REVIEW ARTICLE

Vaping epidemic: challenges and opportunities

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Abstract

This article is a timely, concise, and unbiased analysis of the national and international responses to the spate of vaping-related lung illnesses and deaths and the epidemic of teen vaping. In view of the recent outbreak of vaping-related lung injuries and deaths in the USA and the epidemic of teen vaping, the viewpoints and recommendations presented in this article have immediate policy implications in the USA and around the world. The perspectives and recommendations are expected to assist medical communities, public health professionals, and regulatory authorities in addressing complex issues related to vaping regulation, which are intertwined with public health, economy, and politics of nations, worldwide.

Keywords Electronic cigarettes (e-cigs) · Health risk · Public health · Regulation · Teen vaping

Introduction

Electronic cigarettes (e-cigs) use, otherwise known as 'vaping', is promoted as a safe or less harmful alternative to smoking or as an aide to smoking cessation [1]. Since the introduction of e-cigs into the US market over a decade ago, the appeal and popularity of vaping have significantly increased [2]. Accordingly, there has been a massive and steady rise in vaping prevalence, especially among adolescent never smokers and adult smokers seeking a putatively less harmful tobacco substitute [3]. Meanwhile, the number and type of e-cig products have increased exponentially, albeit little or no systematic regulation of sales has been in place [4].

E-cigs are handheld battery-powered vaporizing devices that simulate tobacco smoking by heating a liquid to produce an inhalable aerosol (vapor) [5]. The liquid, also referred to as 'e-liquid/e-juice', contains a mixture of propylene glycol, glycerin, flavors, nicotine at variable concentrations (incl. zero) and other substances and additives, e.g., cannabinoids (optional), such as tetrahydrocannabinol (THC) and cannabinoid (CBD) oils [1]. Of note, THS is the main psychoactive mind-altering compound in marijuana that produces the infamous "high". In recent years, significant increases in marijuana vaping have been reported, especially among adolescents [6, 7]. Vaping replicates some of the behavioral aspects of cigarette smoking, including the hand-to-mouth action, but without burning tobacco, which is responsible for production of a myriad of toxicants and carcinogens. Because vapor in e-cigs is not produced as a result of tobacco pyrolysis, vaping is claimed to be, at best, a safe, and at worst, a less unhealthy alternative to smoking [1]. However, chemical analyses of e-cig liquid and vapor have shown the presence of many of the same toxicants and carcinogens as those found in tobacco smoke, albeit in generally lower concentrations [2, 4]. Currently, investigating the biological consequences of exposure to e-cig-derived toxicants and carcinogens is a high-priority research area [8].

Epidemic of teen vaping

Recent data from National Institutes of Health's (NIH) Monitoring the Future Survey show a significant rise in American teens' use of e-cigs in just a single year, with 37.3% of 12th graders reporting use in the past 12 months, compared to 27.8% in 2017 [9, 10]. The data from the NIH survey confirm the 2018 National Youth Tobacco Survey, which demonstrates a surge in e-cig use among youth,

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reaching epidemic proportions [11]. The number of high school students who use e-cigs has increased by 78% last year to approximately 3.6 millions, which correspond to about 21% of all US high school students. Similarly, use among middle school students has risen by 48% [11]. Due to these alarming trends, many experts in public health and tobacco control have voiced concerns that we might be on the verge of addicting a new generation to the harmful effects of nicotine use.

