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Assessment and Anesthetic Management of Patients With Vaping History: An Evidence- Based Educational Module

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Assessment and Anesthetic Management of Patients With Vaping History: An Evidence-Based Educational Module

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ABSTRACT

Background

Since its debut in the US market, electronic vapor delivery systems (EVDS) have become a significant social trend. Compelling evidence points to a meteoric rise in e-cigarette usage throughout the US, particularly among young people. Presently, 3.6 million teenagers and 10.8 million adults use ECs, with a proliferation of utilization increasing from 0.6% in 2011 to 11.3% in 2017 and from 2.4% to 6% in adolescents and adults, respectively. In patients with a vaping history, does a modified preoperative assessment enhance the anesthetic management? The primary goal of this DNP project was to improve the knowledge of the deleterious effects of ECs use among anesthesia providers and develop a focused assessment for adequate surgical risk stratification and enhanced anesthetic management of patients with a history of vaping.

Methods

The principal methodology of the planned project was to administer an electronic educational module to anesthesia providers that focuses on improving the knowledge of the harmful effects of ECs use and promoting an enhanced assessment and anesthetic management of patients with a history of vaping. The first phase implemented the project by conducting an online pretest to gauge baseline knowledge and attitudes on the subject. The second phase comprised a voiceover PowerPoint presentation as the primary means of learning that included essential information regarding ECs use, related physical alterations in different body systems, and the anesthesia implications and related management for patients with a history of vaping. The project's third phase involved a posttest to evaluate knowledge gained and any changes in anesthesia provider attitudes about the subject presented.

Results

Nine (*n*=9) participants consented to partake in the educational module, and 100% completed the pretest and posttest questionnaires. Most participants were female (*n*=7, 77.78%), as opposed to male (*n*=2, 22.22%). The results assessed the knowledge gained from the educational intervention module. Most questions validated increased correct answers when the pretest and posttest interventions were compared.

Discussion

The results indicated a statistical difference in the pretest and posttest following the educational module. The data exhibited a percentage increase in the providers' knowledge of the main active components of ECs and the ventilatory complications associated with ECs usage. One key outcome is the 44.45% increase in the number of providers extremely likely to implement an enhanced preoperative respiratory assessment for patients with a chronic vaping history. One major limitation is the small sample size (*n*=9) despite the more significant number of prospective participants (*n*=44) invited to participate, yielding a response rate of only 20.45%. In conclusion, the QI project aimed to improve the knowledge of anesthesia providers regarding ECs usage and its related physical alteration, in addition to motivating anesthetists to implement a more focused preoperative assessment for this patient population. The author believes the data showed that the QI project increased anesthesia providers' knowledge and attitudes. A positive correlation exists between the knowledge gained and increased affirmative attitudes toward implementing change.

Keywords: *Vaping, electronic cigarettes, e-cigarettes, anesthesia, surgery*.

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INTRODUCTION

Problem Identification

After being launched to the global market in the middle of the 2000s, electronic cigarettes (ECs) use has risen steeply. Given the evidence of the harmful effects of traditional nicotine cigarettes, the public is now more aware of these products' adverse effects on health. As a result, conventional cigarette (CC) use has significantly decreased in North America over the past few decades due to increased public awareness and better tobacco legislation and restrictions.[1] Contrarily, there has been ongoing global growth in electronic cigarette usage.[1] As of 2019, about 6% of adults in the US are e-cigarette users,[2] and the number only continues to grow exponentially with the increasing popularity of ECs. Due to their increased nicotine content and other compounds such as electronic-liquid flavoring, e-cigarettes, commonly known as vaping, give users a feeling of renewed energy.[2] Additionally, ECs have gained acceptance, as they are primarily advertised as a safe and effective mode of smoking cessation.[3]

Current investigations have revealed that ECs are not as safe as initially marketed and may yield deleterious impacts on lung and cardiovascular function.[1-2,4,5] As a result, the Centers for Disease Control and Prevention (CDC) revised its recommendations regarding ECs in August 2018, highlighting the potential intoxicating and detrimental consequences of nicotine usage and the dangers of additional active ingredients, such as propylene glycol (PG) and vegetable glycerin (VG), within e-cigarettes to the respiratory tract and other organs.[6] Much like combustible cigarettes, EC emissions are directly associated with triggering pulmonary inflammatory responses, including cytotoxicity and tissue damage.[4] Consequently, these devices increase the likelihood of respiratory problems, such as laryngospasm and bronchospasm, due to pulmonary physiological alterations.[4] For adequate surgical risk stratification and perioperative

anesthetic management, anesthesia practitioners need a comprehensive understanding of their patients' ECs usage history and awareness of its impact on various organ systems.

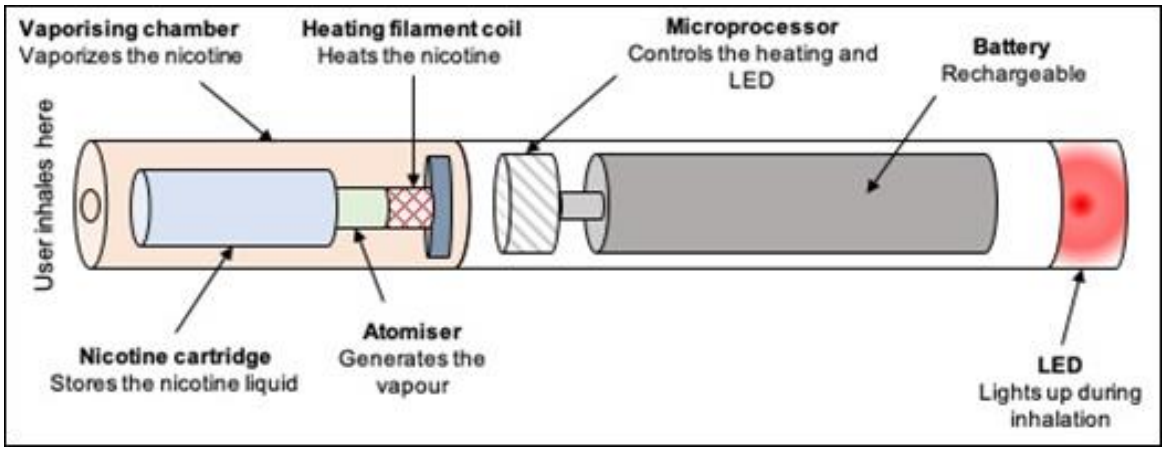
Background

Since its debut in the US marketplace in the mid-2000s, electronic vapor delivery systems (EVDS) have evolved into a significant social trend. The devices are available in several configurations and are commonly termed "electronic cigarettes," "e-cigs," and "vape pens."[7] EVDS use, also known as "vaping," was initially advertised as a practical and safer substitute for conventional cigarette smoking because it enabled users to vape nicotine, marijuana—Tetrahydrocannabinol (THC) and Cannabidiol (CBD)—or numerous different flavorings without the need for combustion and smoke inhalation.[7] ECs consist of a long container housing an electrical heat source, a liquid reservoir, and a replaceable power supply (Figure 1).[4] These battery-operated electronics eliminate the requirement for combustion through a thermal reaction between the device's coil (heating element) and liquid to generate an aerosol inhaled via a mouthpiece.[7,8] Nicotine (0-24 mg), PG, and VG (for flavor) are the main components of the electronic-liquid reservoir.[9] Traces of toxic metal alloys, tobacco-specific N-nitrosamines, and diacetyl may be found in the liquid breakdown products formed by ECs when heated.[10]

Updated literature suggests that vaping is not as harmless as once advertised; researchers have identified cytotoxic carrier ingredients and cancer-causing chemicals within the vapor that may be harmful once consumed.[7] In addition, due to the relative novelty of EVDS products, there are no current standardized guidelines for adequate patient assessment and perioperative anesthetic management. The effects of ECs on the respiratory and cardiovascular systems can influence various aspects of anesthetic delivery for patients with a vaping history.[4,11-12]

Therefore, anesthesia providers must equip themselves with adequate knowledge for proper assessment and anesthetic management of this patient population.

Figure 1. E-Cigarette Design (Adapted from Qasim et al[35])



Scope of the Problem

The widespread acceptance of e-cigarettes threatens decades of progress in tobacco control by leading individuals to experiment with a new addiction whose protracted adverse effects remain unclear.[13] Compelling evidence points to a meteoric rise in e-cigarette usage throughout the US, particularly among young people.[13] According to statistics from Mirbolouk et al., 1 in 20 Americans has tried electronic cigarettes.[14] Presently, 3.6 million teenagers and 10.8 million adults use ECs, with a proliferation of utilization increasing from 0.6% in 2011, reaching as much as 11.3% in 2017, and from 2.4% to 6% in adolescents and adults, respectively.[11,13]

Early in 2019, patients hospitalized throughout the US reported experiencing the first occurrences of e-cigarette or vaping, product usage-related lung injury (EVALI).[15] EVALI seems to be an immediate or chronic proinflammatory syndrome with symptomatology spanning from moderate (hypoxemia, difficulty breathing, chronic cough with chest discomfort, and bronchitis) to profound acute respiratory distress syndrome (ARDS).[4,15-17] The CDC believes that vitamin E

acetate, often mixed with illegal cannabinoid vaping products, could be the primary probable trigger of EVALI, while other substances have also been suspected.[15] Researchers have also discovered that increasing the number of times individual vapes daily over 5 proliferates the chances of developing EVALI.[11] As of December 2019, a count of 2409 cases have been reported to the CDC.[15]

Consequences of Problem

Pulmonary Effects

Because of bronchial physiological modifications, EVDS products increase the likelihood of ventilatory complications such as laryngospasm and bronchospasm.[4] EVDS have various adverse effects on the respiratory system, including reduced ventilation, enhanced metabolic stress, impeded lung development, and weakened immunity to pathogenic microbes.[1-2,5,7,18,19] Smoking nicotine-containing ECs promotes significant bronchial hyperreactivity, distal airspace expansion, mucin formation, and secretion of inflammatory mediators and proteolytic enzymes.[20] Rodents exposed to ECs aerosols for an extended period developed chronic obstructive pulmonary disease (COPD) symptoms.[20] Furthermore, nicotine-containing and nicotine-free e-liquids suppress the immune responses of the respiratory system, which is crucial in the lung's protection versus HRV illnesses.[21] Frequent vaping could promote dose-dependent and combinatorial consequences on the incidence of perioperative cardiorespiratory illness, particularly asthma and COPD clinical manifestations, hypersensitivity bronchiectasis, diffuse pneumonia, and prothrombotic incidents.[4,11,13,16-17]

EVALI

As previously stated, there is a direct correlation between ECs usage and the development of EVALI. Individuals experiencing EVALI generally always exhibit constitutional, pulmonary,

and digestive system manifestations.[15] Patients with this condition will have radiographic evidence of recurrent fibrinous or reactive pneumonitis, widespread alveoli effusion, and extensive cellular diffuse pneumonia with bronchiectasis.[22] Varying degrees of intensity span from those that do not necessitate medical intervention to those that necessitate intensive care unit (ICU) care and, frequently, non-invasive ventilation or intubation, plus respiratory support.[15] These patients may present unique challenges for intraoperative ventilation, necessitating the utilization of significant amounts of fraction of inspired oxygen (FiO_2) and positive end-expiratory pressure (PEEP) to provide an appropriate gas exchange.[15]

Cardiovascular Effects

Nicotine, carboxylates, and other pollutants found in ECs vapor pose the greatest threat to cardiovascular health.[4] Most cardiometabolic complications are directly linked to nicotine's capacity to activate catecholamines, resulting in enormous blood pressure fluctuations, vascular endothelium damage, an elevation in triglycerides, and decreased insulin sensitivity.[23] St-Helen et al[24] presented data suggesting ECs are powerful nicotine delivery devices, producing nicotine concentrations equivalent to or greater than conventional cigarettes with comparably elevated amounts of systemic accumulation.[24] In a similar study, Ramôa et al[25] emphasized that nicotine distribution from certain EVDS can surpass traditional cigarettes. Finally, Nocella et al[26] examined the effects of ECs on platelet function. The authors revealed that smokers and nonsmokers lacking cardiac diseases experienced an elevation in platelet activation after using EVDS products.[26] Increased platelet aggregation can lead to thrombus formation and escalate the risk of cerebrovascular accidents and pulmonary embolus.

Immunologic Effects

Since some EVDS products possess greater nicotine concentrations than conventional cigarettes, their use can compromise cellular oxygenation and increase the risk of surgical site infection, necrosis, and prolonged tissue regeneration.[4] Chaumont et al[2] concluded overexposure to a high-wattage, high-volume PG/VG vapor generated prolonged tissue oxygen deprivation and had more severe adverse effects on tissue circulation. There is an inverse relationship between nicotine use and collagen protein synthesis/production.[4,27] ECs are associated with a propensity for protracted tissue regeneration and an increased prevalence of surgical wound infections.[27]

Anesthetic Effects

E-cigarettes have generated volatile organic contaminants (VOC), particularly toluene, in most identified samples of ECs aerosols.[4,28] Quickly absorbed by the lungs at high enough concentrations, VOC exposure causes lethargy, immobilization, sedation, and even loss of consciousness; however, cognitive functionality and behavioral competence are impaired at reduced concentrations.[29] Notably, data suggest that toluene possesses several of the same properties as CNS-depressant substances, such as benzodiazepines, ketamine, and volatile inhalational agents.[30] Additionally, nicotine has also been linked to patients exhibiting an amplified opioid requirement postoperatively.[4,11] Evidence indicates a correlation between chronic nicotine use and increased opioid tolerance.[4] As a result of the elevated levels of nicotine in certain ECs, patients are at much greater risk of increased opioid requirements intra- and postoperatively. Substantial nicotine use correspondingly reduces the effectiveness of aminosteroid paralytics.[4] Furthermore, nicotine use over an extended period increases the production of the P450 liver enzyme CYP1A2, which is responsible for the metabolism of

rocuronium and vecuronium, resulting in a more significant requirement for a starting dosage of these muscle relaxants among chronic nicotine users.[4]

Knowledge Gaps

Comprehensive pilot research at the Ohio State University determined a knowledge deficit and erroneous beliefs about the effectiveness and health implications of electronic cigarettes (ECs) among healthcare practitioners.[31] Regarding this result, anesthesia professionals must engage in more research and receive education on these novel devices. Due to the relative novelty of electronic vapor delivery systems (EVDS) products, there are no current standardized guidelines for adequate patient assessment and perioperative anesthetic management. In addition, the effects of ECs on the respiratory and cardiovascular systems can influence various aspects of anesthetic delivery for patients with a vaping history.[4,11,12] Therefore, for adequate surgical risk stratification and perioperative anesthetic management, anesthesia practitioners need a comprehensive understanding of their patients' ECs usage history and awareness of its impact on various organ systems.

It is standard practice for anesthetists to inquire about a patient's use of conventional cigarettes and habits. However, it has become increasingly apparent that questioning patients whether or not they use electronic cigarettes is as crucial.[4] Some anesthesia providers lack the expertise and understanding to assess and discuss the risks and sequela of these products with patients and family members. Anesthetists should comprehend the risks associated with electronic cigarettes and how they relate to the preoperative preparation of patients undergoing general anesthesia.

