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A Review of Teen and Adolescent Attitudes Regarding E-cigarettes and Their Relevance to Education

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Abstract

Over the last ten years, while teenage use of cigarettes has diminished, their use of electronic nicotine delivery systems (e-cigarettes) has increased. Adolescent e-cigarette use includes risks and challenges which are unique and different from adolescent use of traditional cigarettes. Many of the risks of e-cigarettes are not well known or well understood, especially by the teen population. A robust understanding of what entices adolescents and teens to use e-cigarettes is critical for schools in crafting an effective response. This paper reviews the literature on teen and adolescent perspectives on e-cigarettes and provides suggestions for using this information to guide school response in the form of educational programs around e-cigarettes in the United States.

Keywords: vaping, e-cigarettes, adolescent, teen, school

A Review of Teen and Adolescent Attitudes Regarding E-cigarettes and Their Relevance to Education

In the last decade, as teen usage of combustible cigarettes has steadily declined, e-cigarette use has trended in the opposite direction (Center for Disease Control and Prevention [CDC], 2019b). In 2014, a tipping point was reached, and e-cigarettes became the most commonly used tobacco product among middle school and high school students in the United States (Arrazola et al., 2015). The number of teens engaged in vaping suggests the phenomenon will continue, and even increase, in the future. Awareness of peers engaging in traditional smoking is correlated with teens smoking themselves (Eisenberg & Forster, 2003) and the sharp increase in teens using e-cigarettes has shown similar correlation to peer attitude and usage (Barrington-Trimis et al., 2015).

The nicotine in e-cigarettes is habit forming (Glasser et al., 2017; The National Academies of Science Engineering and Medicine [NAM], 2018), particularly for adolescents (US Department of Health and Human Services [HHS], 2016) and is specifically dangerous to the growing adolescent brain (England, Bunnell, Pechacek, Tong, & McAfee, 2015). Despite the absence of tar in e-cigarettes, they have been shown to cause serious health issues including impairing cellular metabolism (Glasser et al., 2017), cardiovascular disease (Wang et al., 2018) and most recently, lung failure (CDC, 2019b). In addition, e-cigarette vapor contains vaporized trace metals and other carcinogenic chemicals, even when they are nicotine-free (NAM, 2018).

Despite these significant risks, adolescents underestimate the level of risk present in e-cigarettes from nicotine addiction as well as health implications of e-cigarette usage (Johnston, O'Malley, Miech, Bachman, & Schuenberg, 2015). As research into vaping is still in its infancy, many critical questions about the long-term health effects of vaping remain unanswered (NAM,

2018). While schools may have considerable experience with teens engaging in risky behaviors, vaping presents a new and unique challenge.

In this article, the term "e-cigarettes" and the verb "vaping" will be used interchangeably to refer to both ENDS (electronic nicotine delivery systems) and ENNDS (electronic non-nicotine delivery systems). ENDS and ENNDS utilize liquid refills which when inserted into the device are heated, vaporizing the liquid and any chemicals and additives contained in it (World Health Organization [WHO], 2016). Liquid refills for use in e-cigarettes are produced with varying levels of nicotine as well as those which are nicotine-free (WHO, 2016) both of which are used by teens (Johnston et al., 2015). One of the most popular brands of e-cigarette in the US is JUUL, founded in 2015. By the end of 2017, JUUL had the highest market share (29%) of any e-cigarette producer in the US (King, Gammon, Marynak, & Rogers, 2018). This paper will review e-cigarette research, focusing specifically on teen and adolescent attitudes towards e-cigarettes, detail current educational initiatives and suggest how an understanding of attitudes can guide further school action in the US.

Origins and Description

E-cigarettes were first patented in China in 2003 (Demick, 2009). August of 2006 was the first record of US customs ruling on the tariff status of e-cigarettes and this would seem to be their introduction into the United States (US Custom and Broder Protection, 2006). In 2009, the Food and Drug Administration (FDA) began to take action on regulating the import of e-cigarettes triggering a legal battle as to which devices are under FDA regulatory control (CASAA, 2012-2019).

There are several different types of e-cigarettes that all exist in the current market. Initial e-cigarettes looked very similar to combustible cigarettes and were either disposable (they could

not be recharged or refilled) or rechargeable, containing just a battery and an atomizer to heat the liquid contained inside (Glantz & Bareham, 2018). Second generation e-cigarettes, also known as tank systems, have a higher capacity battery and a larger tank to allow for more vaping between charges (Glantz & Bareham, 2018; WHO, 2016).

Unlike traditional cigarettes, nicotine intake in e-cigarette usage is difficult to measure. Variability between devices and even users, makes drawing generalizable conclusions about level of nicotine exposure difficult (Glasser et al., 2017). Puff duration and volume of nicotine is higher in e-cigarettes than combustible cigarettes, however, puff count tends to be lower in newer vapers than in comparable cigarette users (Glasser et al., 2017).

Teen Usage

As e-cigarettes gain popularity in general, they have quickly become broadly used by the adolescent population (Dutra & Glantz, 2017; Schneider & Diehl, 2016). The sharp increase of e-cigarette use in adolescents comes as traditional combustible cigarette use continues to decline in the same population. The use of traditional cigarettes has dropped by more than 50% in the high school population over the last 20 years, with recent rates of teens using cigarettes within the past 30 days at under 11% nationwide (CDC, 2016). By contrast, in 2016, 45% of high school students reported having used e-cigarette products and 24% have used them within the past thirty days (CDC, 2016). A National Institutes of Health (NIH) 2015 survey of almost 45,000 high school students confirmed these results, finding that e-cigarette use had a 30-day prevalence which was higher than traditional cigarettes (Johnston et al., 2015).

