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Adolescent use of electronic nicotine delivery systems

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Abstract: Use of electronic nicotine delivery systems is flourishing among adolescents. The long-term effects have not been fully determined; however, literature suggests there is potential for significant harm. Providers must be aware of usage trends, device safety, and product knowledge. Adolescents should be evaluated through routine screening, and cessation counseling should be initiated.

Tobacco usage dates back many centuries, with conflicting information about its impact on health. Social consumption of tobacco rose quickly until the 1950s when research emerged in Britain linking smoking to lung cancer.[1] In 1964, the U.S. Surgeon General published a landmark report that exposed the negative health effects of smoking.[2] Despite the efforts of antismoking campaigns and identified cancer links, tobacco usage continued. According to the CDC, tobacco usage in the total U.S. adult population gradually decreased from 1965 through 2013.[3] Notably, adolescent tobacco use has steadily declined, whereas the reported use of electronic nicotine delivery systems (ENDS) in this population has significantly

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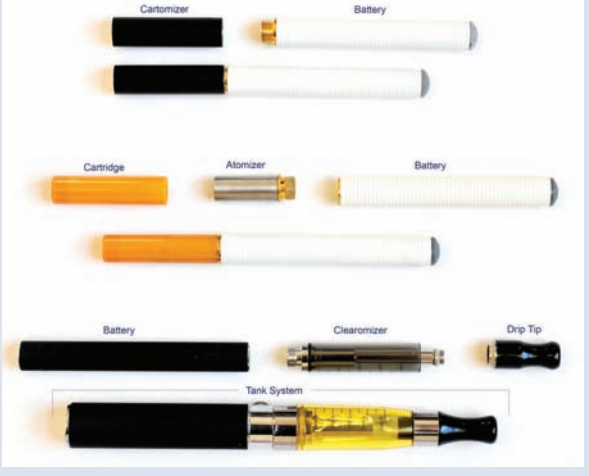
increased according to the U.S. Department of Health and Human Services (USDHHS).[4]

After working decades to reduce tobacco-smoking rates, the emergence of modern day ENDS into the U.S. market began in 2007, which created an alternate path to nicotine usage.[5] The initial unregulated marketing of ENDS enticed both the adult smoking population as well as the youth to experiment with the new technology. According to the USDHHS, the number of youth using ENDS more than tripled from 2011 to 2015.[4] Therefore, a surge of nicotine usage among U.S. youth has emerged and undermined the reduction of smoking rates and nicotine addiction.

Examples of ENDS and FDA regulations

There are several terms used to describe ENDS including vapes, vaporizers, vape pens, hookah pens, electronic cigarettes (e-cigarettes or ecigs), and e-pipes. These products use a liquid (also referred to as e-liquid) that contains nicotine, various flavorings, as well as other substances such as propylene glycol and vegetable glycerin. The liquid is heated into an aerosol that the user inhales. The following are a few examples of the devices:

In 2016, the FDA finalized a rule extending regulatory authority of the Center for Tobacco Products to cover all tobacco products, including ENDS that meet the definition of a tobacco product. The FDA now regulates the manufacture, import, packaging, labeling, advertising, promotion, sale, and distribution of ENDS, including the components and parts of the device but not accessories. ENDS may be manufactured to look similar to cigarettes, cigars, or pipes. The following are examples of e-cigarette devices and their components:



Source: United States Food and Drug Administration. Vaporizers, E-cigarettes, and other Electronic Nicotine Delivery systems (ENDS). 2017. https://www.fda.gov/TobaccoProducts/Labeling/ProductsIngredientsComponents/ucm456610.htm.

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Background

ENDS were developed in China with a goal to assist smoking cessation, and the devices were marketed during the early 2000s.[6] Over the past decade, the popularity of ENDS has skyrocketed, with the devices being available globally. Internet accessibility has contributed to market expansion, and many ENDS products are sold via the Internet with variable pricing and regulation.