Proposal Solution

Focused Assessment

Patient history and physical examination are the pillars of an efficient preoperative assessment.[4] When developing and delivering optimal treatment, anesthetists must know the possibility of organ function modifications. In order to appropriately advise and promote prospective anesthetic treatment techniques for individuals who vape, it is necessary to determine how EVDS usage impacts respiratory, cardiac, and immunological functionality.[7] Anesthetists have an essential role in evaluating surgical risk stratification and addressing perioperative morbidity linked with vaping to enhance management and outcomes.[12] Developing and executing a targeted preoperative screening method that evaluates vaping users and the level of their consumption, usage behaviors, device type, and nicotine concentrations would enhance the clinical representation of this population of patients.[12] This information is crucial for creating preoperative care guidelines for such individuals.

Dudaryk et al[12] executed a trial, paper-based assessment instrument to distinguish individuals with a history of EVDS use. The author's preliminary findings underscored that many vaping patients testified about using THC-containing marijuana products.[12] It is imperative to recognize individuals using THC-containing ECs, given that the bulk of cases of EVALI has been linked with such practice.[4,12,15,22] The information collected will enable us to evaluate the comparative hazard of vaping in relation to unfavorable perioperative respiratory complications (hyperreactive airway, hypoxia, unreadiness for extubation, and unexpected ICU admission).[12] Differentiating patterns of consumption and types of vaping products being used represents the initial step to evaluate the perioperative risks of these patients, formulate tailored anesthetic management strategies, and develop triage standards for subsequent referrals to a specialist such as a pulmonologist or a cardiologist.[12]

Perioperative Management

The respiratory changes that develop in patients who utilize ECs amplify the hazard of pulmonary complications such as laryngospasm or bronchospasm.[4] In addition, as with traditional cigarette smokers, vapers should be anticipated to pose a heightened risk of hypersensitive airways. Therefore, it would seem logical for anesthesiologists to provide similar anesthetic care to long-term vapers as they do to individuals with COPD and sensitive airways due to the systemic inflammatory alterations caused by ECs exposure.[4,20] Thus, anesthetists may find it advantageous to acquire baseline pulmonary function tests, utilize bronchodilators preoperatively and intraoperatively when indicated, and heighten the plane of anesthesia prior to airway manipulation.[4]

Elevations in heart rate, blood pressure, cardiac contractility, myocardium oxygen demand, myocardium excitation, and peripheral cardiovascular resistance are all examples of the acute adverse effects caused by nicotine.[4,11,17] In addition, prolonged nicotine use may promote intra-operative high blood pressure, arrhythmias, and an O2 supply/demand mismatch in the myocardium.[11] Consequently, patients with a long-standing nicotine vaping history are at increased risk of hemodynamic instability. Hence, the anesthetist should implement stricter heart rate and blood pressure controls and utilize cautious dosing of ephedrine and dexmedetomidine.[11]

Anesthetists must be cognizant of the relationships between ECs and anesthetic agents, such as volatile gases, narcotics, and paralytic drugs.[4] Vapers arriving to the OR for emergencies may be experiencing the CNS-depressing adverse effects of volatile organic compounds in ECs.[4] If patients seem to be experiencing these symptoms, particular care must be given to adapt to their reduced anesthetic needs. Intraoperative VOC poisoning may affect the minimal alveolar

concentration (MAC) required to produce the appropriate degree of anesthesia; [4,11,17] thus, prudent administration of anesthetic agents for induction and maintenance must be conducted. The effects of nicotine on the enzyme CYP1A2 lead to the modified metabolism of aminosteroid muscle relaxants.[4,11,23] Consequently, a greater dosage of vecuronium and rocuronium may be necessary to achieve therapeutic concentrations during induction and maintenance of anesthesia. Anesthesia providers should employ peripheral nerve stimulators to direct cautious dosing and titration of paralyzing agents.

Research by Chiang et al[32] concluded that nicotine-dependent individuals seemed to experience hyperalgesia or a decreased threshold for pain following general anesthesia. Because some ECs include a significant quantity of nicotine, surgical patients who vape might necessitate an enhanced postoperative narcotic regimen.[4,11] Lastly, nicotine's adverse ionotropic factors promote persistent tissue hypoxemia.[1-2,4,7,19] Patients must be informed appropriately concerning the amplified hazard of prolonged wound healing and increased risk of surgical site infections associated with EVDS use.

SUMMARY OF LITERATURE REVIEW

Methods

Search Keywords

A literature search was performed using PubMed, EMBASE, and CINAHL. The query was conducted using a combination of MeSH terms, truncated phrases, key phrases, and Boolean logic. Key terms were: “vaping,” “electronic cigarettes,” “e-cigarettes,” “electronic nicotine delivery systems,” “smokeless tobacco,” “anesthesia,” “surgery,” “peri-operative,” “respiratory impacts,” “pulmonary,” and “lung.” The search results were limited to publications from 2012 to

2022. Additional limitations were applied to the query results. These limitations included non-English articles and empirical evidence of a non-clinical nature.

Eligibility Criteria

Following an initial search employing the above criteria, the automation algorithms yielded full-text quantitative studies. Inclusions criteria were publications of original randomized controlled trials (RCTs), systematic review/meta-analysis of RCTs, and nonrandomized trials that evaluated the usage of ECs and its effects on respiratory, cardiovascular, and immunological function as well as its effects on anesthetic delivery. Articles excluded were those that assessed the effects of conventional tobacco use on different organ systems, focused primarily on combustion cigarettes, or were nonexperimental/observational studies or qualitative/descriptive studies.

Search Strategy

The search was executed systematically utilizing search engines, keywords, and findings are listed in Table 1. Each of the retrieved publications was evaluated for relevancy by examining the title, abstract, and conclusion and applying established criteria for inclusion and exclusion to omit non-relevant studies. An additional search of the retrieved articles employing an ancestry approach yielded further reports relevant to the topic and met inclusion criteria. An ancestry approach allows for the exploration of potentially relevant data by examining articles listed in the cited reference of already established pertinent research.

Following the preliminary search, all publications retrieved in subsequent searches were compared to those in the literature review matrix, and duplications were eliminated throughout the selection process. During the selection process, the review matrix was completed, and each paper that satisfied the eligibility requirements was represented in this table. The examination of

the chosen databases yielded the extraction of 10 articles. In addition, the ancestry search of these papers yielded ten more relevant articles for a sum of 20 relevant studies.

Results

Respiratory Alterations

Several studies provided evidence highlighting the adverse respiratory effects associated with ECs usage. In a systematic review of 38 RCTs, Novelli et al[7] established that EVDS use decreases pulmonary function tests (PFTs)—FEV1, FEV1/FVC, FEF 25–75%, and FEF 75–85%— and vaping may potentiate existing lung disease, such as asthma. In addition, EVDS exposure can cause ventilation/perfusion mismatches.[7] Antoniewicz et al[1] conducted a double-blinded, crossover design RCT with results alluding to a significant conducting airway obstruction directly following exposure to EVDS containing nicotine. The findings were mirrored in a placebo-controlled, crossover, single-blinded RCT by Chaumont et al,[2] which inferred acute vaping of an aerosol of PG/VG at high wattage and in a large amount induced sustained tissue hypoxia, an airway epithelial injury, and small airway constriction. In a controlled clinical trial, Garcia-Arcos et al[20] discovered that effects generally linked with the onset of COPD, such as cytokine production, bronchial hyperreactivity, and respiratory cell deterioration, were caused by exposure to nicotine-containing fluids in e-cigarettes, which the study participants inhaled.

Brożek et al[5] piloted a three-phase full cross-sectional, laboratory-based RCT to investigate the immediate and short-term respiratory effects of e-cigarette usage. The study outcomes include a reduction in nitric oxide concentration in exhaled air (FeNO).[5] *Nitric oxide* is a sensitive indicator associated with eosinophilic inflammation and pulmonary oxidative stress.[5] Reduction of FeNO shortly after using e-cigarettes may imply that the aerosol from the e-

cigarette alters the lung homeostatic mechanisms, possibly in the context of inflammatory reaction to the ECs vapor.[5] In contrast, Chaumont et al[19] explored the reversibility of the acute effects of vaping on respiratory parameters by short-term ECs cessation in a randomized, investigator-blinded, 3-period crossover study RCT. The authors determined that short-term discontinuation of vaping appeared to normalize the lung's inflammatory profile, but it had no effect on improving spirometry characteristics related to respiratory mortality and morbidity, such as FEV or lung-diffusion capacity.[19]

Cardiovascular Modifications

Antoniewicz et al[1] also measured the effects of ECs on cardiovascular function. Following exposure to EVDS with or without nicotine, the authors noticed a substantial rise in systolic and diastolic blood pressures that persisted for 30 minutes.[1] Additionally, inhalational exposure to nicotine-containing EVDS was also associated with a sharp increase in arterial stiffness, which returned to baseline levels 30 minutes after exposure.[1] Elevated arterial stiffness is a cardiovascular risk factor for events such as myocardial infarctions and strokes, irrespective of blood pressure.[1] Finally, Nocella et al.[26] performed a 2-phase crossover single-blind RCT study measuring the effects of ECs on platelet function. The investigators observed a proliferation in platelet activation in smokers and nonsmokers without cardiovascular disease after e-cigarette use.[26]

Immunologic Impairment

Wu et al[21] piloted a laboratory-controlled clinical trial assessing the effects of EVDS on airway epithelium properties, including pro-inflammatory response and intrinsic immunological resistance against respiratory virus infections. The research presented solid evidence that e-cigarettes harm respiratory function, with a specific emphasis on airway epithelium

inflammatory response and innate immunity in adolescent individuals.[21] In addition, the evidence suggests that any e-liquid, even those without nicotine, increases the likelihood of pro-inflammatory reactions and human rhinovirus (HRV) infection.[21] Furthermore, nicotine-free and nicotine-containing e-liquids suppress airway natural immunity, which is critical in the lung's defensive system against HRV infections.[21]

Nicotine Concentration

Lastly, 2 separate studies evaluated the effectiveness of EVDS products as nicotine delivery systems. First, Ramôa et al[25] directed four independent double-blind laboratory RCT sessions examining the nicotine plasma concentration in experienced EVDS users. The results were alarming, as they highlighted that compared to traditional tobacco cigarettes, certain EVDS seem to have a higher nicotine delivery profile.[25] The findings were mirrored in a study conducted by St-Helen et al[24], which inferred ECs might be extremely effective nicotine delivery devices, capable of delivering nicotine at levels that are on par with or even more significant than those found in conventional cigarettes, with equivalent degrees of systemic retention.[24]

Discussion

The evidence presented by the search of the literature highlights the detrimental health effects of EVDS use. The respiratory modifications EVDS use produces are of specific importance, as these changes can make anesthetic management of this patient population more challenging. Since their initial launch, ECs have been promoted as a safer alternative to conventional cigarettes. A decade later, the literature disproves the latter to be accurate. Despite these documented alterations in respiratory, cardiovascular, and immunologic health, a knowledge gap exists among healthcare providers regarding EVDS use.[31] Anesthetist awareness and understanding of these changes are pivotal for adequate anesthetic management and

subsequent care. One alarming finding is the ability of some EVDS products to deliver higher nicotine concentrations compared to conventional cigarettes. Nicotine has various documented detrimental effects, leading to more taxing anesthetic management. The research provided some insight into the acute effects of ECs use, but very scant data exists on the chronic health effects that might occur due to vaping. Further research is necessitated to explore the chronic adverse effects associated with EVDS use.

Table 1. Search Results for Key Terms on E-Cigarettes Use and Health Consequences

Search Engine	Search Terms	# Retrieved	# Met Inclusion
PubMed	(Vaping OR Electr* cigarette*) AND (Anesthe*)	204	28
EMBASE	Vaping AND Anesthesia	39	7
EMBASE	(E-cigarette OR electronic cigarette OR e-cig OR electronic nicotine delivery system OR vaping) AND (surgery OR surgical OR peri-operative, operative)	317	33

Literature Review Matrix

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Novelli et al,[7] 2022	Systematic Review/Meta-analysis Purpose: To determine the effects of EVDS usage on the pulmonary system in order to inform future anesthetic recommendations for vaping patients - Search of databases CINAHL and PubMed from Jan 2010 to Oct 2020 - 38 RCTs and experimental studies with a control group or control period	*N* = 38 out of 73 potential studies Setting: NR Attrition: NR	DV1 = PFTs DV2 = Alterations in ventilation DV3= Impaired mucociliary clearance DV4= Tissue destruction DV5= Disrupted immune response DV6= Oxidative stress and DNA fragmentation IV1 = Vaping w/ nicotine IV2 = Vaping w/o nicotine IV3 = Sham-vaping	PFTs • FEV1 • FEV1/FVC • FEF 25–75% • FEF 75–85% Alterations in ventilation •SpO2 •FeNO •DLCO Impaired mucociliary clearance •MUC5AC Tissue destruction •MMP Disrupted immune response •LLM Oxidative stress & DNA fragmentation •SAE •AM All articles were systematically assessed for risk of bias per Cochrane Handbook for Systematic Reviews of Interventions utilizing standardized survey questions constructed by the lead study authors and mentor. These survey questions included categorical checklists to determine whether each article met the criteria for low risk, high risk, or unclear risk in each bias category.	• Compared with sham vaping, vaping without nicotine decreased FEF-25% and FEV1/FVC. • E-cigarettes decreased all PFTs • Increased MUC5AC (mucin 5 AC), and MUC4 gene expression in e-cigarette users. • Increased MMP levels in EVDS users' sputum. • Exposure led to changes in phenotype and virulence of key lung pathogens, which may increase bacterial persistence and inflammatory potential.	• Pulmonary function test results, including reductions in FEV1, declined after EVDS use. • Vaping may potentiate existing lung disease, such as asthma. EVDS exposure can cause ventilation/ perfusion mismatches. • Airway constriction, inflammation, epithelial cell damage, and a reduction in surfactant levels were observed after EVDS use. • EVDS exposure leads to impair mucociliary clearance, induce cytotoxicity, and disrupt the pulmonary immune response, thus increasing the risk for infection.	While cessation of vaping remains the safest strategy, anesthesia providers are advised to examine patients for EVDS usage in the preoperative period and utilize the information collected by this systematic review to guide subsequent treatment.	Limitations: • Results of this review cannot be generalized to all age groups. Articles that examined pediatric subjects under the age of 18 were specifically excluded. • Application of this study's findings are limited to the availability of data focusing on acute versus chronic effects of EVDS exposure. The effects of chronic EVDS use is not well described by the literature. Level I – Good Quality.

