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The Impact of E-cigarette Use on Subsequent Cigarette Use in Adolescents: A Systematic
Review

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ABSTRACT

BACKGROUND: The use of e-cigarettes for recreational purposes in adolescents has rapidly escalated, with similar addictive ingredients as cigarettes and a higher risk for addiction due to multiple factors including brain development. Increasing research has examined the impact of e-cigarette use on subsequent cigarette use in adolescents, yet the evidence has not been systematically reviewed.

PURPOSE: To examine if there is a relationship between e-cigarette and cigarette use in adolescents.

METHODS: Ten articles were found through PubMed, PsycINFO, and Google Scholar. Key terms used included (e-cigarettes OR vape OR Juul OR vape pen OR mod) AND (cigarettes) AND (progression OR advancement OR development). Additional filters limited the age range to 12-19 years old, English language, and within a five-year publication date.

RESULTS: Findings show that there is a positive correlation between adolescents using e-cigarettes and subsequent cigarette use. Studies show that adolescents using e-cigarettes are up to eight times more likely to use cigarettes than never users. Factors including age, gender, and sensation seeking increased the likelihood of both initial e-cigarette use and subsequent cigarette use. Poly use and other substance use were also correlated with e-cigarette use.

DISCUSSION: E-cigarettes have the potential to become the next origin of nicotine addiction in younger generations. This review provides evidence showing that adolescent e-cigarette use is associated with a higher likelihood of subsequent use of e-cigarettes and cigarettes. This points out the need for future research to focus on the issues of e-cigarette use in adolescents to prevent and improve health outcomes.

TABLE OF CONTENTS

LIST OF FIGURES	iii
LIST OF TABLES	iv
ACKNOWLEDGEMENTS	v
Chapter 1 Introduction.....	1
Significance to Nursing	2
Purpose Statement	3
Chapter Summary	4
Chapter 2 Background.....	5
E-cigarettes vs Cigarettes	5
Developmental Considerations of Adolescents	8
Nicotine in Adolescents.....	9
Addiction	10
Reasons for Smoking.....	11
Health Risks.....	12
Regulations	14
Chapter Summary	14
Chapter 3 Methods	16
Inclusion and Exclusion Criteria	17
Chapter 4 Results.....	29
Study Design.....	29
Setting and Sample Size	29
Never Use	30
Ever Use.....	31
Past 30-day Use	32
Poly Use.....	33
Frequency of use.....	33
Sensation seeking.....	34
Cigarette to E-cigarette	35
Age and Gender	36
Smoking Intention	37
Other Substances	38
Summary.....	38
Chapter 5	40

Discussion.....	40
Summary of Findings	40
Strengths	42
Limitations	42
Implications for Clinical Practice	43
Future Research	44
Conclusions.....	45
References	46

LIST OF FIGURES

Figure 3.1. Article Selection Tree..... 18

LIST OF TABLES

Table 1.1. Definitions	3
Table 3.1. Summary of Studies Reviewed	19

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Chapter 1

Introduction

In 2021, it was estimated that there were approximately 42.5 million users of tobacco products in the United States (Center for Disease Control and Prevention [CDC], 2022b). Of that 42.5 million, 40 million were adult users of cigarettes and 2.5 million were adolescent users of different tobacco products, most commonly e-cigarettes (CDC, 2022b). While cigarettes have been around since the beginning of the 19th century, e-cigarettes are relatively new in comparison. E-cigarettes differ from cigarettes in many ways, but the presence of nicotine in both products as well as other characteristics of e-cigarettes could potentially create smoking habits in adolescents.

In 2003, the e-cigarette, also referred to as a vape, vape pen, mod, or Juul, was invented by Hon Lik, a Chinese pharmacist (Naskar & Jakati, 2017). He created the e-cigarette with the intentions of having a device that could deliver nicotine in a safer manner than smoking a combustible cigarette to help cigarette users quit or reduce the harmful effects of cigarettes. (Naskar & Jakati, 2017). The e-cigarette device was first introduced into Chinese markets in 2004 and by the mid 2000s was introduced into United States markets and promoted as a smoking cessation tool (Naskar & Jakati, 2017). In recent years, in addition to being utilized by smokers attempting to quit, the use of e-cigarettes for recreational purposes in middle and high-school-aged adolescents has escalated rapidly. According to the American Lung Association (ALA), from 2011 to 2019, there was a 1650% increase of e-cigarette use in middle schoolers and a 1733% increase in high schoolers (ALA, 2020a). From 2018 to 2019 alone, there was a

33% increase in the use of e-cigarettes in adolescents (ALA, 2020a). This is in part due to targeted marketing focused on flavors being added to the liquid and promoting e-cigarettes as less harmful than cigarettes.

Encouragingly, from 2019 to 2020, there was an 8% decrease in the rate of adolescent e-cigarette use; however there was no change in cigarette use (Federal Drug Administration [FDA], 2021). The introduction of the Tobacco 21 law at the end of 2019 raised the age for purchasing tobacco products from 18 to 21 years (ALA, 2020b). In addition, at the beginning of 2020, the FDA placed restrictions on companies adding flavorings other than tobacco or methanol (ALA, 2020b). Taken together, these two government steps may have contributed to this decrease in tobacco use by adolescents.

Underlying reasons for the decrease in adolescent use is important to understand because it has been suggested that the introduction to e-cigarettes at a young age has the potential to lead to subsequent cigarette use in adolescents. In fact, tobacco use is often established in adolescence; 90% of adults who report daily cigarette use indicate that they first tried cigarettes before the age of 18 (CDC, 2022a). While there has been a decrease in the number of adolescents using e-cigarettes, a large portion of those who are using them are using more often, suggesting a strong nicotine dependence (FDA, 2021). This concerning trend provides support for the importance of focusing scholarly attention on the issues of tobacco use in adolescents.

Significance to Nursing

The adverse effects of tobacco products have been well documented throughout the past years. There are currently over 16 million people living with illness resulting from the use of

cigarettes, with smoking accounting for 1 in 5 deaths every year (CDC, 2021a). Tobacco is the leading cause of lung cancer and is connected to other conditions like heart disease and chronic obstructive pulmonary disease (COPD). According to the CDC, more than \$225 billion dollars are spent on medical care for smoking-related diseases in adults in the United States, “as cigarettes are the leading cause of preventable disease, disability, and death” (CDC, 2021a). As addiction occurs more easily in younger ages, preventative measures, such as providing education to adolescents, can help reduce the number of lifelong users, which can lower healthcare costs.

Purpose Statement

The aim of this review was to synthesize the evidence on current use of e-cigarettes in adolescents and subsequent cigarette use. This study attempted to answer the following question:

1. In adolescents, ages 12-19, how does the use of e-cigarettes impact the development of a cigarette smoking habit?

Table 1.1. Definitions

Adolescents	“The phase of life between childhood and adulthood (ages 10-19) in which there is rapid physical, cognitive, and psychosocial growth” (WHO, 2022).
Cigarettes	A thin cylinder of tobacco leaves and chemical additives rolled in paper, lit, and smoked (FDA, 2022)
E-Cigarettes	A device which comprised of a battery, heating element, cartridge, liquid solution (e-liquid), and mouthpiece. It works through the vaporization of liquid (Ruszkiewicz et al., 2020)

Dual-User	“The use of e-cigarettes, smokeless tobacco, or other tobacco products in addition to combustible cigarettes” (NCI, n.d)
Addiction	“Compulsive drug-seeking and use, even in the face of negative health consequences” (NIDA, 2021, para. 1)
Withdrawal	“Occurs as a result of dependence, when they body becomes use to having the drug in the system” (NIDA, 2021, para. 4)
Nicotine	A addictive chemical derived from the tobacco plant that stimulants the central nervous system (NCI, n.d)

Chapter Summary

E-cigarettes, despite being endorsed as a safer alternative to cigarettes, still pose a serious threat to the health of adolescents. As there are a multitude of health risks associated with cigarette use, it is important to evaluate if the use of e-cigarettes in adolescent is associated with subsequent cigarette use. This review will examine the patterns of e-cigarette use within adolescents.

Chapter 2

Background

To understand the potential issues caused by e-cigarettes, it is important to first understand the general function of e-cigarettes as well as their effects in adolescents. This chapter discusses the main components of both e-cigarettes and cigarettes, specifically key chemical components that are found in each, with an emphasis on the addictive chemical nicotine. In addition, it discusses the developmental stage of adolescents, how nicotine uniquely affects this age group, and reasons why adolescents begin using nicotine products. Finally, the chapter concludes with a discussion of the potential health risks that can arise with the use of tobacco products as well as regulation that have already been put in place for e-cigarettes.