Vaping-related severe lung injury and death

In the past several months, the health concerns about vaping have escalated to an unprecedented level both in the USA and around the world. Since August 2019, the Centers for Disease Control and Prevention (CDC), the US Food and Drug Administration (FDA), state and local health departments, and other clinical and public health partners have been dealing with a nation-wide outbreak of vaping-related severe lung illnesses, also referred to as "e-cig, vaping, or product use-associated lung injury (EVALI)". National and state data have shown a sharp increase in symptoms or cases of EVALI in August 2019, a peak in September 2019, and a gradual, but persistent decrease since then. As of 18 February 2020, a total of 2,807 hospitalized EVALI cases or deaths has been reported to CDC from all 50 states, the District of Columbia, and two US territories, including Puerto Rico and US Virgin Islands. Sixty-eight deaths have been confirmed in 29 states and the District of Columbia. Analysis of data from patient reports and product sample testing has revealed that THC emulsified with vitamin E acetate-containing e-cigs or vaping products, especially those obtained from informal sources like friends, family, or in-person or online dealers, are strongly linked to EVALI. As such, Vitamin E acetate has been detected in product samples tested by FDA and state laboratories and in EVALI patients' lung fluid samples [bronchoalveolar lavage (BAL)] tested by CDC from geographically diverse states. In contrast, no vitamin E acetate has been found in the lung fluid of people who did not have EVALI. As it stands, however, there is not sufficient evidence to rule out the contribution of other chemical constituents of THC- or non-THC-containing vaping products to some of the reported EVALI cases. In light of the above findings, the continued decline in EVALI cases reported since September 2019 has been ascribed to (I) increased public awareness of the risk associated with THC-containing e-cigs or vaping products, (II) removal of vitamin E acetate from some vaping products, and (III) law enforcement actions taken against the sale and distribution of illicit e-cigs and vaping products [12].

National and international reactions to the call for e-cig regulation

Worldwide, backlash against e-cig use is gaining more momentum. On Wednesday 18 September 2019, India joined the list of countries to effectively ban the sale, import, advertising, and production of e-cigs [13]. An emergency ordinance, to be converted into law by the parliament, was approved by the Prime Minister, Narendra Modi. According to this executive order, first-time offenders will face up to one year in prison and a fine of 100,000 rupees (~ $1,400), while repeat offenders will be sentenced to 3 years in prison and 500,000 rupees (~ $7,000) fine. Simply possessing e-cigs or similar devices will also be an offense, punishable by up to 6 months imprisonment and a fine of up to 50,000 rupees (~ $700) [13].

Thus far, 42 other countries have banned e-cig sale, 55 countries allow sale, but have put restrictions on where and how e-cig products can be sold, while 30 countries regulate the amount of nicotine used in e-cig devices [14]. For example, Singapore has an outright ban on e-cigs, whereas Japan allows sale and distribution of non-nicotine e-cigs and "heat-not-burn" tobacco products. Because liquid nicotine is highly regulated in Japan, vaping devices with nicotine-containing e-juices are banned; however, non-nicotine e-cigs and heated smoking devices, *e.g.*, "I Quit Original Smoking" (IQOS), are widely marketed and sold. Legislation on e-cigs is also being tightened in other countries; in July 2019, China, home to nearly one-third of the world's smokers (300 million Chinese smoke tobacco), announced a need for "severely strengthening the supervision of e-cig". Just days prior to India's ban on e-cigs, vaping products from Juul, the San Francisco-based world's largest maker of e-cigs with 72% of the market share, were mysteriously vanished from online Chinese marketplaces [14]. India's ban also came on the heels of New York becoming the first US state to ban flavored vape products on 17 September 2019. A similar emergency directive had earlier been approved in Michigan and expected to go into effects in a few weeks' time. However, the New York state's emergency ban on flavored vaping products was later challenged in court by the Vapor Technology Association, an industry group, and two of its member businesses. The request for injunction against enforcing the ban argued that it would force vaping businesses across the state to close. In January 2020, Acting State Supreme Court Justice, Catherine Cholakis, blocked the ban by ruling that the state Public Health and Health Planning Council overstepped its authority last September when it issued the emergency ban. In her ruling, Judge Cholakis stated that regulating the vaping industry is a job for the state Legislature, not the executive branch, whose

function is to implement policy set by lawmakers. Kyle Kotary, a spokesman for Governor Andrew Cuomo (D), called Cholakis' decision "unfortunate," but added that the judge had acknowledged the seriousness of the vaping issue in her ruling. "That said, we're reviewing the decision, evaluating our procedural options and moving forward with comprehensive legislation to address the public health concerns related to vaping," the Governor's spokesman, also added.