DV= dependent variable; EVDS = electronic vapor delivery systems; FEV1 = amount of air exhaled may be measured during the first second; FEV1/FVC = ratio that reflects the amount of air you can forcefully exhale from your lungs; FEV50% = instantaneous flow representing the flow rate at half of expiration; FEF25–75% is an average value over the mid-vital capacity range; FEF 75-85% = Forced end-expiratory flow measurement used in diagnosis of small airways dysfunction from routine spirometry tracings; IV= independent variables; MMP= matrix metalloproteinase (responsible for tissue breakdown); NR = Not recorded; PFTs = pulmonary function tests; FeNO = fractional exhaled nitric oxide; DLCO= diffusing capacities for carbon monoxide; LLM=lipid-laden macrophages; SAE= Small airway epithelium; AM= alveolar macrophages

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Antoniewicz et al,[1] 2019	RCT: Randomized, double-blinded, crossover design Purpose: To examine the acute effects of e-cigarette aerosol inhalation, w/ & w/o nicotine, on vascular and pulmonary function in healthy volunteers Preliminary Examination: ECG, dynamic spirometry, pregnancy test, & routine blood tests Exclusion criteria: Cardiovascular, respiratory, systemic or chronic disease, symptoms of infection or inflammation within 2 weeks prior to study start, BMI ≥ 30 or pregnancy	*N* = 15 out of 17 potential subjects (9 Females, 6 Males, mean age 26 ± 3 years) Setting: Lab Attrition: 11%, 2 subjects were excluded due to elevated cotinine values at baseline, indicating non-compliance with the study protocol.	DV1: Respiratory measurements DV2: Vascular measurements IV1: E-cigs w/ nicotine IV2: E-cigs w/o nicotine CV1: E-liquid composition CV2: E-cig settings CV3: Puff interval and duration	Respiratory measurements • Dynamic spirometry VC & FEV1 • IOS • FeNO Vascular measurements • SBP • DBP • HR • PWV • AIx75 Statistical analyses were performed with SPSS 24.0 and GraphPad Prism 7.0. Prior to analysis, data were checked for normality both visually and by Shapiro–Wilk test. Skewed variables were checked for outliers and analyzed following logarithmic transformation and two-way repeated measures ANOVA was performed. If Mauchly's test for sphericity was violated, Greenhouse–Geisser corrected results were presented.	**Respiratory** VC +/- nicotine • 30 min (+) 4.92 ± 1.18 (-) 4.98 ± 1.21 • 2 hrs (+)4.94 ± 1.22 (-)4.96 ± 1.20 • 4 hrs (+)4.96 ± 1.18 (-)5.00 ± 1.20 • 6 hrs (+)4.96 ± 1.19 (-)4.97 ± 1.20 **Vascular** SBP +/- nicotine • 0 mins (+)119.3 ± 9.5 (-)114.5 ± 13.2 • 10 mins (+)117.4 ± 13 (-)111.2 ± 16.1 • 20 mins (+)113.7 ± 10.3 (-)109.3 ± 15.5 • 30 mins (+)114.5 ± 12 (-)108.8 ± 15.4 • 2 hrs (+)111.1 ± 10.1 (-)109 ± 10.2 • 4 hrs (+)109.1 ± 9.5 (-)108.8 ± 11.7	**Vascular** • +/- nicotine exposure there was significant increase in SBP & DBP that remained elevated for 10 and 30 min. • HR, PWV, and AIx75 increased significantly following + nicotine and remained elevated for 20 min as compared to – nicotine exposure. **Respiratory** FeNO increased significantly at 2h after both +/- nicotine. VC decreased following exposure to +/- nicotine and remained decreased after 2h. FEV1 did not change significantly over time.	Study shows an acute increase in arterial stiffness, both in terms of PWV and AIx75, following exposure to +nicotine, with a return to baseline values 30-min post-exposure. Impulse oscillometry exhibited conducting airway obstruction directly following exposure to ECA containing nicotine.	**Limitations** IOS, spirometry, and FeNO measurements did not start directly following ECA inhalation. They were performed after the vascular assessments, i.e., 30 min after exposure. Cannot exclude a possible impact of ECA on pulmonary measurements during the initial 30 min. Level I – Good quality

SBP systolic blood pressure, DBP diastolic blood pressure, HR heart rate, PWV pulse wave velocity, AIx75 heart-rate corrected augmentation index; DV= dependent variable; FeNO = fractional exhaled nitric oxide; IOS = impulse oscillometry; IV= independent variables; NR = Not recorded; PG = propylene glycol; VG = vegetable glycerin; FEV1 = amount of air exhaled may be measured during the first second; VC = vital capacity; ECA = electronic cigarette aerosol; CV=Controlled variable

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement And Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Chaumont et al,[2] 2018	RCT: Placebo-controlled, randomized, crossover, and single-blinded study Purpose: To validate that acute vaporization of a PG and VG mix (50:50), under intense use conditions, alters lung and skin microvascular functions via an oxidative stress pathway	*N* = 33 (16 Males, 17 Females, Average age 23 ±0.4 years) Setting: Academic center (Erasme University Hospital, Brussels, Belgium) Attrition: NR	DV1: Transcutaneous O2 tension DV2: Serum CC16 CV1: PG/VG (50:50) mix CV2: 25 puffs of (50:50) mix vaporized at 60 W IV1: Subohm vaping exposure IV2: Sham vaping IV3: BSL	Measurements • Transcutaneous O2 tension • CC16 A statistical analysis using analysis of covariance for crossover trial, with baseline measurement as covariate, was used for transcutaneous gas tensions to exclude a carryover effect and to detect significant session effects. Variables were compared by paired Student's *t*-test in case of Gaussian distribution. Wilcoxon signed rank test in case of non-Gaussian distribution.	Acute exposure to high-wattage e-cigarettes: induced a 60-min skin tissue hypoxia with the nadir reached during the first 30 mins after exposure (mean ±SEM) (84 ±2 mm Hg to 70 ±4 mm Hg; $p < 0.001$ vs. baseline Injured the lower airway, as reflected by serum CC16 rise within the vaping session (median: 4.6 [3.6–6.75] to 5.65 [4.5–7.4]; $p = 0.012$ vs. baseline	Subohm vaping induces transcutaneous hypoxia, which cannot be explained by a microvascular dysfunction nor an oxidative stress imbalance Vaping induced lung gas exchanges perturbations, which decreased PaO2 resulting in tissue hypoxia. Vaping induced deep lung inflammation as reflected by a rise in CC16. The CC16 increase and small airway constriction could be a result of lung irritative aldehydes produced by the e-cigarette tested	Acute vaping of an aerosol of PG/VG at high wattage and in a large amount induced a sustained tissue hypoxia, an airway epithelial injury, and small airway constriction	Limitations: Validity to the findings are not generalizable due to small sample size and no variation in age group. Additionally, endothelial microvascular function and oxidative stress remained unaffected. Level I – Good quality

PG = propylene glycol; VG = vegetable glycerin; NR = Not recorded; DV= dependent variable; IV= independent variables; CV= Controlled variable; Sham vaping (same procedure with e-cigarette turned off); Subohm vaping: devices delivering a high energy level to low coil resistance (↑heat & vapor production); BSL = baseline; CC16= club cell protein 16 (major lung anti-inflammatory protein)

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement And Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Brożek et al,[5] 2019	RCT: Full cross-sectional study, laboratory-based intervention study (pre-post-post) Purpose: assess acute, short term respiratory responses (airflow, FeNO, O2 saturation, exhaled air temperature) to using e-cigs in exclusive e-smokers and dual users. Compare these effects with responses to smoking a tobacco-cigarette in exclusive tobacco smokers. Exclusion criteria chronic diseases, history of lung conditions, any allergic diseases, medication intake within last 2 weeks, acute illnesses or infections in the last 2 weeks, influenza vaccination in the last 2 weeks, or current pregnancy or lactation.	N = 120 (4 groups n = 30) • (30 non-smokers) • (30 exclusive e-cigarette users) • (30 dual users) • (30 cigarette smokers) (age 21.7 ± 2.1y/o) Setting: Respiratory Function Laboratory at the Department of Epidemiology, Medical University of Silesia in Katowice Attrition: NR	DV1:SpO2 DV2 FeNO DV3: Exhaled CO DV4: temperature of exhaled air DV5: Spirometric testing. IV1: T-Subjects, IV2: E-Subjects IV3: T/E-Subjects CV1: C-Subjects	Measurements (1) SpO2; (2) FeNO in exhaled air; (3) exhaled CO; (4) temperature of exhaled air; (5) spirometric testing. Data analysis was performed using Statistica 12. Data were described using means, standard deviations, and medians for quantitative variables and percentages for qualitative variables. Normality of distributions was tested using the Shapiro-Wilk test. Differences in the distribution of quantitative variables were evaluated based on the results of the Student's *t*-test or non-parametric tests, in the case of repeated variables the paired Student-*t*-test and Wilcoxon test were used	The study groups differed significantly only in terms of FeNO levels ($p = 0.02$) and exhaled CO concentration ($p = 0.0001$). Compared with C-group, lower values of FeNO were found in T-Group ($p = 0.01$) and in T/E-Group ($p = 0.006$) in the first minute after exposure: mean by 2.1ppb in T-Group, by 1.5 ppb in E-Group and by 2.2ppb in T/E-Group. CO concentrations were significantly lower in the C-group than in T-Group ($p = 0.003$), E-Group ($p = 0.01$) and T/E-Group ($p = 0.0001$). (T-Group) (T/E-Group), significant decreases (PEF) and (MEF75) at the first minute after cigarette or e-cigarette use	Following exposure, statistically significant decreases in PEF and MEF75 were found in T-Group and T/E-Group compared with control. Five minutes of e-cigarette use were sufficient to trigger a decrease (FeNO) levels in E-Subjects & T/E-Subjects.	Acute, short-term respiratory responses to the use of e-cigarettes include a decrease in concentration (FeNO), increase in airway temperature and decrease (PEF, MEF25, MEF75) in tobacco smokers and dual users. The pattern of respiratory responses to the use of an e-cigs by e-cigarette users is similar to the responses to smoking a tobacco cigarette by tobacco smokers.	Limitations Subjects used their own e-cigarette freely, and the number and time of puffs were not controlled by the test protocol. Strengths One of the largest experimental studies in the field of e-cigarette using that follows a "real-life scenario," including subjects, who regularly use e-cigarettes. Level I – Good quality

FeNO = fractional exhaled nitric oxide; NR= Not recorded; T-Subjects = Group cigarette smokers; E-Subjects = Group composed of E-Cigarette users; T/E subjects = Group composed of dual users; C-Subjects= control group composed of non-smokers; DV= dependent variable; IV= independent variables; CV=Controlled variable; CO = carbon monoxide; PEF = peak expiratory flow; MEF25,75 = maximal expiratory flow at 25%, and 75% of FVC; SpO2= O2 saturation

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement And Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Ramôa et al,[25] 2016	RCT: Four independent randomized double-blind laboratory sessions Purpose: To examine the extent to which liquid nicotine concentration influences the plasma nicotine concentration of experienced ECIG users. A secondary purpose was to examine how puff topography was influenced by liquid nicotine concentration. Exclusion criteria history of chronic disease, psych condition, use of prescription medication, THC use >10days and/or alcohol use >25days in the past 30days	*N* = 16 (15 Males, 1 Female) Mean (SD) age was 29.6 (5.8) years Setting: Laboratory Inclusion criteria aged 18–55, used ≥1 ml ECIG liquid/day for ≥3 months at a liquid nicotine concentration of ≥12mg/ml Attrition: NR	DV1: Plasma nicotine DV2: Puff topography CV1: E-cig Device (3.3-Volt, 1000 mAh battery with a 1.5-Ohm, dual-coil) CV2: E-liquid (PG/VG [70:30] mix) CV3: Puff times, duration, and intervals IV1: E-Liquid nicotine concentration 0mg/ml IV2: E-Liquid nicotine concentration 8mg/ml IV3: E-Liquid nicotine concentration 18mg/ml IV4: E-Liquid nicotine concentration 36mg/ml	Measurements • Plasma Nicotine • Puff Topography For plasma nicotine data, to maintain statistical power in the preliminary report while limiting Type I error, authors conducted a set of a priori comparisons using dependent samples *t*-tests in which, at each measurement time point, the mean plasma nicotine concentration for the 0mg/ml condition was compared to the corresponding mean of the 8, 18, and 36 mg/ml condition. Because these comparisons were non-orthogonal at each time point, a Bonferroni correction was applied.	Plasma Nicotine Significant ($p<0.05$) differences were observed between 0 and 8 mg/ml immediately after the first bout (timepoint 5min) through 45mins and then also immediately after the second bout (timepoint 65) through 105 minutes [$ts(15) < -3.2$] Puff Topography mean (SD) volume was 154.5 ml (155.5) for 0mg/ml, 176.0 ml (131.6) for 8mg/ml, 114.7 ml (61.9) for 18mg/ml, and 78.5 ml (39.5) for 36 mg/ml.	These results demonstrate that, in experienced ECIG users, mean plasma nicotine concentration after 10 puffs from CV1 is related directly to liquid nicotine concentration. At the highest concentration tested (36 mg/ml), a difference (post-bout minus pre-bout) in plasma nicotine concentration can be observed. Thus, some ECIGs are so efficient at delivering nicotine that they appear capable of exceeding the nicotine delivery profile of a combustible tobacco cigarette.	This study demonstrates a relationship between ECIG liquid nicotine concentration and user plasma nicotine concentration in experienced ECIG users. Nicotine delivery from some ECIGs may exceed that of a combustible cigarette. The rationale for this higher level of nicotine delivery is uncertain.	Limitations Study lacked sensitivity for many comparisons that may be of interest and a larger sample size would allow for these analyses using statistical techniques that take into account the overall experiment-wise error rate. Results reported were obtained from a homogenous sample that was primarily male and white. Level 1 – Good quality

ECIGs = Electronic cigarettes; SD= standard deviation; CV= Controlled variable; DV= dependent variable; IV= independent variables; PG = propylene glycol; VG = vegetable glycerin; NR= Not recorded

