

Electronic Nicotine Delivery Systems: Current trends and patient education opportunities for dental hygienists

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Abstract

Concerns regarding the overall health consequences, product safety, impact on youth brain development, and possible gateways to other tobacco products of Electronic Nicotine Delivery Systems (ENDS) are increasing. However, evidence suggests little is known about ENDS among health care professionals and the public. The purpose of this review was to explore the literature for opportunities to inform dental patients about the possible health consequences of ENDS and prevention strategies to consider for implementation in dental practice. A literature search was conducted on ENDS appeal, product users, health and safety concerns, regulations, major health care organization positions, research needs, and use in tobacco cessation strategies. Search terms included ENDS (electronic nicotine delivery systems), tobacco cessation, tobacco use intervention, dental education, dental professionals, dental hygiene, health care professionals and health professional organizations. The following data sources were utilized: PubMed, MEDLINE, Google Scholar, and the Smoking, and Tobacco Abstracts and News Bulletin. Published articles from peer-reviewed journals, relevant websites, and government documents were included; 85 resources were selected as most relevant for this review. Health risk related ENDS research, without updated information prior to 2010, was excluded. Opportunities exist for dental hygienists to develop a greater awareness about ENDS based on scientific evidence in order to assist patients in making informed decisions regarding ENDS use.

Keywords: electronic nicotine delivery systems, ENDS, tobacco cessation, tobacco use intervention, dental education, dental professionals, e-cigarettes

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Introduction

Statistics from the United States Department of Health and Human Services (HHS) “Health Consequences of Smoking - 50 Years of Progress,” showed that from 2005-2009 smoking and exposure to secondhand smoke, were responsible for more than 480,000 deaths annually.¹ An additional report finding was the identification of changing patterns of tobacco use, with a decrease of traditional tobacco and increased use of non-traditional products including the use of what is known as electronic cigarettes.¹ These findings have implications for dental hygienists who provide guidance and education regarding tobacco use. Originally developed and designed by a Chinese pharmacist in 2003 as a safer use of nicotine, minus tobacco, e-cigarettes were originally promoted with claims of emitting vapor rather than smoke.³ Introduced in the United States in 2007,³ electronic cigarettes have also been referred to as electronic nicotine delivery systems (ENDS), electronic smoking device, e-hookah, e-vapor device, hookah pen,

personal vaporizer, vape or vapor pen, vapor cigarette, mods, tank systems and others.^{1,4-9} It has been estimated that over 95% of ENDS are manufactured in China leading to product quality concerns.⁹ Over 5,000 vape shops exist in the United States, with more opening every month, creating challenges for research studies regarding product safety.¹⁰

A review of the literature suggests that there is a gap in the knowledge among healthcare professionals regarding ENDS and there is a lack of credible resources on safety and effectiveness of use for the public.^{9, 11, 12-19} Healthcare challenges have resulted due to the lack of public health data regarding the health implications, potential environmental impact, along with rapidly evolving ENDS technology.²⁰ Appropriately educated dental hygienists can be effective in assisting patients in tobacco cessation and in patient education strategies.^{12,13} The purpose of this literature review was to explore opportunities to inform dental patients and the public

about possible health consequences of ENDS and prevention strategies to consider for implementation in dental practice.

ENDS Appeal and Promotion

The basic design of a typical e-cigarette consists of a mouthpiece to withdraw the vapor, a tank which holds the liquid nicotine or “juice”, a battery, and a heating apparatus that vaporizes the juice (Figure 1).²¹ With over 500 types and more than 7,000 flavors available, the various flavors are particularly appealing to youth.⁹ A cross-section of ENDS prototypes are shown in Figure 2. The most popular product has been designed to resemble a flash drive and is USB charged, with increasing reports of youth use during school hours.²³⁻²⁵ Commonly known by the brand name JUUL (JUUL Labs, San Francisco, CA), this product features a nicotine flavored pod that contains concentrations higher than those found in a cigarette (Figure 3).²³⁻²⁵ Containing as much nicotine as a pack of cigarettes, youth users often share devices and refer to the process of using them as “juuling”.²⁴ Johnston et al. found between 52% - 75% of youth in the 8th, 10th and 12th grades believed that ENDS mist only contains flavoring and were unaware of the nicotine content.²⁷ ENDS products have also been used for the delivery of illicit substances, with marijuana most commonly reported.^{7,9}

