EC PULMONOLOGY AND RESPIRATORY MEDICINE
Review Article

The Economic, Business and Health Impact of E-Cigarettes

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Abstract

In recent decades, the tobacco business has been transformed by the electronic cigarette (e-cigarette), which is often regarded as a safe substitute to traditional cigarettes. E-cigarettes are made up of a rechargeable battery, an atomizer (or heating element/coil), and a liquid that contains a solvent (generally propylene glycol (PG) and vegetable glycerin (VG)), nicotine, and other additives such as flavors. E-cigarettes do not contain tobacco, but they do deliver nicotine to the brain. Vaping is the act of inhaling the vapor or aerosol generated by an electronic cigarette into the lungs. Since e-cigarettes use e-liquid heating instead of tobacco combustion, some manufacturers claim that e-cigarettes are less hazardous to the lungs than tobacco use.

Many customers have been won over by other unique features such as the possibility to change the nicotine level and the variety of appealing flavors available. These characteristics have increased the demand of such devices and subsequently, increased its supply. Nonetheless, due to a paucity of data, the safety of e-cigarette use and its potential as a smoking cessation method remain debatable. Current and former smokers, as well as adolescents who have never smoked, are all using e-cigarettes at an alarming rate. Long-term health consequences are unknown, but new preclinical and clinical research show that e-cigarettes may not be safe and can trigger cellular changes similar to conventional tobacco smoke. This review article overviews the pulmonary aspects of vaping as well as the economical aspect, examining the factors influencing the demand and supply of e-cigarettes, the behavioural economics and the negative externality of consumption.

Keywords: *Health Impact; E-Cigarettes; Propylene Glycol (PG); Vegetable Glycerin (VG)*

Introduction

The World Health Organization (WHO) estimates that, globally, smoking causes over US$500 billion in economic damage each year. Tobacco smoking is still the largest cause of avoidable mortality in the world, and it is the single most important risk factor for chronic illnesses including chronic obstructive pulmonary disease (COPD) and lung cancer. Despite widespread awareness of the hazards of tobacco and tobacco components, new tobacco-based products like heat-not-burn products (IQOS) and e-cigarettes, often known as vape devices or more officially as electronic nicotine delivery systems, are becoming increasingly popular (ENDS). Vaping is intended to mimic the process of smoking but without the release of thousands of toxicants, including several carcinogens, that occur when tobacco is burned. Since there are reduced amounts of toxicants involved with combustion, it is thought that these products can be used as a quitting strategy for heavy smokers and therefore as a means to enhance overall health [1]. Even if they are more effective than nicotine replacement treatments (NRT) for certain people, there is little scientific evidence to back up this claim. Despite the fact that vaping is usually thought to be safer than smoking, the long-term health implications of e-cigarette usage remain unknown.

While the relative emergence of e-cigarette usage makes long-term consequences difficult to evaluate, there is a growing body of evidence suggesting that e-cigarette use may have effects similar to cigarette smoking at the cellular, clinical, and population levels.

Furthermore, there are an increasing number of health risks connected with vaping, particularly in light of a recent outbreak of serious lung disease (linked to counterfeit vaping goods) termed "vaping product-associated lung illness (EVALI)" or "vape lung" [2].

EVALI is linked to a variety of respiratory problems, including shortness of breath, coughing, and hypoxemia [3]. As a result, the use of e-cigarettes lacks long-term data on the safety of long-term use; is linked to an epidemic of acute vaping-related lung damage; and raises serious concerns about the creation of a new generation of nicotine-dependent young adults. This review will focus on the inhalation toxicity of vaping products and their disruption of cellular and molecular processes that may contribute to respiratory illness, while simultaneously examining the demand, supply, and government intervention mechanisms.

Firms involved in the production and supply of nicotine vaping products

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7454013/

The market is made up of companies that are involved in the manufacture and marketing of NVPs at various stages (different levels of vertical integration) [4]. In three stages, NVPs are created and marketed: 1) manufacturing vaping devices and liquids; 2) product marketing; and 3) consumer distribution and sale via the internet, vape shops, and other retail outlets.