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Nocella et al,[26] 2018	RCT: Two- phase crossover single-blind study Purpose: To compare the impact of e-cigarettes with conventional cigarettes on platelet function in healthy adult smokers and nonsmokers Exclusion criteria (1) No history of acute or chronic organic, metabolic, and inflammatory diseases; (2) no fever and infections in the last 3 months; (3) no history of CV pathological symptoms; (4) no allergies; (5) normal BP levels and heart rhythm; (6) no antioxidants and antiplatelet drugs.	*N* = 40 (20 smokers – 11 females, 9 males) (20 nonsmokers – 10 females, 10 males) Age (years) 28.0 ±5.3 Setting: Laboratory Attrition: NR	DV1: sCD40L DV2: sP-selectin DV3: Platelet aggregation IV1: Smoker group IV2: Nonsmoker group IV3: T-cigarette IV4: E-cigarette CV1: Nicotine concertation CV2: Puff times CV3: Interval between phases	Measurements • sCD40L • sP-selectin • Platelet aggregation • Cotinine concentration Continuous variables are described as mean ±standard deviation, and categorical variables as count (%). Student's unpaired *t*-test and analysis of variance were used for normally distributed continuous variables. Differences between percentages were assessed by the chi-square test. The crossover study data were analyzed for the assessment of type of cigarette and time of measurement, by performing a split-plot analysis of variance (ANOVA). Pairwise comparisons were corrected by *t*-test for paired data. A value of $p < 0.05$ was considered statistically significant. All analyses were carried out with SPSS V.18.0.	sCD40L(ng/ml) After T-cigarette Nonsmokers (3.8 ±0.9) Smokers (3.3 ±1.0) After E-cigarette Nonsmokers (3.2 ±1.1) Smokers (2.7 ±0.56) sP-selectin(ng/ml) After T-cigarette Nonsmokers(10.6 ±2.0) Smokers(9.3 ±2.7) After E-cigarette Nonsmokers(7.8± 2) Smokers(7.0 ±2.7) Platelet aggregation (%) After T-cigarette Nonsmokers(93 ±7) Smokers(79 ±8.7) After E-cigarette Nonsmokers(71 ±18) Smoker(73 ±8.7)	Baseline characteristics were similar in smokers and nonsmokers although smokers had higher baseline levels of sCD40L and sP-selectin markers than nonsmokers. After having smoked/vaped either a T-cigs or an E-cig, significant changes in the levels of sCD40L, sP-selectin and platelet aggregation (all p 0.01) were detected in both smokers and nonsmokers. In nonsmokers, there was significant difference in platelet aggregation ($p < 0.001$), sCD40L ($p = 0.007$) and sP-selectin ($p = 0.007$) from the ANOVA performed on crossover study data	In smokers and nonsmokers without cardiovascular disease, use of both products leads to an increase in platelet activation. The effect of E-cigarettes in smokers showed a less detrimental impact than T-cigarettes but only for platelet aggregation.	Limitations: Did not systematically record the occurrence of adverse events during smoking. The study was not based on a randomization list in order to reduce the variability of markers of platelet function. Operators that performed laboratory analyses were blinded to subject assignment. Level II (lacks randomization to groups)

BP = Blood pressure; CV = Cardiovascular; DV= dependent variable; IV= independent variables; CV= Controlled variable; sCD40L = Soluble CD40L an 18-KDa trimer that is shed by activated T lymphocytes and platelets; sP-selectin = cell adhesion molecule that is expressed on activated endothelial cells, and is thus part of the atherosclerosis process in the body; NR= Not recorded

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement And Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
St-Helen et al,[24] 2016	Pilot project: consisted of a standardized e-cigarette session Purpose: To measure the systemic retention of nicotine (PG), and (VG) in e-cigarette users, and assess the abuse liability of e-cigarettes by characterizing nicotine pharmacokinetics and assess the potential abuse liability of e-cigarettes by characterizing nicotine pharmacokinetics in experienced users Exclusion criteria: pregnancy, use of nicotine metabolism altering medications, user of zero- nicotine e-cigarettes, chronic diseases, and active substance abuse or dependence	*N* = 13 (6 females, 7 males) Setting: Clinical Research Center at the San Francisco General Hospital Inclusion criteria: Exclusive e-cigarette users or dual users ≤ 5 tobacco cigarettes per day, who used e-cigarettes at least once daily for 3 months or more, and had saliva cotinine levels ≥30 ng/mL were eligible. Attrition: NR	CV1: Number and time interval between puffs DV1: Plasma nicotine concentrations DV2: PG & VG concentrations DV3: MNWS DV4: QSU-Brief DV5: PANAS IV1: E-cigs users IV2: E-cigs & E-liquid	Measurements • Plasma nicotine concentrations • PG & VG concentrations Questionaries • MNWS • QSU-Brief • PANAS The amount of nicotine, VG, and PG delivered (mg) were estimated as the amount of e-liquid vaped (mg) × the concentration of nicotine, VG, and PG in the e-liquid, respectively. Changes in individual items and overall scores for MNWS, QSU, and PANAS were assessed using paired *t*-test. All analyses were carried out using SAS v. 9.4. Statistical tests were considered significant at $\alpha < 0.05$.	Average saliva cotinine levels at screening was 212 ng/mL and did not differ between self-reported exclusive e-cigarette users (217 ng/mL) and dual electronic and tobacco cigarette users (199 ng/mL) ($p = 0.79$) 1.3 mg of nicotine (median 1.4, range 0.4–2.6 mg) was delivered in 169 mg of vaped e-liquid (median 210 mg, range 46–463 mg) from 15 puffs. An average of 93.8% (median 99.6%, range 49.0–99.9%) or 1.2 mg of nicotine (median 1.1 mg, range 0.4– 2.4 mg) was systemically retained.	E-cigarettes delivered an average of 1.3 mg (range 0.4 to 2.6 mg) of nicotine from 15 puffs, similar to or higher than average reported yields of 0.5 to 1.5 mg nicotine per tobacco cigarette. Systemic retention of nicotine from e-cigarettes is high, averaging 94%, resulting in uptake of about 1.2 mg (0.4 to 2.4 mg) of nicotine from 15 puffs. Data shows VG and PG are also highly retained in the body, averaging 84% and 92%, respectively	E-cigarettes can be highly efficient as nicotine delivery devices, delivering levels of nicotine comparable to or higher than tobacco cigarettes with similar high levels of systemic retention	**Limitations:** Small sample size. Lack of randomization of sample group. Little control over puff duration and selected brand of e-cig utilized by each test individual leading to poor replicability of the study. Participants varied by age, BMI, smoking status, and typical e-cigarette use, which could have influenced the variability in nicotine uptake and PK Level III (quasi-experimental)

PG = propylene glycol; VG = vegetable glycerin; NR= Not recorded; DV= dependent variable; IV= independent variables; CV= Controlled variable; MNWS= The Minnesota Nicotine Withdrawal Scale; QSU-Brief= Questionnaire for Smoking Urges; PANAS= Positive and Negative Affect Scales; PK= pharmacokinetics

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Chaumont et al,[19] 2020	RCT: Randomized, investigator-blinded, 3-period crossover study Purpose: To assess the acute effects of vaping and their reversibility on biological/clinical cardiorespiratory parameters (serum/urine pneumoproteins, hemodynamic parameters, LFTs and diffusing capacities, transcutaneous gas tensions) Exclusion criteria: 1) No acute or chronic illness; 2) no past or present symptoms of cardiopulmonary disease; 3) no medication use; and 4) no hypertension as defined by clinical guidelines	*N* = 30 (30 Males, mean age 38 ± 2yr) Regular and exclusive e-cigarettes users since 38 ± 3mo Setting: Lab – Erasme University Hospital, Brussels, Belgium Attrition: NR	DV1: Serum/urine pneumoproteins (CC16) DV2: Hemodynamic parameters (SBP/DBP/HR) DV3: LFTs & Diffusing capacities (DLCO & DLNO) DV4: Transcutaneous gas tensions (TcpO2 TcpCO2) IV1: E-cigs w/ nicotine (Acute nicotine vaping session) IV2: E-cigs w/o nicotine (Acute nicotine free vaping session) IV3: Acute sham-vaping CV1: Number and duration of puffs CV2: Time interval between puffs CV4: Time interval between sessions CV5: Setting and temperature	Measurements • Serum/urine pneumoproteins, • Hemodynamic parameters, • LFTs & Diffusing capacities, • Transcutaneous gas tensions Data were tested for normality using the Kolmogorov–Smirnov test. The Bonferroni–Holm method was used to counteract the problem of multiple comparisons. Correlation analyses used the Pearson's correlation coefficient. The R-software was used, with statistical significance set at 0.05.	Nicotine Session • TcpO2↓10min after vaping (–4.1 ±1.1 vs. +1.4 ±0.8mmHg; p = 0.016) •SBP↑ 5 ±1 to 13 ±2 mmHg (p < 0.001) DBP↑from 4 ±1 to 8 ±1mmHg (p > 0.001) •Serum CC16 7.6 [6.1–9.4] mcg/L; p = 0.011 Nicotine-Free •TcpO2↓10min after vaping (–3.7 ±0.8 vs. +1.4 ±0.8 mmHg, p = 0.039) •Serum CC16 6.5 [5.2–9.4] mcg/L; p = 0.004 Stop-Session •↑FEF-25% vs nicotine-free session (2.5 [0.7– 3.2] vs. 2.0 [0.6–2.7] L/s; p = 0.001) •Serum CC16 8.1 [6.8–10.3] mcg/L	E-cig cessation decreases baseline heart rate and lung inflammation and increases FEF-25%, suggesting that high-wattage vaping alters airway function. The increase in serum CC16 suggests that vaping triggers inflammation in the small airways. Short-term vaping cessation seemed to improve the lung's inflammation profile.	Short-term e-cigarette cessation in regular users decreases baseline HR and increases CC16 and FEF-25%, suggesting a slight improvement of airway status. Five days of vaping cessation also modified the urine metabolomic signature. Acute nicotine and nicotine-free vaping decreased TcpO2, likely as a result of transient lung gas exchange disturbances.	**Limitations** Did not monitor vaping conditions during the 5 days before the experimental sessions. Study enrolled only male participants; the results should be replicated in female participants. All participants were former tobacco smokers, baseline SpO2, DLCO, and DLNO were abnormally low relative to age. Level I – Good quality

NR= Not recorded; DV= dependent variable; IV= independent variables; CV= controlled variables; Sham vaping (same procedure with e-cigarette turned off); TcpO2= transcutaneous O2; TcpCO2= carbon dioxide tensions; LFTs= lung function test; SBP systolic blood pressure, DBP diastolic blood pressure, HR heart rate; DLCO= diffusing capacities for carbon monoxide; DLNO= diffusing capacities for nitric oxide; CC16= club cell protein 16 (major lung anti-inflammatory protein); SpO2= pulse oximetry; FEF25%= Forced expiratory flow at 25% of the pulmonary volume

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Wu et al,[21] 2014	Controlled clinical trial/experiment without randomization Purpose: To examine the effects of e-liquid on the production of IL-6, HRV infection and the expression of host defense molecules (e.g., SPLUNC1) in primary human airway epithelial cells from young healthy non-smokers.	*N* = 15 (5 – Normal hTBE cells from tracheas and bronchi of young healthy non-smokers) (5 – SPLUNC1 deficient mice) (5 – Control mice) Setting: Lab - Department of Medicine, National Jewish Health, Denver, Colorado Attrition: NR	DV1: IL-6 protein DV2: SPLUNC1 DV3: HRV RNA DV4: LDH IV1: Nicotine-free e-liquid IV2: Nicotine e-liquid IV3: HRV-16 IV4: HVR-1B CV1: hTBE cells CV2: Culture dishes with BEGM	Measurements • LDH • IL-6 protein • human SPLUNC1 • HRV RNA Data are presented as means ±SEM. One-way analysis of variance (ANOVA) was used for multiple comparisons, and a Tukey's post hoc test was applied where appropriate. Student's *t*-test was used when only 2 groups were compared. A *p* value < 0.05 was considered significant.	• Exposure to e-liquid without nicotine increased IL-6 protein levels in a dose-dependent manner at both 24 and 48 h. • Cells exposed to tobacco-flavored e-liquid (w/o or w/ nicotine) had higher levels of HRV load than unexposed cells at both 6 and 24h. • SPLUNC1 deficient mice had significantly higher HRV loads in lung tissue than the control mice. •Compared with medium controls, SPLUNC1 mRNA expression was significantly reduced by e-liquid without nicotine and with nicotine	E-liquid induces IL-6 production in primary human airway epithelial cells. E-liquid promotes HRV infection in primary human airway epithelial cells. E-liquid inhibits the expression of SPLUNC1, a host defense molecule against HRV infection	Study has provided strong data suggesting the deleterious health effects of e-cigarettes on the lung, with a particular focus on airway epithelial inflammation and innate immunity in young people. The data suggest that even nicotine-free e-liquid promotes pro-inflammatory response and HRV infection. Moreover, both e- liquid without nicotine and with nicotine inhibits lung innate immunity that is involved in lung defense against HRV infection.	**Limitations** Did not examine the signaling pathways underlying IL-6 up- regulation by e-liquid treatment Did not examine the effects of e-cigarette vapor with various flavors and nicotine strengths on epithelial functions in the absence or presence of HRV infection Level II – Good quality

NR= Not recorded; DV= dependent variable; IV= independent variables; CV= controlled variables; HVR= Human rhinovirus; IL-6= interleukin pro-inflammatory cytokine; SPLUNC1= short palate, lung, and nasal epithelium clone 1; LDH= lactate dehydrogenase; hTBE= normal human tracheobronchial epithelial cells; BEGM= bronchial epithelial cell growth medium

Citation	Design/Method	Sample/Setting	Major Variables Studied and Their Definitions	Measurement and Data Analysis	Findings	Results	Conclusions	Appraisal: Worth to Practice/Level
Garcia-Arcos et al,[20] 2016	Controlled clinical trial/experiment without randomization Purpose: To study investigated the effects of exposure to aerosolized nicotine-free and nicotine-containing e-cigarette fluid on mouse lungs and normal human airway epithelial cells	N = 15 (*Vitro*) (5 female, 10 male) healthy non-smokers Aged 25-58y/o N = 30 (*Vivo*) (A/J mice) Setting: Lab Attrition: NR	DV1: Plasma nicotine level DV2: LDH DV3: p-PKCα DV4: ERK DV5: CFTR function IV1: Nicotine-free e-liquid IV2: Nicotine e-liquid IV3: PBS aerosol CV1: hTBE cells CV2: A/J mice exposure length & intervals	Measurements ***In vivo*** • Plasma nicotine levels • Histological analysis • Cell viability analysis • Immunoblot analysis Measurements ***In vitro*** • ATP-stimulated K+ ion conductance • IL-6 protein • Mucociliary clearance • Percent of ciliated surface F-tests, D'Agostino-Pearson Omnibus normality tests, non-parametric Friedman test and Student's *t*-test were performed on all data sets. One-way analysis of variance was used for comparisons of more than two groups followed by a post-hoc test for linear trend analysis on human cell samples. Data are represented as dot plots with a line denoting the mean and bars denoting the SEM. GraphPad Prism Software was used for all data analysis and graphical representations.	• The FEF_{50}/FVC ratio was significantly reduced from 23±1.2 in mice exposed to nicotine-free e-cigarette fluids to 15±1.5 in mice exposed to e-cigarettes containing 18 mg/mL nicotine (average±SEM; $p < 0.01$) • BALF cells increased from 130 000±27 000 cells/mouse in the mice exposed to nicotine-free e-cigarette fluids to 280 000±41 000 cells/mouse in the mice exposed to nicotine-containing e-cigarette fluids ($p < 0.01$; mean±SEM) • Nicotine-containing e-cigarette vapours had significantly reduced CBF 8hr after exposure (5.2±0.5 Hz vs 2.6±1 Hz; $p = 0.01$; $p < 0.05$)	Inhalation of nicotine-containing e-cigarettes increased airway hyperreactivity, distal airspace enlargement, mucin production, cytokine, and protease expression (patho-genesis and progression of COPD). NHBE cells exposed to nicotine-containing e-cigarette vapor showed impaired ciliary beat frequency, and airway surface liquid volume. Exposure of NHBE cells to nicotine for 5 days increased IL6 secretion. Inhalation of nicotine in e-cigarette fluids activates PKCα/ERK signaling in the lung.	Exposure to inhaled nicotine-containing e-cigarette fluids triggered effects normally associated with the development of COPD including cytokine expression, airway hyperreactivity and lung tissue destruction. These effects were nicotine-dependent both in the mouse lung and in human airway cells. Thus, these findings highlight the potential dangers of nicotine inhalation during e-cigarette use.	Limitations: This study looked at only the short-term effects of nicotine-free and nicotine containing e-cigarettes; thus, future research is necessary to study and understand the chronic long-term effects of these devices. Level II – Good quality

DV= dependent variable; IV= independent variables; CV= controlled variables; IL-6= interleukin pro-inflammatory cytokine; NHBE= Normal human bronchial epithelial cells; PBS= phosphate-buffered saline; LDH= lactate dehydrogenase; ERK= phosphorylated extracellular regulated kinase; p-PKCα= phosphorylated protein kinase Cα; CFTR= Cystic fibrosis transmembrane regulator function; FVC= functional vital capacity; FEF_{50}= Forced expiratory flow at 50% of FVC; BALF= bronchoalveolar lavage fluid; CBF= ciliary beat frequency

PURPOSE AND OBJECTIVES

PICO Question

In practicing anesthesia providers, does an educational module on the deleterious effects of electronic cigarette use enhance the assessment and anesthetic management of patients with a vaping history?

