

# Understanding Vaping or Electronic Nicotine Delivery Systems (ENDS)

## Background

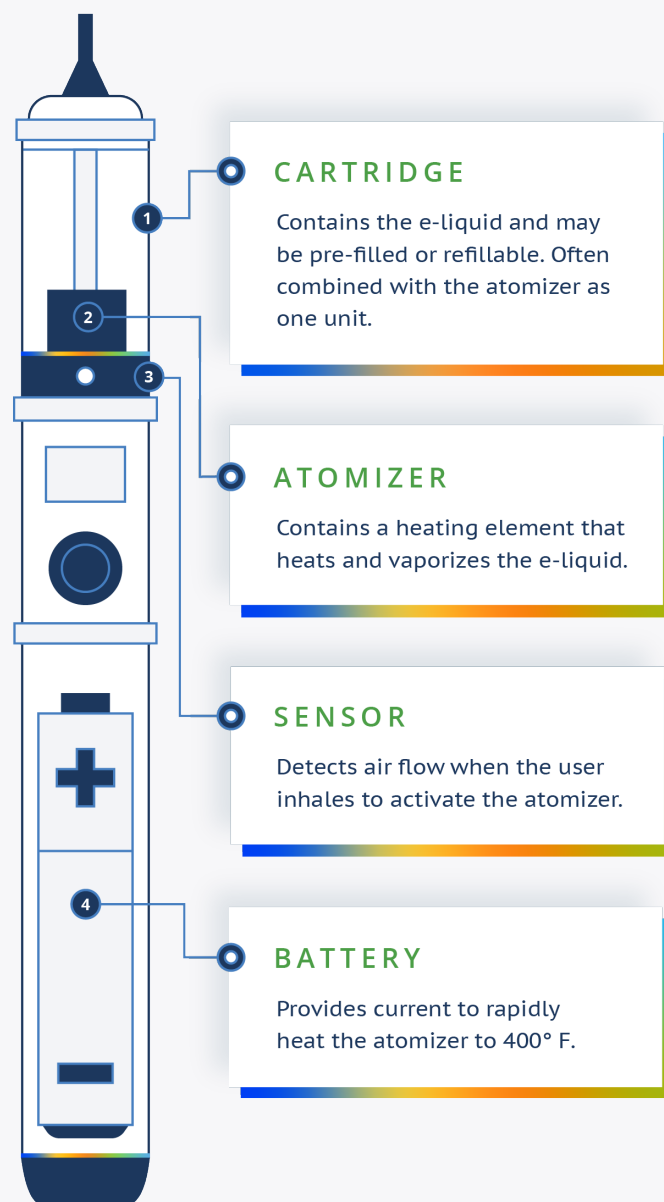
Electronic nicotine delivery systems (ENDS), also known as e-cigarettes or vapes, are battery-powered devices that convert a liquid into vapor that the user inhales (called vaping). These “e-liquids” typically contain various formulations of nicotine, glycerol, propylene glycol, tobacco alkaloids, pH modifiers, and flavoring agents. Since their inception, ENDS products have evolved rapidly as usage has grown, the market has changed, and new products have been developed. It is estimated that there are currently over 460 ENDS brands and more than 7,700 flavors available on the internet.<sup>1</sup> Table 1 provides an overview of various ENDS formats.

## How do ENDS work?

Despite the rapid evolution and wide variety of ENDS products, the basic operation of these devices remains the same.<sup>2</sup> Figure 1 shows the main components of a representative ENDS device. Typically, when a user inhales from the device, air flow is detected by a sensor. This sensor contains a microprocessor that activates a heating element or atomizer. The atomizer heats and vaporizes the e-liquid stored in the cartridge, which the user inhales. The vaporized e-liquid then cools down and condenses to form a cloud of e-liquid aerosols. The cartridge also contains the mouthpiece for the device. In some models, if there is no sensor present, the atomizer will be activated by pushing a button. Some models also feature a light-emitting diode (LED) that is triggered when the user inhales to mimic the glow of burning tobacco in a traditional cigarette. Types of ENDS products differ primarily in appearance, the nature of the e-liquid solution, the capacity of the cartridge containing the e-liquid (sometimes called the tank), the nature of the heating element, and the size and type of battery.<sup>1</sup>

## ENDS and Human Health

Since the ENDS process does not involve combustion, these devices do not produce ash, fire, or smoky smells.