Characteristics

Battery-operated ENDS devices use an atomizer with a heating coil to heat a liquid until it is vaporized and inhaled.[7] Newer technologies added a cartomizer or a clearomizer to the atomizer design. This technology allowed for increased delivery of nicotine, longer vaping time, and the ability to monitor the amount of fluid left in the reservoir.[8] A cartomizer is similar to an atomizer but is longer in size and uses a cotton-like-fiber wick to hold the liquid.[8] A clearomizer has a larger capacity tank system for holding the fluid and the clear design allows the user to monitor the fluid level (see *Examples of ENDS and FDA regulations*).[8]

Types

A variety of ENDS products are available. Some of the delivery systems resemble cigarettes and are referred to as e-cigarettes. Other ENDS have an assortment of shapes, including vape pens, boxes, e-hookahs, hookah pens, and e-pipes. Cigarette flavors range from candy to traditional tobacco and come in over 7,000 flavors.[9] Many of the delivery systems' designs and flavorings are created with taste and name preferences for youth.[10,11]

Current regulations

Prior to 2016, the FDA did not have the authority to oversee tobacco products such as e-cigarettes, hookah tobacco, and other products (including pipe tobacco and cigars).[12] Therefore, it was not prohibited for retailers to sell the products to individuals under the age of 18. In May 2016, the FDA extended their regulatory authority over the previously unregulated products.[12] Currently, 48

states have passed regulations related to youth purchasing ENDS products.[13] However, as of September 2017, the sale and distribution of e-cigarettes remain unregulated by the states of Michigan and Pennsylvania.[13]

Harmful effects

It is known that cigarette smoking can lead to life-threatening illnesses, such as chronic obstructive pulmonary disease. Yet, the long-term effects of ENDS have not been fully determined. A common misconception is ENDS products are safer when compared with the use of traditional tobacco and marketed as a healthier alternative to smoking.[14] Typically, adolescents perceive the use of ENDS as less harmful than smoking cigarettes.[15]

Many individuals who use ENDS have positively reviewed the products and their usage despite the limited knowledge of health effects, and in a survey of healthcare professionals in England, the majority approved the public use of ENDS.[16] However, research supports ENDS vapor inhalation can negatively affect body systems, including lungs, oral mucosa, and cardiovascular and neurologic systems.

Pulmonary

As many as 75% of the flavorings (such as popcorn, caramel, butterscotch, and strawberry) used in ENDS contain diacetyl and 2,3 pentanedione.[9] These chemical compounds are linked with the development of the restrictive lung disease obliterative bronchiolitis, also known as bronchiolitis obliterans, which is also known as "popcorn lung." The severity of the pulmonary manifestations of bronchiolitis obliterans range from a mild cough and asthma to extreme dyspnea on exertion; the damage to the pulmonary system is permanent.[9,17]

The inhalation of chemical flavorings for ENDS is unregulated, and their effect on the pulmonary system is poorly understood.[9] Additionally, ENDS flavors that contain diacetyl and 2,3-pentanedione are attractive to the youth and reflect the taste of candy or cocktails. The effect of dangerous chemicals on the still maturing pulmonary system is not well studied, and long-term damage severity is unknown at this time.

Nicotine effects

There is a significant risk to young children who accidently ingest liquid nicotine used in ENDS. It is estimated that 1 teaspoon of liquid nicotine can be fatal.[18] Since the nicotine in ENDS is not standardized, it is difficult to determine the amount of nicotine ingested to cause toxicity.[17] Nicotine toxicity affects the cardiovascular, gastrointestinal, neuromuscular, integument, central nervous, and pulmonary systems.

The most commonly observed adverse reactions of nicotine toxicity include nausea, vomiting, and eye irritation.[18] Other nontoxic adverse reactions from the use of ENDS include development of dry oral mucous membranes and oral epithelial cell damage.[19] Furthermore, multiple, daily, continued ENDS usage can lead to oral cancer secondary to potential cell mutation and oral ulcerations.[19]

Adolescent ENDS checklist[20,23]

- How old are you?
- How would you describe your school performance?
- How would you describe your relationship with others?
- Do you use tobacco or smokeless tobacco? If so, what types? If you use e-cigarettes:
  - How old were you when you first started using e-cigarettes?
  - What was the reason you start using e-cigarettes?
  - Do you use e-cigarettes daily or only on the weekends?
  - Do your parents/guardian know you use e-cigarettes?
  - Do your friends or family use e-cigarettes?
  - Do you use e-cigarettes with your family or friend?
  - Are you aware of the harmful effects of e-cigarettes?
  - Are you interested in e-cigarette cessation?