Population (P): Anesthesia providers

Intervention (I): Educational module on the effects of electronic cigarette use

Comparison (C): No educational module

Outcomes (O): Enhanced anesthetic assessment and management

DNP Project Goal

The primary goal of this Doctor of Nursing Practice (DNP) project was to improve the knowledge of the deleterious effects of ECs use among anesthesia providers and develop a focused preoperative assessment for adequate surgical risk stratification and enhanced anesthetic management of patients with a history of vaping.

Goals and Outcomes

SMART Goals

Projects without well-formulated goals lack foundation, applicability, and focus. Therefore, a crucial element for the practical completion of a scholarly project is to formulate objectives and outcomes that are specific, measurable, attainable, relevant, and time-bound (SMART).

Specific. The main objective of this scholarly project is to develop an educational module to assess and improve the knowledge gap of the systemic effects of ECs use among anesthesia

providers. Moreover, implement a focused pre-operative assessment for adequate identification and perioperative anesthetic management for patients with a vaping history. By developing a pre-educational assessment tool utilizing a Qualtrics anonymous survey, every participant can be assessed for a knowledge gap on ECs usage and sequela. Using this data, the author developed an educational module based on scholarly articles to present to anesthesia providers to fill the knowledge gap on the subject. Following the educational presentation, the author administered a post-educational assessment to determine whether or not there were improvements in the anesthesia providers' knowledge base and attitudes regarding the use of electronic cigarettes. Lastly, the author introduced a modified or focused preoperative assessment to enhance the anesthetic management of patients who utilize electronic cigarettes.

Measurable. Projects without measurable goals cannot meet benchmarks of completion. For this quality improvement (QI) project, implementing a pre- and post-educational module survey can quantify the percentage of improved knowledge after the intervention. For the target audience of anesthetists, an overall 50% improvement in the knowledge gap was an acceptable benchmark to meet for project outcomes. In addition, a focused pre-operative assessment could be implemented via the facility's electronic health record (EHR) Epic by adding survey questions to the pre-anesthetic assessment.

Attainable. The project's goals and outcomes are very attainable, as they require minimal resources for achievement. The objectives are realistic and lack complexity granting the project a higher success rate from a conceptual perspective. There are obstacles to the effective execution of QI initiatives. Management, staff development and skills, insufficient resources, corporate culture, and general reluctance to change are major themes that impede the success rate of quality improvement initiatives.[33]

Relevant . The DNP project highlighted the detrimental effects of vaping and emphasized the importance of adequate comprehension of the systemic changes that occur due to its effects on appropriate anesthetic management. Compelling evidence points to a meteoric rise in e-cigarette usage throughout the U. S., particularly among young people.[14] According to statistics from Mirbolouk et al., 1 in 20 Americans has tried electronic cigarettes.[15] Presently, 3.6 million teenagers and 10.8 million adults use ECs, with a proliferation of utilization increasing from 0.6% in 2011, reaching 11.3% in 2017, and from 2.4% to 6% in adolescents and adults, respectively.[11,13] The topic is highly relevant to anesthesia practice as statistical trends only point to increased use of EVDS products.

Time-Bound. Completion and achievement of the DNP project goals and outcomes were sequential, as the project was divided into 3 DNP courses. Course instructors and clinical liaisons had to approve the project entirely. Once approved, the pre- and post-education module surveys were executed in 2 weeks each. The educational module was implemented over 1 month to allow for maximum staff participation.

CONCEPTUAL UNDERPINNING/THEORETICAL FRAMEWORK

SWOT Analysis

The objective of a SWOT analysis is to evaluate institutional strengths, weaknesses, improvement opportunities, and possible threats that may jeopardize the project's success.

Strengths

The anesthesia team at the QI project immersion site consist of veteran attending anesthesiologists, anesthesia residents, skilled certified registered nurse anesthetist (CRNAs), and resident nurse anesthetist (RNAs). The diverse structure of the team was a strength as it incorporated the skills and expert knowledge of attendings and CRNAs and open-mindedness

and readiness for change implementation of anesthesia residents and RNAs. The willingness to update current practices based on revised evidence-based guidelines is pivotal for QI success. The anesthesia group is not unfamiliar with academic work since it holds a scholastic association with all local nurse anesthesia university programs. Additionally, the institution maintains a certified affiliation with Columbia University.

Weaknesses

A noted weakness at this immersion site is that it had a predominant geriatric patient population. For this specific project, the literature shows that most of the at-risk population are adolescents and adults with ages ranging from teenage years to individuals in their mid-30s to 40s.[11,13-15] Consequently, stakeholders involved in the project might not perceive the need to implement a QI plan. An additional weakness was the relatively small size of the institution and the volume of patients it caters to monthly.

Opportunities

The DNP project brings forth the opportunity to address a growing global problem. Currently, there are no standardized guidelines for the anesthetic management of patients with a vaping history. The facility and its anesthesia staff could be pioneers in this novel challenge by piloting a proper preoperative risk stratification method for this patient population. In addition, an enhanced assessment can help identify organ system dysfunction and mitigate possible intra- and post-operative complications.

Threats

The most noticeable institutional threats are time constraints, mediocre allocated recourses, and inadequate staffing. Inadequate staffing could be a significant hindering factor to the development and implementation of the DNP project. In order to properly educate all

anesthesia staff, some time away from the clinical setting must be approved. There were not enough staff members to cover for employees engaged in educational modules. One possible solution could be home educational modules, but without the incentive of pay, some anesthetists might not participate because they would be forfeiting some of their free time.

METHODOLOGY

Setting and Participants

The clinical site chosen for this project was a small community hospital in Miami Beach, Florida, with 597 licensed clinical beds. Currently, no specific preoperative assessment exists for adequate risk stratification for patients with a history of ECs usage. The primary participants for this scholarly project were anesthesiologists, CRNAs, anesthesia residents, and RNAs.

Description of Approach and Project Procedures

There are various challenges to properly executing a QI project. Some challenges could be attaining internal approval for the change, ensuring effective oversight, and combining with existing programs.[34] Additional challenges could emerge without a supportive organizational culture, maintaining momentum while changing, and documenting and positively publicizing the outcomes of the change.[34] Participative leadership was essential for obtaining employee involvement for the DNP project. Balancing constrained organizational resources and conflicting day-to-day operational activities might cause organizational leaders to ignore the significance of the initiative.

The principal methodology of the project was to administer an electronic educational module to anesthesia providers that focus on improving the knowledge of the harmful effects of ECs use and promoting an enhanced assessment and anesthetic management of patients with a history of vaping. All phases of the educational module can be completed using a computer,

tablet, or smartphone. The project was implemented in the first phase by conducting an online pretest to gauge baseline knowledge and attitudes on the subject. The second phase was comprised of a voiceover PowerPoint presentation as the primary means of learning that includes essential information regarding ECs use, its related physical alterations in different body systems, and the anesthesia implications and related management for patients with a history of vaping. The project's third phase involved a posttest to evaluate knowledge gained and any changes in anesthesia provider attitudes about the subject presented. The results provided feedback regarding the impact of the educational intervention and how the attained knowledge positively changed anesthesia provider attitudes.

Protection of Human Subjects

Prior to the launch of the educational module, project approval was required by the Institutional Review Board (IRB) of Florida International University (FIU). The QI project was exempt from IRB approval of the use of human subjects (**Appendix A** displays Review Board approval). All participants were contacted and recruited via email. Participation was strictly anonymous and entirely optional. No anesthesia providers' personal identifiers were collected or stored. Prior to participation, every subject signed an informed consent. All questionnaire answers for the pre- and post-educational module remained anonymous, protecting the privacy of each participant. No injury, threat, or distress was foreseen to be experienced from participation in the project.

Data Collection

Data collected about the educational module's effectiveness were analyzed from the survey results. The initial pre-educational survey, implemented via Qualtrics, can provide a knowledge baseline that can then be used as a comparison for improvement against the results of

the post-educational survey. Survey participants were asked about their willingness to implement an enhanced preoperative assessment tailored for patients with a history of vaping. The survey provided a measurable value of the total of anesthetists willing to implement change. Additional gathered data comprised the following: participant's age, gender, ethnic background, level of education, and years of clinical practice. The gathered data were confidential, and no personal identifiers were documented throughout any section of the QI project.

Data Management and Analysis Plan

The individual responsible for leading the project was the Doctor of Nursing Practice (DNP) student, who oversaw the administration of the surveys. The information gathered was securely archived in a password-controlled database called Qualtrics, which was only accessible to the principal investigator and the DNP project supervisor. In order to ensure the preservation of confidentiality, participants' personal identifiers were not documented. The effectiveness of the intervention's effects were assessed by conducting a statistical examination to compare the responses obtained in the pretest and posttest assessments.

RESULTS

Pretest Demographics

The pretest demographics are illustrated in ***Table 2***, shown below.

Table 2. Participant Demographics

Demographics	**n(%)**
Total Participants	9 (100%)
Gender	
Female	7 (77.78%)
Male	2 (22.22%)

Age	
18 – 25	0 (0%)
26 – 35	3 (33.33%)
36 – 50	3 (33.33%)
51 – 75	3 (33.33%)
Ethnicity	
White	2 (22.22%)
Black/African American	1 (11.11%)
Hispanic	6 (66.66%)
Asian	0 (0%)
Position/Title	
Resident	0 (0%)
CRNA	9 (100%)
Anesthesiologist	0 (0%)
Highest Level of Education	
Bachelor's	0 (0%)
Master's	3 (33.33%)
Doctorate/PhD	6 (66.67%)
Years of Practice	
1 – 2 years	1 (11.11%)
2 – 5 years	3 (33.33%)
5 – 10 years	1 (11.11%)
Over 10 years	4 (44.44%)

Nine (n = 9) total participants consented to partake in the educational module with 100% completion of the pretest and posttest questionnaire. Most participants were female (n = 7,

77.78%), as opposed to male (*n* = 2, 22.22%). The racial background of each participant was recorded with a diverse representation of various ethnicities. The range of ethnicities represented included: White (*n* = 2, 22.22%), Black/African American (*n* = 1, 11.11%), and Hispanic (*n* = 6, 66.66%). Data were collected regarding the participant's position/title, and the results recorded revealed that all participants were certified registered nurse anesthetists (CRNAs) (*n* = 9, 100%). The participants were asked about the length of time practicing, concluding that the practice period ranged: 1 – 2 years (*n* = 1, 11.11%), 2 – 5 years (*n* = 3, 33.33%), 5 – 10 years (*n* = 1, 11.11%), and over 10 years (*n* = 4, 44.44%). Participant's age was also tallied, revealing that all participants were over the age of 25 years old, 26 – 35 years old (*n* = 3, 33.33%), 36 – 50 years old (*n* = 3, 33.33%), and 51 – 75 years old (*n* = 3, 33.33%).

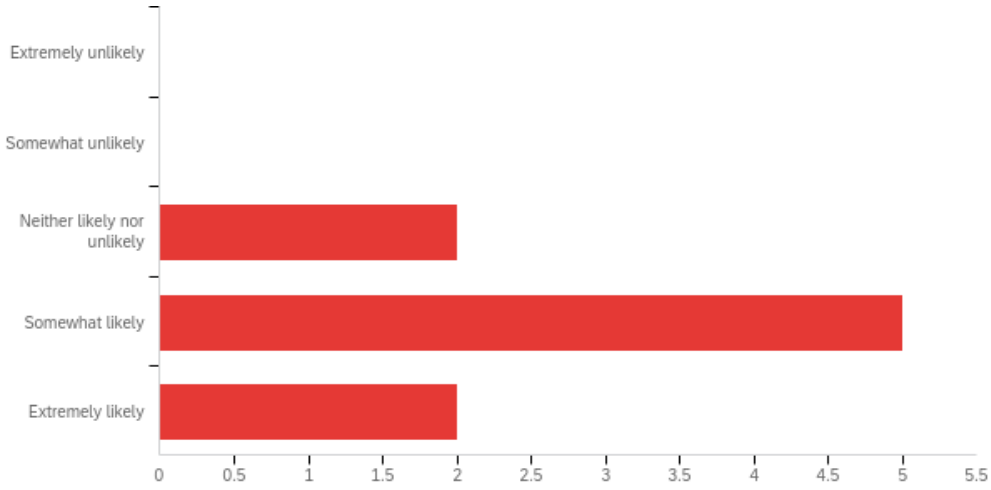
Pretest: Assessment of Baseline Knowledge

Before implementing the educational video module, the participants were asked a series of questions to assess their current knowledge and understanding of electronic cigarettes (ECs) and the physiological sequela associated with their use. Eight participants (*n* = 8, 88.89%) were able to distinguish 2 of the 3 main active ingredients in ECs (nicotine and propylene glycol – PG), with 3 participants (*n* = 3, 33.33%) identifying the third main active ingredient (vegetable glycerin – VG). A sum of 4 participants (*n* = 4, 44.44%) erroneously selected alcohol as an active ingredient in ECs. When questioned about what ventilatory complications are associated with ECs usage, 9 participants (*n* = 9, 100%) appropriately chose bronchospasm, and 5 participants (n=5, 55.55%) chose laryngospasm. Contrarily, 1 participant (*n* = 1, 11.11%) incorrectly chose increased work of breathing as an answer.

There is a direct correlation between ECs usage and the development of e-cigarette or vaping, product usage-related lung injury (EVALI). When questioned about which respiratory

alterations occur in this patient population, 2 participants (*n* = 2, 22.22%) accurately selected widespread alveoli effusion, and 5 participants (*n* = 5, 55.55%) selected pneumonia with bronchiectasis. In contrast, 6 participants (*n* = 6, 66.66%) improperly selected increased secretions, and 4 (*n* = 4, 44.44%) wrongfully selected cough. Toluene is generated as a byproduct of ECs aerosol and possesses several of the same properties as various anesthetic agents. When questioned about which anesthetic agents possessed similar properties to toluene, 4 participants (*n* = 4, 44.44%) properly selected benzodiazepines, 8 (*n* = 8, 88.89%) rightly chose ketamine, 7 (*n* = 7, 77.78%) correctly selected volatile anesthetic agents, and 4 (*n* = 4, 44.44%) inaccurately selected etomidate. Lastly, when asked how likely they were to implement an enhanced respiratory preoperative assessment for patients with a chronic vaping history, two respondents (*n* = 2, 22.22%) stated "neither likely nor unlikely," five (*n* = 5, 55.56%) said "somewhat likely," and two (*n* = 2, 22.22%) indicated "extremely likely." Figure 2 illustrates the number of responses to the likeliness of executing an enhanced respiratory pre-operative assessment.