Recent 30 day usage results from the CDC for high school students are 27.5% for electronic cigarettes as opposed to 5.8% for traditional cigarettes (CDC, 2019c). Newer research suggests that even these numbers are understated due to the way teens are asked about their e-

cigarette use. Teens were found to indicate non-use when asked about e-cigarette usage in general, but they would report use when asked about a specific device or brand (Morean et al., 2018).

Exposure and Availability

Environmental factors that contribute to increased adolescent e-cigarette use include their exposure to e-cigarette advertisements and the availability of e-cigarettes (Camenga et al., 2018; Miech et al., 2018). Exposure to vaping through advertising has been associated with increased vaping usage in adolescence (Kwon, Seo, Lin & Chen, 2018; Mantey, Cooper, Clendennen, Pasch, & Perry, 2016). In 2014, 68.9% of middle and high school students (18.3 million) were exposed to e-cigarette advertisements from at least one source (Singh et al., 2016). Tobacco product advertising correlates to initiation of tobacco products among adolescents. Many of the themes which attract teens in such advertising, including rebellion and sexual attractiveness, are also used to advertise e-cigarettes (MMWR, January 2016), making current e-cigarette advertisements specifically inviting to adolescents (Padon, Maloney, & Cappella, 2017). Adolescent brain activity (measured with fMRI neuroimaging) and self-reporting both demonstrate the significant impact of e-cigarette advertising (Chen et al., 2017). Chen et al. (2017) found that teen participants had increased brain activity in areas of the brain associated with cognitive control, reward, visual processing/attention and memory when viewing e-cigarette advertisements, as compared to similar advertisements for other products.

Teens believe that they can easily acquire e-cigarettes (Camenga et al., 2018; Miech et al., 2018). Substantial evidence points to the fact that online purchasing plays a significant role in this availability (Glasser et al., 2017). In a 2015 study (Williams, Derrick, & Ribisl), over 75% of online sales to minors were successful despite state regulations requiring age verification.

Similarly, Kong et al. (2017) found that adolescents reported being refused service online at half the rate they were refused service at brick and mortar shops.

Nicotine and Addiction

Nicotine presents a danger as an addictive substance, particularly for adolescents (HHS, 2016), and a chemical that retards brain development. Nicotine exposure during adolescence, where the prefrontal cortex and other higher order cognitive functions are developing, can produce changes in brain chemistry and architecture by impairing the development of neurons and brain circuitry (England, Bunnell, Pechacek, Tong, & McAfee, 2015).

Dopamine, a chemical in the brain responsible for pleasure, is the mechanism for reinforcing nicotine and causing addiction. Nicotine, when introduced quickly in high dosages, has physical effects that reinforce continued self-dosing due to the positive enhancements felt and to avoid the negative withdrawal symptoms associated with cessation (Benowitz, 1996). E-cigarettes have the potential to deliver a sufficient dose of nicotine to the brain that would induce dependence, similar to cigarettes (Glasser et al., 2017; St. Helen, Havel, Dempsey, Jacob, & Benowitz, 2016). Although the amount of nicotine delivered depends heavily on the type of device, the liquid used and individual user differences (Glasser et al., 2017), there is substantial evidence that e-cigarette use results in symptoms of dependence (NAM, 2018).

Dangers of vaping

The claim that e-cigarettes are less dangerous than traditional cigarettes is far from proven. A 2016 study (Shivalingappa, Hole, Van Westphal, & Vij) found that vapor from e-cigarettes impairs cellular metabolism in an *in vitro* model of heart disease in a way parallel to smoke from traditional cigarettes. In contrast, a literature review concluded that most studies find that the toxic effect on cells from vaping tends to be less than that caused by combustible

cigarette smoke (Glasser et al., 2017). Users of e-cigarettes also report symptoms such as chest pain, palpitation, as well as signs of cardiovascular disease such as coronary artery disease and an arrhythmia (Wang et al., 2018).

Diacetyl, a compound known to cause lung damage, has been found in e-cigarette liquid (Allen et al., 2016; Farsalinos, Kistler, Gillman, & Voudris, 2015). In addition, evidence has been found that even non-nicotine liquid used in vaping can inhibit immune cell function in the lungs, potentially making users more susceptible to infection (Clapp et al., 2017).

Research has recently been done on the short-term physiological effects of vaping. Non-smokers who took a number of puffs from e-cigarettes using non-nicotine liquid were found to have temporary restricted blood flow in the artery and vein in the thigh, through comparisons of Magnetic Resonance Imaging (MRI) scans before and after vaping. While it was not entirely clear what causes this, the authors concluded that vaping causes a transient impact on endothelial function (Caporale et al., 2019). On the other hand, a study that explored exposure of epithelial lung tissue to combustible cigarette smoke and e-cigarettes aerosol, found that while cigarette smoke has a pronounced negative effect, aerosol from e-cigarettes did not (Czekala et al, 2019).