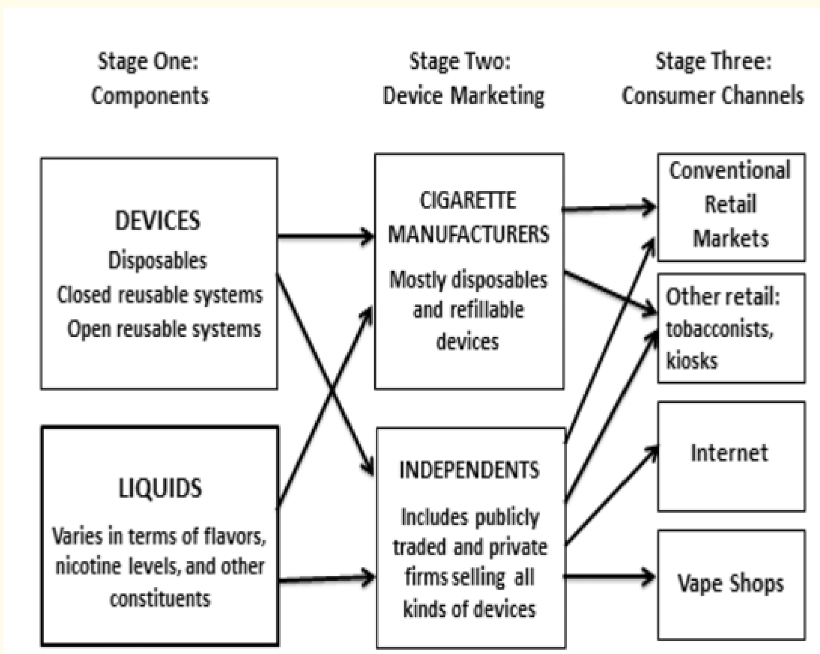

Figure 1: *Source [5].*

Although most vaping devices are made in China [6], certain firms, like BAT and Altria, manufacture their products in the United States. Liquid refills for open systems are often supplied in bottles, whereas cartridge refills for closed systems are more common. Some liquids are made in China, but they are increasingly being imported from other nations, notably the United States [6]. Vape stores or private consumers can produce nicotine and flavoring mixes for open systems.

Unlike the cigarette industry, where manufacturers typically sell through wholesalers to brick-and-mortar stores, NVPs were initially sold entirely through ecommerce platforms in 2006. Between 2009 and 2012, purchase channels grew to include shopping mall kiosks and more traditional retail locations, with companies selling primarily disposable and rechargeable cigalikes through traditional retail [6,7]. Some outlets began offering tank-style devices in 2013, but vape shops began to play a larger role in the industry [6-9]. Vape shops provide a wide range of brands and tastes, as well as a place for customers to talk about goods, try samples, and obtain personalized product information [6,10-13].

Table 1 shows the various NVP purchasing channels [14], with e-cigarettes (disposables and closed reusables) and vaporizers segregated (tanks and mods). In 2017, sales in traditional retail (convenience stores, food, drug, and grocery stores), internet and other retail (kiosks and tobacconists), and vape shops were expected to be $1.4 billion, $1.4 billion, and $1.8 billion, respectively. E-cigarettes and vaporizers are available in stores and online, whereas NVPs are presently only available in traditional retail outlets.

Estimated Sales of the US Vapor Market (In millions)

Purchase Channel Categories	2014	2015	Market Shares 2015***	2016	2017	Market Shares 2017***	2018 expected	Market Shares 2017***
E-cigarettes (Disposables and Closed Systems)	1,000	1,400	42.4%	1,600	1,400	31.8%	3,800	57.6%
Mass Market Retail*	600	600	18.2%	700	700	15.9%	2,600	39.4%
Online	200	400	12.1%	500	400	9.1%	800	12.1%
Other Retail**	200	400	12.1%	400	300	6.8%	400	6.1%
Vapors/Tanks/Mods & Personal Vaporizers (Open System)	1,500	1,900	57.6%	2,500	3,000	68.2%	2,800	42.4%
Mass Market Retail*	300	300	9.1%	500	500	11.4%	400	6.1%
Online and Other Retail	300	400	12.1%	600	700	15.9%	600	9.1%
Vape Shops	900	1,200	36.4%	1,400	1,800	40.9%	1,800	27.3%
Total	2,500	3,300	100.0%	4,100	4,400	100.0%	6,600	100%