Figure 2. Pretest Likeness of Implementing an Enhanced Pre-Op Assessment



Posttest: Assessment of Learning

A posttest was administered following the presentation of the PowerPoint educational module to assess the knowledge gained by the participants. The posttest intervention questionnaire consisted of the same questions found in the pretest. Results assessed the knowledge gained from the educational intervention module and are listed below (Table 3). Most questions validated an increase in the number of correct answers when the pretest and posttest interventions were compared. Of significant value is the increase of provider knowledge in the questions regarding the main active components of ECs, the respiratory alterations that occur due to EVALI, and which anesthetic agents possessed similar properties to toluene. Similarly, there was a rise in the number of pretest providers (n = 2, 22.23%) to posttest providers (n = 6, 66.67%) that stated "extremely likely" to implement an enhanced preoperative assessment. Figure 3 represents the posttest values.

Figure 3. Posttest Likeness of Implementing an Enhanced Pre-Op Assessment

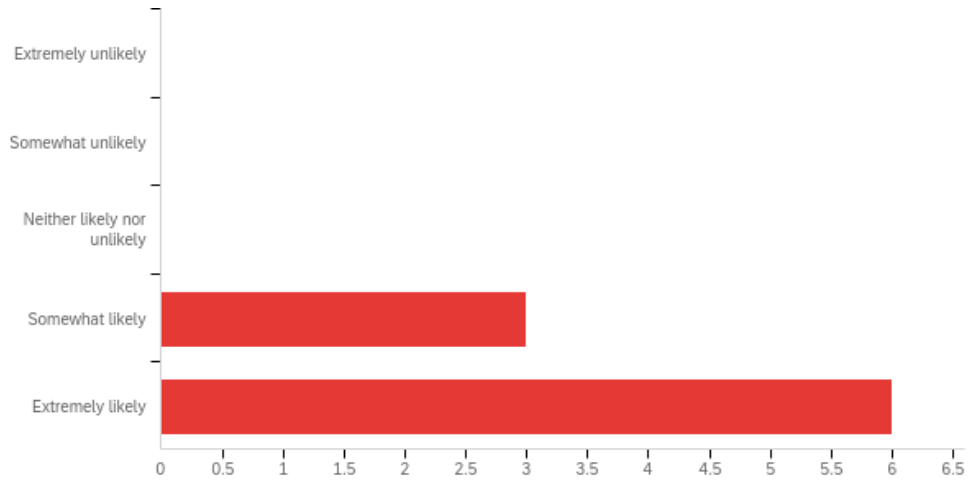


Table 3. Pre- and Posttest Responses

Question (10)	Pretest	Posttest	Difference
1. The main active ingredients in electronic cigarettes (ECs) are: (Select 3)			
a. Nicotine	n=8, 88.89%	n=9, 100%	+ 11.11%
b. Propylene glycol (PG)	n=8, 88.89%	n=9, 100%	+ 11.11%
c. Vegetable glycerin (VG)	n=3, 33.33%	n=9, 100%	+ 67.67%
d. Alcohol	n=4, 44.44%	n=0, 0.00%	- 44.44%
Correct Answer: A, B, C			
2. ECs use can compromise cellular oxygenation and _____ the risk of surgical site infection, necrosis, and _____ tissue regeneration.			
	n=9, 100%	n=9, 100%	0.00%
a. Increase & Prolong	n=0, 0.00%	n=0, 0.00%	0.00%
b. Decrease & Prolong	n=0, 0.00%	n=0, 0.00%	0.00%
c. Increase & Increase	n=0, 0.00%	n=0, 0.00%	0.00%
d. Decrease & Decrease			
Correct Answer: A			
3. Some electronic vapor delivery systems (EVDS) products possess greater nicotine concentrations than conventional cigarettes. (True or False)			
True	n=9, 100%	n=9, 100%	0.00%
False	n=0, 0.00%	n=0, 0.00%	0.00%
Correct: True			
4. What ventilatory complications are associated with ECs usage: (Select 2)			
a. Laryngospasm	n=5, 55.55%	n=9, 100%	+ 44.45%
b. Bronchospasm	n=9, 100%	n=9, 100%	0.00%
c. Fatigue	n=0, 0.00%	n=0, 0.00%	0.00%
d. Increased WOB	n=1, 11.11%	n=0, 0.00%	- 11.11%
Correct: A, B			
5. Electronic cigarettes have evolved into a significant social trend. (True or False)			

True	n=9, 100%	n=9, 100%	0.00%
False	n=0, 0.00%	n=0, 0.00%	0.00%

Correct: True

6. Exposure to ECs aerosols for an extended period can lead to the development of COPD symptoms. (True or False)

True	n=9, 100%	n=9, 100%	0.00%
False	n=0, 0.00%	n=0, 0.00%	0.00%

Correct: True

7. There is a direct correlation between ECs usage and the development of e-cigarette or vaping, product usage-related lung injury (EVALI). What respiratory alterations occur in these patients? (Select 2)

a. Widespread alveoli effusion	n=2, 22.22%	n=8, 88.89%	+ 66.67%
b. Pneumonia with bronchiectasis	n=5, 55.55%	n=9, 100%	+ 45.45%
c. Increased secretions	n=6, 66.66%	n=1, 11.11%	- 55.55%
d. Cough	n=4, 44.44%	n=0, 0.00%	- 44.44%

Correct: A, B

8. Toluene, a volatile organic contaminant (VOC), is generated as a byproduct of ECs aerosol and possesses several of the same properties as: (Select 3)

a. Benzodiazepines	n=4, 44.44%	n=9, 100%	+ 55.56%
b. Ketamine	n=8, 88.89%	n=9, 100%	+ 11.11%
c. VAA	n=7, 77.78%	n=8, 88.89%	+ 11.11%
d. Etomidate	n=4, 44.44%	n=1, 11.11%	- 33.33%

Correct: A, B, C

9. A greater dosage of vecuronium and rocuronium may be necessary to achieve therapeutic concentrations during induction and maintenance of anesthesia for patients with a long-term history of vaping. (True or False)

True	n=8, 88.89%	n=9, 100%	+ 11.11%
False	n=1, 11.11%	n=0, 0.00%	- 11.11%

Correct: True

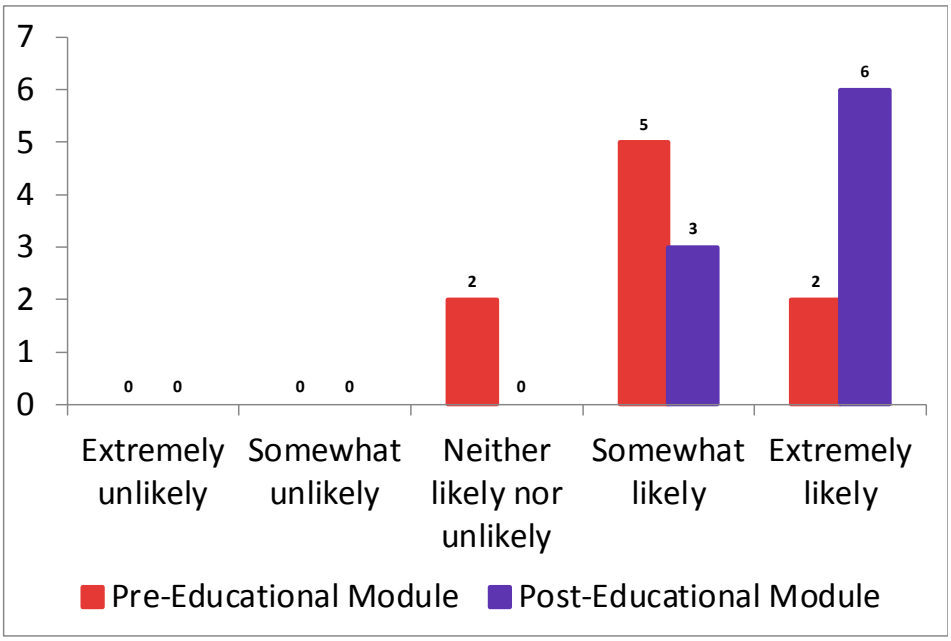
10. How likely are you to implement an enhanced respiratory pre-operative assessment for a patient with chronic vaping history?			
Extremely unlikely	n=0, 0.00%	n=0, 0.00%	0.00%
Somewhat unlikely	n=0, 0.00%	n=0, 0.00%	0.00%
Neither likely nor unlikely	n=2, 22.22%	n=0, 0.00%	- 22.22%
Somewhat likely	n=5, 55.56%	n=3, 33.33%	- 22.23%
Extremely likely	n=2, 22.22%	n=6, 66.67%	+ 44.45%

DISCUSSION

Summary of Data

The results indicated a statistical difference in the pretest and posttest following the educational module. The data exhibited a percentage increase in the providers' knowledge of the main active components of ECs and the ventilatory complications associated with ECs usage. Question 1 revealed an 11.11% increase in 2 of the correct answers and, most significantly, a 67.67% increase in the remaining right answer choice; it also showed a decrease of 44.44% in the incorrect answer choice. Question 4 displayed a 44.45% increase in 1 of the correct possible answers and an 11.11% decrease in the incorrect answer choice. Notably, Question 7 revealed a 66.67% and 45.45% increase in the right answer choices while revealing a 55.55% and 44.44% decrease in the selection of incorrect answers. Additionally, Question 8 displayed a significant increase in the selection of the 3 appropriate answer choices 11.11%, 11.11%, and 55.56%, respectively. One key outcome is the 44.45% increase in the number of providers extremely likely to implement an enhanced preoperative respiratory assessment for patients with a chronic vaping history. Figure 4 illustrates the statistical increase in pre- versus post-educational module response of providers willing to implement an enhanced anesthetic assessment.

Figure 4. Pre- vs. Posttest Likeness of Implementing an Enhanced Assessment



Limitations

This quality improvement (QI) project is not without limitations. One major limitation is the small sample size (n = 9) despite the more significant number of prospective participants (n = 44) invited to participate, yielding a response rate of only 20.45%. Another limitation is the lack of anesthesia provider diversity, as all participants (n = 9) were CRNAs. A larger, more diverse sample size would permit a more accurate exemplification of the preexistent knowledge of the use and physical alterations associated with ECs utilization and provide the project with more robust generalizability. It would also validate the efficacy of the educational module and intervention. Additional limitations of this QI project were the inclusion of a solitary hospital facility and the limited time frame (1 month) that participants were allotted for survey completion. Potential strategies to mitigate limitations are to focus on problems with recruitment, permit for expansion of participation to other sites, and extend the time to participate.

Implications to Advanced Nursing Practice

The collected results provided insightful data on anesthetists' knowledge and beliefs on EVDS use and this novel patient population. Equipped with data from the conducted literature search, the author provided and disseminated valuable evidence that can assist in proper surgical risk stratification and anesthetic management. A core goal in Advanced Nursing Practice is closing the knowledge gap between research and clinical practice. The author believes the QI project can achieve this goal, thus enhancing the safety and quality of care provided for patients presenting to surgery with a vaping history.

CONCLUSION

In conclusion, the QI project aimed to improve the knowledge of anesthesia providers regarding ECs usage and its related physical alteration, in addition to motivating anesthetists to implement a more focused preoperative assessment for this patient population. The author believes the data showed the QI project successfully increased anesthesia providers' knowledge and attitudes. There is a positive correlation between the knowledge gained and increased affirmative attitudes toward the implementation of change. The QI project shows the potential for delivering enhanced patient care due to the provision of evidence-backed data and the enrichment of knowledge.

Plan for Sustaining the Practice Change

Deficient motivation and inadequate communication are disadvantageous to the collaboration required for effectively completing the DNP project. Therefore, it is essential to communicate appropriately with leadership stakeholders to ensure they have the necessary knowledge required for the planning process and can help articulate the project's goals and advantages. Establishing a collegial partnership generates an atmosphere in which leadership

stakeholders are motivated to regard QI efforts as a crucial element of their day-to-day operational activities prioritizing. In addition, institutional stakeholders may be essential in assigning secured time and finances, effectively eliminating significant obstacles in establishing and implementing the project.

The DNP student may establish mentorship ties with senior stakeholders who are enthusiastic about the DNP project. In addition, the author might search for members of the anesthesia team who are receptive to the project's goals and can serve as advocates for project implementation and sustainability. Employee education and training are other crucial factors in developing and maintaining efficacious QI projects. Creating competencies and establishing training that assists others in recognizing the importance of the project may be used to combat a lack of understanding about the goal of the quality improvement initiative.

Quality improvement via the implementation of change is a vital step towards enriched patient care. Nevertheless, the QI project fails to provide long-term benefits without sustaining the practice change. Sustention of the practice change requires the involvement of multiple stakeholders. Anesthesia providers must be willing to carry out an enhanced pre-op assessment for the specific patient population on a daily basis. Information technology (IT) can launch a specific assessment tab under the respiratory system during the pre-op assessment tailored to further evaluate patients with a pertinent vaping history. Finally, the patients, the most critical factor, must be cooperative in providing non-omissive history regarding their vaping habits.

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APPENDIX

Appendix A – IRB Approval Letter

FIU | Research & Economic Development
FLORIDA INTERNATIONAL UNIVERSITY

MEMORANDUM

To: Dr. Valerie Diaz

CC: David Perez Mirabal

From: Carrie Bassols, BA, IRB Coordinator CeB

Date: March 6, 2023

Proposal Title: "Assessment and Anesthetic Management of Patients with Vaping History: An Evidence-Based Educational Module"

The Florida International University Office of Research Integrity has reviewed your research study for the use of human subjects and deemed it Exempt via the **Exempt Review** process.

IRB Protocol Exemption #: IRB-23-0090 **IRB Exemption Date:** 03/06/23
TOPAZ Reference #: 112819

As a requirement of IRB Exemption you are required to:

1) Submit an IRB Exempt Amendment Form for all proposed additions or changes in the procedures involving human subjects. All additions and changes must be reviewed and approved prior to implementation.
2) Promptly submit an IRB Exempt Event Report Form for every serious or unusual or unanticipated adverse event, problems with the rights or welfare of the human subjects, and/or deviations from the approved protocol.
1) Submit an IRB Exempt Project Completion Report Form when the study is finished or discontinued.

Special Conditions: N/A
For further information, you may visit the IRB website at http://research.fiu.edu/irb.

Appendix B – Support Letter from Faculty

Miami Beach Anesthesiology Associates, Inc.