E-cigarettes vs Cigarettes

Cigarettes are primarily made up of dried tobacco leaves in combination with over 7,000 chemical additives wrapped in paper and ending in a filter (Food and Drug Administration [FDA], 2022). Some of those chemicals are the same that are found in rat poison, paint thinners, and even nail polish remover. Of the 7,000 chemicals, at least 70 of those chemicals are known carcinogens, or cancer-causing chemicals (American Cancer Society, 2020a). E-cigarettes in comparison are composed of a battery, a cartridge with a liquid solution, a heating element and a mouthpiece and works through the vaporization of liquid (Ruszkiewicz et al., 2020). While it has been determined that in general, the liquid of e-cigarettes is made up primarily of propylene glycol, vegetable glycerin, and nicotine, there are many different types of liquids that can be smoked through e-cigarettes (Dinardo & Rome, 2019) Yet, there are a scare number of reports

on the toxic elements in the liquid of e-cigarettes. Many of the chemicals included in cigarettes are also present in e-cigarettes, including heavy metals, formaldehydes, and nicotine.

Heavy Metals. In both cigarettes and e-cigarettes, heavy metals such as arsenic, cadmium, and lead have been discovered. Heavy metals in cigarettes come from the growth of the tobacco plant itself. Metals like arsenic are often found in cigarettes because of contaminated ground water used to water the plants (WHO, 2018). Other metals are absorbed by the tobacco plant from the soil, much of which is enriched with fertilizers containing these metals (Caruso et al, 2013). The heavy metals in e-cigarettes, on the other hand, come from both the e-liquid and components the device itself such as the metallic coil (Ruszkiewicz et al., 2020).

While these heavy metals will not have toxic effects in smaller amounts, chronic smokers will accumulate high levels throughout the years of use. Lead and cadmium are particularly dangerous because of their long half-life in the body (Caruso et al, 2013). The most common effects of extended arsenic exposure are skin lesions and skin cancer but is also implicated in the development of bladder and lung cancer (WHO, 2018). Arsenic as well as cadmium are also implicated in noncancerous diseases that affect the cardiovascular and renal systems (Caruso et al, 2013). Cadmium primarily affects the kidneys, which contributes to renal tubular dysfunction and kidney stones. High levels of cadmium are associated with respiratory disorders including chronic obstructive pulmonary disease (COPD) and lung cancer (WHO, 2010a). While there is not enough evidence to classify lead as a carcinogen, it is still poisonous to the body in high levels and can lead to anemia, ataxia, and paralysis (WHO, 2010b).

Formaldehyde. Formaldehyde has also been found to be produced by both tobacco products. It is a colorless gas that is found in many household products but also naturally found in the body. In cigarettes, it is formed as other chemical additives, like sugars and gum, in the tobacco are burnt (National Institute for Public Health and the Environment, 2018). This differs from e-cigarettes, which produce formaldehyde as a byproduct of propylene glycol and glycerol vapor degradation. It is irritating to the skin and eyes but also associated with the development of leukemia and cancer of the nose and trachea (National Institute for Public Health and the Environment, 2018).

Nicotine. Nicotine is the primary addictive ingredient in any tobacco product, including cigarettes and many e-cigarette products. When the user inhales the smoke or vapor, the nicotine is breathed into the lungs and in less than 10 seconds pumped from the heart into the bloodstream to the brain (CDC, 2021b). When that bloodstream arrives to the brain, the nicotine binds with and activates nicotine acetylcholine receptors (nAChRs) in both the peripheral and central nervous system (CDC, 2021b). The complete function of nicotine is unknown; however, nicotine causes a release of neurotransmitters such as glutamate, norepinephrine, and dopamine (Zarrindast & Khakpai, 2019). Dopamine is integral in feelings of pleasure and heavily implicated in the reward center of the brain and addiction (Zarrindast & Khakpai, 2019). Glutamate is important in synaptic plasticity, which is significant in learning and memory (Zarrindast & Khakpai, 2019). Finally, norepinephrine is part of the body's fight or flight response and helps to rev the body up by increasing the heart rate, blood pressure, and cardiac output (Zarrindast & Khakpai, 2019).

To understand the significance of the chemical components of e-cigarettes and cigarettes, especially nicotine, it is important to view them in context of the developmental considerations of adolescents as this is a unique time of physical and cognitive growth.

Developmental Considerations of Adolescents

Adolescence refers to the transitional period between childhood and adulthood, marked by physical, behavioral, and cognitive changes (Jaworska & MacQueen, 2015). Adolescence, while not defined by puberty, often coincides with it. Puberty is a period of growth and development of primary and secondary sex characteristics. Both genders will see a rapid increase in height and weight and in addition, boys will see the testes enlargement and voice deepening while girls will begin developing breasts and have the onset of menarche (Jaworska & MacQueen, 2015).

Some of the biggest changes that occur during adolescence happens in the brain. The adolescent brain matures from the oldest regions to the newer more complex regions (Yuan et al, 2015). The limbic system, which helps process behavioral and emotional responses, matures faster, while areas like the prefrontal cortex is one of the last to be fully formed. The prefrontal cortex is responsible for controlling impulses, forming judgements, and making decisions and isn't fully formed until the 20s. This leaves an imbalance in the "maturation of subcortical emotional and reward focused systems as well as cortical executive and impulse control systems" (Yuan et al., 2015, p.3399). This is thought to be a cause of increased risk-taking behaviors in adolescents as they have not yet developed the cognitive control to resist impulses. As adolescents mature and their prefrontal cortex develops, they begin to develop "the ability to

control impulses and delay gratification in favour of goal-directed and more optimized outcomes and behaviours” (Jaworska & MacQueen, 2015, p. 292).

Adolescence is also a time of major neuronal changes in the brain. In childhood, there is an excess of neurons and synaptic connections than are needed (Spear, 2013). During adolescence, the brain goes through synaptic pruning in which the brain breaks down connections that aren't used and reinforces those that are to make processing more efficient (Spear, 2013). This is often referred to as the “use it or lose it” phase of brain development and why it is easier to learn new things like foreign languages or athletics at younger ages. Simultaneously, the axons of neurons become myelinated, which increases the speed at which neurons can communicate across distant parts of the brain reduce the amount of energy need to do so (Spear, 2013). This further reinforces the synaptic pathways that remain following pruning.

Nicotine in Adolescents

Nicotine will affect the brain no matter what age the user is, however, nicotine has unique effects on adolescent brains and can impact development. Compared to an adult, the adolescent brain is more sensitive to the addictive effects of nicotine because of the continuing development of the brain. As discussed previously, adolescence is a time of synaptic pruning where synapses that are frequently used are strengthened. If adolescents begin using nicotine products, the brain will strengthen connections between the intake of nicotine and feelings of pleasure, forging a path to addiction. This occurs more easily in adolescents than it does in adults, because adult brains have, for the most part, already fully developed. In addition, chronic nicotine use in adolescents has been associated with “diminished cognitive function, which could lead to

reduced attention span and enhanced impulsivity” (Ruszkiewicz et al., 2020). Nicotine in adolescents has also been connected to an increased susceptibility to other drugs of abuse (Yuan et al, 2015).

Addiction

The reward center of the brain is heavily involved in developing an addiction. Addiction occurs when there is a need for a substance regardless of the negative consequences of using that substance (National Institute on Drug Abuse [NIDA], 2021). Nicotine is a highly addictive substance because of its ability to affect the mesolimbic pathway, which is the reward center of the brain (NIDA, 2021). When nicotine reaches the brain, it causes a release of dopamine, which gives a reinforcing euphoric feeling. Nicotine will take over the reward pathway, attaching to nicotine receptors and releasing dopamine which will cause a craving for more nicotine (CDC, 2021b). Overtime, the nicotine will cause changes in the brain as the presence of nicotine will create more nicotine receptors, each that send signals for more nicotine (CDC, 2021b). Addiction is a learned behavior, and through repeated stimulation, the body learns that it needs nicotine for that dopamine release and the reward system loses its ability to be stimulated without nicotine. The sensitivity to nicotine is decreased with addiction, so higher dosages of the drug are required to illicit the same response. The positive side of this is that once smoking is stopped, the brain immediately begins to gradually return to normal (CDC, 2021b)

However, in the beginning of quitting nicotine, the lack of dopamine being produced can illicit withdrawal symptoms. Nicotine is quickly delivered to the brain, but the effects dissipate just as quickly, leaving users in a vicious cycle to of attempting to sustain the pleasurable effects

and avoid withdrawal. Some of these symptoms include “irritability, craving, depression, anxiety, cognitive and attention deficits, sleep disturbances, and increased appetite” (NIDA, 2021). Avoidance of these withdrawal symptoms is an important component of continued tobacco use and credited for many people’s failure to quit smoking.

Reasons for Smoking

An important aspect to examine when looking at adolescent tobacco use patterns is the reasons why adolescents begin using tobacco products in the first place. Determining the root cause of tobacco use can be helpful to learn how to prevent use or where interventions can occur to try and prevent adolescents from trying any products or switching to other products. Some of the key reasons for adolescents to begin smoking include peer pressure, the reward system of the brain, and flavorings that are present in e-cigarettes.