In the summer of 2019, more than 200 teens were hospitalized with breathing issues believed to be tied to vaping (Kaplan & Richtel, 2019). By the end of November of 2019, the CDC (2019b) had received reports of at least 2,172 cases, from 49 states, of lung injury with 42 cases of death tied to e-cigarettes and theorized that these cases are tied to unknown chemical exposure. Initial findings found that the injury to the lungs presented as a chemical burn from an inhaled substance (Butt et al., 2019). Vitamin E acetate, a thickening agent added to some vaping liquids, has been identified as a possible cause. The CDC (2019b) recommends that people do not vape THC and that vitamin E acetate no longer be used as an additive. Layden et al. (2019)

concluded that although the particular feature(s) of e-cigarettes that cause this spate of respiratory illness has not been definitively identified, "this cluster of illnesses represents an emerging clinical syndrome or syndromes" (p. 1) and further research is necessary.

Especially in light of these developments, there is insufficient data to conclude that e-cigarettes can be safely used without serious health issue over and above those already tied to combustible cigarette use. The NAM (2018) report conclusion that there is no available evidence that e-cigarettes cause cardiovascular or respiratory disease in humans reflects this lack of sufficient research and needs to be re-examined in light of more current research published after the report's August 2017 cutoff.

Irrespective of conclusions about the relative harm of e-cigarettes as compared to traditional cigarettes, they are certainly harmful. E-cigarettes have been shown to contain potentially harmful chemicals and additives. A review of literature (Qasim, Karim, Rivera, Khasawneh, & Alshbool, 2017) concludes that vapor from e-cigarettes is not emission-free and contains chemicals which can be harmful, in some cases at levels which rival traditional cigarettes. This has ramifications for individuals who vape, as well as those around them. A review of the literature (Collaco, Drummond, & McGrath-Morrow, 2015) recommended treating the vapor produced by e-cigarettes as second-hand tobacco smoke until further research is conducted into its effects. Later studies have also found that those living in a home with e-cigarette users experience nicotine exposure (Ballbe et al., 2014) as do those in a simulated environment patterned after exposure in a social setting (Melstrom et al., 2018). Specific chemicals and their potential harm will be discussed in the section on additives.

Additives

One of the potential dangers of vaping is the presence of metals and chemicals that are known to be dangerous in other contexts including substances that are carcinogens and those that cause lung disease. The NAM (2018) review concluded that there is substantial evidence that carcinogenic chemicals are present but there is not enough evidence that the amounts are large enough to increase the risk of cancer. More research on the long-term effects of vaporizing these additives is needed.

The NAM (2018) review found some evidence that metals are present in higher dosages than in combustible cigarettes (aside from cadmium which is definitely lower in e-cigarettes). A 2016 study (Palazzolo, Crow, Nelson, & Johnson) found trace metals at levels lower than traditional cigarettes, but still present in significant amounts. Nickel, a known carcinogen, has been associated with lung cancer and bronchitis (Hess et al., 2017), and was found in quantities significantly higher than in traditional tobacco products (Palazzolo et al., 2016). Although some smaller studies found only trace amounts of metals (e.g. Beauval et al., 2017), larger studies found significant concentrations of metals in vaping liquid (Hess et al., 2017). In addition, Olmedo et al. (2018), found that the amount of metal in the aerosol being inhaled was potentially far higher than what was found in the liquid. In their study of e-cigarette liquid, Hess et al. (2017) found lead, a toxic metal that has been linked to cardiovascular disease (Olmedo et al., 2018), manganese, a potent neurotoxin, and chromium, a metal that causes emphysema and decreased lung function when inhaled (Hess et al., 2017).

In 2000 a food additive called diacetyl, used in microwave popcorn, was found to cause severe respiratory complications after extended exposure to fumes created when it was heated (Kreiss et al., 2002). The condition was nicknamed “popcorn lung”, due to its initial discovery. A

2015 study (Farsalinos et al.) tested 159 different samples of flavored e-cigarette refill liquid for diacetyl and acetyl propionyl (another additive that has been shown to cause similar lung respiratory issues in animal experiments) and found that almost 75% of the samples contained at least one of the chemicals. A 2016 study (Allen et al.), that focused on the most popular e-cigarette brands, had almost identical results. Other dangerous additives, such as diethylene glycol (a known carcinogen found in antifreeze), have been found in a significant minority of refill liquid used in e-cigarettes (Palazzolo, 2013). Although in many cases these chemicals are found in very small quantities, not enough is known about prolonged exposure to determine the impact on the user (Pisinger & Dossing , 2014; Qasim et al., 2017).

Even when it comes to non-nicotine liquid, some of these concerns are still present. Additionally, it should also be noted that a number of studies have found liquid which is marketed as "nicotine-free" to contain significant amounts of nicotine (Pisinger & Dossing, 2014). The NAM (2018) and Glasser et al. (2017) literature reviews found high variability in the presence and levels of toxic chemicals among devices and e-liquids. Even how the individual user utilizes the vape can significantly impact the level of metals inhaled (NAM, 2018).

FDA Regulation

Due to the dangers present in e-cigarettes documented in the dangers and additives sections, the FDA eventually began oversight of e-cigarettes. Understanding the history of the FDA's role and policies is critical in appreciating the reality at the time of different research studies. Vaping is a new enough phenomenon that the degree of longitudinal research is currently lacking. Compounding the dearth of research, recent policy changes impact the landscape of e-cigarette production and teen usage, making studies that are only a few years old, obsolete. Adding to the need for caution in drawing conclusions from research is the fact that

much of the earlier published literature involved studies which are too small and involve conflicts of interest, such as funding from electronic cigarette companies or authors who have served as consultants for these companies (Pisinger & Dossing, 2014).