Mount Sinai Medical Center • Division of Anesthesia

S. Howard Wittels MD
Chairman

Hector Davila MSS, MD
Executive Director

Guillermo Garcia MD
Vice Chairman

Sebastian Baquero MD

Christopher Bauer MD
Obstetrics Chief

Vicente Behrens MD

Mario Consuegra MD

Jayanand D'Mello MD
Research Coordinator

Laura Foster MD

Pablo Fumero MD

Pedro Garcia MD
Residency Program
Assist. Director

Howard Goldman MD

Alejandro Guzman MD

Rick Hasty MD

Flor Marin MD

Mark Nakajima MD

Gerald Rosen MD
Residency Program
Director

Jason Wigley MD

Alexander Volsky MD

J.P. Mato DNP, CRNA
CRNA Director & SRNA
Coordinator

Paula Schultz DNP, CRNA
OB-Chief CRNA

February 2, 2023

Valerie J. Diaz, DNP, CRNA, PMHNP-BC, APRN, CNE, CAPT, USN, NC
Assistant Professor
Department of Nurse Anesthetist Practice
Florida International University

Dr. Diaz

Thank you for inviting Miami Beach Anesthesiology Associates to participate in the Doctor of Nursing Practice (DNP) project conducted by David Perez Mirabal entitled *"Assessment & Anesthetic Management of Patients with Vaping History: An Evidence-Based Educational Module"* in the Nicole Wertheim College of Nursing and Health Sciences, Department of Nurse Anesthetist Practice at Florida International University. I have granted the student permission to conduct the project using our providers.

Evidence-based practice's primary aim is to yield the best outcomes for patients by selecting interventions supported by the evidence. This proposed quality improvement project seeks to investigate and synthesize the latest evidence to increase providers awareness regarding the risk and deleterious sequela related to electronic cigarette use.

We understand that participation in the study is voluntary and carries no overt risk. All Anesthesiology providers are free to participate or withdraw from the study at any time. The educational intervention will be conveyed by a 15-minute virtual PowerPoint presentation, with a pretest and posttest questionnaire delivered by a URL link electronically via Qualtrics, an online survey product. Responses to pretest and posttest surveys are not linked to any participant. The collected information is reported as an aggregate, and there is no monetary compensation for participation. All collected material will be kept confidential, stored in a password encrypted digital cloud, and only be accessible to the investigators of this study: David Perez Mirabal and Dr. Valerie Diaz.

Once the Institutional Review Board's approval is achieved, this scholarly project's execution will occur over two weeks. David Perez Mirabal will behave professionally, follow standards of care, and not impede hospital performance. We support the participation of our Anesthesiology providers in this project and look forward to working with you.

Respectfully,

Jampierre (J.P.) Mato, DNP, CRNA, APRN
Executive CRNA Director
SRNA Coordinator/Supervisor
Electronic Mail: Jampierre@bellsouth.net
Mobile Phone: 954-668-6080

4300 Alton Road, Suite 2454, Miami Beach, FL 33140
Office (305) 674-2742 • Facsimile (305) 674-9723

Appendix C – IRB Consent

Consent To Participate in A Quality Improvement Project

Summary Information

Things you should know about this study:

Purpose: Educational module to increase providers' awareness of the deleterious effects of electronic cigarette use.

Procedures: If the participant chooses to participate, they will be asked to complete a pretest, watch a voice PowerPoint, and then a posttest

Duration: This will take about a total of 20 minutes total.

Risks: There will be minimal risks involved with this project, as would be expected in any type of educational intervention, which may include mild emotional stress or mild physical discomfort from sitting on a chair for an extended period.

Benefits: The main benefit to you from this research is increase the participants knowledge on the deleterious effects of electronic cigarettes use.

Alternatives: There are no known alternatives available to the participant other than not taking part in this quality improvement project.

Participation: Taking part in this quality improvement project is voluntary.

Please carefully read the entire document before agreeing to participate.

Number of Study Participants:

If the participant decides to be in this study, they will be one of 15 people in this research study.

Purpose of the Project

The participant is being asked to be in a quality improvement project. The goal of this project is to increase providers' knowledge on the deleterious effects of electronic cigarette use

among anesthesia providers and develop a focused pre-operative assessment for adequate surgical risk stratification and enhanced anesthetic management of patients with a history of vaping. If you decide to participate, you will be 1 of approximately 15 participants.

Duration of the Project

The participation will require about 20 minutes.

Procedures

If the participant agrees to be in the project, PI will ask you to do the following things:

1. Complete an online 10 question pretest survey via Qualtrics, an Online survey product for which the URL link is provided
2. Review the educational PowerPoint Module lasting 15 minutes via Qualtrics, an Online survey product for which the URL link is provided.
3. Complete the online 10 question posttest survey via Qualtrics, an Online survey product for which the URL link is provided.

Risks and/or Discomforts

The main risk or discomfort from this research is minimal. There will be minimal risks involved with this project, as would be expected in any type of educational intervention, which may include mild emotional stress or mild physical discomfort from sitting on a chair for an extended period.

Benefits

The following benefits may be associated with participation in this project: An increased participants knowledge of the risk and deleterious sequela related to electronic cigarettes use and the ability to develop a focused pre-operative assessment for adequate surgical risk stratification and enhanced anesthetic management of patients with a history of

vaping. The overall objective of the program is to increase the providers' knowledge based on the current literature.

Alternatives

There are no known alternatives available to the participant other than not taking part in this project. However, if the participant would like to receive the educational material, it will be provided to them at no cost.

Confidentiality

The records of this project will be kept private and will be protected to the fullest extent provided by law. If, in any sort of report, PI might publish, it will not include any information that will make it possible to identify the participant. Records will be stored securely, and only the project team will have access to the records.

Participation: Taking part in this quality improvement project is voluntary.

Compensation & Costs

There is no cost or payment to the participant for receiving the health education and/or for participating in this project.

Right to Decline or Withdraw

The participation in this project is voluntary. The participant is free to participate in the project or withdraw the consent at any time during the project. The participant's withdrawal or lack of participation will not affect any benefits to which you are otherwise entitled. The investigator reserves the right to remove the participant without their consent at such time that they feel it is in their best interest.

Researcher Contact Information

If you have any questions about the purpose, procedures, or any other issues relating to this research project, you may contact David Perez, MSN, RN at (786)763-5745 or dpere526@fiu.edu, and Dr. Valerie J. Diaz, DNP, CRNA at 305-348-9027 or vdiaz@fiu.edu.

IRB Contact Information

If the participant would like to talk with someone about their rights pertaining to being a subject in this project or about ethical issues with this project, the participant may contact the FIU Office of Research Integrity by phone at 305-348-2494 or by email at ori@fiu.edu.

Participant Agreement

I have read the information in this consent form and agree to participate in this study. I have had a chance to ask any questions I have about this study, and they have been answered for me. By clicking on the "consent to participate" button below I am providing my informed consent.

Appendix D – IRB Waiver for QI Projects at MBAA

Miami Beach Anesthesiology Associates, Inc.

Mount Sinai Medical Center • Division of Anesthesia

S. Howard Wittels MD
Chairman

Hector Davila MSS, MD
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Jason Hoyos DO
Residency Program
Co-Assistant Director

Flor Marin MD

Gerald Rosen MD
Residency Program
Director

Jason Wigley MD
Residency Program
Co-Assistant Director

Alexander Voisky MD

Jennifer Wright MD

J.P. Mato DNP, CRNA
CRNA Director & SRNA
Coordinator

Paula Schultz DNP, CRNA
OB-Chief CRNA

March 7, 2023

Dr. Jorge Valdes, DNP, CRNA, APRN, FAANA
Chair, Associate Professor Department of Nurse
Anesthesiology Florida International University

Re: IRB Waivers for Quality Improvement Projects with Miami Beach Anesthesiology Associates

The following students have proposed some interdepartmental education modules. These quality improvement projects are internal projects belonging to Miami Beach Anesthesiology Associates. Internal review board approval is not necessary for our departmental improvement projects per Mount Sinai Medical Center's advocate, Yvonne Ortiz.

The projects will involve surveying anesthesia providers from Miami Beach Anesthesiology Associates at Mount Sinai Medical Center of Florida.

Then **educational modules** performed by the students will be included a pre-test, ZOOM recorded educational module with a post-test lasting less than 20 minutes.

The following projects have been proposed and approved by our educational department and deem these projects IRB exempt.

Disposable Laryngeal Electrodes for Intraoperative Neuromonitoring: An Educational Module- **Mercado-Hernandez, David**

Implementation of a Formal Preceptor Teaching Tool in the Clinical Setting to Promote a Learner-Centered Teaching Environment- **Lyndi Bailey**

Improving the incidence of Postoperative Delirium in the Elderly: A Quality Improvement Project- **Acevedo, Yalysher**

Assessment & Anesthetic Management of Patients with Vaping History: An Evidence-Based Educational Module-**Perez Mirabal, David**

Immunomodulation Effects of Propofol versus Sevoflurane based Anesthesia on Deadly Cancers: A quality improvement educational project- **Tatiana Amaya Rivera**

Advantages of intravenous administration of remimazolam over midazolam in inflammatory bowel disease patients undergoing endoscopic procedures: an educational module- **Alexis Perez**

Dexmedetomidine as an Adjuvant for Spinal Anesthesia in Adult Parturients Undergoing Cesarean Section: An Evidence-Based Educational Module-**Kueser, Kathleen**

4300 Alton Road, Suite 2454, Miami Beach, FL 33140
Office (305) 674-2742 • Facsimile (305) 674-9723

Appendix E – Pre and Posttest Questionnaire

Introduction

The primary aim of this QI project is to increase providers awareness of the deleterious effects of electronic cigarette use.

Please answer the question below to the best of your ability. The questions are either in multiple choice or true/false format and are meant to measure knowledge of the physiological changes that occur due to electronic cigarette use, and the impacts on anesthetic management.

Personal Information

1. **Gender:** Male Female Other_____
2. **Ages 25 and above: _____**
3. **Ethnicity:** Hispanic Caucasian African American Asian Other_____
4. **Position/Title:** CRNA Anesthesiologist Resident Anesthesiologist Assistant
5. **Level of Education:** Certificate Bachelors Masters DNP PhD
6. **How many years have you been a perioperative provider?**

Over 10 5-10 years 2-5 years 1-2 years

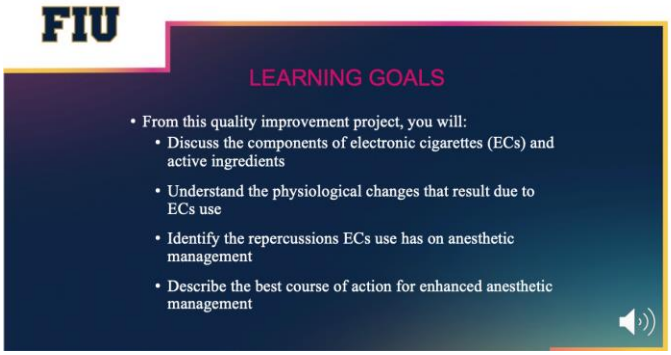
Questionnaire

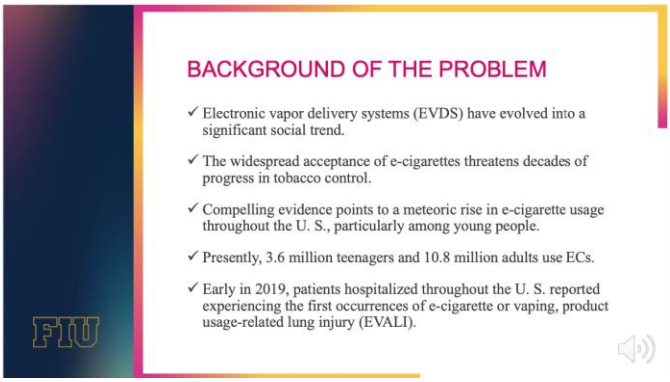
1. **The main active ingredients in ECs are: (Select 3)**
    a. Nicotine
    b. Propylene glycol (PG)
    c. Vegetable glycerin (VG)
    d. Alcohol

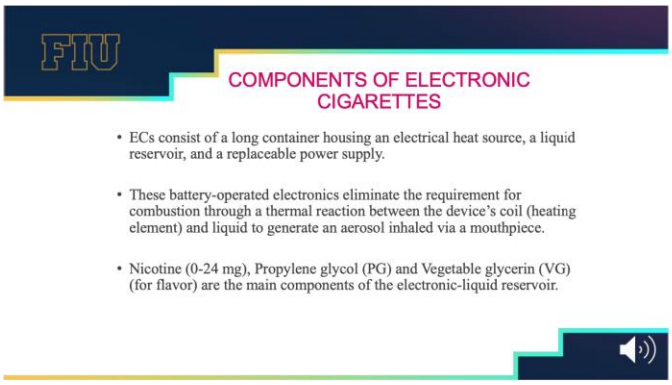
2. **ECs use can compromise cellular oxygenation and _____ the risk of surgical site infection, necrosis, and _____ tissue regeneration.**
    a. Increase & Prolong
    b. Decrease & Prolong
    c. Increase & Increase
    d. Decrease & Decrease
3. **Some EVDS products possess greater nicotine concentrations than conventional cigarettes.** (True of False)
4. **What ventilatory complications are associated with ECs usage: (Select 2)**
    a. Laryngospasm
    b. Bronchospasm
    c. Fatigue
    d. Increased WOB
5. **Electronic cigarettes have evolved into a significant social trend.** (True or False)
6. **Exposure to ECs aerosols for an extended period can lead to the development of COPD symptoms? (**True or False)
7. **There is a direct correlation between ECs usage and the development of EVALI. What respiratory alterations occur in these patients? (Select 2)**
    a. Widespread alveoli effusion
    b. Pneumonia with bronchiectasis
    c. Increased secretions
    d. Cough

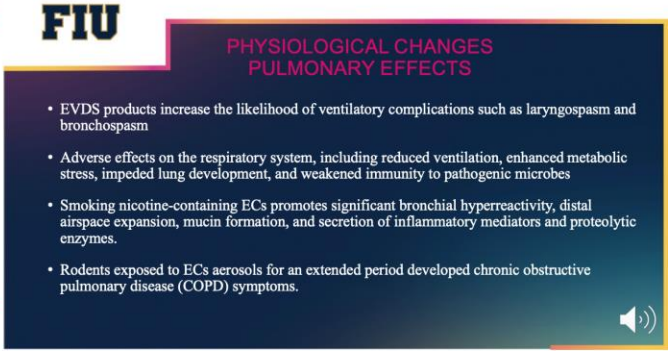
8. **Toluene, a volatile organic contaminant (VOC), is generated as a byproduct of ECs aerosol and possesses several of the same properties as: (Select 3)**
    a. Benzodiazepines
    b. Ketamine
    c. VAA
    d. Etomidate
9. **A greater dosage of vecuronium and rocuronium may be necessary to achieve therapeutic concentrations during induction and maintenance of anesthesia for patients with a long-term history of vaping.** (True of False)
10. **How likely are you to implement an enhanced respiratory pre-operative assessment for a patient with chronic vaping history?**
    a. Very likely
    b. Most likely
    c. Same as every patient
    d. Not likely