Figure 1. Components of Electronic Nicotine Delivery Systems

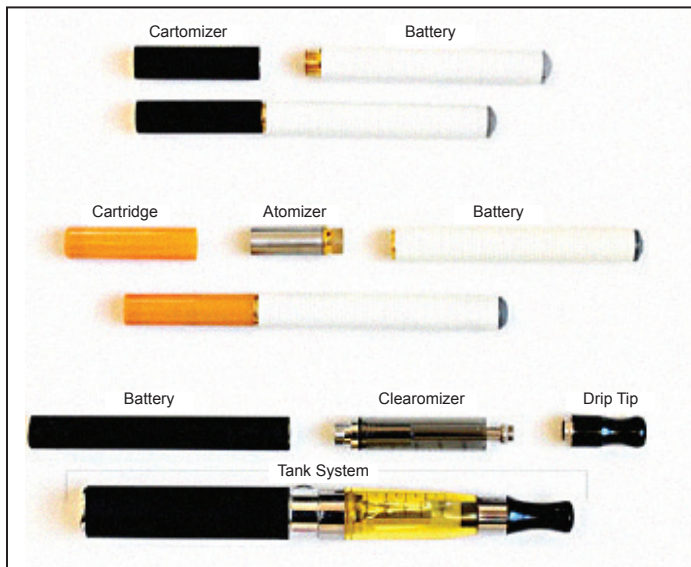


Image courtesy of the United States Food and Drug Administration²²

ENDS product packaging frequently use youth-oriented and cartoon-like images with flavors and themes appealing to youth.^{23, 28} Investigators of one study found 82% of the current youth ENDS users engage in using because of

Figure 2. Variations of ENDS products



Image courtesy of the United States Food and Drug Administration²²

Figure 3. JUUL product design



Photo credit: Evan Godell, University of Detroit Mercy Dental, Detroit, MI

appealing flavors.²⁹ Product marketing approaches help create a common misconception among youth that ENDS are a safer and healthier alternative to traditional tobacco.^{29,30} In a 2014 Truth Initiative report on youth and young adult exposure to ENDS product marketing, it was shown that advertising across TV and print reached approximately 80% of 13 to 17-year-olds and 94% of 18 to 24-year-olds.³¹ An analysis of National Youth Tobacco Survey (NYTS) 2014 findings, associated the surge in youth use of ENDS with increased exposure to advertising.²⁸

The 2016 NYTS revealed nearly 80% of youth reported exposure to ENDS marketing from at least one source.²⁸ Current ENDS marketing approaches lack restrictions and appear reminiscent of those used in advertising traditional tobacco products with misleading messaging designed to attract youth.^{9,28} Receptivity to ENDS product advertising has also been found to be associated with trying a cigarette.³²

Adults may be initially drawn to ENDS for tobacco cessation efforts however, safety and efficacy studies have conflicting results.¹⁰⁻¹⁶ Reasons for adult ENDS use include the behavioral aspect that resembles cigarette smoking and the perceived social acceptability.³³⁻⁴⁰ Other reasons cited relate to less negative public perceptions, being viewed as “vapers” rather than “smokers,” and product features allowing for preferences in flavors, dosage and voltage.^{40, 41} Research using content analysis of public postings on social media related to ENDS use from 2012-2015 demonstrated that in 2012, quitting combustibles was the major reason for ENDS use (43%). Three years later in 2015, social image (39%) emerged as a primary reason suggesting that the use of ENDS is moving away from use as an aid for quitting combustibles.⁴²