Peer Pressure. A significant shift during adolescence is the movement away from family influence. Adolescence, “is a time of social reorientation, during which adolescents spend more time with peers and peers increasingly affect adolescents’ self-concept, wellbeing and behavior” (Foulkes & Blakemore, 2018, p. 315). The desire to fit in creates an environment where peer’s opinions become of the utmost importance, so adolescents are more likely to engage in behaviors that their peers do. If an adolescent is surrounded by peers who use e-cigarettes or cigarettes, they may feel pressure to do the same as to not stand out.

The Reward System. Another major reason for adolescent tobacco use is that adolescents are more motivated by reward and more likely to take risks due to the immaturity of their prefrontal cortex (Yuan et al., 2015). This makes the rewarding properties of nicotine are more potent. Not only are adolescent more prone to risk-taking, but they also tend to be more optimistic about their ability to quit whenever they want (CDC, 2022a).

Flavorings. One of the primary reasons adolescents begin using e-cigarettes in favor of cigarettes is because of the multitude of flavorings offered. Cigarettes are known to have an unpleasant taste and smell, while e-cigarette liquids can come in flavorings ranging from candy to coffee, making the experience more pleasant. These flavorings help decrease the perception of risk as youth report believing fruit and candy flavors were less harmful than tobacco flavored, despite no evidence to support this notion (Meernik et al, 2019).

Health Risks

One major concern for adolescents using e-cigarettes and transitioning to cigarettes is the multitude of health risks associated with cigarettes, including lung cancer, strokes, heart disease, and chronic obstructive pulmonary disease (COPD). Perhaps more concerning is the lack of knowledge around the long-term effects of e-cigarettes because of their novelty (American Cancer Society, 2020b). However, there have been indications of serious lung disease associated with e-cigarette use including trouble breathing, fatigue, and weight loss (American Cancer Society, 2020b).

Lung Cancer. Cigarette smoking is the leading cause of lung cancer in the United States, with an increasing risk the longer and more often cigarettes are used (Mayo Clinic, n.d.). It is believed that cigarettes cause lung cancer because the carcinogens within the smoke damages the cells lining the lungs (Mayo Clinic, n.d.). Over time, the body can no longer repair the damage and the cells mutate into cancerous cells. Lung cancer can cause shortness of breath, fluid in the chest, and metastasis, which is often fatal (Mayo Clinic, n.d.).

Chronic Obstructive Pulmonary Disease (COPD). Chronic obstructive pulmonary disease is caused by long term exposure to irritants such as cigarette smoke (Mayo Clinic, 2020). Cigarette smoking is the leading cause of COPD in developed countries and there is evidence suggest e-cigarette can worsen it (Mayo Clinic, 2020). Cigarette smoke can cause two contributing diseases to COPD, emphysema and chronic bronchitis, which cause airflow blockage. Emphysema damages the alveoli, or air sacs, in the lungs causing airways to rupture and the lungs to overfill (Mayo Clinic, 2020). In chronic bronchitis, there is narrowing of the airways caused by inflammation of the bronchial tubes that can also have an increased mucus production (Mayo Clinic, 2020). In chronic cigarette smokers, the COPD can cause them shortness of breath, wheezing, and a chronic productive cough (Mayo Clinic, 2020). COPD can further result in respiratory infections, heart problems, and lung cancer (Mayo Clinic, 2020).

Stroke and Heart Disease. Smoking can lead to a stroke and heart disease because it damages the lining of the arteries, which leads the buildup of plaque in the blood vessels, ultimately hardening the vessel in a process known as atherosclerosis (American Stroke Association [ASA], 2021). If the plaque ruptures, it can cause the formation of blood clots, which block the flow of

blood or break off and travel throughout the body (ASA, 2021). Depending on whether the clot blocks a vessel leading to the brain or the heart, the clot can result in a stroke or heart attack.

Both heart attacks and strokes can be severely debilitating, if not fatal.

Regulations

In 2009, the Family Smoking Prevention and Tobacco Control Act was enacted, which allowed the “FDA authority to regulate the manufacture, distribution, and marketing of tobacco products” (FDA, 2020, para. 1). This law restricts the marketing of cigarette products, including sales to minors and tobacco brand sponsorships. It also required companies disclose the ingredients in their tobacco products and have scientific evidence their requires that their “modified risk” claims for harm are true (FDA, 2020).

The most recent regulations to be placed on tobacco products came in 2019 when Tobacco 21 was signed into law, raising the legal purchasing age from 18 to 21. This followed the American Lung Association advocating for an increase in purchasing age after “the National Academy of Medicine revealed that “Tobacco 21” could prevent 223,000 deaths among people born between 2000 and 2019” (ALA, 2020b, para. 2).

Chapter Summary

Adolescents is a period of rapid growth where youth are more susceptible to the effects of both e-cigarettes and cigarettes. The development of a tobacco product habit is riskier in this age group due to the development of brain systems, the strong influence of peers, and increased risk tasking behavior. The ease of addiction in adolescents, in combination with innumerable harmful

substances present in tobacco products and the known health risks associated with cigarettes, it is imperative to explore the relationship between e-cigarettes and subsequent cigarette smoking.

Chapter 3

Methods

This section discusses the process of searching literature for a systematic review of behavioral effects of vaping in adolescents related to nicotine. Literature was found through PubMed, PsycINFO, and Google Scholar. PubMed and PsycINFO were used because of their abundance of health-related articles.

In the three databases, the terms (e-cigarettes OR vape OR Juul OR vape pen OR mod) AND (cigarettes) AND (progression OR advancement OR development) were used. The additional filters of adolescent age range from 13-18 years old, English language, and within a five-year publication date were then applied. The original search terms yielded 359 results in PubMed and 140 results in PsycINFO.

After scanning titles and abstracts, a large portion of the articles from both databases were excluded because they were (a) not related to the progression of e-cigarettes to cigarettes, (b) took place outside of the United States, (c) or were outside of appropriate the age range. The initial evaluation of the titles and abstracts of the articles resulted in 40 articles from PubMed and 22 articles from PsycINFO that were possibly relevant for the review. Five of the articles from PsycINFO were also excluded because they were duplicates from PubMed, leaving a total of 17 articles from PsycINFO. After careful full-text analysis of the remaining 57 articles, 6 articles from PubMed and 3 articles from PsycINFO were identified for adhering to the inclusion criteria and included in the systematic review. In addition, 1 article was found by searching the names of the studies that had already been included in the systematic review into Google Scholar and scanning articles that study had been included in. In total 10 articles were selected to be included in this systematic review.

Inclusion and Exclusion Criteria

Articles were included in this systematic review if they met the inclusion criteria of (a) data was collected from participants who were 12-19 years old, (b) written in the English language, (c) completed in the United States (US), and (d) examined the relationship between the use of e-cigarettes and the subsequent use of cigarettes. It was important to only include research that occurred in the United States because other countries have different regulations and laws on tobacco and e-cigarettes (Kennedy, et al., 2016). Articles were only included if they were published within the last five years (2017-2022). E-cigarettes have rapidly evolved and grown in popularity since their introduction into US markets, so it was imperative to have the most up-to-date data and studies available for review. Articles were excluded if they focused on adult populations because nicotine has unique effects on developing adolescent brains compared to adult brains. After reviewing many articles, an additional exclusion criterion was added after a pattern of concurrent alcohol or cannabis use with e-cigarettes was present. While research of e-cigarette use leading to other substance abuse was relevant, it was important to isolate e-cigarette use as an independent cause of cigarette usage.

