, personality, and substance use disorders.[24] Both earlier-life and later-life depression are associated with a higher risk for dementia.[25] Depression has been identified as a risk factor for many diseases, including heart disease,[26] diabetes,[27] stroke,[28] and even osteoporosis.[29] Depression is a major public health issue that contributes to an economic burden of tens of billions of dollars in the United States each year.[30]

Identifying Depression in the Population: The Patient Health Questionnaire (PHQ-9)

The Patient Health Questionnaire (PHQ-9) was developed in 2001 as a screener for depression and was intended for use in primary healthcare settings. The 9-item patient-

administered questionnaire is an adaptation of the provider-conducted PRIME-MD diagnostic tool used by clinicians to assess patients for common mental health disorders. The questionnaire is based on the criteria for depression diagnosis as defined in the DSM-IV. The questions directly assess each of the criteria for depression diagnosis. For example, the screener asks: “Over the last 2 weeks, how often have you been bothered by any of the following problems?: Little interest or pleasure in doing things.” Patients' responses range from 0 (not at all), to 3 (nearly every day). The scores for each question are summed to produce a total score from 0-27. A total score of less than 5 indicates no depression, and scores between 5-9, 10-14, 15-19, and 20+ indicate mild, moderate, moderately severe, and severe depression, respectively. A final question on this screener asks, “How difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?” Responses range from “not difficult at all” to “extremely difficult.” This question serves as a measure of self-perceived severity of symptoms.[21]

Over the past two decades, the PHQ-9 has been employed and validated all over the world on diverse patient populations.[31] It has been validated as an effective tool for identifying depression in primary care settings,[21] psychiatric patients,[32] and the general population.[33]

Depression and E-Cigarettes

The association between current depression and e-cigarette use among U.S. adults is not known, but similar studies suggest there could be a relationship. A study using data from the Korea National Health and Nutrition Examination Survey (KNHANES) found that participants with depressed mood were higher in number in the group of people who had used e-cigarettes than in other groups.[3] In the United States, a cross-sectional study using the Behavior Risk Factor Surveillance System (2016-2017) found that e-cigarette users had higher odds of reporting

a history of clinical diagnosis of depression compared with participants who never used e-cigarettes.[4] Some studies suggest a bidirectional relationship. In one 2020 study, current e-cigarette users reported having depression at a significantly higher rate than non-users and former users.[34]

The link between depression and combustible cigarette use has long been established. In a 21-year longitudinal study, those with depression had higher rates of daily cigarette smoking and were more likely to be nicotine dependent.[35] The inverse relationship is supported by empirical evidence as well. In another longitudinal birth cohort study, researchers found that combustible cigarette use increases the risk of depressive symptoms.[36] The question of causal direction in this relationship mirrors the same in the association between depression and e-cigarette use.

Nicotine is believed to be the reason for which e-cigarettes and combustible cigarettes have been adopted by people with depressive symptoms. Those with depressive symptoms may be more likely than the average person to use nicotine, because nicotine may have antidepressant-like effects.[16] In another large study published in 1993, researchers found that a history of nicotine dependence was a risk factor for major depression.[37]

In summary, depression and e-cigarette use are both salient public health concerns in 2022. Understanding the relationship between depression and e-cigarette use could inform policy and identify those at risk for initiating a potentially dangerous activity.

Methods

Data

This study is a secondary data analysis using publicly available data from The National Health and Nutrition Examination Survey (NHANES), a nationally representative cross-sectional study that provides data to assess the health of the US population over time. Because of the COVID-19 pandemic, data collection halted in March 2020. Information collected in the 2017-2018 NHANES is combined with the 2019-March 2020 data to create one nationally representative dataset. Participants include non-institutionalized US residents.[38]

Participants were included in this analysis if they 1) were at least 20 years old, 2) had a complete Depression Screener, 3) had available smoking data, and 4) had no missing data for relevant demographic information. A total of 10,980 participants were excluded (Figure 1). The final analytic sample consists of 4,580 participants.