ENDS User Demographics

Data confirm increased popularity and use of ENDS by youth.^{9,43} From 2011 to 2015, the rise in ENDS use represented a ten-fold increase. ENDS are used more frequently than any other tobacco product and are used more often by youth than adults.^{9,44} The 2016 NYTS reports ENDS use among middle school students at 4%, representing a population of close to 500,000.⁴⁴ High school student use was reported at 11%, indicating approximately 1.6 million users.⁴⁴ Additional findings indicate dual use of tobacco products for middle school students at 3% and high school student use was at 10%, with nearly half of youth using more than one product.⁴⁴ Another finding for youth revealed 17% of middle and high school students believe using ENDS is less harmful than other forms of tobacco.⁴⁵ While ENDS were the most popular product used by middle and high school students NYTS survey findings demonstrated a decline in tobacco product use in 2016 as compared to 2015.⁴⁶

Research on prevalence of adult ENDS use identified nearly one third of current users as never smokers, which may indicate that ENDS use is contributing to nicotine addiction and re-normalization of tobacco use.⁴⁷ Data from the National Center on Health Statistics (NCHS) showed that of current cigarette smokers who had tried to quit smoking in the past year, over 50% had tried ENDS.³³ and nearly 10% of 18-24 year-olds who never smoked a cigarette, had tried ENDS.³³ National Health Interview Survey (NHIS) 2016 data indicate that 15% of adults aged 18 and older reported ever having tried ENDS, even once, a higher level when compared to 13% identified in 2014.^{33,48} Adult awareness of e-cigarettes rose from 77% in 2012 to 94% in 2014 as reported by the Health Information National Trends Survey,¹⁴ while 48% of current or former smokers responded that they have tried ENDS, substantiating findings from other national surveys.^{14,48}

Health and Safety Concerns

There is a gap in the literature regarding guidance on safety of ENDS use.^{9,49,50} Studies have identified possible exposure to

nicotine, volatile organic compounds, carcinogenic compounds, and heavy metals emitted into the air as ultrafine particles all have potential for causing health consequences.^{8,51,52} Flavoring chemicals have been implicated as having an effect on the respiratory system.⁵² Additional research suggests that flavorings may influence free radical production, potentially damaging living cells.⁵³ Exposure to nicotine as well as other chemicals may have secondhand exposure health harms.^{54,55} Nicotine exposure has been linked to tachycardia, vasoconstriction, and hypertension.⁵⁶ Liquid nicotine exposure resulting from ingestion or through contact with skin or eyes can be toxic.^{9,49} Findings from several studies suggest nicotine exposure may result in insulin resistance, preterm births, and impaired development of fetal brains and lungs.^{1,11,12}

Nicotine exposure during adolescence is of particular concern due to potential lifelong consequences, with multiple studies identifying addiction vulnerability and impact on brain development.^{1,9,12,46,49,55} Research has demonstrated that youth ENDS use progresses to cigarette smoking, with a recent study showing youth being more than four times more likely to progress to cigarette smoking.^{30,49,57-59,60} Youth ENDS use has been linked not only to an increased risk of trying conventional cigarettes and waterpipe, but additionally, multiple product use was shown to be more frequent than single product use.³⁰ Other findings revealed the presence of at least five potentially harmful toxicants that suggest an increased youth cancer risk.⁶¹ Nicotine use in any form by youth has been deemed unsafe and ENDS, with or without nicotine, carries risk for harm to health.^{9, 49,61} Intervention strategies for youth should focus on use prevention of all tobacco products, including ENDS.^{9,28,31,49,60-63}

Explosions and fires have resulted while using ENDS and a recent National Academies of Sciences, Engineering, and Medicine report reveals that the number of fires or explosions can be expected to increase.^{2,49} With 195 separate incidents reported between January 2009 and December 2016, 62% occurred when the device was actively used or carried in a pocket.²