Figure 3.1. Article Selection Tree

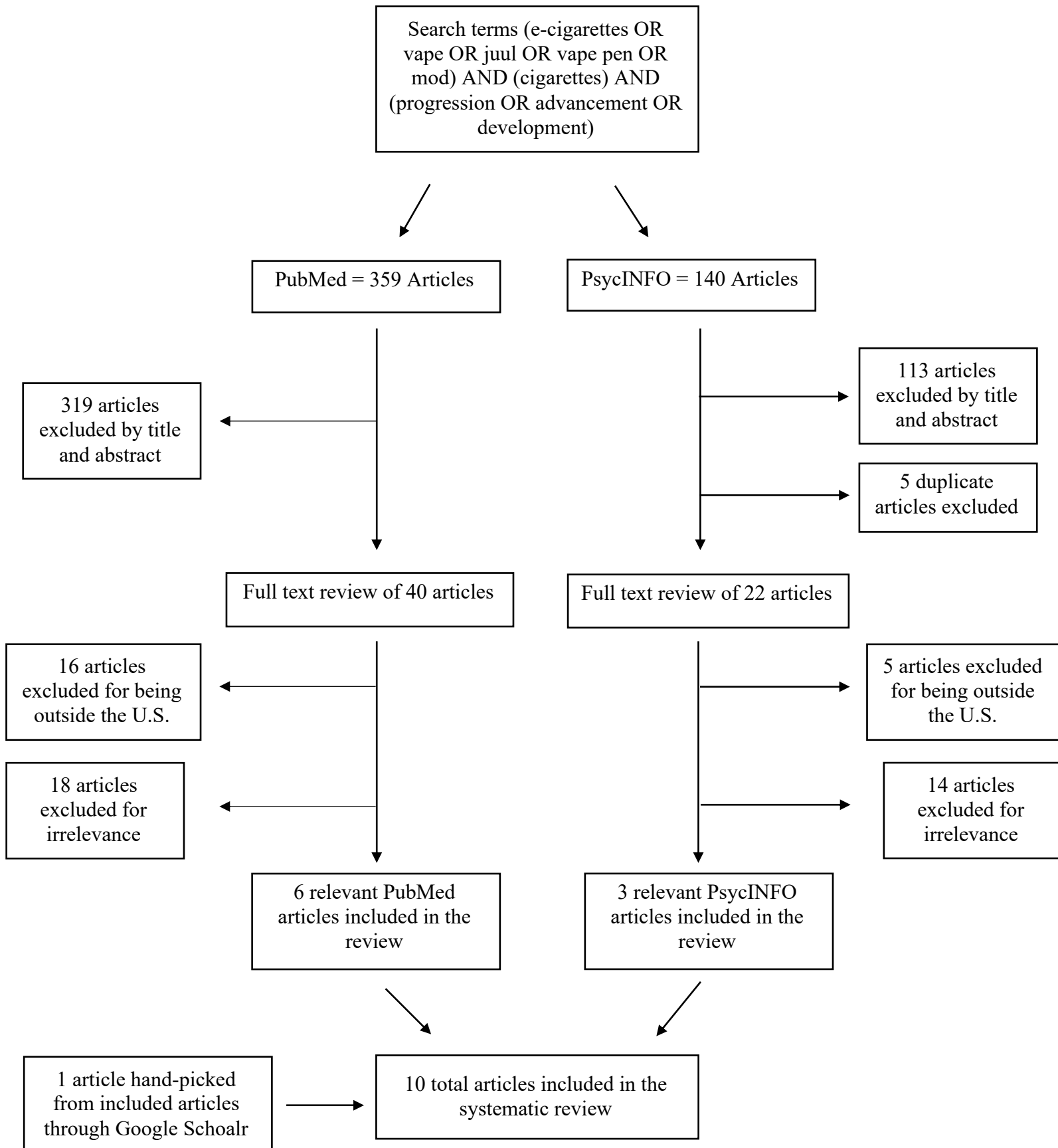


Table 3.2. Summary of Studies Reviewed

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
<p>Miech, R., Patrick, M.E., O'Malley, P.M., & Johnston, L.D. (2017). E-cigarette use as a predictor of cigarette smoking: Results from a 1-year follow-up of a national sample of 12th grade students. <i>British Medical Journal</i>.</p>	<p>The objective of this study was to determine if vaping is a predictor for cigarette use in youth without previous smoking experience. As a secondary objective, the study also examined if vaping desensitizes youth to the dangers of smoking.</p>	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: Questionnaires</p> <p>Setting: High schools in the 48 contiguous states</p> <p>Sample: 347 12th grade students</p>	<ul style="list-style-type: none"> • Questionnaires from the Monitoring the Future (MTF) study were distributed <ul style="list-style-type: none"> ○ 4 out of 6 forms included questions on vaping • Questionnaires readministered at an average follow-up period of 13.4 months • Attrition weight used to control the potential influence of panel attrition • Imputed data used to control for missing items in the data 	<ul style="list-style-type: none"> • Incidence of cigarette smoking among never users of cigarettes was 4x greater for those who vaped at baseline at 1 year follow up • Incidence of cigarette smoking among those who had ever used a cigarette before the survey was 2x greater for those who used vaped at baseline • Recent vapers compared to never users were 4x more likely to believe cigarette smoking does not pose a great risk 	<p>Strengths:</p> <ul style="list-style-type: none"> • Nationally representative sample <p>Limitations:</p> <ul style="list-style-type: none"> • Did not look at substance being vaped • Small sample size • Did not include questions about smoking susceptibility, smoking expectations, affiliation with smokers, perception of friends' attitudes towards smoking <p>Level & Grade: IIIB</p>

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
Barrington-Trimis, J. L., Kong, G. Leventhal, A. M., Liu, F., Mayer, M. Cruz, T. B., Krishnan-Sarin, S. & McConnell, R. (2018). E-cigarette use and subsequent smoking frequency among adolescents. <i>Pediatrics</i> .	The purpose of this study is to determine if there is an association between e-cigarettes and frequency of cigarette use	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: Paper-and-pencil questionnaires</p> <p>Setting: High schools based in Southern California and Connecticut</p> <p>Sample: 6,258 high schoolers from 9th -12th grade</p>	<ul style="list-style-type: none"> • Questionnaires inquiring about age of first use of products and the number of days the product was used in the past 30 days • Questionnaires readministered 6-16 months later to assess use of cigarettes and e-cigarettes • Categorized into never users and ever users • Ever users were further categorized as experimenters, infrequent users, or frequent users as well as exclusive e-cigarette users, exclusive cigarette users, and dual product users 	<ul style="list-style-type: none"> • 7% of never users and 21% of e-cigarette users began using cigarettes at follow up <ul style="list-style-type: none"> ○ After smoking was initiated the amount smoked was similar in those who were never-users and e-cigarette users at baseline • At follow up exclusive e-cigarette users at baseline reported <ul style="list-style-type: none"> ○ continued exclusive use of e-cigarettes (28.5%) ○ exclusive use of cigarettes (5.5%) ○ dual product use (12.7%) 	<p>Strengths:</p> <ul style="list-style-type: none"> • Large population with diverse participants • Compared data from three different studies <p>Limitations:</p> <ul style="list-style-type: none"> • Each study collected data for different confounding variables, so some of the data was not directly comparable • Self-reported data <p>Level & Grade: IIIB</p>

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
<p>Bold, K. W., Kong, G., Camenga, D. R., Simon, P., Cavallo, D. A., Morean, M. E., & Krishnan-Sarin, S. (2018). Trajectories of e-cigarette and conventional cigarette use among youth. <i>Pediatrics</i></p>	<p>To examine the association and directionality of the use of different tobacco products over time</p>	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: Paper-and-pencil anonymous surveys</p> <p>Setting: High schools across the state of Connecticut</p> <p>Sample: 808 high schoolers</p>	<ul style="list-style-type: none"> • Have you ever tried an e-cigarette or cigarette? (yes/no) • Opened ended self-report of past-month use of e-cigarettes and categorical self-report of cigarettes use in the past month • Analysis run using Mplus software 	<ul style="list-style-type: none"> • Past 30-day use of e-cigarettes or cigarettes predicted a higher likelihood of use of the same product at subsequent waves • Compared to never users, individuals using e-cigarettes were <ul style="list-style-type: none"> ○ > 7 times more likely to report cigarette use at Wave 2 ○ 4 times more likely at Wave 3 • Past-month cigarette use did not predict future e-cigarette use 	<p>Strengths:</p> <ul style="list-style-type: none"> • Match longitudinal data for the same high school across three different time points • Anonymous surveys <p>Limitations:</p> <ul style="list-style-type: none"> • The sample population was not diverse racially or socioeconomically <p>Level & Grade: IIIA</p>

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
<p>Chaffee, B. W., Watkin, S. L., & Glantz, S. A. (2018). Electronic cigarette use and the progression from experimentation to established smoking. <i>Pediatrics</i></p>	<p>The purpose of this study is to establish if an association between e-cigarette smoking exists and if an established smoking habit develops in those who had tried cigarettes.</p> <p>Hypothesis: In participants who tried cigarette smoking (<100 cigarettes), use of e-cigarettes would be positively associated with an established cigarette smoker within 1 year</p>	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: In-home, in-person, computer-assisted interviews</p> <p>Setting: In-home across the United States</p> <p>Sample: 1,295 adolescents from the Population Assessment of Tobacco and Health (PATH) Study who had tried cigarettes (<100)</p>	<ul style="list-style-type: none"> • Interviewees were asked ever use, lifetime uses, and days in the past 30 days of tobacco use in Wave 1 <ul style="list-style-type: none"> ○ Repeated at Wave 2 and evaluated for smoking habits. • Likert-type scales to adjust for confounding variable including cigarette warning label exposure and sensation seeking (liking frightening things, willingness to break rules, preference for unpredictable friends) 	<ul style="list-style-type: none"> • Baseline e-cigarettes users was a positive and significant predictor of progression to current established smoking (≥ 100 cigarettes and past-30 days smoking) than never users • There is a stepwise increase in the probability of past 30 day cigarette smoking <ul style="list-style-type: none"> ○ E-cigarette never use: 26.6% ○ E-cigarette former use: 36.1% ○ E-cigarette past 30-day use: 45.3% 	<p>Strengths:</p> <ul style="list-style-type: none"> • Participants were drawn from the PATH study, which is a large, nationally representative sample <p>Limitations:</p> <ul style="list-style-type: none"> • A multitude of confounding variables that cannot be ruled out that are also predictive of youth cigarette smoking • Response bias from self-reported data <p>Level & Grade: III A</p>