Study Measures

E-cigarette use

The outcome of interest is current e-cigarette use. E-cigarette use is measured via a checkbox in the NHANES questionnaire. Participants who report using tobacco products in the past 5 days are asked to check off which products they used. Participants that check e-cigarettes are classified as being current e-cigarette users. All other participants who do not check e-cigarettes, including those who do not report any tobacco use, were classified as not current e-cigarette users.

Depression

The exposure of interest is current depression measured through the PHQ-9. The PHQ-9 is a questionnaire administered as part of the NHANES Mobile Examination Center (MEC)

interview. Each answer corresponds to a score for each question. For example, if a participant answers "Several days" to the question "Over the last 2 weeks, how often have you been bothered by the following problems: feeling down, depressed, or hopeless?," the participant's score for that question is a 1. The scores for each question 1-9 can be summed to create a total score from 0-27. A score of 10 or above indicates moderate to severe depression. A score below 10 indicates no depression to mild depression. The individual question scores are summed and used to classify participants as having current depression (PHQ-9 score of 10 or above) or not having current depression (a score of less than 10). This cutoff is used in research and in diagnosing patients in clinical settings.[33]

Impact of Depression on Daily Life

The 10th question on the PHQ-9 Depression Screener administered by NHANES asks "How difficult have these problems made it for you to do your work, take care of things at home, or get along with people?" This question is not included in the calculation of a participants score, but serves as an indicator of their depressive symptoms' impact on their life and/or severity of symptoms. Those who respond "Not at all difficult" or "Somewhat difficult" to this question are classified as "symptoms less impactful." Those who responded "Very difficult" or "Extremely difficult" were classified as "symptoms highly impactful."

Demographic characteristics

Demographic data, including age, race/ethnicity, sex, education, marital status, and income, as well as current combustible cigarette use, are considered potential confounders in both analyses. Race categories include Mexican American, Other Hispanic, Non-Hispanic White, Non-Hispanic Black, Non-Hispanic Asian, and Other Race – including Multi-Racial. Education categories included "less than 9th grade," "9-11th grade (includes 12th grade with no diploma),"

"high school graduate/GED or equivalent," "some college or AA degree," and "college graduate or above." Marital status categories include "married/living with Partner," "widowed/divorced/separated," and "never married." Income is included as a ratio of family income to poverty (possible values 0-4.98, or 5 where 5 represents a value greater than or equal to 5.00). These demographic variables are measured via questionnaire. Current combustible cigarette use is measured in the same manner as current e-cigarette use.

Statistical Analysis

Univariate analyses are conducted on all variables to describe sample characteristics and ensure they were correctly specified for the model. We conducted logistic regression to estimate the association between depression and e-cigarette use among all participants. Both unadjusted and adjusted models included age, race, sex, marital status, income and education were estimated. Based on the literature that indicated combustible cigarette and e-cigarette use may be highly related,[34] we tested the interaction term cigarette*ecigarette. To accommodate the significant interaction, we conducted a stratified multiple logistic regression to evaluate the association between depression and e-cigarette use among combustible cigarette smokers and cigarette non-smokers separately. Finally, we conducted an additional analysis to investigate the association between the impact of participants' depressive symptoms and e-cigarette use. The outcome of interest was current e-cigarette use. The exposure of interest was the impact of participants' depressive symptoms. The analyses account for survey weight, cluster and stratum. Analyses were conducted using SAS Studio 3.81.

Results

Characteristics of the Study Population, NHANES 2017-2020 (Pre-Pandemic)

The sample consisted of 43.3% (95% CI: 41.0-45.6) males and 56.7% (95% CI: 54.4-59.0) females (Table 1). The average age of the sample was 47.6 (95% CI: 46.2-49.0). The most prevalent race/ethnicity was Non-Hispanic White at 66.2% (95% CI: 61.3-71.1) followed by Non-Hispanic Black at 10.4% (95% CI: 7.8-13.0). The majority of the sample, 59.6% (95% CI: 56.5-62.7), were married or living with a partner. 90.3% of the sample completed high school or higher education. The average ratio of family income to poverty in the sample was 3.0 (95% CI: 2.9-3.1).

