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The Rise of E-cigarettes Among Youth: A Public Health Crisis; Review of Current Prevalence and Risk

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ABSTRACT

Electronic cigarettes (E-cigarettes) entered the U.S. marketplace around 2006, and by 2014, they have become the most widely used tobacco product among U.S. youth. Between 2011 and 2015, E-cigarettes use among middle and high school students has increased 900%. In 2018, more than 3.8 million U.S. youth reported use of E-cigarettes. E-cigarettes present a health hazard to both users and nonusers, due to exposure to nicotine, other harmful substance, carcinogens and metal particles detected in the solution and aerosols of E-cigarettes. The risk related to this increase of E-cigarettes use among American youth necessitates regulatory efforts, legislative intervention, and proactive counter-promotion efforts to safeguard their well-beings. In addition, more research is needed to determine the public health effects of E-cigarettes among youth.

Introduction

Significant progress has been made in reducing conventional cigarette smoking among U.S. youth [1]. Electronic cigarettes (E-cigarettes) entered U.S. Market in 2006 from China where it was patented as an "Electronic automatizing cigarettes". By 2010, there were several brands of E-cigarettes sold in the USA. In 2011, E-cigarettes were added to the National Youth Tobacco Survey (NYTS) on tobacco product use. By 2014, E-cigarettes became the most used tobacco product by U.S. youth [2]. E-cigarette devices, or "vapes", are handheld devices designed to deliver emissions for inhalation by heating a solution that commonly contains humectant, nicotine and flavoring chemicals. When introduced to U.S. market, E-cigarettes were marketed as a tool for smoking cession and safe alternative to conventional cigarettes [3].

Types of Electronic Cigarettes

1. There has been a substantial evolution of E-cigarettes since their introduction. The first-generation E-cigarette are cigarette lookalikes, or "cigalikes". The second generation E-cigarettes are called vape pens, which have a refillable reservoir for electronic cigarette liquid (E-liquid). The third-generation e-cigarettes are frequently known as pod mods or "pods" which is a modified tank systems (wattage and voltage can be modified). The fourth generation E-cigarettes JUUL", was first introduced 2015 and rapidly became the most popular E-cigarette brand in USA, accounting for over 75% of E-cigarette retail market in 2018 [4].

2. JUUL, which is shaped like a flash drive, has been described as "The IPhone of E-cigarette" due to its modern and user-friendly design that requires only a sliding pod (nicotine cartridge). The

size of JUUL and its resemblance to USB flash drive allow to be easily concealed from authority figures and can be used in places where no smoking allowed [5]. This this made JUUL very popular among youth to such extent that Juuling is synonymous with vaping among youth.

3. E-cigarette solution often known as E-juice or E-liquid contains three types of Chemicals: a humectant, nicotine, and artificial flavoring [6]. The two most commonly used humectants are propylene glycol and vegetable glycerin. Both are recognized as safe for ingestion but there is little known about their safety for long term inhalation. E-cigarette solutions are often labeled with nicotine concentration, between 0-24 mg/ml, however, JUUL has much higher nicotine concentration up to 69 mg/ml [17] and each pod is marketed as equivalent to 1 pack of cigarettes (i.e. 200 puffs). In addition, JUUL utilizes protonated nicotine which help to reduce the aversive taste and smell [8]. Most brands of E-cigarette solution are also available in a variety of youth-appealing flavors as fruits, desserts, candy and soda. Menthol is a common compound found in both in mint and tobacco-flavored E-cigarette solution. These flavors mask the unwanted tastes and smells which often cited the reason for youth E-cigarette experimentation [9]. Fortunately, the growing pressure from public health related agencies and after investigation by the FDA in 2018, JUUL agreed to suspend most of its flavored E-cigarettes retail sales to reduce the accessibility to youth. On June 23, 20220, the FDA denied authorization for JUUL to continue selling its product in the United States and issued Marketing Denial Orders banning any further marketing or sale of the products effective immediately. However, that order was blocked by the U.S. Court of Appeals in Washington, D.C. the next day.