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
<p>McCabe, S.E., West, B. T., & McCabe, V. V. (2018). Associations between early onset of e-cigarette use and cigarette smoking and other substance use among US adolescents: A national study. <i>Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco.</i></p>	<p>To study the relationship between adolescent use of e-cigarettes and subsequent substance use.</p>	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: Paper-and-pencil questionnaires</p> <p>Setting: High school classrooms</p> <p>Sample: 2,299 high school seniors in public and private schools across the United States</p>	<ul style="list-style-type: none"> • Categorized e-cigarette, cigarette, and other drug use by asking participants how often they used the products in their lifetime and in the past 30 days, divided into any use or no use groups • Age of onset for each substance 	<ul style="list-style-type: none"> • E-cigarette use created a significant increase in the likelihood of lifetime cigarette smoking as well as the use of other substances • There is a significant association between e-cigarette smoking and future cigarette smoking, whether it is the experimental use of e-cigarettes or regular use. Regular users have a stronger association, but it is still significant for experimental users. • The odds of cigarette smoking were greater for early-onset e-cigarette users compared to later onset. 	<p>Strengths:</p> <ul style="list-style-type: none"> • Usage was evaluated for each age group individually <p>Limitations</p> <ul style="list-style-type: none"> • No adjustments for missing data so the results are likely conservative and underestimate substance use behaviors • Not including data on dropouts who are more likely to engage in substance use <p>Level & Grade: IIIB</p>

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
<p>Watkins, S. L., Glantz, S. A., & Chaffee, B. W. (2018). Association of noncigarette tobacco product use with future cigarette smoking among youth in the Population Assessment of Tobacco and Health (PATH) Study, 2013-2015. <i>JAMA Pediatrics</i>.</p>	<p>To examine if there is a relationship between noncigarette tobacco use and subsequent cigarette use in adolescents who has previously never smoked a cigarette</p> <p>Hypothesis: Youth who had never tried a cigarette at baseline, the use of e-cigarettes is associated with the initiation of cigarette smoking within 1 year.</p>	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: In-person, computer-assisted interviews</p> <p>Setting: In-home across the United States</p> <p>Sample: 10,384 adolescents between the ages 12-17</p>	<ul style="list-style-type: none"> • Whether a cigarette had ever been smoked (ever use/never use) • Whether a cigarette had been smoked in the last 30 days (former use/30-day use) • Use of one tobacco product or multiple (only use/poly-ever use) • Statistical analysis of causal influences, sensation seeking, and seasonal variation 	<ul style="list-style-type: none"> • The likelihood of cigarette initiation were almost double for those e-cigarette users • Past 30-day use of e-cigarettes was significantly associated with trying cigarettes • Using multiple noncigarette tobacco products increased the risk of using cigarette. 	<p>Strengths:</p> <ul style="list-style-type: none"> • A nationally representative sample from the PATH study <p>Limitations:</p> <ul style="list-style-type: none"> • Residual confounding variables • Response bias from self-administered surveys <p>Level & Grade: IIIB</p>

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
<p>Berry, K. M., Fetterman, J. L., Benjamin, E. J., Bhatnagar, A., Barrington-Trimis, J. L., Leventhal, A. M. & Stokes, A. (2019). Association of electronic cigarette use with subsequent initiation of tobacco cigarettes in US Youths. <i>JAMA Network Open</i></p>	<p>To answer the question, “Is electronic cigarette (e-cigarette) use among tobacco-naïve youth associated with subsequent risk of cigarette initiation?”</p>	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: In-home, in-person, computer-assisted interviews</p> <p>Setting: In-home across the United States</p> <p>Sample: 6,123 adolescents between 12-15 years old</p>	<ul style="list-style-type: none"> • Tobacco naïve at Wave 1, e-cigarette and other noncigarette product use measured at Wave 3 • Risk group measures <ul style="list-style-type: none"> ○ Risky behaviors ○ Sensation seeking ○ Cigarette susceptibility • Age, sex, race, ethnicity, parental education, residence, living with a tobacco user, warning on cigarette packages, recalling favorite tobacco advertisements 	<ul style="list-style-type: none"> • Prior e-cigarette users were 4.09 times as likely to ever use cigarettes • Prior-cigarette users were 2.75 times more likely to still be using cigarettes a follow up • Low-risk youth who used e-cigarettes had a similar probability of cigarette use as high-risk individuals with no prior tobacco use • 21.8% of cigarette use was associated with prior e-cigarette use 	<p>Strengths:</p> <ul style="list-style-type: none"> • A nationally representative sample from the PATH study • Initial cohort was completely tobacco naïve <p>Limitations:</p> <ul style="list-style-type: none"> • Observational data does not allow for the establishment of a causal relationship • Does not examine varying e-cigarette products and characteristics <p>Level & Grade: IIIA</p>

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
<p>Evans-Polce, R. J., Patrick, M. E., McCabe, S. E., & Miech, R. A. (2020). Prospective associations of e-cigarette use with cigarette, alcohol, marijuana, and nonmedical prescription drug use among US adolescents. <i>Drug and Alcohol Dependence</i>.</p>	<p>To understand if e-cigarettes put adolescents at risk for developing cigarette and other substance use habits</p>	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: Paper- and-pencil questionnaires</p> <p>Setting: Randomly selected high schools across the United States</p> <p>Samples 717 12th graders</p>	<ul style="list-style-type: none"> • Self-reported habits in the past 30 days and 12 months including e-cigarettes, cigarettes, alcohol, and nonmedical prescription drugs (NMPD) • Six different forms were randomly administered. A year later, a follow-up survey was completed by a randomly selected half of the participants and two years later for the other half 	<ul style="list-style-type: none"> • Cross-sectionally, e-cigarettes were associated with greater odds of cigarette, alcohol, marijuana, and NMPD use • Longitudinally, there was also a positive relationship between e-cigarettes and cigarette, alcohol, marijuana, and NMPD use a year later 	<p>Strengths:</p> <ul style="list-style-type: none"> • The Monitoring the Future study is nationally representative and provides protections to ensure reliable responses • Random selection of high schools <p>Limitations:</p> <ul style="list-style-type: none"> • Smaller sample size • Wide confidence intervals • Self-report bias <p>Level & Grade: IIIA</p>

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
<p>Owotomo, O., Strizel, H., McCabe, S. E., Boyd, C. J., & Maslowsky, J. (2020). Smoking intention and progression from e-cigarette use to cigarette smoking. <i>Pediatrics</i>.</p>	<p>To determine whether there is an association between e-cigarette use and smoking intention and whether that leads to the development of a smoking habit.</p>	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: In-home, in-person, computer-assisted interviews</p> <p>Setting: In-home across the United States</p> <p>Sample: 8,661 adolescents aged 12-17 years</p>	<ul style="list-style-type: none"> • Smoking history was determined through questions regarding ever use of cigarettes and e-cigarettes • Smoking intention was determined by the question <ul style="list-style-type: none"> ○ Do you think you will smoke a cigarette in the next year? • Exposure to advertisements, perception of addictiveness, and parental/guardian disapproval of cigarette smoking, peer smoking perception, and perception of ease of access were also measured 	<ul style="list-style-type: none"> • Those who smoked e-cigarettes at Wave 2 had four times the odds of cigarette smoking at Wave 3 than never users • At Wave 3, 9.71% of adolescents who used e-cigarettes but had no intention of cigarette smoking advanced to conventional cigarette smoking within a year 	<p>Strengths:</p> <ul style="list-style-type: none"> • Participants were selected from the PATH study which draws participants from across the nation to create a diverse sample • Involved participants who had never used an e-cigarette before • Robust sample size <p>Limitations:</p> <ul style="list-style-type: none"> • The length between waves; intention behavior associations are stronger when they are measured closer in time than 1 year. <p>Level & Grade: III A</p>