Across all participants, the prevalence of e-cigarette use was 3.5% (95% CI: 2.5-4.4), and the prevalence of combustible cigarette use was 18.8% (95% CI: 16.7-20.9). The prevalence of depression was 12.6% (95% CI: 11.1-14.1).

Prevalence of Depression among E-Cigarette and Cigarette Users and Non-Users

The prevalence of depression among e-cigarette users was 20.3% (95%: 13.5-27.0), while the prevalence of depression among e-cigarette non-users was 12.3% (95% CI: 10.7-13.9) (Figure 2). The prevalence of depression among cigarette users was 21.6% (95% CI: 18.1-25.2), while the prevalence of depression among cigarette non-users was 10.5% (95% CI: 9.0-12.0).

Association Between Depression and E-Cigarette Use Stratified by Combustible Cigarette Use

In Table 2, we show the results of logistic regression models estimating the association between depression status and current e-cigarette use in all adults and stratified by combustible cigarette use. The unadjusted model in all adults showed a positive and statistically significant association between depression and e-cigarette use (odds ratio [OR]=1.8, 95% CI: 1.1-3.0). The

adjusted model in all adults showed a positive, but not statistically significant association (adjusted odds ratio [aOR]= 1.3; 95% CI: 0.8-2.2).

There was a significant interaction between e-cigarette use and combustible cigarette use in the adjusted model, and therefore we conducted the analysis stratified by the use of combustible cigarettes. Among cigarette non-users, the adjusted relative odds of using e-cigarettes was 3.2 (95% CI: 1.8-5.7) times higher among those with depression compared to those without depression, after adjusting for age, sex, race, education level, marital status, and income.

Among cigarette users, the odds of using e-cigarettes were not significantly different between those with depression and those without depression, after adjusting for age, sex, race, education level, marital status, and income (aOR: 0.6; 95% CI: 0.3-1.3).

Association Between Impact of Depressive Symptoms and E-Cigarette Use

Neither the unadjusted nor the adjusted model indicated a statistically significant association between impact of depressive symptoms and e-cigarette use among cigarette non-users (Table 3).

Discussion

There was a significant positive association between depression and e-cigarette use among U.S. adults. The association between depression and e-cigarette use is even stronger among those who do not use combustible cigarettes (aOR: 3.2; 95% CI: 1.8-5.7). The prevalence of depression is markedly higher among those who smoke e-cigarettes or combustible cigarettes than those who do not (Figure 2). Results indicate that there is not a significant association between impact of depressive symptoms and e-cigarette use among cigarette nonsmokers (Table 3). Among adults, depression is a significant risk factor for e-cigarette use.

This study's findings align with recent literature which indicates that depressed mood,[3] and reported history of clinical diagnosis of depression[4] are associated with e-cigarette use. This study is unique in that it measures current depression via a validated screener rather than previous clinical diagnosis, as in Obisesan et al. (2019). It also measures current e-cigarette use rather than "ever use" as reported in Lee et al. (2020).