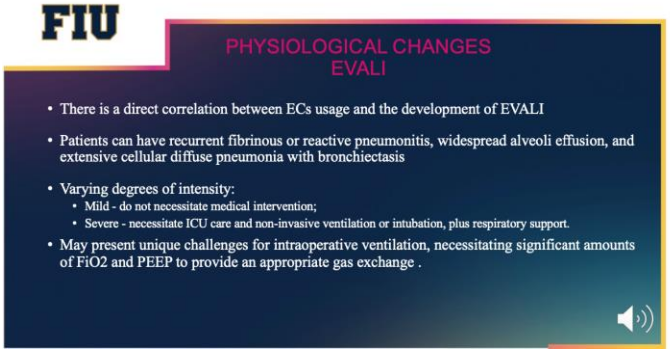
Appendix F – Educational Module PPT

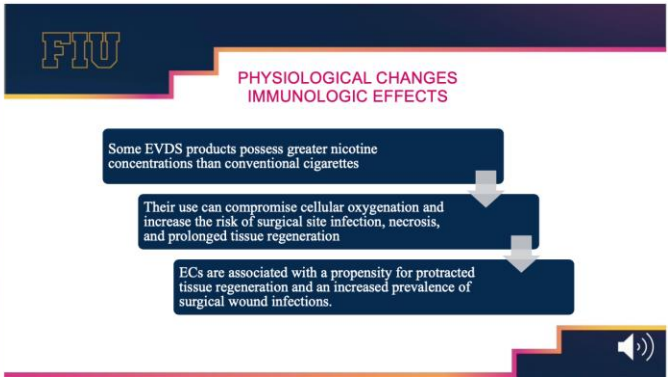


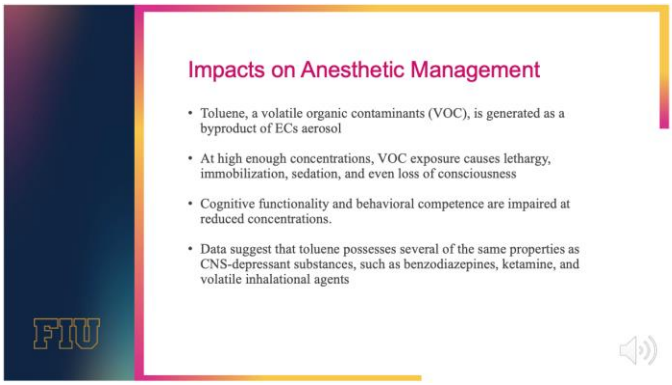


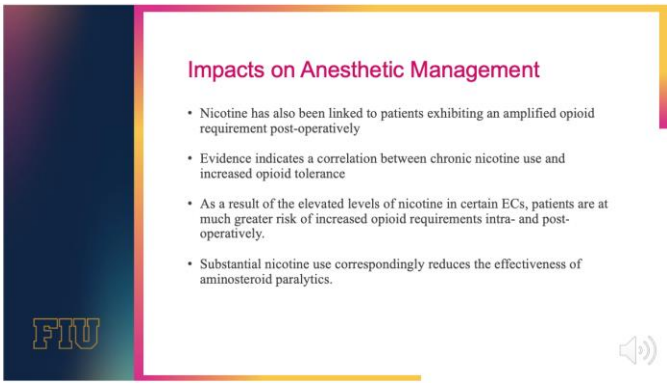




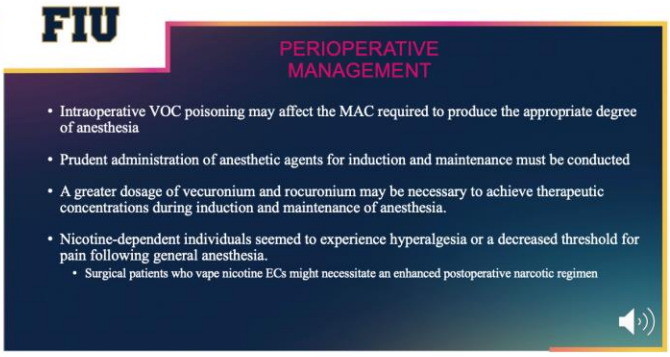

FIU
PHYSIOLOGICAL CHANGES
EVALI
• There is a direct correlation between ECs usage and the development of EVALI
• Patients can have recurrent fibrinous or reactive pneumonitis, widespread alveoli effusion, and extensive cellular diffuse pneumonia with bronchiectasis
• Varying degrees of intensity:
• Mild - do not necessitate medical intervention;
• Severe - necessitate ICU care and non-invasive ventilation or intubation, plus respiratory support.
• May present unique challenges for intraoperative ventilation, necessitating significant amounts of FiO2 and PEEP to provide an appropriate gas exchange .

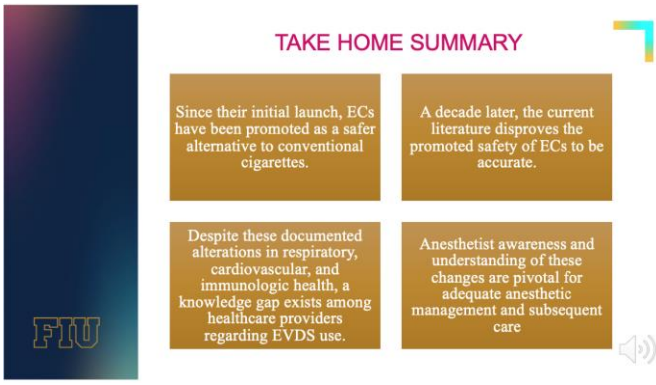

FIU
PHYSIOLOGICAL CHANGES
IMMUNOLOGIC EFFECTS
Some EVDS products possess greater nicotine concentrations than conventional cigarettes
Their use can compromise cellular oxygenation and increase the risk of surgical site infection, necrosis, and prolonged tissue regeneration
ECs are associated with a propensity for protracted tissue regeneration and an increased prevalence of surgical wound infections.


Impacts on Anesthetic Management
• Toluene, a volatile organic contaminants (VOC), is generated as a byproduct of ECs aerosol
• At high enough concentrations, VOC exposure causes lethargy, immobilization, sedation, and even loss of consciousness
• Cognitive functionality and behavioral competence are impaired at reduced concentrations.
• Data suggest that toluene possesses several of the same properties as CNS-depressant substances, such as benzodiazepines, ketamine, and volatile inhalational agents
FIU


Impacts on Anesthetic Management
• Nicotine has also been linked to patients exhibiting an amplified opioid requirement post-operatively
• Evidence indicates a correlation between chronic nicotine use and increased opioid tolerance
• As a result of the elevated levels of nicotine in certain ECs, patients are at much greater risk of increased opioid requirements intra- and post-operatively.
• Substantial nicotine use correspondingly reduces the effectiveness of aminosteroid paralytics.
FIU


FIU
PERIOPERATIVE
MANAGEMENT
• Vapers should be anticipated to pose a heightened risk of hypersensitive airways
• Bronchodilators preoperatively and intraoperatively when indicated and heighten the plane of anesthesia prior to airway manipulation
• Patients with a long-standing nicotine vaping history are at increased risk of hemodynamic instability.
• Anesthetist should implement stricter heart rate and blood pressure controls and utilize cautious dosing of ephedrine and dexmedetomidine.


FIU
PERIOPERATIVE
MANAGEMENT
• Intraoperative VOC poisoning may affect the MAC required to produce the appropriate degree of anesthesia
• Prudent administration of anesthetic agents for induction and maintenance must be conducted
• A greater dosage of vecuronium and rocuronium may be necessary to achieve therapeutic concentrations during induction and maintenance of anesthesia.
• Nicotine-dependent individuals seemed to experience hyperalgesia or a decreased threshold for pain following general anesthesia.
• Surgical patients who vape nicotine ECs might necessitate an enhanced postoperative narcotic regimen


TAKE HOME SUMMARY
Since their initial launch, ECs have been promoted as a safer alternative to conventional cigarettes.
A decade later, the current literature disproves the promoted safety of ECs to be accurate.
Despite these documented alterations in respiratory, cardiovascular, and immunologic health, a knowledge gap exists among healthcare providers regarding EVDS use.
Anesthetist awareness and understanding of these changes are pivotal for adequate anesthetic management and subsequent care
FIU


TAKE HOME SUMMARY
In order to appropriately advise and promote prospective anesthetic treatment techniques for individuals who vape, it is necessary to determine how EVDS usage impacts respiratory, cardiac, and immunological functionality
Anesthetists have an essential role in evaluating surgical risk stratification and addressing perioperative morbidity linked with vaping to enhance management and outcomes
Differentiating patterns of consumption and types of vaping products being used represents the initial step to evaluate the perioperative risks of these patients, formulate tailored anesthetic management strategies
FIU

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Appendix G – QI Dissemination PTT

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3

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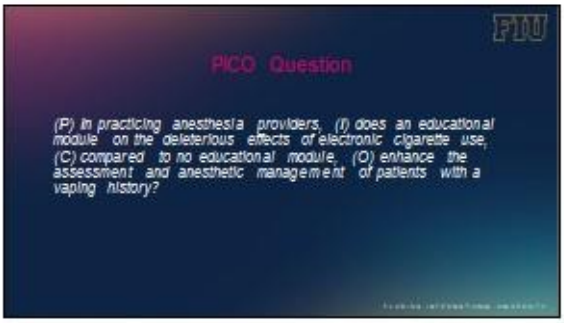


6

Methods

QI Project Structure

- Pre-test vs. Post-test results analysis

Distribution

- An invitation via email was sent to a list of MBAA anesthesia providers with concise information about the voluntary structure of the educational module, its subject matter, and the author's contact details. The anesthetists are a diverse cohort of CRNAs with varying levels of knowledge and experience. The invitation message contained a link to the Qualtrics platform, where prospective participants could complete the educational module, pre-test and post-test survey.

Data Collection:

- Randomized and anonymized pre- and post-educational questionnaires
- The survey collected participant demographic data for generalization purposes.
- The information was recorded safely on the Qualtrics platform.

7

Methods

Educational Module

- Prior to completion of the educational module a consent for participation was obtained
- The completion of the pre-educational questionnaire was necessitated to gain access to the educational video
- Post completion of the pre-educational survey, participants viewed the educational video
- Access to the educational module was restricted to a 4-week time frame from the commencement of the module.
- The post-education examination mirrored the pre-educational questionnaire for assessment of gained knowledge

Data Analysis

- At the end of the data acquisition period, the project team analyzed the pre- and post-test questionnaires to determine whether or not the respondents' awareness of the dangers of ECs usage had increased.

8

Results

Sample size (n=9) despite the more significant number of prospective participants (n=44) invited to participate, yielding a response rate of 20.45%. The completion rate for each started survey was 100%

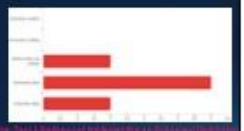
Participant Demographics:

- Most participants were female (77.78%) vs male (22.22%).
- Ages ranged from: 26 – 35 y/o (33.33%), 36 – 50 y/o (33.33%), and 51 – 75 y/o (33.33%).
- White (22.22%), Black/African American (11.11%), Hispanic (66.66%)
- 100% of participants were CRNAs with an educational level: MSN (33.33%), DNP (66.67%)
- Years of practice: 1 – 2 (11.11%), 2 – 5 (33.33%), 5 – 10 (11.11%), and over 10 years (44.44%).

9

Results - Pre-Test: Assessment of Baseline Knowledge

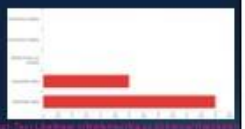
- Four participants (44.44%) erroneously selected Alcohol as an active ingredient in ECs
- Ventilatory complications are associated with ECs usage, four participants (44.44%) did not choose laryngospasm. One participant (11.11%) incorrectly chose increased work of breathing as an answer.
- Respiratory alterations that occur in patients with EVALI six participants (66.66%) improperly selected increased secretions, and four (44.44%) wrongfully selected cough.
- Likeliness to implement an enhanced respiratory assessment for patients with a chronic vaping history, two respondents (22.22%) stated "neither likely nor unlikely," five (55.56%) said "somewhat likely," and two (22.22%) indicated "extremely likely."



10

Results - Post-Test: Assessment of Learning

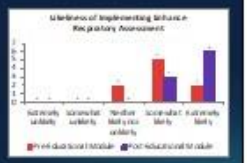
- All participants (100%) correctly selected all active ingredient in ECs
- All participants (100%) selected the correct ventilatory complications associated with ECs usage.
- Respiratory alterations that occur in patients with EVALI one participants (11.11%) improperly selected increased secretions, and zero (0.00%) wrongfully selected cough.
- Likeliness to implement an enhanced respiratory assessment for patients with a chronic vaping history, three respondents (33.33%) said "somewhat likely," and 6 (66.67%) indicated "extremely likely."



11

Discussion

- The results indicated a statistical difference in the pre-test and post-test following the educational module.
- The data exhibited a percentage increase in the providers' knowledge of the main active components of ECs and the ventilatory complications associated with ECs usage.
- Notably, Question 7 regarding the respiratory alterations due to EVALI revealed a 66.67% and 45.45% increase in the right answer choices while showing a 55.55% and 44.44% decrease in the selection of incorrect answers.
- One key outcome is the 44.45% increase in the number of providers extremely likely to implement an enhanced respiratory assessment for patients with a chronic vaping history.



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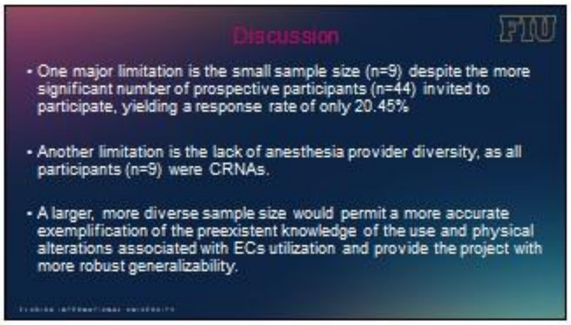

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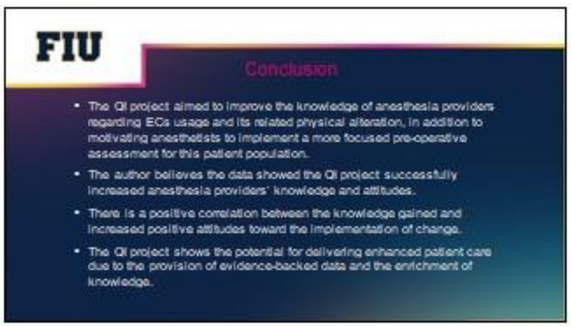

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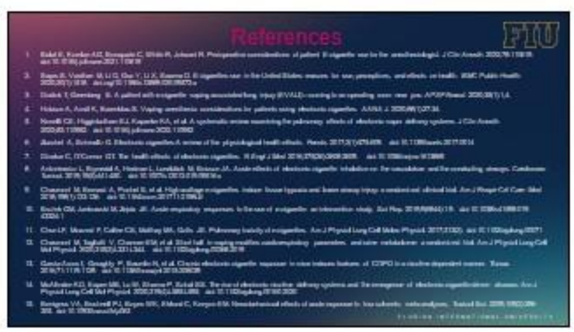

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