Author, Year, Title, and Journal	Purpose	Study Design and Participants	Measures	Key Findings	Strengths & Limitations
<p>Hair, E. C., Barton, A. A., Perks, S. N., Kreslake, J., Xiao, H., Pitzer, L., Leventhal, A. M., & Vallone, D. M. (2021). Association between e-cigarette use and future combustible cigarette use: Evidence from a prospective cohort of youth and young adults, 2017-2019. <i>Addictive Behaviors.</i></p>	<p>To examine the relationship between e-cigarette use and smoking initiation as well as continued e-cigarette use</p>	<p>Type of Study: Descriptive Correlational</p> <p>Data Collection: Online questionnaires</p> <p>Setting: In-home across the United States</p> <p>Sample: 3360 adolescents and young adults aged 15-21</p>	<ul style="list-style-type: none"> • E-cigarette and cigarette status inclusive of never users, ever users, and current users • Adjusted for age, race/ethnicity, gender, household tobacco use, financial situation, and sensation seeking • Sensation Seeking Scale <ul style="list-style-type: none"> ○ Liking exploring new places, frightening things, wild parties, new experiences ○ Spontaneity ○ Rule breaking 	<ul style="list-style-type: none"> • 27.5% of youth who started using e-cigarettes had tried a combustible cigarette a year later • 7% of those use ever used cigarettes were current cigarette smokers a year later • Being male, living in a house with other users, and high sensation seeking scores were more likely to initiate cigarette use 	<p>Strengths:</p> <ul style="list-style-type: none"> • Data collection in 2018-2019 allows for a more accurate portrayal of current e-cigarette trends <p>Limitations:</p> <ul style="list-style-type: none"> • The researchers are not aware of the type or brand of e-cigarette products used • Language in the survey may have led to exclusion of people who don't approve of e-cigarettes <p>Level & Grade: IIIB</p>

Chapter 4

Results

The past chapters have reviewed pertinent background information and methods used to find articles included in this review. The purpose of this chapter is to analyze the 10 articles included in the systematic review and present the most current information available on trends related to e-cigarette to subsequent cigarette use in adolescents.

Study Design

This review encompasses a total 10 articles, published between 2017 and 2021 (Barrington-Trimis et al., 2018; Berry et al., 2019; Bold, et al., 2018; Chaffee et al., 2018; Evans-Polce et al., 2020; Hair et al., 2021; McCabe et al., 2018; Miech et al., 2017; Owotomo et al., 2020; Watkins et al., 2018). All articles included have a descriptive correlational design utilizing surveys. One of the included articles also utilized both a cross-sectional and longitudinal design when examining the data (Evans-Polce et al., 2020).

Setting and Sample Size

The studies chosen for this review each conducted surveys as the method for data collection. In five of the articles, the surveys were administered online, in an in-home setting (Berry et al., 2019; Chaffee et al., 2018; Hair et al., 2021; Owotomo et al., 2020; Watkins et al., 2018) while the other five articles were conducted as paper-and-pencil questionnaires in high school classrooms (Barrington-Trimis et al., 2018; Bold, et al., 2018; Evans-Polce et al., 2020;

McCabe et al., 2018; Miech et al., 2017). Eight of the studies utilized a national study bank; either the PATH Study (Berry et al., 2019; Chaffee et al., 2018; Owotomo et al., 2020; Watkins et al., 2018), the Monitoring the Future Study (Evans-Polce et al., 2020, McCabe et al., 2018; Miech et al., 2017), or the Truth Longitudinal Cohort (Hair et al., 2021). The other two articles collected data from high schools located throughout the state of Connecticut (Barrington-Trimis et al., 2018 & Bold, et al., 2018) and Southern California (Barrington-Trimis et al., 2018).

The ten articles had a wide range of sample sizes. Three of the articles had less than 1000 participants (Bold, et al., 2018; Evans-Polce et al., 2020; Miech et al., 2017), three articles had between 1,000-5,000 participants (Chaffee et al., 2018; Hair et al., 2021; McCabe et al., 2018), three articles had between 5,000-10,000 participants (Berry et al., 2019; Barrington-Trimis et al., 2018; Owotomo et al., 2020), and one had >10,000 participants (Watkins et al., 2018).

Never Use of Tobacco Products

As a baseline for e-cigarette and cigarette use, four of the articles studied “never use,” or never having used any products, even one or two puffs (Barrington-Trimis et al., 2018; Chaffee et al., 2018; Hair et al., 2021; Watkins et al., 2018). These studies all reveal a similar result that never users are significantly less likely to ever use cigarettes. Barrington-Trimis et al. (2018) found that 89.2% who reported never use at baseline remained a never user at follow up phases.

Each study did however show that a small percentage of never users did initiate cigarette use at some point during the study, regardless of having never previously tried e-cigarettes or cigarettes. Chaffee et al. (2018) found that never users of e-cigarettes had at 26.6% probability of having used a cigarette in the past 30 days at follow up a year later. Barrington-Trimis, et al. (2018) found that 9.2% of the never smoking youth at baseline had initiated cigarette use. Hair et

al. (2021) found that 2.4% who has never used e-cigarettes had tried cigarettes one year later. Similarly, Watkins et al. (2018) found that of never smoking youth, 4.6% tried a cigarette for the first time between Waves 1 and 2 of their study.

While some of the studies found that never users had tried or experimented with cigarettes, two studies also found that never users progressed to current use, defined as use within the past 30 days. Both Hair et al. (2021) and Watkins et al. (2018) both found that over 2% of never users were current users of cigarettes at follow up.

Ever Use of Tobacco Products

Ever using an e-cigarette, is defined as having used an e-cigarette product, even if it was only 1-2 puffs. It was discovered that having ever used an e-cigarette was associated with a significant increase in the likelihood of using cigarettes at follow up (Barrington-Trimis et al., 2018; Berry et al., 2019; Chaffee et al., 2018; Evans-Polce et al., 2020; Hair et al., 2021; Miech et al., 2017; Watkins et al., 2018). Three of the articles found that baseline ever e-cigarette users had around four times the odds of reporting cigarette use at follow up (Barrington-Trimis et al., 2018; Berry et al., 2019; Miech et al., 2017). In comparison, Watkins et al. (2018) found that there was over double the likelihood of any cigarette use for ever users of e-cigarettes. Evans-Polce et al. (2020) found that when compared to never users, e-cigarette users had almost eight times the odds of cigarette use. Barrington-Trimis et al. (2018) also found that ever e-cigarette users had over seven times the odds of reporting exclusive e-cigarette use and almost nine times the odds of reporting dual product use when compared to baseline never users.

While those studies examined experimenting or frequent use together in one category, Chaffee et al. (2018) specifically looked at the trends between ever e-cigarette use to current

cigarette smoking (>100 cigarettes and use in the past 30 days). They found that e-cigarette use in Wave 1 had double the odds of established cigarette smoking a year later in Wave 2 (Chaffee et al., 2018). Similarly, Hair et al. (2021) found that over one-third of their participants who had started e-cigarette use in 2018 were current users (past-30 day use) of cigarettes in 2019. In addition, Miech et al. (2017) found that for adolescents who had a history of smoking cigarettes but not recently, vaping was correlated with more than double the likelihood of a reuptake of cigarettes in the year between baseline and follow up.

Past 30-day Use of Tobacco Products

Investigating further into ever use, five of the articles further categorized their ever users into past-30 days users (Barrington-Trimis et al., 2018; Bold et al., 2018; Chaffee et al., 2018; Evans-Polce et al., 2020; Watkins et al., 2018). Barrington-Trimis et al. (2018) found that people who have not used either product, whether it be cigarettes or e-cigarettes in the past 30 days were had a higher likelihood of remaining nonusers. In the longitudinal portion of their study, where initial data was collected at age 18 and again a year later at age 19, Evans-Polce et al. (2020) found that over a third of the participants who were e-cigarette users reported past-30 day use of cigarettes compared to 6% of non-users.

Results from Chaffee et al. (2018) revealed that there the probability of past 30-day cigarette smoking had increasing stepwise progression. Those who were never users of e-cigarettes at baseline (Wave 1), had a 26.6% probability of past 30-day cigarette smoking a year later at Wave 2. Former use and past 30-day e-cigarette use had a 36.1% and 45.3% probability respectively of past 30-day cigarette use at Wave 2 (Chaffee et al., 2018). Chaffee et al. (2018)

and Watkins et al. (2018) both determined that a significant predictor for trying cigarettes and past 30-day cigarette use was baseline past 30-day e-cigarette.

Bold et al. (2018) found that past month use of any product predicted a higher probability of that same product being used at subsequent waves. Past 30-day users of e-cigarettes at the first wave of their study were also found to be seven times more likely to report subsequent cigarette use at a year later at second wave and four times as likely two years later in the third wave.

Poly Use of E-cigarettes and Cigarettes

One article suggested that users of e-cigarettes do not just transition to exclusive cigarettes and instead become what is known as a poly user, known as using multiple tobacco products (Barrington-Trimis et al., 2018). It was discovered that 12.7 % of baseline past 30-day exclusive e-cigarette users, were dual users of e-cigarettes and cigarettes at follow up (Barrington-Trimis et al., 2018). In comparison to past 30-day never use and exclusive e-cigarette or cigarette use, those who were dual users were significantly less likely to report not using any product at follow up. Instead, the dual users reported the highest likelihood of continued past 30-day dual use at follow up (Barrington-Trimis et al., 2018).