This study has certain limitations. The NHANES 2017-March 2020 dataset does not measure marijuana use, which literature suggests is a potential confounder.[34] The number of e-cigarette users in the sample was relatively small (125 of 4580), but this prevalence aligns with recent research and the sample can be presumed to be representative.[2] Only those who attend the Mobile Examination Clinic are administered the Depression Screener, so only those with the motivation and ability to make it to the MEC are in the analysis.[38]

Strengths of the study include generalizability and the use of high-quality measurement tools for study covariates. The NHANES is a reliable and valid source for nationally representative data.[38] The PHQ-9 tool is a well-known and valid clinical diagnostic tool used to measure depression in the general population.[33]

Next steps to follow this study would include further research to establish a directional relationship between depression and e-cigarette use. A prospective cohort study would be useful for this purpose. It would be especially interesting to assess the relationship between depression and e-cigarette use among youth, with nationally representative current smoking data and current mental health data. Additionally, further research is required to determine if other mood disorders, such as anxiety, that are often comorbid with depression, are also associated with e-cigarette use. Finally, further research on the acute and long-term health effects of e-cigarette use is required to ensure policymakers are well informed to make decisions regarding the regulation of these devices.

Public Health Implications

The findings of this study are important because e-cigarette use is becoming more popular,[2] cigarette use is becoming less popular,[39] and rates of depression have increased dramatically over the course of the pandemic.[5] Though there are known short-term harms associated with e-cigarette use, the long-term health effects of chronic use are not yet clear. Based on decades of research on combustible cigarettes, we know that nicotine is addictive and a substance detrimental to the human body. To better understand the populations that are at risk for high consumption of e-cigarettes, we must determine the risk factors that are associated with the use of these devices. Depression is endemic in the United States. We know that those with depression are more likely to be nicotine-dependent. This research indicates that those with depression are at a significantly higher than average risk for e-cigarette use. By establishing the relationship between depression and e-cigarette use, we can increase the body of knowledge surrounding e-cigarette use necessary to impose laws and regulations on the production and sale of these devices.