Evidence-based research identifying the impact of ENDS on oral health is limited with much of what is known based on laboratory studies.⁴⁹ Poor wound healing and DNA damage effecting the periodontal ligament have been suggested, as well as the possibility of human fibroblast damage due to ENDS product fluids with or without nicotine.^{64,65} Flavoring chemicals can release inflammatory proteins leading to cell damage

and increased risk for periodontal disease; higher risks are associated with frequency of use.²¹ Other research has identified damage linked to the nanoparticles contained in the vapor,^{49,66} with one study showing ENDS users reporting mouth irritation, oral ulcers, sore throat, and coughing.⁶⁷ Potential carcinogenicity has been suggested as a concern with exposure to the mouth and throat.⁸ Burns, broken teeth and damage to supporting oral structures have all been reported when using ENDS products.⁶⁸ Conclusive evidence on health harm is difficult when considering different ENDS use patterns, varying sample sizes and groups being studied, along with the wide-range of ENDS products available.^{3,9,11,14,20,49,71,76} Research findings are considered to be at a very early stage, calling for further investigation and the need for evidence-based studies.⁴⁹

Harm Reduction and Tobacco Cessation

Efficacy of ENDS use for smoking cessation has insufficient evidence due to a limited number of studies, small sample sizes and findings limited to short-term results.^{9,49, 67} Inconsistencies also occur due to the wide variability of product type, design, and contents.^{9,49,50,69,70} Continued use of ENDS after a failed attempt to quit combustible tobacco is not uncommon as a potential consequence.^{9,49} Research suggests that when the use of combustible tobacco is reduced but not completely eliminated while simultaneously using an ENDS product, improved health is unlikely.^{20,49}

The United States Preventive Services Task Force (USPSTF) provided evidence-based recommendations on the use of ENDS in December 2016 stating that there is a lack of evidence regarding the effect of ENDS use for tobacco cessation and stressing the need for more quality studies.¹⁵ The 2018 National Academies of Sciences, Engineering, and Medicine report on the public health consequences of e-cigarettes concluded that there is limited evidence to demonstrate ENDS effectiveness when used in conjunction with tobacco cessation efforts, citing study limitations based on evidence drawn exclusively from laboratory testing of ENDS ingredients.⁴⁹ Further findings from the National Academies report concluded that studies evaluating chemical toxicity through use of cultured bacteria or tissue samples were inconclusive since the results were limited to in vitro studies.⁴⁹ Some studies have suggested ENDS may have a place in reducing health risks when compared to the potential detrimental health effects of using combustible tobacco,^{9,54} creating a dilemma for health care providers when providing guidance regarding ENDS use. While short-term ENDS use may be less harmful than combustible tobacco, harms of long-term use, levels of safe use, along with other variables

are unknown, supporting the need for more evidence-based research and product regulation.^{11, 49, 50,71}

Regulation of ENDS

Research is limited regarding the potential health harms related to exposure to secondhand ENDS aerosol, however several studies suggest smoke and tobacco-free environment policies should include ENDS.^{8,9, 49,72} Smoke-free environment legislation has been expanded in some areas in the United States (U.S.) prohibiting the use of ENDS in indoor as well as outdoor spaces due to concerns regarding toxicity of ENDS emissions, creating confusion about compliance with smoke-free laws.^{49,73} Although no federal laws had been enacted July 1, 2018, there were 752 municipalities, 11 states, and two territories prohibiting ENDS use in 100% smoke-free environments.⁷³ In addition, the CDC September 2017 report identified 47 states, along with the District of Columbia, Guam, Puerto Rico, and the U.S. Virgin Islands have implemented restrictions on the sale of ENDS to minors.⁷⁴ The U.S. Food and Drug Administration (FDA) extended their authority to regulate all tobacco products, including ENDS as of August 8, 2016.⁷⁵ Under the final FDA rule, manufacturers of new products are now required to report the ingredients contained in their products and to undergo premarket review as a condition for receiving authorization for marketing and selling their products.⁷⁵ Regulation of ENDS products is essential in order for consumers to identify product ingredients and aerosol content.^{49,76}

Health Care Organization Policies

Multiple professional organizations have policies opposing ENDS use for tobacco cessation including the American Medical Association, the American Association for Respiratory Care, American Lung Association, and the World Health Organization, among others.⁹ With clearly developed policies regarding ENDS use, dental and other health care related organizations could be influential in providing appropriate guidance regarding evidence-based practices for tobacco cessation and for prevention strategies that address ENDS.^{9,13,16,68}