Frequency of E-cigarette and Cigarette Use

Another aspect of cigarette use that two of the articles examined was comparing how often e-cigarettes and cigarettes were used at baseline and at follow ups (Barrington et al, 2018; Bold et al, 2018). Barrington-Trimis et al. (2018) discussed how once cigarette use had been initiated, regardless of whether someone started off as a baseline never user or e-cigarette user,

the frequency that cigarettes were used after initiation was the same for both groups (Barrington-Trimis et al., 2018) For example, only 7% of never users initiated cigarette use compared to 21% of e-cigarette users. However, at follow-up, regardless of being a never user or e-cigarette user, of those who had initiated cigarettes approximately 70% were experimenting with cigarettes, approximately 20% reported infrequent use, and approximately 10% reported frequent use (Barrington-Trimis et al., 2018).

In addition, Bold et al. (2018) reported that there were significantly higher rates of low (1-5 days), moderate (11-20 days), and heavy (21-30 days) e-cigarette use at Wave 3 when compared to the Waves 1 and 2. More specifically, in the two years between Wave 1 to Wave 3, heavy cigarette use increased from 10.3% to 26% and heavy e-cigarette use increased from 15.3% to 20.5% (Bold et al., 2018)

Impact of Sensation Seeking on Tobacco Use

Two of the articles discovered a correlation between sensation seeking, which is the tendency to pursue new experiences and feelings, and tobacco product use (Berry et al. 2019; Hair et al, 2021). In this study, Berry et al. (2019) categorized their subjects into high and low risk groups. These groups were based on the participants reports of ever having used alcohol, marijuana, or prescription drug abuse, three statements on sensation seeking, and three questions on cigarette susceptibility. Those who had used any of those products and agreed with the three statements or showed susceptibility to the questions were categorized as high risk. No use, disagreement with the statements, and no signs of susceptibility were considered low risk. When the data was analyzed, they found that those who had ever used an e-cigarette but were

considered low risk had a similar probability of becoming a cigarette user when compared with high-risk individuals with no prior tobacco use (Berry et al., 2019).

Using a sensation seeking questionnaire where participants were asked eight questions about their tendencies using a five-point Likert scale, Hair et al. (2021) came to a similar conclusion to Berry et al. (2019). Hair et al. (2021) concluded that respondents who scored greater than an average of four points were more likely to be ever cigarette users at follow up portions of the study than respondents scoring less than an average of four points.

Transition from Cigarette to E-cigarette Use

Contrasting the original question being investigated, three of the studies also considered the opposite trend of whether there is a pattern of those who use cigarettes becoming e-cigarette users (Barrington-Trimis et al, 2018; Bold et al, 2018; Hair et al, 2021). Results from Bold et al. (2018) suggested that there is a unidirectional relationship between cigarettes and e-cigarette. They found that past 30 day use of e-cigarettes was correlated with future cigarette use, however, the same did not hold true for those with past month cigarette use and future e-cigarette use. Barrington-Trimis et al. (2018) however did find that of those who were exclusive cigarette users, 9.3% of those users had transitioned to exclusive e-cigarette use a year later. Similarly, Hair et al. (2021) found that any combustible tobacco in 2018 use was associated with current use of e-cigarettes in 2019.

Impact of Age and Gender on Tobacco Product Use

A significant factor in subsequent cigarette use was the age of the first use of e-cigarettes. Two of the studies concluded that the younger an adolescent is at the age of initiation, the more likely they are of continuing to use e-cigarettes and move on to cigarette use (Hair et al, 2021; McCabe et al., 2018). One of the studies found that those aged 15-20 years old at first use had three times the odds of being a current e-cigarette user than those aged 21-27 at first use (Hair et al, 2021).

In the study conducted by McCabe et al. (2018), initiation of e-cigarette use in 11th grade made up the largest portion of the participants, followed by 12th then 10th grade. Despite only accounting for 10% of the participants, those who initiated e-cigarette use in 9th grade had the highest odds of reporting subsequent cigarette use. For those who had initiated e-cigarette use at or before 9th grade, 69.6% of them reported having ever used cigarettes. The study concluded that the odds of ever using cigarettes was 14 times greater for adolescent who had an early onset of e-cigarette user when compared with participants who were never users. Even when compared to later onset e-cigarette users, early onset users still had higher odds of subsequent cigarette and other substance use (McCabe et al., 2018).

Breaking it down further, McCabe et al. (2018) distinguished between experimental e-cigarette users and more regular e-cigarette users as a function of age of onset. They discovered that participants who used e-cigarettes more regularly had significantly increased odds of subsequent cigarette use. When compared to never users, the estimated odds of ever using cigarettes were over 27 times higher for more regular e-cigarette users who had an onset of e-cigarette use in 9th grade or earlier (McCabe et al., 2018) The odds were only eight times as high for experimental users under the same conditions (McCabe et al., 2018). Similar patterns were

present for early onset age and use of other substance like marijuana, alcohol, and nonmedical prescription drug use.

While most studies chose to examine general patterns of use and did not differentiate between genders, one study did examine the connection between gender and cigarette use. The study concluded that males are almost three times as likely to be a current smoker than females a year later at follow up (Hair et al., 2021).

Intentions of Smoking Cigarettes

An important variable to look at is whether adolescents have any intention of using cigarettes in their lifetime. Many adolescents who use e-cigarette have no intentions of ever using cigarettes. However, Owotomo et al. (2020) found that even amid adolescents who had no intentions of smoking at Wave 2, 9.71% of e-cigarette users had progressed to cigarette smoking one year later at Wave 3 in comparison to 1.51% of never users. Among adolescents who at Wave 2 had smoking intentions, 17.36% of e-cigarette users versus 10.04% of never e-cigarette users, had advanced to cigarette smoking by Wave 3 (Owotomo et al., 2020).

Furthermore, Miech et al. (2017) found that never smokers of cigarettes who viewed there being risk in cigarette smoking, but had recently used e-cigarettes, had a significant incidence of cigarette smoking in the following year. Among respondents who were classified as never users of cigarettes in 12th grade, those who had recently vaped had four times the probability of shifting their views away from cigarettes posing a “great risk” compared to never users of e-cigarettes.

Impact of E-cigarettes on Marijuana and Non-Medical Prescription Drug Use

Along with subsequent cigarette use, two studies found that e-cigarette use was also correlated with a higher risk of using other substances including marijuana and non-medical prescription drugs (Evans-Polce, 2020; McCabe et al., 2018). The first study found that over half of the participants who used e-cigarettes at age 18 reported using marijuana at age 19 compared to 16% of non-users (Evans-Polce et al., 2020). In addition, 14% of e-cigarette users at age 18 reported use of non-medical prescription drugs compared to only 1% of non-users (Evans-Polce et al., 2020).

Additionally, in the other study it was found that 85.7% of those whose first use of e-cigarettes was in 9th grade reported later marijuana use, compared to 56.3% of those who started in 12th grade and 26.9% who were never users of e-cigarettes (McCabe et al., 2018). This study however found that e-cigarette users who reported using other substances were more likely to report having initiated use of those substances before or at the same time as e-cigarettes (McCabe et al., 2018).

Summary

By examining different factors surrounding e-cigarette use, this chapter discusses the current literature available on e-cigarette use and subsequent cigarette use. The literature included in this review came to similar conclusions that there is an increase in likelihood of using cigarettes when there is a history of e-cigarette use. Factors like age, sensation seeking, and smoking intentions significantly influence the odds of cigarette use, with articles finding an increase in the likelihood of use. Not only did articles find a correlation between e-cigarettes and

cigarettes, but also a relationship between e-cigarettes and the subsequent use of other substances as well.

Chapter 5

Discussion

The previous chapters of this review have examined the purpose of this review, reviewed background related to the topic, provided the research methods, and discussed results of the literature included in the review. This chapter will discuss a summary of the findings, strengths and limitations of this review, implications for practice, needs for further research, and conclusions. Ultimately, this goal of this chapter is to provide an answer to the research question: In adolescents, ages 12-19, how does the use of e-cigarettes impact the development of a cigarette smoking habit?