***Table 1:** Estimated sales of the us vapor market (in milions).*
***Source:** Wells Fargo Securities Equity Research*

Consumers who use each of these buying channels may have distinct smoking and socio-demographic profiles, but they transition between them. NVPs are frequently discovered by consumers via the internet [15,16]. Although some users utilize vape shops and other retail locations, many users, especially frequent users [17], continue to buy via the internet. Furthermore, the same manufacturer's items may be sold through all three channels. Almost half of internet sellers also sold in brick-and-mortar stores, and 60% provided wholesale options for their items [5]. Vape stores are sometimes linked to online businesses [18].

Despite the fact that liquids are part of the NVP industry, entry obstacles are more likely to arise in the manufacture of vaping devices due to their more difficult and specialized manufacturing than liquids. Most of the promotion and marketing is done by device manufacturers. Consumers can buy devices directly from vape shops, traditional stores, or other retailers, or indirectly through the internet or mail order sales. The relevant consumer market is vaping device sales across all purchasing channels, owing to channel rivalry.

Growing market for vapes https://www.grandviewresearch.com/industry-analysis/e-cigarette-vaping-market

The worldwide e-cigarette and vape industry was estimated at USD 15.04 billion in 2020, with a compound annual growth rate (CAGR) of 28.1% projected from 2021 to 2028. Over the forecast period, the rising emphasis on adopting safer alternatives to smoking is expected to promote the use of e-cigarettes and vape devices.

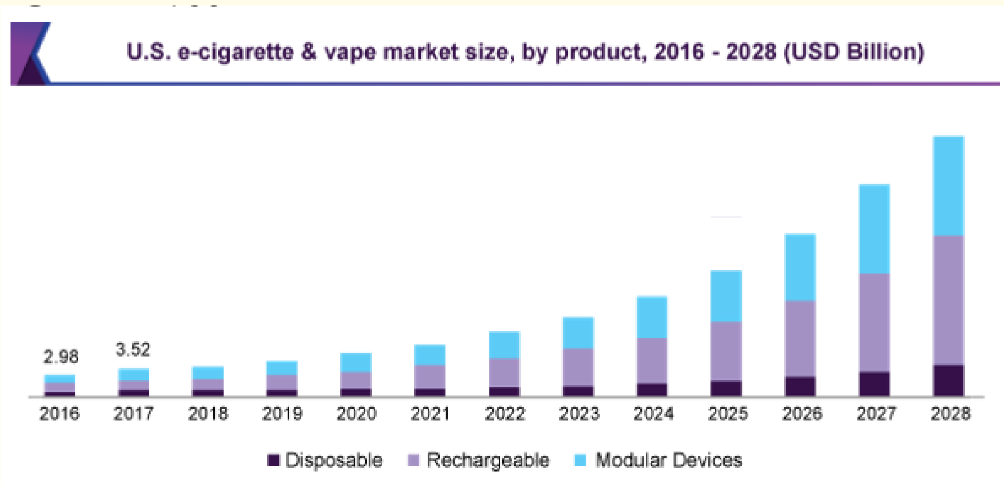

Figure 2: *Source [19].*

Since 2016, the e-cigarette and vape market has changed significantly, with devices becoming more efficient in terms of battery life and the amount of flavors available. Furthermore, a wide range of tastes, including menthol, tobacco, fruits and nuts, and chocolate, are available on the market, attracting a huge number of clients, thus increasing the demand for NVPs. Furthermore, the decreasing cost-effectiveness of these devices has boosted consumer adoption, which is projected to fuel market growth during the forecast period [19].