**Figure 1:** Basic components of an ENDS device. From CDCTobaccoFree. Electronic Cigarettes (E-cigarettes) [https://www.cdc.gov/tobacco/basic\\_information/e-cigarettes/index.htm](https://www.cdc.gov/tobacco/basic_information/e-cigarettes/index.htm).

These features often lead to the perception that ENDS are safe alternatives to cigarettes and other traditional tobacco products.<sup>3</sup>

*While ENDS emissions may contain lower concentrations of certain toxic and/or carcinogenic compounds as compared to tobacco cigarettes, ENDS aerosols are not harmless water vapor as some claim.*

Researchers have found a complex mixture of numerous unknown chemicals in ENDS emissions and have identified chemicals of concern such as industrial chemicals, pesticides, and flavorings linked with possible toxic effects and respiratory irritation.<sup>4</sup> The aerosols that ENDS users breathe, and non-users are exposed to second hand, may also contain metal contaminants derived from components of the heating element as well as other volatile organic compounds (VOCs), and ultrafine particles. In fact, it is often difficult for consumers to know exactly what specific chemicals ENDS products do contain. For example, e-cigarettes marketed as containing no nicotine have been found to contain nicotine upon analysis.<sup>5</sup> This is concerning since nicotine is a highly addictive substance that is toxic to developing fetuses and can harm brain development, which continues past the teen years into the mid-20s.<sup>6</sup> ENDS use can increase the risk of heart disease,<sup>7</sup> a myriad of lung disorders and lung damage,<sup>8</sup> high blood sugar (prediabetes),<sup>9</sup> and has been shown to negatively impact oral health.<sup>10</sup> Additional research is still needed to fully understand the long-term health impacts of ENDS use.

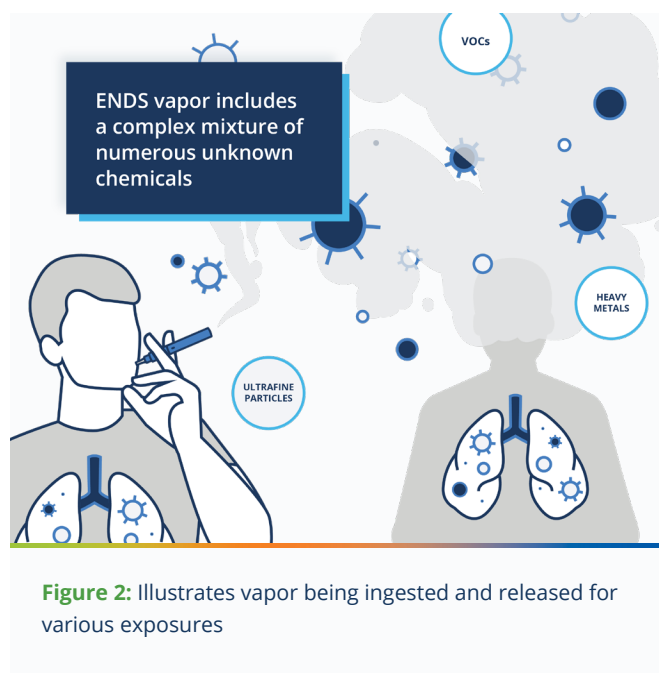
## ENDS Usage

When ENDS products first appeared on the market in the 1990s and early 2000s<sup>11</sup>, many viewed them as a potential aid for smoking cessation. In fact, some studies have found that using e-cigarettes with nicotine can help smokers stop smoking as compared to the use of placebo e-cigarettes. However, more recent studies show that among adult smokers who try ENDS to stop smoking, most do not ultimately stop using traditional cigarettes but rather continue to use both products. Among adult e-cigarette users aged 45 years and older, about 30% were either current or former regular cigarette smokers, and only 11% had never been cigarette smokers.<sup>2</sup> In contrast, among e-cigarette users aged 18–24 years, 40% had never been traditional cigarette smokers.<sup>12</sup>