Summary of Findings

Overall, when taken together, the articles included in this systematic review suggest that there is a correlation between the use of e-cigarettes and subsequent use of cigarettes. The studies included in this review reached the same conclusion of that the use of e-cigarettes does lead to a higher probability of cigarette use at follow up. However, there were variations in the likelihood of subsequent cigarette use. As expected, people who had never used an e-cigarette were likely to continue to be a never user of both e-cigarettes and cigarettes (Barrington-Trimis et al., 2018; Chaffee et al.; 2018, Hair et al.; 2021, Watkins et al., 2018). With no introduction into the habit, there is little reason to begin using. The more recent the use of e-cigarettes, especially use within the past 30 days, the higher likelihood of continuing with e-cigarettes and using cigarettes later (Barrington-Trimis et al., 2018; Berry et al., 2019; Bold et al., 2018; Chaffee et al., 2018; Evans-Polce et al., 2020; Hair et al., 2021; Miech et al., 2017; Watkins et al., 2018). This is possibly contributed to recent exposure to the addictive element of nicotine drawing the adolescent back

to using. This brings out the idea that even one or two puffs from an e-cigarette significantly increase the risk of continued e-cigarette use and cigarette use.

Importantly, those whose first tobacco product was e-cigarettes were likely to use cigarettes the same amount as those whose first tobacco products were cigarettes (Barrington-Trimis et al., 2018). This suggests that using e-cigarettes is not lessening the use of cigarettes and is instead providing another avenue to cigarette use. In addition, from one wave to the next, there was an increase in how much e-cigarettes and cigarettes were used. This is most likely a product of the addictive nature of the nicotine that is present in both e-cigarettes and cigarettes (Bold et al. 2018).

There are some factors that do appear to increase an adolescent's chances of initiating e-cigarette and cigarette use. Having a high sensation seeking score was consistently correlated with use of both products (Berry et al., 2019). Adolescents are already at a higher risk for a high sensation seeking score because they are in the developmental stage where risk-taking is common. Their brains have not reached the stage of development where they are well equipped to be able to resist impulses. This lack of prefrontal cortex development ties in with another significant risk factor; the younger that someone starts the more likely they are to become users. Not only has the younger brain not developed as much to value good judgement over impulses, the younger the use, the more time the brain has to reinforce the pathways that associate nicotine with feelings of euphoria and happiness. Even in low-risk adolescents and adolescents who thought they would never use cigarettes, e-cigarette use was a commonality in those who later used cigarettes (Owotomo et al., 2020; Miech et al., 2017). This suggests that the addictive nature of nicotine and the development of the adolescent brain play powerful roles in building these habits for adolescents.

While there is a lot of evidence showing there is a correlation between the two substances, there are also factors that may contribute to adolescents not progressing past e-cigarettes. E-cigarettes tend to be cheaper, do not carry the same harsh smell as cigarettes, and are seen as more socially acceptable among peers as there is not yet a stigma surrounding e-cigarettes as there is for cigarettes. These reasons may also be a big factor in some adolescents choosing to start using e-cigarettes in place of cigarettes.

Strengths

One of the most notable strengths of this systematic review is the sample size and demographics of the articles include. Of the ten articles evaluated, seven of the articles had over 1,000 participants and eight of the studies gathered data from national studies. This large and broad range of data means that it is easier to make generalization and those generalization will be more accurate as the data will be more representative of the population. In addition, larger sample sizes make outliers and trends more obvious than in a smaller sample size. Another strength of the studies included in this review is that most of the surveys allowed the participants to remain anonymous. In the case of this research, which evaluates a sensitive topic, anonymity is important as teenagers might be less inclined to give honest answers if they feel as though their response could put them at risk.

Limitations

There were multiple limitations to this systematic review including the studies included all being descriptive correlational and the year of data collection. The method of all the studies

was descriptive correlation, which only allows for a correlational relationship to be drawn. The lack of interventions or variable controls does not allow for a causal relationship to be drawn between the e-cigarettes and cigarettes because there is no way to prove one variable is causing the other. However, the correlational results from this systematic review can give a strong direction for future research. The other limitation comes from the year that the data sets were collected. Although the articles included in this review were published within the last five years, the data in many of the studies was collected almost 10 years ago. As a new technology, e-cigarettes are rapidly evolving with new designs and e-liquids, so it is possible that the data collected 10 years ago is no longer an accurate representation of e-cigarette and cigarette use now.

Implications for Clinical Practice

Regardless of whether adolescent e-cigarettes use does contribute to subsequent cigarette use, one of the most important clinical implications of this research is the healthcare team's role in reducing e-cigarette and cigarette use in adolescents. This includes assessing adolescents about their smoking status and as well as their risk for initiating in order to appropriately help the adolescents. In addition, the healthcare team plays a big role in the education of adolescents on the health risks of both e-cigarettes and cigarettes. Part of this education is ensuring adolescents are aware that e-cigarettes contain addictive ingredients like nicotine and the impact of nicotine on developing brains. Moreover, the healthcare team should emphasize in their education that there is not a lot of research on the long-term effects of e-cigarette use. By providing accurate information on the potential consequences of e-cigarettes and cigarettes the healthcare team can hopefully discourage kids from taking up tobacco products in the first place. It is also important

that the healthcare team is also prepared to offer resources for adolescents who want to quit using e-cigarettes before a lifetime habit occurs.

The healthcare team can also help to reduce e-cigarette use in adolescents by advocating for tobacco free environments such as school and at home. Parental and peer use are big risk factors for e-cigarette use in adolescents so reducing the exposure to it will help reduce the number of people who start. This will also help reduce health consequences related to secondhand smoking as well.

Future Research

While a causal relationship could not be established from this systematic review because of the correlational design of the articles included, this review does offer a strong direction for future research. This review has established that there is a relationship between the use of e-cigarettes in adolescents and subsequent cigarette use. To be able to establish a causal relationship, future research should focus on randomized control trials and interventions which could examine the outcomes of individual variables related to e-cigarette and cigarette use in adolescents.

Additionally, one key factor that was not closely examined in this systematic review that could have important implications in future research are the ingredients that e-cigarette liquids contain. Despite e-cigarettes being common commodities, it is hard to find research that shows a comprehensive list of ingredients in the e-liquids, partly because there are thousands of variations in the e-liquids. While many of the known and shared ingredients in the variations are considered food safe, there is no research on what the effects of inhaling large amounts of these ingredients will be in the long term.

Finally, future research should focus on what the long-term effects of e-cigarettes are. As stated throughout this review, e-cigarettes are a relatively new invention, which makes it hard to know what health issues using an e-cigarette may have in the future. The long-term effects of cigarettes are well established and well known to be detrimental to people's health, and it is important to know similar effects will become present from e-cigarettes.

Conclusions

This systematic review examined the relationship between e-cigarettes and cigarettes in the adolescent population. The articles included support the conclusion that there is a correlation between the two substances and that those who use e-cigarettes are at a higher risk of becoming cigarette users. Stricter policies surrounding e-cigarettes for adolescents should be enforced; policies regarding e-cigarettes in the adolescent population should continue to evolve as more research come available in order to minimize the availability of e-cigarettes to the younger populations. Future research should focus on establishing a causal relationship between the two substances as well as establishing health consequences of e-cigarette use.

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* Indicates articles that are used in the matrix table

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EDUCATION

The Pennsylvania State University

Bachelor of Science, Nursing – Intended

Expected Graduation: May 2023

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Schreyer Honors College Scholar

Fall 2019 - Present

Dean's List

Fall 2019 - Present

CLINICAL EXPERIENCE

Capstone | 80 hours

Spring 2023

- Pediatric ICU, Hershey Medical Center, Hershey, PA

Nursing Care of the Adult Client with Complex Health Problems B | 90 hours

Spring 2023

- Neuro ICU, Hershey Medical Center, Hershey, PA

Mental Health Nursing | 90 hours

Spring 2023

- Pennsylvania Psychiatric Institute, Harrisburg, PA
- Lebanon Veteran's Associations Medical Center, Lebanon, PA

Community and Family Health Nursing | 90 hours

Fall 2022

- Varied Locations

Nursing Care of the Adult Client with Complex Health Problems A | 90 hours

Fall 2022

- Heart & Vascular Progressive Care Unit, Hershey Medical Center, Hershey, PA

Nursing Care of the Child/Adolescent | 45 hours

Spring 2022

- Varied Locations

Nursing Care of the Childbearing Family | 45 hours

Spring 2022

- Women and Child Services, Mount Nittany Medical Center, State College, PA

Nursing Care of the Medical-Surgical Patient | 90 hours

Fall 2021

- Medical-Surgical, Mount Nittany Medical Center, State College, PA

Nursing Care of the Older Adult | 90 hours

Fall 2021

- Juniper Village at Brookline Rehabilitation and Skilled Care
State College, PA

WORK EXPERIENCE

Nurse Extern, Neurology Unit, PRN

- **Swedish Medical Center**, Englewood, CO

May 2022 - Present

- Prioritized care for up to 18 patients including bathing, toileting, and ADLs
- Monitored vital signs, glucose levels, and intake and output
- Repositioned immobile patients every two hours to prevent skin breakdown and pressure ulcers

CERTIFICATIONS

American Heart Association Basic Life Support

Expires May 2024