In June 2009, the Family Smoking Prevention and Tobacco Control Act was signed into law, giving the FDA regulatory power over tobacco. The act banned sale to youth, restricted marketing (banning such practices as giving away cigarettes or name-brand tobacco merchandise) and required product warning labels and disclosure of ingredients (FDA, 2018). Although e-cigarettes were imported to the US starting in 2006 (US Custom and Broder Protection, 2006), it was not until 2016 that the FDA finalized a rule extending regulatory authority to include electronic nicotine delivery systems (ENDS). Under this new rule the FDA regulated the manufacture, import, packaging, labeling, advertising, promotion, sale, and distribution of ENDS, including components and parts of ENDS and some material for vaping ENNDS (FDA). It became illegal to sell e-cigarettes to anyone under 18 and retail stores were required to ask for identification for any person under 27 years of age. Producers were also required to submit ingredient lists and include warning labels like other tobacco products. Steps have also been taken to stop the marketing of e-cigarette products in ways similar to youth-market oriented food products (FDA, 2019).

Due to legal action against the FDA (McGinley, 2017) the date for e-cigarettes to be registered with the FDA was moved from 2018 to 2022 for non-combustible products, like e-cigarettes. The response to this delay was further legal action against the FDA, this time from physicians and special interest groups citing concern for adolescents in the intervening time before the oversight of vaping products would go into effect (Lavito, 2018).

Relevance of Adolescent Attitudes Regarding E-cigarettes to Education

Teen Interest and Perceptions

Teen Interest

Equally as concerning as current usage data for adolescents, is data on teen interest in trying e-cigarettes. Vaping continues to show signs of becoming a socially acceptable and normalized behavior in teens (Measham, O'Brien, & Turnbull, 2016). Teens in large numbers express a willingness to try e-cigarettes, suggesting that the numbers of teens engaged in vaping will continue to remain significant for some time. Krishnan-Sarin, Morean, Camenga, Cavallo and Kong (2015) found that in a group of 3,600 high school students in Connecticut over 30% who hadn't yet vaped said they would use e-cigarettes in the future, although only 12% identified as currently using electronic cigarettes. Kong, Morean, Cavallo, Camenga, and Krishnan-Sarin (2015), in a survey of middle school, high school and college students, found that curiosity about vaping was even higher, between 50% and 60% in all three groups. Openness to trying e-cigarettes has been shown to be a significant risk factor for actually vaping in the future (Kwon et al., 2018). Understanding what attitudes contribute to this curiosity is necessary to effectively reverse the trend of adolescent and teen e-cigarette use.

The teen attitudes relating exclusively to the e-cigarettes, as opposed to traditional cigarettes, cited in the literature can be organized into a two by two matrix (figure 1). The horizontal axis breaks the factors into aspects of vaping that are perceived as positive and those that are negative aspects of combustible cigarettes, not present in e-cigarettes. A second distinction, organized in the two columns, separates aspects are related to the internal perception of e-cigarette users from those that are external – visible attributes of the devices used for vaping

or the act of vaping. These distinctions will be helpful for organizational purposes and will also have ramifications on how to educate teens.

	External	***Internal***
Perceived Positives	Flavors Design Price Point	Peer Validation
Absence of Barriers	Ease of Concealment	Perceived Risks Lack of Psychological Barriers

Figure 1 – Aspects of Teen Interest

Flavor

Teen self-reporting and objective data both demonstrate the fact that flavor is a significant factor in teen e-cigarette usage. E-cigarettes represent a more enticing option for teens than traditional cigarettes, most pronounced during the high school years, due to the flavors (Kong et al., 2015). This motivation represents a threat not encountered with combustible cigarettes that are not generally experienced as "tasting good." In national studies, over half of adolescent users cited experimentation or curiosity as the main reason for vaping. However, a close second was the taste and flavors, reported by between 30% and 40% of users (Johnston et al., 2015; Patrick et al., 2016). In later studies the flavor of e-cigarettes remained an important part of teen interest (Camenga et al., 2018; deAndrade, Angus, & Hastings, 2016; Tsai et al., 2018) and in some cases, moved to the most significant determinant for adolescents considering experimenting with e-cigarettes (Zare, Nemati, & Zheng, 2018).

Pepper, Ribisl and Brewer (2016), based on a phone survey of over 1100 teens, found that teens are more likely to try e-cigarettes offered by a friend when the liquid is flavored. When compared to the control of tobacco flavor, teens were more than four times as likely to use

candy-flavored and five times as likely to use fruit flavored e-cigarettes. Alcohol flavored e-cigarettes had a slightly higher positive response rate (4%) than the tobacco control (2.2%), indicating that it is these specific types of flavors that entice teens and not simply the presence of any flavor. Pepper et al. (2016) controlled for the difference in risk perception of flavors as opposed to non-flavored e-cigarettes and still found that flavor was related to higher rates of teen usage. Although some research found that flavor was not a significant factor in adolescent choice to use e-cigarettes, a survey of the literature found thirteen separate studies confirming adolescent interest in flavors, especially sweet flavors like candy and fruit (Zare et al., 2018).