Nicotine https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7278963/

Nicotine is one of the most common components in e-liquids and NVPs. Nicotine is the most common alkaloid in tobacco, and it acts as a natural pesticide throughout the plant. Nicotine is rapidly absorbed when tobacco smoke enters the tiny airways and alveoli of the lungs, most likely because nicotine dissolves in the fluid of the human lung, which promotes transfer across membranes. Nicotine binds to nicotinic acetylcholine receptors (nAChRs), which can be found in the central and peripheral nervous systems, as well as other organs. nAChRs are ligand-gated ion channels that cause the release of neurotransmitters, such as dopamine, which is responsible for rewarding behavior. Endothelial, pulmonary epithelial, immunological, and muscle cells all express these receptors [20-22]. Nicotine may contribute to cardiovascular disease in smokers [23] and may affect the operation of the respiratory and gastrointestinal systems, in addition to contributing to the addictive qualities of tobacco smoke.

Cellular alterations from e-cigarette exposure

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7278963/

Toxicity induced by e-liquids and the resulting aerosol can be caused by a variety of elements, including the e-composition, liquid's temperature, dosage, duration, and cell type. The first line of defense against infections and inhaled toxicants, such as those found in cigarette smoke and e-cigarette aerosols, is the respiratory epithelium. More than 50 distinct cell types line the lower respiratory tract (from the trachea to the alveoli), the majority of which are epithelial [24]. Basal cells, goblet cells (which create mucin), and Clara cells, a non-ciliated secretory cell that produces Clara cell secretory protein, are interspersed among ciliated epithelial cells (CCSP). An epithelial layer and extracellular matrix surround the gas-exchanging alveoli, which are bordered by capillaries. Within the alveoli, there are three types of cells: type I pneumocytes, which help with gas exchange; type II pneumocytes, which produce pulmonary surfactants to reduce surface tension; and alveolar macrophages, which are phagocytic cells that help with host defense [24,25]. A number of lung illnesses, including cancer and COPD, can be triggered by epithelial damage. It is widely established that smoking weakens the epithelial barrier, increasing permeability of the respiratory epithelium and impairing host defense, resulting in bacterial clearance being reduced. Furthermore, tobacco smoke promotes lung inflammation, oxidative stress, and DNA damage [26]. Studies are now showing that e-cigarettes reduce cell integrity and cause inflammation, two effects that appear to be irrespective of the type of vaping device used, the type of cell used, and the presence of flavors and other e-liquid components (e.g., solvents and nicotine) [24,27-30].

Clinical impact of e-cigarette use on the respiratory system https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7278963/

Although there is some evidence that e-cigarettes may aid in smoking cessation or decrease, the long-term health consequences of vaping are mainly unclear. Furthermore, e-cigarette use by a former never-smoker may not be without risk, especially if beginning occurs at a young age, when illness takes longer to develop, or in those who already have pulmonary comorbidities. According to the evidence described above, e-cigarette usage is linked to unfavorable cellular events that might lead to pulmonary changes. The growing number of research demonstrating that prolonged e-cigarette usage can have harmful clinical consequences that are both comparable and distinct from conventional cigarettes is cause for worry. Since e-cigarettes are such a new product, the overall health implications of vaping remain unknown. This lack of agreement is attributable to a variety of variables, including constantly developing e-cigarette technology, e-liquid composition variation, and the lack of standardization in e-cigarette products, all of which make comparing results across research difficult. This is in contrast to traditional cigarettes, which have well-known health effects and generally homogenous produced goods. Many in the public health sector, such as the Canadian Cancer Society and the Canadian Thoracic Society, concur, however, that while e-cigarettes may be useful for smoking cessation in certain people, they are not without risk [31,32]. The dangers are fewer than those of traditional tobacco smoke, according to toxicologic study, but the clinical impact for those who use e-cigarettes for a long time is unknown.

The difference in liquid composition (inclusion of cannabis derivatives and/or flavoring compounds linked with pulmonary toxicity) and hardware between counterfeit goods complicates the capacity to make inferences about the health consequences of e-cigarettes (e.g. type of heating coil). Over the last decade, there have been several case reports of acute lung illnesses, leading to the identification of a new clinical entity known as EVALI in 2019. The majority of EVALI cases were linked to the use of counterfeit goods, according to a CDC research [33].

