**e-cigarettes: a hazard or a help?**

**By Sam Gutterman**

**What are they?**

Seemingly from out of nowhere in 2006[[1]](#footnote-1), electronic-cigarettes (more commonly referred to as e-cigarettes or e-cigs – a major segment of “electronic nicotine delivery systems”, which includes e-hookahs, mods, vape pens, vapes, and tank systems) have become increasingly popular around the world. Their use has been controversial -- whether or to what extent their use is unhealthy and what motives underlie their use.

Being an electronic nicotine-delivery system (ENDS), they are designed to deliver nicotine without tobacco smoke and a reduced number of chemicals. They produce an aerosol by heating a liquid that contains a solvent (e.g., vegetable glycerin, propylene glycol, or a mixture of these), one or more flavorings, and nicotine (concentration from 0 to 24 mg per milliliter, with the nicotine in some cases omitted – inclusion of nicotine has been more popular than those without, even though nicotine is widely known to be addictive). The evaporation of the liquid at the heating element is followed by rapid cooling to form an aerosol. The process of smoking e-cigarettes is referred to as vaping, after the vapor (rather than smoke) it creates. Each e-cigarette includes a battery, a reservoir that contains the liquid, and a vaporization chamber with a heating element. There has been a wide variety of components used, with varying quality of both contents and labeling, especially in its early years.

There are significantly fewer chemical ingredients in e-cigarettes than in tobacco cigarettes. For example, they have no tar or carbon monoxide and usually only trace levels of metals, which are all elements of tobacco cigarettes. However, although the composition of e-cigarettes varies widely by brand, Poznański et al. (2017) indicated that various analyses of particles in e-cigarette vapor have shown its similar composition to regular cigarettes. The chemical compounds include acetaldehyde, acrolein and acetone. In addition, aromatic hydrocarbons, i.e., toluene and p-xylene, were identified. The analyses also showed the presence of heavy metals, including cadmium, nickel and lead, which are also present in the smoke of regular cigarettes. More detailed analysis of the smoke generated by e- and tobacco cigarettes adds to the list of typical elements of tobacco smoke the following: sodium, iron, aluminium, potassium, copper, magnesium, zinc, chromium and manganese. The list of elements included in e-cigarette vapor also contains boron, silicon, calcium, sulphur, tin, barium, zirconium, strontium, titanium, lithium – many of which have a documented adverse effect on the cells of the respiratory system. In one study, 42 e-liquids manufactured by 14 different producers were examined, with chemical compounds including aromatic hydrocarbons, with particularly high concentration of various chemical compounds found in flavored e-liquids. Each sample contained formaldehyde.

Overall, studies of potentially toxic substances in e-cigarette aerosol have indicated that the substances present include some known or suspected carcinogens, such as formaldehyde and acetaldehyde, although these compounds are found in substantially lower concentrations in e-cigarette aerosol than in the smoke from tobacco cigarettes.

**Use**

Current use has increased over the last several years, as the prevalence of cigarette smoking has decreased in many countries. For example, according to McMillen et al. (2015), while in 2010 a total of about 1.8% of U.S. adults reported used an e-cigarette at some time, a rate that rose to about 13.0% by 2013. Reports of “current use” increased from about 0.3% to 6.8% during this period. Based on the 2014 National Health Interview Survey as reported by Schoenborn and Gindi (2015), 12.6% of U.S. adults had tried an e-cigarette at least once and about 3.7% of adults currently use e-cigarettes, with men e-smoking more than women, and those in their twenties e-smoking more often than those older than those ages (Singh et al. (2016)). E-cigarette smokers tend to be younger, more educated and have higher income than non-users. About a third of current e-cigarette users had never smoked tobacco or were former tobacco smokers.

About 16% of American high-school students in 2015 reported any use within the preceding 30 days (almost 30% ever-e-smoked), partly in response to marketing of the products, especially marketing of flavored e-cigarettes. It appears that flavoring agents have played a significant role in the industry’s targeting of children and youth – this suggests that efforts are being made to attract new smokers to e-smoking, rather than just to ultimately convert current smokers to cease all types of smoking.

Somewhat surprisingly, a survey of 4,444 college students (Sutfin et al. (2013) from eight colleges in North Carolina showed that e-cigarette use was not motivated by the desire to stop smoking cigarettes. Experimentation with e-cigarettes is increasing among adolescents, which should serve as a great concern, even if most of the young e-cigarette users also smoke tobacco-products. In fact, most adolescents who smoke e-cigarettes also smoke tobacco products.

WHO (2014) indicated that the use of e-cigarettes in places where smoking is not allowed (i) increases the exposure to exhaled aerosol toxicants of potential harm to bystanders, (ii) reduces quitting incentives, and (iii) may conflict with the smoking de-normalizing effect.