Epidemiology of E-Cigarette Use

The 30 days use of E-cigarettes among high school students in USA has increased from 1.5% in 2011 to 20.8% in 2018. A similar increase was seen in middle school students from 0.6% in 2011 to 4.9% in 2018 [10]. The following factors have contributed to the increase of E-cigarette use in U.S. youth:

Marketing

The increase in E-cigarette use in U.S. youth is fueled by the marketing of E-cigarettes in media including television, video games and social media. E-cigarette companies have promoted their products with the presumptive claims that they are healthier and safer than conventional cigarettes [11]. While television advertisements for conventional cigarettes were banned in 1971, more than 75% of middle and high school students had seen a television advertisement for E-cigarette in 2016 [12] which showed to increase the likelihood of the use of E-cigarettes in youth [13].

Youth Misperception

Youth reported the view that E-cigarettes are safer and more socially acceptable than conventional cigarettes which contributed to increased use [14,15].

Peer and Social Influences

The perception of E-cigarettes as being "cool" and socially acceptable is the most common reasons for experimentation of E-cigarettes among youth [16]. In addition, youth who expect a "friendly" response to E-cigarettes were more likely to use E-cigarettes [17]. Furthermore, having friends who use E-cigarettes was associated with 7-fold increase in risk of E-cigarette use among youth [18].

Health Harms of E-cigarettes

Data is emerging of tobacco toxicant exposure found in E-cigarette users as high urine concentration of nicotine, metals, volatile organic compounds (VOC), and tobacco-specific nitrosamine was found to be elevated in adult exclusive E-cigarette users compared to non-tobacco users [19]. FDA recognized propylene glycol and vegetable glycerin as safe for ingestion but not for aerosolization and inhalation [20]. The long-term effects of inhaling these materials are still unknown. In addition, nicotine use in youth might lead to lifelong tobacco use, as the adolescent brain is more susceptible to nicotine addiction even with intermittent exposure. Data shows that 90% of adult cigarette smokers began smoking before age 18 years [21]. Nicotine serum level can be as high in E-cigarette users as with conventional cigarette users and even higher in JUUL users [22,23]. The increase in nicotine contents in E-cigarettes will likely increase the risk of nicotine dependence, with 3.5 times increase in the likelihood of initiating conventional cigarette smoking [24,25]. Furthermore, E-cigarette smoking at age of 14 is associated with fourfold increase in the risk of cannabis use later on [26]. In addition, E-cigarette use can be harmful to others as secondhand aerosol exposure from E-cigarettes contains significant levels of harmful chemicals, and thirdhand aerosol exposure from the nicotine and toxicants that are present in the environment and surfaces after the use of E-cigarette has shown potential to cause harm to others [27,28]. Furthermore, accidental E-cigarette liquid ingestion, occurring mostly in children under the age of five, is both common and can be lethal as a standard E-cigarette liquid container contains several times the lethal dose of nicotine in children [29,30].

The Use of E-Cigarettes for Smoking Cessation

Some manufacturers explicitly or implicitly promoted E-cigarettes as a tool for smoking cessation without FDA approval. The current evidence in support of E-cigarette as smoking cessation specifically for youth remains inconclusive due to low quality of the published research [11,31,32].

Conclusion and Recommendations

The use of E-cigarette is rapidly increasing in U.S. youth. Despite being generally safer than conventional cigarettes, the increasing nicotine concentration in the most commonly used form of E-cigarettes raises the concern for nicotine dependence in youth. There is also growing concern about potential risk of future conventional cigarette and cannabis use in youth who start E-cigarette at such young age. There is also growing evidence of potential secondhand and thirdhand risk. All these factors point to the need for further research and multiple levels of interventions to address this growing public health epidemic. These interventions should involve parents, teachers, pediatricians and communities.

1. Parents need to be educated about the types of E-cigarettes and their risk, set good example by being tobacco free themselves, and adapt tobacco free rules at home.
2. Teachers need to be educated about the type of the types of E-cigarettes and their risks, develop and implement tobacco free school policies, and engage students in discussions about the risk of E-cigarettes.
3. Pediatricians should screen children for E-cigarette use, provide prevention counseling in clinical practice, and offer referral for tobacco cessation counseling and FDA approved tobacco dependence pharmacotherapy.
4. Communities should implement evidence-based population-based strategies to decrease E-cigarette use in youth, including strategies to restrict access and E-cigarette advertising that target youth.

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