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Escalating Safety Concerns Are Not Changing Adolescent E-Cigarette Use Patterns: The Possible Role of Adolescent Mental Health

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Emerging evidence on the effects of e-cigarettes on the lungs [1,2], brain [3], heart, and blood vessel functions [4–6] and related adolescent addiction [7] forcefully detracts from claims that "e-cigarettes are a safer alternative to cigarettes" [8]. Since September 2019, the Centers for Disease Control and Prevention has issued guidelines asking all youth and young adults to stop using e-cigarettes [9]. An outbreak of more than 2,000 lung illnesses and deaths have been linked to e-cigarettes/vaping. However, persuasive advertising, e-cigarette flavors, peer pressure, and changing social norms result in continued adolescent e-cigarette initiation and use. Furthermore, evidence about the addictiveness of e-cigarettes is mounting, with many youth finding it difficult to quit. All eyes are on the scientific and public health community to characterize the youth e-cigarette epidemic and to provide targeted, evidence-based solutions.

This issue of the *Journal of Adolescent Health* provides the latest, national longitudinal data to confirm that patterns of adolescent e-cigarette use remain dangerously and consistently high. Veliz et al. [10] used data from the Population Assessment of Tobacco and Health across three time points (from 2015 to 2016) to show that most adolescents using e-cigarettes in the past 30 days had previously never used any other tobacco products. Evans-Polce et al. [11] using Monitoring the Future data (2015–2017) similarly find that compared with cigarettes, more adolescents were initiating tobacco with e-cigarettes instead of cigarettes. Data from the 2015 to 2017 National Youth Tobacco Survey, studied by Odani et al. [12], showed that e-cigarette users were three times more likely to go on to use cigarettes. These findings support preliminary data from the latest National Youth Tobacco Survey that adolescent e-cigarette use continues to rise, with 27.5% of high school students reporting e-cigarette use in the past 30 days [13]. Furthermore, there is no particular sociodemographic group at greater or less risk of using e-cigarettes [14]. That adolescents are addicted to e-cigarettes is a sentiment echoed by parents, educators, and adolescents across the country. Sustained patterns of use demonstrate that adolescents' e-cigarette behavior is not just a fad or likely to decrease over time [15], with many adolescents addicted to e-cigarettes [7,16].

Known factors responsible for adolescents' use of e-cigarettes include aggressive e-cigarette advertising and marketing [17–20], leading to a lower perception of risk of e-cigarettes [21–23], appealing flavors [22,24,25], and lack of underage sales restrictions and regulation. Results from three new studies in this issue of the *Journal of Adolescent Health* suggest that adolescent mental health is another important aspect linked to e-cigarette use. A study by

Staff et al. [26] showed that adjustment problems, delinquent behavior, and substance use were associated with adolescent dual users (those using both e-cigarettes and cigarettes) and e-cigarette–only users, compared with nonusers. The study by Veliz et al. [10] showed that adolescent dual use of e-cigarettes likely contributed to tobacco and substance use disorders. This is one of the first studies to report on long-term health consequences from using e-cigarettes. Linked with frequent use and addiction of Juuls, the study by Case et al. [27] reported that Juul, the most popular pod-based e-cigarette, has a high nicotine concentration, and most adolescents reportedly use it to obtain a higher nicotine hit. The authors further expressed concern that Juul users go on to use cigarettes for want of an even higher nicotine hit, leading to dual use. Notably, there would be no dual use without e-cigarettes, as e-cigarettes are the most commonly used product among adolescents today [28]. Overall, these studies are leading a new focus on the relationship between adolescent mental health problems as related to and potentially fueling part of the youth e-cigarette epidemic.

Given steadily growing levels of e-cigarette and cigarette dual use [29], there is a need to investigate whether mental health problems are a factor responsible for adolescents increasingly transitioning from e-cigarettes only to dual use. Research in this issue by Hiler et al. [30] reported results from a unique approach, which used concept mapping to assess why adolescents dual use. The study found that young adults' transition from e-cigarettes to cigarettes because they need to use cigarettes to manage their stress and anxiety and that they can share cigarettes with peers and parents. We already know that adolescents use e-cigarettes to feel socially connected to their peers; however, using cigarettes with e-cigarettes offers higher nicotine to potentially manage their stress.

Previous studies provide mixed evidence that adolescent mental health problems are associated with e-cigarette use. Some studies show e-cigarette use, compared with other tobacco products, is associated with depressive symptoms [31], attention-deficit hyperactivity disorder, post-traumatic stress disorder, anxiety, impulsivity, and low self-esteem [32]. In contrast, another study found no significant association between depressive symptoms and ever use of e-cigarettes by adolescents [33]. Yet another study showed that adolescents across the board are using e-cigarettes, and that "emotionally healthier" adolescents are more attracted to e-cigarettes compared with combustible cigarettes [34]. There is a need for a future systematic review to synthesize evidence on the link between mental health and adolescent e-cigarette use and to assess reasons for these contradictory findings, which are potentially related to differences in products, measures used, and when the studies were conducted. Systematic reviews show that adolescent cigarette use is associated with anxiety and alcohol use disorder [35], and, bidirectionally, linked with depression [36]. It stands to reason that users of e-cigarettes will likely display similar initiation behaviors or experience similar effects observed among adolescents using conventional tobacco products.

Surveillance and media campaigns apart, limited solutions have been enacted to address underage e-cigarette use. Several adolescent e-cigarette education curricula have been developed, pilot tested, and are being used across the U.S., such as the CATCH My Breath curriculum [37] and the Stanford Tobacco PreventionToolkit [38], among others. However, studies specifically evaluating the effectiveness of program components, such as peer refusal

skills, social influences, and positive youth development, are needed to provide evidence of "what works" to reduce underage e-cigarette use. In light of recent associations between e-cigarette use and mental health problems, the efficacy of integrated mental health and substance use education to contain the current youth epidemic must also be evaluated.

It also cannot be emphasized enough that efforts must be ramped up to develop Food and Drug Administration (FDA)-approved nicotine replacement therapy or other strategies that support adolescents to quit e-cigarettes and dual use. Currently, there is no FDA-approved nicotine replacement for anyone aged younger than 18 years, despite clear evidence that these adolescents are addicted to nicotine and need help to stop using.

Up-to-date data show that overall use of e-cigarettes continues to rise, despite evidence of their damaging health effects. Furthermore, dual use and transition from e-cigarettes to cigarettes show that adolescents are seeking progressively higher nicotine levels. Moreover, the association of adolescent e-cigarette use with mental health problems shown in the articles in this issue, especially long-term disorders, contributes to important evidence that adolescents may be in need of broader strategies to manage stress and improve their resilience to stop using e-cigarettes. Overwhelmingly, the evidence of sustained use, addiction, and associated health harms for adolescents call for immediate and effective regulation of the e-cigarette industry. The FDA cannot miss yet another opportunity to prevent the unraveling adolescent e-cigarette epidemic.

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