According to Andler et al. (2016), survey research carried out in France in 2014 showed that out of more than 15,000 respondents, about a quarter of respondents aged 15 to 75 years have tried smoking e-cigarettes.

To date, most surveys of e-cigarette use are from North America and Europe, so extrapolation to worldwide use would not be appropriate. Nevertheless, e-cigarette availability is widespread around the world.

According to WHO (2014), user behavior can affect the degree of nicotine absorption, e.g., the length of puffs, the depth of inhalation and the frequency of use. Nevertheless, while a faster, deeper puff increases nicotine delivery from a tobacco cigarette, such an approach might diminish it from an e-cigarette due to cooling of the heating element.

In addition to the wide differences in their components and manufacture (as well as the nature of the toxicity of their contents, nicotine solution concentration and emissions), some users modify the devices at home to alter the delivery of nicotine or other drugs. The ease of making such modifications varies widely, as is the ease with which they can be filled with other solutions.

Although the sale of e-cigarettes is prohibited in some countries, it is legal in most. Regulatory reviews have recently or will in the future be studying them, deciding whether to allow them, submit them to a set of less restrictive rules than tobacco cigarettes as devices that facilitate cigarette tobacco cessation or to ban them. In many countries, there is little if any regulation of e-cigarettes. Areas in which regulation may provide benefit include ensuring effective quality control in their production, confirming health claims, use of e-cigarettes in public places, advertising/promotion/sponsorship and packaging.

It has been projected that sales will be about US$10 billion in 2017.

**The debate**

There has been a sometimes passionate debate regarding the use of e-cigarettes, ranging between (1) enthusiastic support from those who believe that e-cigarettes represent a harm reduction tool compared with cigarette tobacco smoking that can be used to move off of the more dangerous cigarette smoking, while (2) the vigorous opposition believe that its use should be discouraged because it could undermine efforts to reduce the use of tobacco use and its long-term effects are as yet undetermined. In summary, can it be a means for current smokers to cease smoking, the first step on the way to start cigarette smoking, or is it bad in and of itself?

According to Hajek (2015), “It appears that some 12–14% of smokers who try e-cigarettes become daily users”. This could be looked at in a positive way, in that e-cigarettes may be less addictive than tobacco cigarettes or negatively, that, based on the percentage who have and are likely to try to use these devices, that this could constitute an increase in those who smoke.

After reviewing the results of several studies, Hajek (2015) concluded that “e-cigarettes reduce urges to smoke and there is preliminary evidence that e-cigarette use facilitates both quitting and reduction in cigarette consumption in smokers interested in quitting smoking. In England, which has the most detailed data on e-cigarettes and cigarette use, the growth in e-cigarettes use has been accompanied by an increase in smoking cessation rates, a continued reduction in prevalence and no increase in smoking uptake. Whether e-cigarettes are contributing to these favourable tobacco control trends is as yet unclear.”

Public Health England (2015) declared and the Royal College of Physicians has agreed that e-cigarettes are likely to be 95% safer than tobacco smoking. based on the facts that:

* the constituents of cigarette smoke that harm health – including carcinogens – are either absent in e-cigarette vapor or, if present, they are mostly at levels much below 5% of smoking doses (mostly below 1% and far below safety limits for occupational exposure) and
* the main chemicals present in e-cigarettes only have not been associated with any serious risk.[[2]](#footnote-2)

In addition, Public Health England (2015) indicated that a recent study conducted by A. McNeill and P. Hajek found that among English adults and youth, regular use of e-cigarettes is found almost exclusively among those who have already smoked. The highest rates of e-cigarette use are found among adult smokers. E-cigarettes have rapidly become the most widely used quitting aid in England. **P. Hajek, Director of the Tobacco Dependence Research Unit at Queen Mary University of London, has said** in 2016 that “there is a clear and strong evidence that such experimentation does not contribute to smoking uptake. The key bit of information in this context is that non-smokers almost never progress to regular use of nicotine-containing e-cigarettes. Adolescents try them and leave them alone. E-cigarettes do not lure non-smoking adolescents even to vaping – let alone to smoking.” Public Health England believes that e-cigarettes have the potential to make a significant contribution to helping people eliminate tobacco smoking, although they caution that this effort comes with risk, which must be regulated and monitored (i.e., the industry—it’s practices and products).