As a result, many various factors, such as age of beginning, current and past cigarette smoking status, and the existence of underlying lung diseases like asthma and COPD, would likely influence the long-term clinical impact of e-cigarettes. Industry and regulatory authorities' ability to regulate these items will also play a role. Although e-cigarettes have far fewer second-hand emissions than tobacco cigarettes [34], the clinical impact of second-hand e-cigarette emissions on nonusers is also unknown.

Respiratory symptoms https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7278963/

E-cigarette usage has been linked to a variety of respiratory symptoms, including acute cough, sore throat, and dry mouth [35]. Four studies that looked at respiratory symptoms in teenagers were cross-sectional and used user self-reported questionnaires, and they found a link between respiratory symptoms and e-cigarette usage. There is a link between e-cigarette usage and chronic bronchitis symptoms (daily cough for 3 months, congestion, or phlegm production that isn't accompanied by a cold in the previous 12 months) [36,37], as well as a self-reported clinical diagnosis of asthma [38].

Acute pulmonary disease https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7278963/

Acute lung illnesses linked to e-cigarette usage have lately gotten a lot of attention attributable to a slew of case reports connecting the two. The vast majority of these cases fall into the EVALI (described below) category, which has been linked to the use of counterfeit vaping goods [39]. The safety of e-cigarettes is debatable, however there is research that suggests they are safe.

Limitations https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7278963/

The pattern of e-cigarette use, or vaping topography, which refers to how an e-cigarette is used and includes parameters such as puff duration, volume of puff, underruff interval, session duration, and frequency, is one of the limitations in extrapolating results from experimental studies to human relevance. Vaping topography has been studied extensively and was shown to vary greatly [40-42]. Puff duration and interval, for example, were 1.5 - 2.1s and 176.7 - 382.7s, respectively [40]. Because of this, as well as the many e-cigarette devices/liquids, brands, and power settings (e.g. battery voltage and coil resistance), drawing inferences about user exposure to e-cigarette aerosols, toxicants, and overall health effect might be challenging [40]. The growing body of data from *in vitro* research and animal models suggesting e-cigarettes have negative pulmonary consequences is based on a variety of experimental methods and exposure regimens, only some of which mirror human exposures. Furthermore, many studies fail to disclose specifics on coil resistance, applied power, and exposure regime when it comes to aerosol generation [43-49].

Government intervention

However, local government prohibitions on the sale of vaping goods and e-liquids in nations such as the United States and India have stifled industry growth. Vape goods are no longer distributed or sold in a number of countries, resulting in reduced sales. For example, the Indian government prohibited e-cigarette manufacture, production, import/export, sale, transit, storage, distribution, and advertising in September 2019. Furthermore, strict trading restrictions have made importing vaping devices for personal use impossible for retail users. However, the vaping industry has created different groups to combat anti-vaping legislation and to regulate the sector for oversight, resulting in the rise of the e-cigarette and vape market.

Conclusion

E-cigarette use is fast increasing among smokers and nonsmokers alike. The chemical makeup of the aerosol created by e-cigarettes varies based on factors including the device, voltage, and e-liquid composition. Many of the chemicals present in e-cigarette aerosols, such as aldehydes, heavy metals, and TSNAs, are hazardous or carcinogenic when compared to tobacco smoke. According to current research, even short-term e-cigarette use promotes cellular inflammation, apoptosis, oxidative stress, and DNA damage in the same way as tobacco smoke does. Many respiratory illnesses, such as COPD, are caused by these pathogenic processes. Clearly, there is a lot we don't know about the effects of vaping, such as whether it causes similar declines in lung function to smoking, how vaping could lead to respiratory illnesses, and which users are more at risk. Although e-cigarettes may appear to be a "lesser of evils" for existing smokers, the impact of e-cigarette products on lung health may not be understood for many years. Long-term epidemiological, toxicological, and clinical research are needed to develop a more robust body of information that will allow us to draw more clear conclusions about the possible hazards of e-cigarette usage. When weighing the risk versus benefit of e-cigarette use, we must consider age, current and prior cigarette smoking, the presence of preexisting lung conditions such as asthma and COPD, and the potential for other pulmonary complications until we learn more about the effects of e-cigarettes on pulmonary health.

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