Tables and Figures

Figure 1. Sample Selection Flowchart

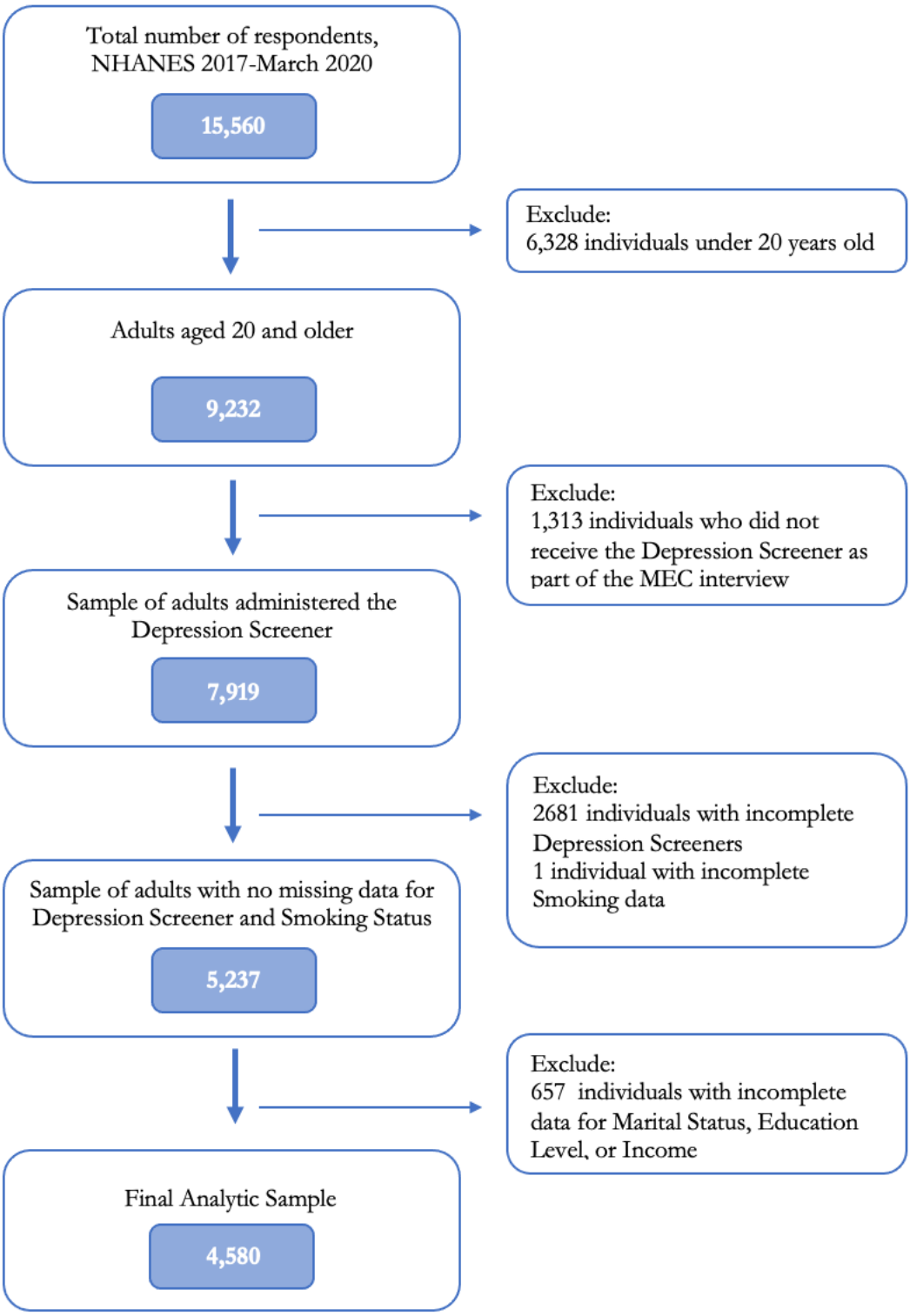

Table 1. Characteristics of the Study Population, NHANES 2017-March 2020 Pre-Pandemic

	n	Prevalence or Mean (95%CI)
Total sample	**4580**	**100**
Sex, %		
Male	2029	43.3 (41.0-45.6)
Female	2551	56.7 (54.4-59.0)
Age, mean	4850	47.6 (46.2-49.0)
Race, %		
Mexican American	496	7.7 (5.3-10.1)
Other Hispanic	450	6.9 (5.3-8.5)
Non-Hispanic White	1800	66.2 (61.3-71.1)
Non-Hispanic Black	1154	10.4 (7.8-13.0)
Non-Hispanic Asian	417	4.2 (2.9-5.5)
Other Race, incl Multi-Racial	263	4.6 (3.5-5.7)
Marital Status, %		
Married/Living with Partner	2508	59.6 (56.5-62.7)
Widowed/Divorced/Separated	1130	20.1 (18.3-21.8)
Never Married	942	20.3 (18.1-22.6)
Ratio of Family Income to Poverty, mean	4850	3.0 (2.9-3.1)
Education level, %		
Less than 9th grade	259	2.8 (2.2-3.4)
9-11th grade (Includes 12th w/ no diploma)	498	6.9 (6.1-7.6)
High school graduate/GED or equivalent	1120	27.0 (24.0-30.1)
Some college or AA degree	1635	32.6 (30.1-35.1)
College graduate or above	1068	30.7 (26.1-35.3)
E-Cigarette Use, %		
E-Cigarette User	125	3.5 (2.5-4.4)
E-Cigarette Non-User	4455	96.5 (95.6-97.5)
Combustible Cigarette Use, %		
Combustible Cigarette User	937	18.8 (16.7-20.9)
Combustible Cigarette Non-User	3643	81.2 (79.1-83.3)
Depression Status, %		
Depression Indicated	620	12.6 (11.1-14.1)
Depression Not Indicated	3960	87.4 (85.9-88.9)

Notes: Unweighted sample sizes are shown next to weighted prevalence and mean estimates that account for survey weight, cluster, and stratum

Figure 2. Prevalence of Depression by E-Cigarette Use and Combustible Cigarette Use