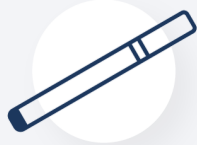



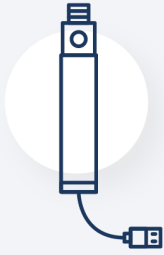
Usage of ENDS has increased dramatically in the United States in the last decade, particularly among adolescents and young adults. In 2018, ENDS were the most used tobacco product among youth with more than 3.6 million U.S. middle and high school students reporting having used e-cigarettes in the past 30 days. This number represents 4.9% of U.S. middle schoolers and 20.8% of U.S. high schoolers. By comparison, only 2.8% of U.S. adults reported being current ENDS users.<sup>2</sup> The most common reasons young people report for using e-cigarettes are:<sup>13</sup>

1. Because a family member or friend used them (39%)
2. Availability of flavors such as mint, candy, or chocolate (31%)
3. Belief that e-cigarettes are less harmful than other forms of tobacco (17%)

The U.S. Surgeon General has declared e-cigarette use among youth and young adults a public health concern<sup>14</sup> and both the American Lung Association and the Food and Drug Administration (FDA) agree that e-cigarette use among young people has reached epidemic levels.<sup>15</sup> Given that product safety testing for ENDS has lagged behind the rapidly evolving and growing ENDS market, there is still much to learn about the effects of ENDS usage on human health.



**TABLE 1: OVERVIEW OF VARIOUS TYPES OF ELECTRONIC NICOTINE DELIVERY SYSTEMS (ENDS)**

ENDS type	Product Characteristics
<p><b>DISPOSABLE (1<sup>ST</sup> GENERATION)</b></p> 	<p><b>“CIG-A-LIKES”</b></p> <ul style="list-style-type: none"> <li>* Designed to mimic combustible cigarettes</li> <li>* Smallest size with two-piece design</li> <li>* Sensor that detects inhalation</li> <li>* Uses LED light to indicate device activation</li> <li>* Non-refillable: 0.7ml to 1.0ml of prefilled e-liquid</li> <li>* Lasts 150-200 puffs</li> <li>* Fixed, low voltage batteries</li> </ul>
<p><b>RECHARGEABLE (2<sup>ND</sup> GENERATION)</b></p> 	<p><b>“VAPE PENS”, “CARTRIDGES”</b></p> <ul style="list-style-type: none"> <li>* Pod system can also be included in this group</li> <li>* Various sizes</li> <li>* Rechargeable batteries</li> <li>* Uses pre-filled or refillable cartridges</li> <li>* Lack of modifications/customization</li> </ul>
<p><b>TANK SYSTEM (3<sup>RD</sup> GENERATION)</b></p> 	<p><b>“TANKS”</b></p> <ul style="list-style-type: none"> <li>* Uses tank system to refill e-liquids</li> <li>* Highly modifiable/customizable</li> <li>* Automatic or manual battery modification format</li> <li>* Smaller in size compared to Mods</li> </ul>
<p><b>PERSONAL VAPORIZER (3<sup>RD</sup> GENERATION)</b></p> 	<p><b>“MODS”</b></p> <ul style="list-style-type: none"> <li>* Bigger in size with longer battery life</li> <li>* Voltage adjustment available: 30 watts to 350 watts</li> <li>* Highly modifiable/ customizable by users’ preference</li> <li>* Rechargeable battery</li> </ul>
<p><b>POD SYSTEM (4<sup>TH</sup> GENERATION)</b></p> 	<p><b>JUULS</b></p> <ul style="list-style-type: none"> <li>* Fixed voltage, similar to 1<sup>st</sup> generation</li> <li>* Most popular device type in the current ENDS market</li> <li>* Pre-filled cartridges (pods)</li> <li>* Each pod = 1 pack of cigarettes (200 puffs)</li> <li>* USB type charging dock</li> <li>* Small battery capacities</li> </ul>

**Table 1:** From Clin Cancer Res. 2015;21(3):514-525. doi:10.1158/1078-0432.CCR-14-2544.

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