In contrast, the U.S. Surgeon General in a report (U.S. Department of Health and Human Services (2016)) on youth and young adults and e-cigarette smoking concluded “Tobacco use among youth and young adults in any form, including e-cigarettes, is not safe. In recent years, e-cigarette use by youth and young adults has increased at an alarming rate. E-cigarettes are now the most commonly used tobacco product among youth in the United States. … E-cigarettes are tobacco products that deliver nicotine. Nicotine is a highly addictive substance, and many of today’s youth who are using e-cigarettes could become tomorrow’s cigarette smokers. Nicotine exposure can also harm brain development in ways that may affect the health and mental health of our kids.” The report concluded that it is a major public health concern that affects youth, pregnant women and fetuses.

In its report on ENDS, the WHO (2015) has taken the position that it is important for countries to regulate e-cigarettes as a potential health hazard. It expresses the view that because the product, the market and the associated scientific evidence surrounding ENDS are all evolving rapidly, all legislation and regulations related to ENDS should be adaptable in response to new scientific evidence, including evaluation of different models for ENDS regulation, as evidence accumulates further. In addition, governments should consider that if their country has already achieved a very low prevalence of smoking and that prevalence continues to decrease steadily, the use of e-cigarettes will not significantly decrease smoking-attributable disease and mortality even if the full theoretical risk reduction potential of e-cigarettes were to be realized. They should also work to minimize the content and emissions of toxicants, to minimize acute nicotine toxicity and require transparent labeling.

Nevertheless, the conclusions of many e-cigarette studies so far can only be viewed as tentative, as most have been of small scale and in some cases have come to contradictory conclusions. Nevertheless, even if e-cigarettes do not contain a majority of the toxins present in traditional cigarettes, it has been shown that nicotine has a negative impact on population segments such as teenagers (brain development) and those pregnant (their fetuses).

An example of potentially adverse results was shown in Moheimani et al. (2017), although its study only covered 23 individuals who were habitual e-smokers for more than a year, which found a shift in cardiac autonomic balance toward sympathetic predominance and increased oxidative stress, both of which are associated with increased cardiovascular risk. Some studies have shown that smoking e-cigarettes increase heart rate and blood pressure to levels comparable to tobacco cigarettes, while other have shown no difference.

Nevertheless, due to the relatively recent introduction of e-cigarettes, few randomized clinical trials addressing the use of e-cigarettes for smoking cessation have been published to date. Neither has there been any studies regarding the long-term effect of e-cigarette smoking. However, there have been many small studies, which have reported inconsistent results both as to the degree of effectiveness of smoking cessation and to health hazards.

Based on studies to-date, although the use of e-cigarettes is likely to help some smokers to switch completely from cigarettes to e-cigarettes, for a sizeable number of smokers the use of e-cigarettes will result in a reduction of cigarette use rather than in quitting—this will lead to more dual use of e-cigarettes and cigarettes.

In contrast, Poznański et al. (2017) indicated that smoking cessation through replacement of regular cigarettes for e-cigarettes does not seem to be a real success. Contradictory evidence has been reported on-- Poznański et al. (2017) found that there was no reliable data supporting the theory that alternative tobacco products (including e-cigarettes) are useful tools for smoking cessation purposes. Supporting this view is the results of a meta-analysis conducted by Kalkhoran and Glantz (2016), who found that the use of e-cigarettes is related to a reduced chance of smoking cessation. Among those who used e-cigarettes to quit smoking, the proportion of those who succeeded was smaller by 28% compared to the group not using e-cigarettes. WHO (2014) showed insufficient evidence to consider e-cigarettes a therapeutic option.

It is speculated that adverse physiological effects of e-cigarettes are less than those from smoking tobacco cigarettes. However, it has not been proven whether or how dangerous they are. The use of e-cigarettes has some biologic effects and possibly health-related effects on persons who have not smoke conventional tobacco products.

Although nicotine is exhaled, the amount is much less than tobacco smoker. As a result, based on the predominant amount of research to date, e-cigarette smoking does not constitute a second-hand smoke hazard. Nevertheless, the U.S. Department of Health and Human Services (2016) indicated that “E-cigarette aerosol is not harmless. It can contain harmful and potentially harmful constituents, including nicotine. Nicotine exposure during adolescence can cause addiction and can harm the developing adolescent brain.”

Even though most e-cigarettes contain nicotine, it appears that smoking e-cigarettes may not be as addictive as cigarette smoking. Some studies have indicated that e-cigarettes have helped people either to quit smoking or to reduce it, although use of both (e-cigarettes and tobacco cigarettes) simultaneously is growing increasingly common (e.g., reportedly some use e-cigarettes where tobacco cigarettes are not allowed or frowned upon, using tobacco cigarettes elsewhere).

