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Review article

A Practitioner's Guide to Electronic Cigarettes in the Adolescent Population

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A B S T R A C T

We present guidance on electronic nicotine delivery systems (ENDS) for health care professionals who care for adolescents. ENDS provide users with inhaled nicotine in an aerosolized mist. Popular forms of ENDS include e-cigarettes and vape-pens. ENDS range in disposability, customization, and price. Growth of ENDS usage has been particularly rapid in the adolescent population, surpassing that of conventional cigarettes in 2014. Despite surging use throughout the United States, little is known about the health risks posed by ENDS, especially in the vulnerable adolescent population. These products may potentiate nicotine addiction in adolescents and have been found to contain potentially harmful chemicals. The growth in these products may be driven by relaxed purchasing restrictions for minors, lack of advertising regulations, and youth friendly flavors. Taken together, ENDS represent a new and growing health risk to the adolescent population, one that health care professionals should address with their patients. We suggest a patient centered strategy to incorporate ENDS use into routine substance counseling.

IMPLICATIONS AND CONTRIBUTION

The use of e-cigarettes by adolescents now exceeds that of conventional cigarettes. This article consolidates rapidly developing literature on the impact of e-cigarettes on adolescent health and provides practitioners with a best practices guide to e-cigarettes, including recommendations for discussing and treating the use of e-cigarettes among adolescent patients.

Electronic nicotine delivery systems (ENDS) are devices, relatively new to the consumer market, that provide users with inhaled nicotine via an aerosol mist. Examples of these devices include electronic cigarettes (e-cigarettes), vape pens, atomizers, vape pipes, hookah pens, e-hookahs, e-vaporizers, e-cigars, and e-pipes. Since their invention in 2004 and introduction in the United States in 2007 [1], ENDS have rapidly gained in popularity, with sales rising from $20 million in 2008 to more than $1.5 billion in 2014 [2]. In 2014, use of ENDS in adolescents surpassed the use of conventional cigarettes: Recent use of ENDS was estimated to be 17% among 12th graders, whereas recent use of cigarettes was 14% [3].

Current assessments of the evidence suggest that ENDS may provide risk reduction compared with smoking conventional cigarettes [4]. However, the variability and unpredictability of the nicotine dose delivered by these devices, the potential adverse health effects of other substances in the nicotine solutions (i.e. "juice"), and the potential for these devices to act as a gateway to nicotine addiction are all causes for concern regarding the health risks of ENDS, particularly for adolescents.

Health care providers caring for adolescents and young adults should be aware of surging ENDS use in this population and, in a preventive health role, should include ENDS in substance use counseling. In this guide, we provide an overall strategy by

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describing ENDS, presenting current trends in use by adolescents, discussing how they affect adolescents, reviewing current regulations of ENDS as they pertain to adolescents, and presenting strategies for practitioners to discuss ENDS products with adolescents.

What Are Electronic Nicotine Delivery Systems?

ENDS contain three principal components—a fluid cartridge, an electronic heating element, and a battery. ENDS devices can be operated either manually, where the user activates the device by pressing a button, or automatically, where a flow sensor detects the air current and activates the device. When the device is activated, the heating element turns on and aerosolizes a solution, sending nicotine aerosol into the lungs. The solution contains a variety of chemicals, including nicotine at levels ranging from 0 to 36 mg/mL (a conventional cigarette contains .7–2.39 mg of inhaled nicotine) [5–9]. The solution also contains humectants such as propylene glycol and glycerin which generate the smoke-like appearance of the aerosol and simulate the effect of smoking [4]. The liquid may also contain a variety of flavors ranging from more common flavors such as tobacco, coffee, and mint to more unusual and youth-oriented flavors such as crème caramel, Italian cream soda, black cherry marshmallow, buttered popcorn, cotton candy, Kool Aid, Fruit Loops, and Hunger of Persephone (Figure 1A) [10]. Refill solutions are commonly sold in sizes ranging from 15-30 mL and range in price from $0.50-1.00 per mL. A typical user will get 300-500 puffs per mL of fluid.