The significant impact of flavors in teen usage of e-cigarettes is demonstrated by teens choosing vaping over traditional cigarette smoking due to flavoring (Modesto-Lowe & Alvarado, 2017; Schneider & Diehl, 2016). The variety of these flavors is also mentioned by adolescents as what draws them into vaping (deAndrade et al., 2016; Hilton, Weishaar, Sweeting, Trevisan, & Katikireddi, 2016; Measham et al., 2016). Non-users are aware of flavors (Camenga et al., 2018) and are more likely to try flavored e-cigarettes than those that are not flavored (Zare et al., 2018), making flavoring a very significant catalyst of teen vaping. Alexander, Williams, and Lee (2019) similarly found that flavor was the most popular reason cited for trying e-cigarettes and most teens reported that their first e-cigarette was flavored. A higher percentage of adolescent users of e-cigarettes (41%) cite flavors as the impetus for vaping, as opposed to 31% of those who are not current users (Tsai et al., 2018). This finding compliments the self-reporting of teens, demonstrating that flavor does in fact lead to use, and it is not simply a perception that teens have. Even advertisements for flavored e-cigarettes caused more interest in vaping among adolescents than similar ads that did not mention flavor (Vasiljevic, Petrescu, & Marteau, 2016).

Flavor also correlated with other attitudes that adolescents have about vaping. Flavor predicted adolescent and young adult perceived risk in e-cigarettes 36% of the time, even more than warning labels, that predicted risk perception 35% of the time (Czoli, Goniewicz, Islam, Kotnowski, & Hammond, 2016). Chen-Sankey, Kong and Choi (2019) found that flavored e-cigarettes are perceived as easier to use by teens than their unflavored counterparts. While the reason for this is not clear, it is another way flavor can make adolescent perception of vaping more positive.

Design

Teens enjoy the look of the vaping devices themselves and want to own them, similar to a preference for owning the latest phone or other gadget (Kong et al., 2015; Measham et al., 2016). The sleek look of JUULs specifically, is mentioned by Hammond, Wackowski, Reid, and O'Connor (2018) in their study on JUUL use by young people in the US. Similarly, how easily the vaping device could be modified was cited in at least one study as a reason for interest among adolescents (Zare et al., 2018). However, although some teens spoke about the design in a positive way, others commented that it looked foolish to use a vape as opposed to a combustible cigarette (deAndrade et al., 2016).

Price Point

Although the prices of e-cigarettes vary significantly based on the type of device, some are cheaper than combustible cigarettes and are marketed as such. For example, on JUUL's website there is a savings calculator that calculates how much a smoker would save by switching from combustible cigarettes to JUUL e-cigarettes (https://www.juul.com/calculator). The lower price point of e-cigarettes is a factor in its appeal to teens (deAndrade et al., 2016; Modesto-Lowe & Alvarado, 2017; Schneider & Diehl, 2016).

However, the evidence suggests that price point is not a significant reason that teens engage in vaping. A survey of California teens found that almost half believed that cigarettes were cheaper than e-cigarettes (Gorukanti, Delucchi, Ling, Fisher-Travis, & Halpern-Felsher, 2017). Additionally, Tsai et al. (2018) reported that in the 2016 national tobacco youth survey, low cost was cited by only about 3% of respondents as a reason they use e-cigarettes, compared to five times as many respondents citing that e-cigarettes are less harmful than combustible cigarettes and ten times as many respondents citing the flavors as a reason for their use. However, in a survey of California 9th and 12th graders, 69.79% and 73.21% respectively, responded that if prices for e-cigarettes were higher teens would be less likely to use them (Gorukanti et al., 2017), suggesting that it may be a contributing factor to usage.

Ease of Concealment

E-cigarettes generally have their own internal heating element and do not require the use of an outside heating source (WHO, 2016). This, along with their compact design, means e-cigarettes are easily hidden. The lower risk of discovery is a reason for teen preference of vaping to traditional cigarette smoking (Hilton et al., 2016; Schneider & Diehl, 2016). Teens cite ability to conceal as a reason they are able to vape in their homes, since their parents "don't know what it is" (Hilton et al., 2016, p.5), and at school (Schneider & Diehl, 2016). The fact that the vapor dissipates quickly along with the lack of residual smell (deAndrade et al., 2016) and the resemblance of devices to USB drives, are additional reasons that vaping can be easily concealed (Polakovick, 2018). Low fear of discovery contributes to the trend of adolescent using e-cigarettes as opposed to combustible cigarettes.

Peer Validation

The social acceptance of smoking among adolescents is influenced by peer usage (Alesci, Forster, & Blaine, 2003) and the same is true of vaping (Barrington-Trimis, 2015). In general, there is a link between peer usage of illicit substances and adolescent experimentation, likely due to peer pressure and the normalization of the behavior within peer groups (Wills & Cleary, 1999). In a survey of over 4,000 students, 22.4% felt the reason adolescents use e-cigarettes was to have a good time with friends (Patrick et al., 2016). As opposed to combustible cigarettes, where peer influence is strongest in middle school (Liao, Huang, Huh, Pentz, & Chou, 2013), for e-cigarettes the influence of knowing that peers are vaping is most influential during the transition from middle school to high school (Carey et al., 2019).

Unique aspects of vaping contribute to the peer validation of e-cigarette use, namely the perception of peers and the ability to do tricks. Peer validation (Modesto-Lowe & Alvarado, 2017) and vaping being seen as "cooler" than traditional cigarettes (Schneider & Diehl, 2016), have also been suggested as reasons for adolescent interest in e-cigarettes. While very few teens cite "famous people use them" as a reason for engaging in vaping, almost 40% agree that a friend or family member's use of e-cigarettes contributed to their own usage, the most often picked reason for vaping among teens (Tsai et al., 2018). Close friends or an adult in the home who smoked was similarly found to be a factor in adolescents beginning to use combustible cigarettes in longitudinal studies (e.g. Abroms, Simons-Morton, Denise, Haynie, & Chen, 2005; Pierce, Distefan, Kaplan & Gilpin, 2005).