On Wednesday 11 September 2019, Donald Trump announced his administration's plan for a ban on most flavored e-cig products believed to be responsible for teen vaping, and the issuance of the FDA's guidance on how to take these products off the market [15]. In response, industry and political allies warned that such a ban would cost thousands of jobs and alienate voters. Two days later, Trump quickly dialed back and softened his rhetoric by tweeting that "While I like the Vaping alternative to Cigarettes, we need to make sure this alternative is SAFE for ALL! Let's get counterfeits off the market, and keep young children from Vaping!". In November 2019, he further backtracked after a White House meeting with tobacco industry giants, vaping advocates, and public health groups. On 2 January 2020, the Trump Administration finally announced a ban on some—but not all—flavored e-cig products, in a compromise that sparked criticism from both vaping advocates and adversaries. The limited ban applies to the cartridge-based e-cig devices manufactured by companies like Juul Labs, which are highly popular among teenagers. Under this ban, companies are prohibited from selling sweet and fruity flavored vape pods and e-liquid cartridges, whilst menthol- and tobacco-flavored products as well as larger, open-tank vaping systems, which users can manually fill with e-liquids of their choice, remain exempt.

In countries where e-cig use is encouraged as a way to quit smoking, the news of spate of U.S. deaths and pulmonary illnesses associated with vaping drew a different reaction. On 12 September 2019, Public Health England (PHE), the country's leading health body, shared its advice by stating that: "Our advice on e-cigarettes remains unchanged— vaping isn't completely risk free but is far less harmful than smoking tobacco. There is no situation where it would be better for your health to continue smoking rather than switching completely to vaping. All UK e-cigarette products are tightly regulated for quality and safety by @MHRAgovuk. It's important to use UK-regulated e-liquids and never risk vaping home-made or illicit e-liquids or adding substances, any of which could be harmful. Smoking kills thousands every year and creating a smoke free generation is one of our top priorities. Vaping is a fraction of the risk of smoking and makes it much more likely you'll quit successfully than relying on willpower alone. The sooner you stop smoking completely the better." The PHE's advice echoed remarks from its head of Tobacco Control, Martin Dockrell,

who had earlier told the Guardian: "Unlike the US, all e-cigarette products in the UK are tightly regulated for quality and safety by the Medicines and Healthcare Products Regulatory Agency and they operate the yellow card scheme, encouraging vapers to report any bad experiences" [16].

Challenges and opportunities for e-cig regulation

The epidemic of teen vaping and the outbreak of vaping-related lung injuries and deaths in the US underscore the urgent need to systematically regulate e-cig manufacturing, marketing, and distribution. However, development of plausible and effective vaping regulations and, most importantly, their enforcement are likely to present unique challenges to different countries across the globe. The challenges may vary depending on the legal, regulatory, economic, and sociopolitical contexts of each nation. For example, India's ban on e-cigs raises the importance of transparency when authorities decide to address a highly 'complex' problem. According to various officials, the government's decision to ban vaping has been in the making for the past two years, and is based, at least, in part, on a white paper by the Indian Council of Medical Research (hardly an ally of the tobacco companies), which warns against the net negative impact e-cigs have on public health and the threat they pose to future generations. Notwithstanding those statements, accusations and suspicions have been floating around the government's motive in imposing a ban on vaping. India has one of the highest rates of tobacco use in the world, with 106 million adult smokers (second only to China) and another 200 million users of chewing tobacco and other such products [17]. The government owns 28% of I.T.C. Limited (ITC, Ltd), a leading manufacturer of cigarettes, which means it directly profits from cigarette sales and high taxes, while also earning immense revenues from exporting $1 billion worth of tobacco annually [13, 14]. Conversely, India's vaping market, which is relatively small and valued at $15.6 millions, relies exclusively on imported vaping products [14]. As a source of revenue for the government, the latter clearly pales into insignificance compared to the locally grown tobacco and the associated industry. Skepticism has also been high as to why the government is bent on banning e-cigs, while tobacco cigarettes and bidis (traditional small, thin, hand-rolled cigarettes wrapped in a tendu or temburni leaf), which are proven to kill one million Indians per year [17], remain exempt. Not only that, the government continues to encourage and subsidize tobacco farming. With 45.7 million people whose livelihoods depend on the tobacco sector [14], the Indian government should embrace this 'opportunity' to make a compelling case that the push for e-cig ban was solely to protect the health and well-being of
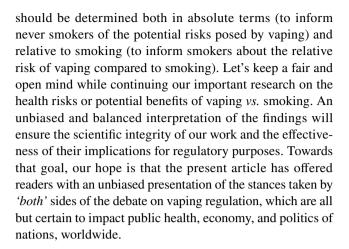
the population, and not economically driven or to appease a large voting bloc.