Future Research Needs

As a relatively new area of study, ENDS research regarding health effects is challenged with procedural problems in part due to the wide variety of brands and models limiting the transferability of study results,^{50,70} Studies of ENDS ingredients have taken place without any standardization of the evaluation process.^{49,50} Conditions where nicotine fluid is overheated in the laboratory can overestimate health consequences.⁵⁰ Human studies may have limited results due to short-term exposure study and potential harm from long-

term use may be underestimated.^{49,50} While animal study results may not be reliable, possibly determined under conditions of overexposure, human studies on long-term ENDS health effects may not generate the same results.^{49,50} Although less harm does not mean safe, the literature suggests the use of ENDS without use of other products is likely to be less harmful over the short-term when compared to combustible tobacco.^{14,49,50} More extensive evidence-based studies need to continue, since long-term consequences are unknown.^{14,47,48,50-52,66,67,77}

The Cochrane Addiction Group has been recognized as providing “gold standard evidence” in identifying the most effective methods to support smoking prevention and treatment.⁷⁸ Essential needs for research identified by this group includes identifying the ways all health care providers can be involved in providing patient treatment and determining the safety of ENDS.⁷⁸ Researchers are challenged with establishing the consistent risk measures for ENDS that are key to the development of best practices for the use of these products.^{49,50,54,79}

Implications for Dental Hygiene Practice

Remarkable progress in the area of tobacco dependence education has been made in dental education programs over the last 25 years. Evidence suggests that with appropriate education, dental hygienists are well-informed, effective health care providers and demonstrate greater engagement with patients regarding tobacco use.^{9,12,13,54,80-82} Dental hygienists have the potential to be the driving force behind patient education on tobacco, smoking and vaping products, including ENDS. With the increasing use of ENDS and the potential impact on oral health, dental hygienists have a unique opportunity and obligation to inform patients regarding the oral and systemic health concerns. Tobacco product use, as part of the health history and patient assessments, should include ENDS in the development of strategies for patient education.^{12,13,84} ENDS discussions with adults could be approached using a risks versus benefits format.^{3,11-13,36} Most studies suggest when providing tobacco cessation guidance, FDA approved medications with evidence supporting their efficacy should be recommended, thus ENDS products are not included at this time.¹² In general, patients should be advised to avoid all tobacco products, including ENDS; dual use of tobacco products should be discouraged.^{20,49,85} Guidance for discussions regarding ENDS in the clinical setting is shown in Table I.

Table I. Guidance for addressing ENDS use in the dental setting

<ul style="list-style-type: none"> • Seek professional development opportunities to become better informed regarding all tobacco and vaping/ENDS products.
<ul style="list-style-type: none"> • Ask all patients regarding tobacco, smoking and vaping/ENDS product use and advise users to quit.
<ul style="list-style-type: none"> • Guide patient quit attempts with scientific, evidence-based approaches to treatment utilizing FDA approved medications.
<ul style="list-style-type: none"> • Advise youth patients about ENDS dangers, including addiction to nicotine and harm to brain development and recommend abstinence from all tobacco and vaping/ENDS product use.
<ul style="list-style-type: none"> • Educate the dental patient with basic information on what is known and unknown about ENDS, to allow for informed decisions regarding use.
<ul style="list-style-type: none"> • Encourage dental professional organizations to establish clear policies for patient guidance on use of all tobacco and vaping/ENDS products.

Conclusion

Review of the literature suggests more thorough evidence-based studies are needed to establish the efficacy of ENDS for tobacco cessation, for the use of ENDS products in harm reduction efforts, and the health effects of ENDS use over time. Available research studies display inconsistencies and are lacking in number and quality. Evidence appears strong regarding the detrimental effects of youth ENDS use and guidance from health care professionals regarding ENDS is needed for youth as well as adults. Health care organization guidelines and recommendations are strongly encouraged, serving as reliable resources on ENDS for health care professionals. Dental hygienists are well positioned to advocate for change with greater awareness of the rapidly rising use of ENDS as a critical public health issue and should seek continuing education opportunities to increase their ENDS knowledge base. Using the current scientific evidence, dental hygienists can provide the appropriate educational strategies to assist adults and youth in making informed decisions regarding the use of ENDS.

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