The ability to "do tricks" with e-cigarettes, and the proliferation of internet memes to this effect, is likely part of the appeal for teens (Camenga et al., 2018; deAndrade et al., 2016). These tricks and performances contribute to vaping becoming socially acceptable among teens

(Measham et al., 2016). In Measham et al.'s (2016, p. 229) study of adolescents in England, many teens responded that the main reason they use e-cigarettes is the ability to do tricks, called "cloud chasing". In another study in England, teens cited "fun tricks" as a significant reason for using e-cigarettes (Hilton et al., 2016, p. 5). Teens in the US, especially slightly older teens, also focused on the tricks and expressed a preference for vaping devices that produce more vapor to facilitate these tricks (Alexander et al., 2019). While some studies do not reference tricks, they may have overlooked the importance of this element. For instance, Tsai et al. (2018) used a survey that had responders choose from a list of reasons teens vape, but having fun and doing tricks were both not options. Over 30% of respondents chose the option of "another reason" and might have chosen these options if they were offered. This is a significant oversight and future research will be more accurate if it includes these choices.

The influence of peers is also visible in the adolescent preference for sharing videos and photos of themselves performing tricks with e-cigarettes (Measham et al., 2016). Social media was also cited by teens as a source that encouraged vaping (Hilton et al., 2016) indicating that social media and peer approval are part of a cycle that catalyzes increased adolescent vaping. More research into the mechanism of peer support and approval will assist in tailoring education to combat this reality.

Perceived Risk

Teens have also been shown to be misinformed about the realities of vaping and the potential risks (deAndrade et al., 2016). In a national study, perceived risk of e-cigarettes by adolescents was found to be the lowest of all illicit substances, including alcohol. Less than 20% of teens saw e-cigarettes as a great risk as compared with over 70% who saw great risk in smoking one or more packs of cigarettes daily (Johnston et al., 2015). Similar discrepancies in

risk perception were found in the United Kingdom (Measham et al., 2016). In small groups, teens also mentioned low levels of perceived risk as a reason they believe adolescents are drawn to vaping (Hilton et al., 2016). Teens have difficulty identifying risks associated with vaping while they are quick to bring up benefits, in contrast to cigarettes where they were hard pressed to find benefits but identified risks easily (Roditis & Halpern-Felsher, 2015). The 2017 NIH study showed that over half of the students who reported vaping erroneously believed the mist inhaled only contained flavoring, demonstrating an extreme lack of awareness of the substances they were inhaling and their risks (Miech et al., 2018).

Margolis, Nguyen, Slavit and King (2016) found that increased harm perception is associated with a lower level of curiosity about e-cigarettes, suggesting that the low risk perception described will cause more teens to be drawn into vaping. Rohde et al. (2018) and Kwon et al. (2018) had a similar conclusion in their studies of adolescents. The connection between low risk perception and initiating vaping holds true both for perception of absolute harm (i.e. that vaping is not harmful) and for perception of harm compared to traditional cigarettes (i.e. that vaping is harmful, but less harmful than combustible cigarettes). Teens who use e-cigarettes also have a low risk perception of tobacco relative to teens who haven't used e-cigarettes (Miech, Patrick, O'Malley, & Johnston, 2017).

Misevaluating risk is also visible in the disparity between perceived and actual risk of sweet flavorings in e-cigarettes. Flavored e-liquids were consistently evaluated as less risky than unflavored liquid by teens despite the fact the additional additives make the flavored liquids a higher risk (Zare et al., 2018).

Lack of Psychological Barriers

Psychological barriers that are present in traditional cigarettes, due to physical manifestations of habitual smoking, are not present in the vaping process. Specifically, undesirable side-effects of smoking including yellowed teeth, stained fingertips and halitosis, are not experienced by e-cigarette users (Schneider & Diehl, 2016). Teens who identify as users, report being unaware that any studies have shown e-cigarettes to be unhealthy (Alexander et al., 2019). Teens describe vaping as fun and highlight the ability to do tricks and the variety of enjoyable flavors (Camenga et al., 2018; Hilton et al., 2016; Measham et al., 2016). Additionally, some flavored e-cigarettes share "sensory similarities" to sweet foods, further reducing psychological barriers to using flavored e-cigarettes (Chen-Sankey et al., 2019, p. 7). These discrepancies mean that teens who might choose not to smoke combustible cigarettes will still consider using e-cigarettes. This attitude is reflected in the low disapproval rates of regular use of e-cigarettes among adolescents, as compared to other risky behaviors (Johnston et al., 2015).

Educational Ramifications

Rates of traditional cigarette smoking in teens are in steady decline, while rates of vaping are increasing rapidly (CDC, 2016; CDC, 2019c). Schools must recognize the new reality on the ground and make focused efforts to educate students on vaping and its effects. Education of adolescents should focus on the internal aspects both absence of barriers (perceived risk and the lack of psychological barriers) and positive (peer validation), as laid out in figure 1. These attitudes can be influenced by education crafted using an understanding of the unique aspects of vaping and adolescent perceptions of e-cigarette use.

Understanding Teen Perception

Vaping is a phenomenon recent enough that most adults in schools have not had personal experience with vaping when they were teens. This makes it both more critical, and more challenging, to understand how adolescents in our schools are perceiving vaping. Although some research has been included in the literature review section, more research must be done on how teens perceive vaping. Part of a school's approach to vaping should include engaging their own students to discover how they perceive and relate to vaping. The significance of social media, both as a catalyst for initiating vaping and as an outlet that reinforces the peer validation of vaping through tricks, must be considered. This practice should be monitored and addressed by schools.