In the United States, the National Youth Tobacco Survey indicates that ever-e-cigarette use among high school students increased from 1.5% in 2011 to 16% in 2015. Concern has been raised with respect to alternative uses of e-smoking. For example, in an initial survey of e-cigarette smoking by adolescents in Connecticut (U.S.) high schools, Krishnan-Sarin et al. (2017) found that there have been significant modifications in the ENDS being made prior to use. They indicate that certain e-cigarettes, such as mods or vape pens, allow users to change voltage, nicotine concentrations, and other components of e-liquids including flavors.

Emerging evidence suggests that e-cigarettes are being used in several alternative ways that may or may not involve nicotine use, such as smoke tricks, use of flavors, and use of other substances such as marijuana. E-cigarettes are also being used for “dripping”[[3]](#footnote-3). This can enhance the experience through manipulation of the nicotine content of the e-cigarette. Krishnan-Sarin et al. (2017) found that among 1,070 high school students surveyed who had previous smoked e-cigarettes, about a quarter of them had practiced dripping—the primary reasons for doing this was that it produced thicker clouds of vapor, made the flavor taste better, provided a stronger throat hit (i.e., by providing increased nicotine) and curiosity, in that order. The large percent of those that practice dripping to produce more vapor suggests, according to Krishnan-Sarin et al., that they are being used for vaping competition and smoke tricks.

A wide range of flavors have been used, produced by various chemicals. Emerging evidence suggests that many flavors contain reactive chemical species that, when vaporized at high temperatures, can form toxic levels of compounds such as formaldehyde.

Based on a representative sample of U.S. middle and high school students in 2011 and 2012 (about 20,000 in each year) who completed the 2011 and 2012 National Youth Tobacco Survey, Dutra and Glantz (2014), found that the use of e-cigarettes was associated with higher odds of ever- or current-cigarette smoking, higher odds of established smoking, higher odds of planning to quit smoking among current smokers and, among experimenters, lower odds of abstinence from conventional cigarettes. In the survey, the use of e-cigarettes does not discourage, and may encourage, conventional cigarette use among U.S. adolescents.

The reported use of e-cigarettes by American adolescents, suggest that they are not being used for smoking cessation purposes.

Ingestion of e-cigarette liquids by young children and e-cigarette explosions have been reported with increasing frequency, but in still in very small numbers. Although in most cases, ingestation will not be fatal, the ingestion by a child of a full 10-ml or 20-ml bottle of nicotine-containing e-cigarette liquid may be lethal. A small, but growing number of nicotine poisonings have occurred.

Dinakar (2015) concludes: “At present, it is impossible to reach a consensus on the safety of

e-cigarettes except perhaps to say that they may be safer than conventional cigarettes but are also likely to pose risks to health that are not present when neither product is used. … More research is needed to understand the effectiveness of e-cigarettes as a smoking-cessation tool, to identify the health risks of e-cigarette use, and to make these products as safe as possible.”

Hajek et al. (2015) suggests that “health-care professionals (HCP) should support smokers unable or unwilling to stop tobacco use who wish to switch to e-cigarettes to reduce harm from smoking. HCP should emphasize the importance of stopping using cigarettes and nicotine altogether.”

**Conclusions**

Clearly, more research and information is needed regarding the effects of using e-cigarettes, especially their usefulness in enabling tobacco cigarette cessation, the incidence of new users and their long-term physiological effects.

E-cigarette smoking represents a double-edged sword for public health. Although it may be easier to replace one highly dangerous addiction (tobacco cigarettes) with a seemingly less dangerous alternative (e-cigarettes), the same dynamics may incent many young people, through addiction to nicotine, with a transition to combustible tobacco. However, since smoking habits begin during the teenage years and early twenties, there is also a major risk that e-cigarettes will help to revive the popular smoking culture that has taken decades to dismantle.

Based on research to date, it is difficult to suggest that their use should be banned entirely. They should be made available as an alternative to other methods of tobacco cessation. Nevertheless, based on differential experience between the United States and the United Kingdom, regular monitoring of developments and findings in this area are warranted. Enhanced regulation and supervision of the e-cigarette industry, including studies regarding appropriate limitations of use (such as to the young) and enhanced labeling may be appropriate.

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Sam Gutterman, April 5, 2017

1. Although the modern e-cigarette was introduced in Europe and North America in 2006, prior attempts at developing a similar device were made, as indicated in http://casaa.org/historical-timeline-of-electronic-cigarettes. [↑](#footnote-ref-1)
2. They note that some flavorings and constituents in e-cigarettes may pose risks over the long-term, but the 5% estimate should have sufficient margin to cover this risk. [↑](#footnote-ref-2)
3. Involves vaporizing the e-liquid at high temperatures by dripping a couple of drops of e-liquid directly onto an atomizer’s coil and then immediately inhaling the vapor that is produced [↑](#footnote-ref-3)