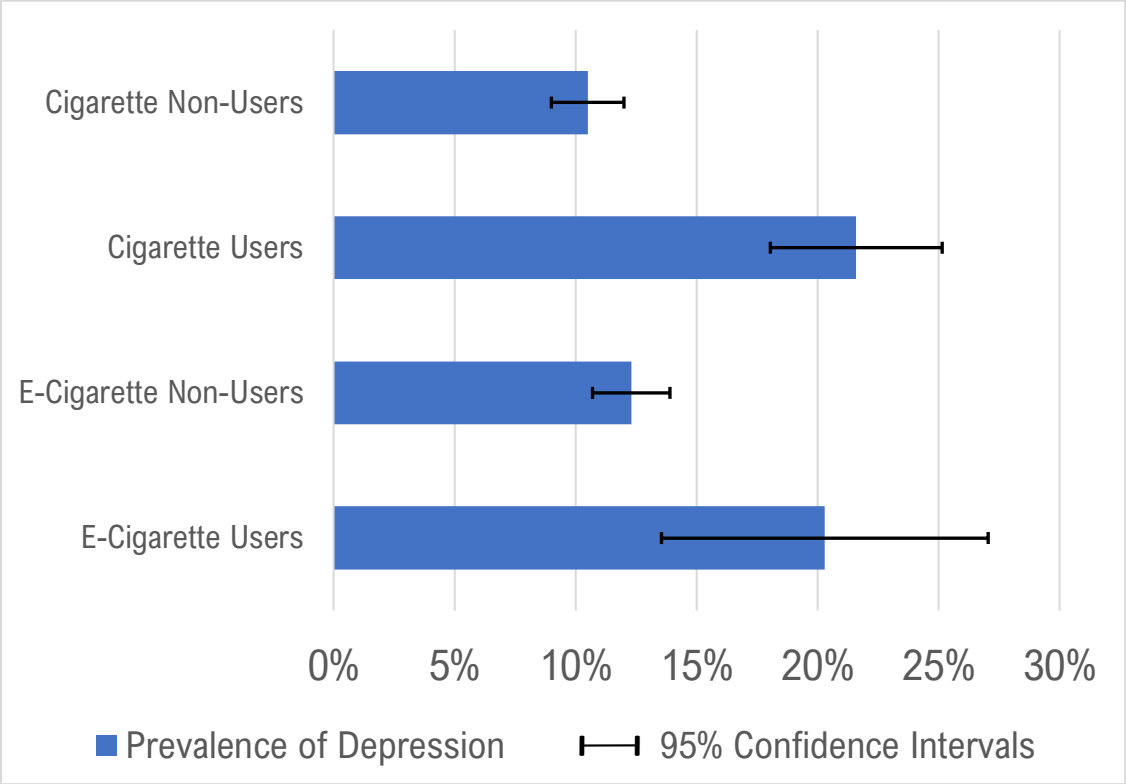

Table 2. Association Between Depression and E-Cigarette Use Stratified by Combustible Cigarette Use				
	All Adults		Stratified by Combustible Cigarette Use	
	Unadjusted Model OR (95%CI)	Adjusted Model* aOR (95%CI)	Cigarette Non-Users* aOR (95%CI)	Cigarette Users* aOR (95%CI)
Depression	1.8 (1.1 – 3.0)	1.3 (0.8-2.2)	3.2 (1.8 - 5.7)	0.6 (0.3 – 1.3)

*Models adjusted for survey weight, cluster, stratum and age, sex, race, cigarette use, education level, marital status, and income

Table 3. Association Between Impact of Depressive Symptoms and E-Cigarette Use Among Cigarette Non-Users		
	Unadjusted Model OR (95%CI)	Adjusted Model* OR (95%CI)
High Impact of Depressive Symptoms	2.8 (1.0 - 8.4)	3.6 (1.0 – 13.4)

Models adjusted for survey weight, cluster, stratum

*Models adjusted for survey weight, cluster, stratum and age, sex, race, education level, marital status, and income

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