Globally, 35 million people are estimated to use e-cigs or "heat-not-burn" tobacco products [14, 17]. Although the global market for e-cigs is still small compared to tobacco cigarettes, it is growing very swiftly. Last year, worldwide sales of tobacco cigarettes reached more than $713 billions, compared to $15.7 billions for e-cigs. By 2023, the sales of vaping products are projected to more than double to $40 billions, while cigarette sales are expected to decline slightly [14, 17]. Governments around the world are facing the predicament of how to best deal with the epidemic of vaping. An ideal solution would entail improving the public's health, as the first and foremost priority, while avoiding compromising the nations' economy, causing social backlash or political fallout, and getting engulfed by a tsunami of litigations, which will, most certainly, be brought by the vaping industry, tobacco companies, and other stakeholders. Presumably, commercial interests in both marketing of e-cig products and delaying/blocking vaping regulations will be a driving factor in most if not all countries involved.

Concluding remarks and future directions

The Latin phrase "scientia potentia est" (translation: "knowledge is power") is a reminder that gaining knowledge on various aspects of vaping can empower us to solve the 'complex' problem of "to vape or not to vape". Philosopher, essayist, poet, and novelist, George Santayana, famously said: "Those who cannot remember the past are condemned to repeat it." Let's remind ourselves of Santayana's phrase and learn from the history of tobacco regulation and smoking prevention. Throughout the years, development of effective regulations on tobacco products leading to successful declines in smoking rates has always been interwoven with scientific breakthroughs providing 'compelling' evidence on the adverse health consequences of smoking [17]. Thus, evidence-based regulations and scientifically driven recommendations on vaping will not only be more effective, sensible, and enforceable, but they will also minimize/eliminate the risk of unintended outcomes, such as inadvertently turning e-cigs into a "prohibitos autem fructum" (translation: forbidden fruit). While research data are accumulating on the adverse biological effects of e-cig use [18–20], evidence is also emerging on the efficacy of vaping combined with behavioral therapy in helping smokers quit [21] (although initial studies have produced mixed results [22]). The existing data clearly demonstrate that vaping is not risk free. This together with the growing concern that vaping may lead to nicotine addiction and smoking, especially among youth, underlines the importance of investigating the health risks associated with vaping. The health risk profile of vaping

should be determined both in absolute terms (to inform never smokers of the potential risks posed by vaping) and relative to smoking (to inform smokers about the relative risk of vaping compared to smoking). Let's keep a fair and open mind while continuing our important research on the health risks or potential benefits of vaping *vs.* smoking. An unbiased and balanced interpretation of the findings will ensure the scientific integrity of our work and the effectiveness of their implications for regulatory purposes. Towards that goal, our hope is that the present article has offered readers with an unbiased presentation of the stances taken by *'both'* sides of the debate on vaping regulation, which are all but certain to impact public health, economy, and politics of nations, worldwide.

Compliance with ethical standards

Conflict of interest Both authors declared that there are no financial or non-financial conflicts of interest.

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