There are three major types of ENDS products. The first type is often described as a “ciga-like,” it is relatively small, resembles a cigarette, and comes in disposable and nondisposable forms. The nondisposable forms have a replaceable cartridge that contains the fluid and heating element that is sometimes referred to as a “cartomizer” (Figure 1B). The disposable products typically cost about $10, while the reusable products cost between $15-30. The second major class of ENDS products is referred to as vape pens or eGos. eGo, a brand initially created by Joytech, has become a common connection size between batteries and fluid cartridges referred to as “clearomizers.” These products are somewhat larger than the “ciga-like” products, are reusable, and offer the user the advantage of adding any fluid, including nicotine-free products, to the chamber for vaping. Vape pens can have a variety of additional features including variable voltage and replaceable tanks/atomizers (Figure 1C). Vape pens typically range in price from $50-100. The last class of ENDS is referred to as advanced personal vaporizers, sometimes termed “mods” or AVPs (Figure 1D). These devices are highly customized to the users’ preferences and typically offer increased aerosol production. Consequently, these can be expensive, ranging in price from $120-200.

In general, there is marked variability in aerosol production by devices [11]. Devices that are button activated have increased aerosol production relative to devices that are activated by air flow [12]. In addition, devices with larger, more powerful batteries can generate a hotter heating element and more aerosol [13].

Trends in Electronic Nicotine Delivery Systems Use Among Adolescents

A nationally representative study of high-school students found that in 2014, they used ENDS products more than conventional cigarettes. Current use (within the past 30 days) was at 17% among 12th-grade students, whereas conventional cigarette current use was 14% among 12th-grade students [3]. Furthermore, monthly use of e-cigarettes has grown exponentially among all high-school students from 1.5% in 2011 to 13.4% in 2014, whereas conventional cigarette use has steadily declined from 15.8% to 9.2% over the same period (Figure 2) [14–16]. Importantly, this survey data referred to ENDS as e-cigarettes, potentially narrowing the responses provided: the results may underestimate true prevalence of ENDS use [14–16]. Adolescents perceive ENDS to be a healthy alternative to conventional cigarettes: only 15% of students perceive ENDS use to pose a great risk to their health, yet 62% believe that smoking a pack of conventional cigarettes poses a great risk to their health [3]. In addition to perceived safety, a qualitative study found that students are motivated to use ENDS because they view ENDS as easy to consume and conceal, accessible, and more aesthetically pleasing than conventional cigarettes [17].

Of particular concern is that increased popularity of ENDS among adolescents may result in an increase in cigarette use because of nicotine addiction and/or renormalization of smoking behaviors. Rates of dual use (ENDS and cigarettes) are high, with 93%–96% of ENDS-using students having smoked a conventional cigarette at some point [3]. Rates of current dual use were assessed in a 2012 survey; these somewhat dated results indicated that about 50% of current ENDS users were also using conventional cigarettes (as defined as use within the last 30 days) [18]. Furthermore, recent survey data from Poland indicate that current dual use (within the last 30 days) has increased from 4% in 2010–2011 to 22% in 2013–2014 of all surveyed students aged 15–19 years (tobacco use is far more common in Poland than the United States) [19]. Recent data from a longitudinal cohort study shows that among high school students that were ever ENDS users 25% went on to be ever conventional tobacco product users, compared with 9% in the population that had never used an ENDS. When controlled for known smoking risk factors, ever ENDS use was positively associated with subsequent conventional tobacco product use (OR, 2.73 [95% CI, 2.00-3.73]). [20] Finally, studies have found that ever ENDS use among adolescents was associated with both an increased openness and greater intention to smoke conventional cigarettes. [21,22] These data raise the concern that ENDS may be an entry point to cigarette use and may act to perpetuate cigarette use.

Risks of Electronic Nicotine Delivery Systems

As the name suggests, the purpose of ENDS is to deliver nicotine—an addictive and potentially toxic exposure—to the user. Nicotine has deleterious effects on the developing brain, harming neurodevelopment in utero and may have effects on brain development in adolescence [23,24]. Adolescence is a critical period of brain development with normal neurobiological changes that allow for increased risk-taking and heightened reactivity to short-term rewards rather than long-term goals. In animal studies, nicotine has been associated with cellular damage as well as acute and persistent changes in different neurobiological pathways within the developing adolescent brain [24]. Behaviorally, adolescents have been found to be more sensitive to nicotine and more likely to demonstrate dependence than their adult counterparts even with relatively low amounts of nicotine exposure and more likely to have continued use into adulthood [23,24]. In fact, 88% of adults who remain daily