Screening and interventions

ENDS usage is often not perceived as smoking. The American Academy of Pediatrics (AAP) suggests that simply asking about smoking or tobacco use may not help providers identify patients and families who use ENDS products.[10,20] Additionally, the AAP recommends providers ask all patients about the use of smokeless tobacco (such as dip or chew) as well as ENDS products.[10,20] Many patients falsely believe that the use of ENDS may assist with smoking cessation. However, the nicotine used in ENDS devices is associated with nicotine dependence and will not be effective as a smoking cessation product.[21]

Siu along with the United States Preventive Services Task Force (as cited in Moyer) found insufficient evidence to recommend for or against ENDS use for smoking cessation.[22,23] Utilizing patient contact during office visits for sports physicals, routine annual exams, or immunizations allows providers to screen and intervene with regards to ENDS and provide education or brief counseling to prevent or reduce the risk of

initiation of tobacco use among school-age children and adolescents (see *Adolescent ENDS checklist*).[20,23]

The use of ENDS is increasing among adolescents who had not previously used traditional cigarettes.[4,24] Implications of ENDS use for healthcare providers are twofold, with providers needing education and having to acquire the skills to provide screening and education. As with tobacco screening, ENDS screening and counseling should be incorporated into every office visit. Providers should address the following ENDS screening components: personal, family, and friend's usage; education about health risks; and provision of cessation counseling.[25,26] Providers are encouraged to recommend the adolescent disclose ENDS use to parents/guardians.

Furthermore, adolescents may benefit from counseling to examine readiness for cessation and determine underlying factors that contribute to ENDS use (school/work performance, personal and familial relationships, and behavioral health concerns). There is division among public health experts as to whether or not ENDS are potentially a less harmful alternative to smoking or a gateway to nicotine dependency. ENDS should not be recommended as a method for smoking cessation.[21]

Although healthcare providers are aware of ENDS usage, few report treating adolescents who have used ENDS.[27] According to Pepper and colleagues, most providers reported learning about ENDS from patients, media, and advertisements rather than from professional sources.[27] Additional professional educational resources need to be available for providers to increase their knowledge concerning ENDS usage and prevention. As providers become knowledgeable in regards to ENDS risks, they can advocate for regulation of ENDS' sales and marketing to adolescents.

Education

Education on the use and dangers related to ENDS should be provided to adolescents and their caregivers. There are many opportunities to interact with both youth and caregivers at school (student conferences), community organizations, and primary care facilities. Furthermore, screening for ENDS use or nicotine dependency can be a starting point for education in the primary care setting.

Essential information to incorporate into education modules include: facts about ENDS and how they work; the risks associated with usage, such as injury to the brain and lungs, carcinogens present in many flavored liquids; the addictive nature of ENDS; and how to take action and protect the health of children, adolescents, and young adults.[4,28] Educational resources can be located at the USDHHS and Stanford University websites.[4,28]

Although a screening tool specific for ENDS is not available, there are several tools that could be used to assess ENDS usage and/or nicotine dependence. Screening tests include the Fagerström Test for Nicotine Dependence, the Hooked on Nicotine Checklist (HONC) developed specifically for adolescents, and the Four Cs Test.[29,30] Other tools, such as the CAGE Questionnaire, can be adapted to garner information related to ENDS usage among the adolescent population. For use in primary care practice, the HONC may be the most appropriate screening tool for this population.

Conclusion

With the increase in consumer demand for ENDS, healthcare providers must be knowledgeable about the potential negative health effects that result from ENDS usage. Regulating the chemicals in liquid products is essential to protecting the public from unknown chemical composition adverse reactions. Provider awareness of the increased adolescent use of ENDS will spur exams and discussions regarding such products during both sick- and well-adolescent visits.

The available literature lacks information substantiating the use of any specific tool that screens for adolescent use of tobacco or ENDS. The authors of this article feel that one implication for future practice is that a tool be developed for this purpose. A tool specifically for use with the adolescent population should be developed and tested extensively for validity and reliability. The use of a simple screening tool during visits will enable providers to obtain a clearer image of whether or not their adolescent patients use ENDS, the rate of product usage, and patient knowledge regarding the safety of the devices and chemical products.

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