Much of the research has highlighted curiosity and experimentation as the most common reasons for adolescents to engage in vaping. However, the good taste (Johnston et al., 2015, Patrick et al., 2016) and variety of flavors (Modesto-Lowe & Alvarado, 2017) were given by a significant number of teens to explain their usage, and in some studies rose to the prime reason (Zare et al., 2018). Perception of a risky behavior as rebellious (i.e. parent disapproval) and peer-approved has been shown to correlate with increases in smoking behavior when it comes to cigarettes (Eisenberg & Forster, 2003). Similarly, teen perception of vaping as a rebellious behavior is one reason teens engage in vaping (Hilton et al., 2016). These understandings of student motivation, coupled with data collected from their specific student population, should help shape a school's approach to adolescent vaping.

Changing Risk Perception

Rohde et al. (2018) found that teen knowledge of e-cigarettes does not predict initiating use. Two important factors that did significantly predict future e-cigarette usage in adolescents

are low risk perception of vaping (Kwon et al., 2018; Rhode et al., 2018) and perception that the likelihood of addiction is low (Kwon et al., 2018). School education programs tailored to adolescents should be informed by this research and focus efforts on education about risks and addiction. Teen risk perception of vaping is very low compared to other risky behavior (Hilton et al., 2016; Johnston et al., 2015), and can be raised through education about hazards specific to vaping. Schools must inform teens about the risks of nicotine, and even nicotine-free vaping, including harmful additives, as documented in the literature review section of this article.

Tracking Policy

Policy changes, including the FDA's inclusion of e-cigarettes in their regulation of tobacco products and state legislation that affects the social acceptability of vaping, must be monitored and understood by schools for two reasons. Firstly, government and state policies must be properly understood for schools and districts to form their own policies. Secondly, the specifics of policy are an important part of educating students about vaping. The fact that legislation and policies are newer, means up to date information is more complex and nascent and may not be easily accessible to students or their families. Schools should facilitate high school and middle school students receiving accurate information about the laws and regulations pertaining to vaping. Resources to assist with this effort are available to schools.

State Resources

A number of states have websites dedicated to guiding schools to resources for e-cigarettes. These websites collect educational resources for schools and recommend elements of a schools' approach to the growing phenomenon of adolescent and teen use of e-cigarettes. In aggregate, these state sites provide significant material for educating students, staff and parents

about e-cigarettes, as well as resources to minimize the workload around crafting and rolling out policies for schools.

The most common elements suggested for schools are evaluating current e-cigarette policies within the school, educating staff, students and parents on vaping and the potential dangers, and using signage or posters around the school. Other recommendations that appeared in only one or two states, but bear mentioning, are tracking school data on vaping, launching a student-run anti-vaping program and advocating with school boards for stronger policies. Tracking data should be considered by more schools in order to collect data on the extent of vaping in their schools. Additionally, tracking data has the potential to demonstrate that vaping may not be as wide-spread as students believe. There is some evidence that peer-run programs are effective in curbing combustible cigarette smoking in schools and should also be considered as a focused intervention for e-cigarettes (MacArthur, Harrison, Caldwell, Hickman, & Campbell, 2015).

Informational resources provided on these state sites include fact sheets or reports from the Surgeon General, CDC and American Lung Association focusing on the risks of e-cigarettes, tobacco addiction and the specific risks of substance abuse on adolescent, developing brains. Educational material geared towards students, parents and school staff, as well as tools to help teens and adults quit nicotine, are also listed. Specific educational programs will be discussed in the next section of this article.

On these sites, a few states included sample school policies for anti-vaping regulations on the school campus and one state (Kansas) also included sample letters and communication to parent and community about school policies around vaping. Figure 2 lists a few of the more robust sites, highlighting specific features.

State	Website	Features
Kansas	http://www.kdheks.gov/tobacco/download/Vape_Free_Schools_Toolkit.pdf	• Sample communication to parents/community • Advice on advocating for stronger policies
Massachusetts	http://makesmokinghistory.org/dangers-of-vaping/schools/	• One of the most comprehensive • Resources on current laws
Minnesota	https://www.health.state.mn.us/communities/tobacco/ecigarettes/docs/schooltoolkit.pdf	• Sample policies for schools • Anti-vaping signage
South Dakota	https://doh.sd.gov/documents/Prevention/tobacco/E-CigaretteVapingHandout.pdf	• Website/Resources crafted for teens

Figure 2. Selection of state toolkits of e-cigarette resources

Educational Programs

A number of programs exist but few, if any, reach the recommended goals of a curriculum set out by the surgeon general and the CDC. The surgeon general recommends that school programs should be "comprehensive, interactive, start early, be sustained, incorporate an appropriate number of lessons, and be integrated into a community-wide approach" (HHS, 2012, p. 792). Education about e-cigarettes should be part of ongoing school health education, introduced in elementary school, intensified in middle school and reinforced during the high school years (CDC, 2019A). Programs should address social acceptability, peer pressure and inform students about health risks. Moreover, these programs should build resistance and refusal skills in students (CDC, 2019A).

Seven popular programs are listed in figure 3. The tobacco prevention toolkit from Stanford Medicine (2019) has the most robust resources for educators including clearly mapped out lesson plans with PowerPoint presentations and Kahoot interactive online quizzes to assess student understanding for each lesson. While no single resource is designed for elementary through high school, a combination of these resources can be utilized in schools to integrate information about e-cigarettes into the existing health curriculum.

Intervention	Description	Population	Source
The Tobacco Prevention Toolkit	Toolkit to be delivered by educators and aimed toward tobacco, e-cigarettes, and vaping	For middle and high school students	Stanford University (School of Medicine)
CATCH My Breath Youth E-cigarette Prevention Program	Provides schools with a free curriculum for middle and high schoolers to educate them on vaping	Ages 11-18	CATCH (Coordinated Approach to Child Health)
Get Smart About Tobacco - Health and Science Education Program	Provides educators and schools with lessons, posters, hands-on experiments and fact sheets about smoking (includes e-cigarettes)	For students in grades 3-7	Scholastic
E-Cigarettes: What You Need to Know (Teacher's Guide)	Provides teachers with resources and student materials about e-cigarettes	For students in grades 6-12	Scholastic
Vaping and JUULING Lesson Plans	Curriculum for teachers to educate about the harms of vaping	For middle and high school students	Physician Advocacy Network
School E-cigarette Toolkit	Provides tools and resources to address vaping products in schools	School staff, for students	Minnesota Dept. of Health
Know the Risks: A Youth Guide to E-cigarettes	A 45 minute presentation on the harms of vaping with a teacher's guide.	Ages 11-18	CDC's Office on Smoking and Health (OSH)

Figure 3. E-cigarette Educational Programs (Table adapted from O'Connor, Pelletier, Bayoumy, & Schwartz, 2019)

The CDC has a tool for evaluating health curricula called the Health Education Curriculum Analysis Tool. The list of goals for student behavioral outcomes for tobacco use is avoid using (or experimenting with) any form of tobacco, avoid second-hand smoke, support a tobacco-free environment, support others to be tobacco-free and quit using tobacco, if already using. Although, these goals are not specific to e-cigarettes, this evaluative tool is a relevant resource with guidelines for what constitutes a successful program. Longitudinal studies of specific programs are needed to determine their effectiveness in curbing adolescent vaping.

When it comes to educational and marketing materials, vaping must be appreciated as a risky behavior that differs from traditional cigarettes in a number of ways. While there is data on the effectiveness of tobacco educational programs, very little research has been conducted into the effectiveness of educational materials focused on e-cigarettes (Cornacchione Ross, Noar, & Sutfin, 2019). O'Connor, Pelletier, Bayoumy and Schwartz (2019), in their comprehensive

review of material designed to influence adolescent use of e-cigarettes, noted that several of the interventions for e-cigarettes reviewed were initially designed for tobacco cigarettes and reapplied to e-cigarettes. It is not known if data on the effectiveness of the original program can be extrapolated to this new application. Additionally, the approach of educational and marketing materials discouraging smoking is not always appropriate, or effective, at discouraging vaping. For example, an FDA anti-smoking campaign aimed at teens included advertising with messages about how cigarettes yellow teeth and nails, playing to teens' focus on their appearance (Sifferlin, 2014). Such messages are not applicable to vaping and would not be an effective way to discourage their use.

The surgeon general, in a 2012 report for the HHS, concluded that although some school-based programs are ineffective, there is sufficient evidence that school-based programs can produce at least short-term reductions in adolescent tobacco use. However, educational material produced by tobacco and e-cigarette companies have been proven to be ineffective (CDC, 2019A). The CDC (2019A) recommends that school-based programs be undertaken along with community-based tobacco prevention strategies, in order to be effective.

A full search on evaluation of programs geared to educating adolescents and teens about e-cigarettes was undertaken and no peer-reviewed academic material was found (O'Connor et al., 2019). Non-academic material was scarce, but whatever existed was reviewed completely. O'Connor et al. (2019) organized the available school-based intervention material into four categories, school policies, curricula, bans on e-cigarette use and education for school authorities. The only evaluative study reported on any of the curricula was for the CATCH My Breath program where, of the 2,255 middle school students studied, 86% said they would be less likely to try e-cigarettes after the program (O'Connor et al., 2019). An evaluative study not

mentioned by O'Connor et al. (2019) is a small study of 105 students who took a one-hour workshop in Rhode Island. Almost all students (98%) self-reported that they were less likely to use e-cigarettes after the workshop (Leyva et al., 2017). However, the small size of this study and the fact that it relies on immediate self-reporting without any longitudinal data severely limits drawing any significant conclusions about effectiveness.

In general, the paucity of data and the lack of longitudinal empirical data makes drawing conclusions about the success of any of these programs premature. Longitudinal studies of the effectiveness of educational programs, community-based programs and public educational programs already in existence, is an important next step in developing this area of education.

Conclusion

The most recent rates of adolescent vaping are more than four times the rates for adolescent use of combustible cigarettes (CDC, 2019c). Teen vaping is a current issue that needs to be addressed by schools. Teens are dangerously misinformed about what vape liquid contains and the potential risks of using e-cigarettes (Miech et al., 2018). An appreciation by teens of the risks involved has been shown to lower the level of curiosity and willingness to experiment with vaping (Margolis et al., 2016). This research suggests that schools should make informing teens about the risks of e-cigarette use a focus of their efforts to curb teen vaping. Understanding the unique aspects of e-cigarettes that make them enticing to adolescents and teens is a critical step in shaping a sound approach to educating them about vaping. Tools and resources exist that can be utilized in educating students but research into their effectiveness is sorely needed. Schools conducting their own research and conversations with their students will help to identify specific attitudes towards vaping which will, in turn, inform further efforts to educate students.

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