

e-Cigarettes: the discussion so far

1. TOPIC

With new research on e-cigarettes and other vaping devices coming out all the time, it can be difficult to separate accurate information from biased interpretations of the data.

There is a lot of money at stake for e-cigarette manufacturers and distributors and most major cigarette companies now own large shares of the industry. Big tobacco companies have been aggressively marketing e-cigarette and heated tobacco products in recent years as they seek new customers. With much of the e-cigarette research being funded by the tobacco industry, there is a legitimate concern that this will skew the discussion about e-cigarettes as historical evidence has demonstrated. The World Health Organisation has warned that misinformation spread by the tobacco industry about e-cigarettes was "a present and real threat."¹

At the same time, many tobacco control and public health professionals have advocated for a product that is considered 'less risky' than smoking cigarettes – the leading, preventable cause of sickness and death in Australia.²

2. DEFINITION/S

An electronic cigarette (e-cigarette) is a battery-operated device that emits doses of vaporised nicotine, or non-nicotine solutions, for the user to inhale. Also known as e-cigs, electronic nicotine delivery systems, vapouriser cigarettes, and vape pens, personal vaporisers are often marketed as a way to stop or cut down on smoking.

3. BACKGROUND

In the US there has been a recent spate of deaths of people with a history of e-cigarette product use or vaping. At least a further 530 people have been hospitalised for lung diseases related to vaping, with many complaining of shortness of breath, coughing, chest pain, fatigue, vomiting and fevers. Of these, most have reported a history of using e-cigarette products containing THC. Many have reported using THC and nicotine. Some have reported the use of e-cigarette products containing only nicotine.³ The cause of illness and death is unknown and still being investigated. This connection between short-term use of e-cigarettes and illness is causing widespread concern, and in some cases, a complete turnaround in thinking about the relative safety of these products.

Many health professionals are very cautious about the benefits of e-cigarettes in smoking cessation. According to the Australian Medical Association (AMA):

The evidence on e-cigarettes, and their role in cessation and the risk they pose to young people, is not conclusive. For this reason, the Australian Medical Association (AMA) supports a precautionary approach. We recognise that, where there is potential to do harm, caution must be exercised. This view is shared by a range of health and medical organisations: Cancer Council Australia, Cancer Australia, the Heart Foundation and the Thoracic Society of Australia and New Zealand, to name a few.⁴

In its *Report on the Inquiry into the Use and Marketing of Electronic Cigarettes and Personal Vaporisers in Australia*, the House of Representatives Standing Committee on Health found that the use of e-cigarettes may be of benefit as a smoking cessation tool, especially for those smokers with

1 World Health Organisation, 'WHO Report on the Global Tobacco Epidemic 2019: Offer Help to Quit Tobacco Use', 26 July 2019, <https://apps.who.int/iris/bitstream/handle/10665/326043/9789241516204-eng.pdf?ua=1>.

2 Cancer Council Australia, 'Smoking and Tobacco Control - Cancer Council Australia', accessed 11 March 2020, <https://www.cancer.org.au/policy-and-advocacy/position-statements/smoking-and-tobacco-control/>.

3 Centres for Disease Control and Prevention, 'Outbreak of Lung Injury Associated with the Use of E-Cigarette, or Vaping, Products', Government, Centers for Disease Control and Prevention, 15 November 2018, https://www.cdc.gov/tobacco/basic_information/e-cigarettes/about-e-cigarettes.html.

4 Michael Gannon, 'AMA Responds to E-Cigarettes Debate', MJA Insight+ (blog), 23 January 2018, <https://www.doctorportal.com.au/mjainsight/2018/3/ama-responds-to-e-cigarettes-debate/>.

a severe mental illness who are among the group who find it most difficult to give up. The report concludes that:

We have therefore formed the conclusion that nicotine e-cigarettes should be available as a consumer good to Australians, subject to regulations which will limit their appeal to non-smokers and young people.⁵

However, it is becoming increasingly clear that vaping may be more dangerous than previously realised.

4. ISSUES & ARGUMENTS

a) Lung injury

A study from the University of Tasmania⁶ has found that heated tobacco devices and e-cigarettes harm the lung cells which protect the airways, just as cigarette smoke does. They can damage lung cells and destroy lung tissue which may lead to fatal diseases such as chronic obstructive pulmonary disease, lung cancer and pneumonia, and can increase the risk of developing asthma, including in unborn children. The study found that cigarette smoke and the vapour from 'heat-not-burn' tobacco devices (such as the IQOS⁷) were highly toxic to the cells at both lower and higher concentrations, while e-cigarette vapour was toxic mainly at higher levels.

This is backed up by current investigations by the U.S. Department of Health and Human Services Centre for Disease Control and Prevention and the U.S. Food and Drug Administration (FDA), state and local health departments, and other clinical and public health partners following a multi-state outbreak of lung injury associated with e-cigarette product (devices, liquids, refill pods, and/or cartridges) use.⁸

A report published in *The Journal of Clinical Investigation*⁹ reviewed the research done by Dr Farrah Kheradmand, a professor of medicine, pathology and immunology at the

Baylor College of Medicine. Kheradmand and her colleagues studied the impact of both traditional cigarette smoke and e-cigarette vapour on three groups of mice. A fourth group was used as a control and exposed only to air. The mice in the e-cigarette group were exposed to either vapour containing nicotine dissolved in the common vaping solvents of propylene glycol and vegetable glycerine, or vapour that came just from the solvents, without the nicotine. The exposure to smoke, vapour or air lasted four months, which would be comparable to years of smoking in humans.

Examination of immune cells from the mouse lungs which had been exposed to vapour uncovered a striking abnormality: The cells were clogged with fat. There were no such changes in the other mice. The researchers initially thought the fat particles, or lipids, filling up the immune cells had come directly from the vegetable glycerine, which is a type of fat. But as it turned out, the fat had come from the animals' own lungs. The fluid lining the lungs contains proteins and lipids. While it's normal for the immune cells to take up some of this fat, when the mice were exposed to e-cigarette vapour, the cells became overwhelmed, and the accumulation went into overdrive.

This affected the cells' ability to defend against pathogens. In the second part of the study, the vapour-exposed mice were also exposed to a virus that normally doesn't kill mice, they were not capable of handling the virus. While the study is only in mice, which means the findings can't be directly applied to people, it does underscore how little is known about e-cigarettes, and how much potential for harm is yet to be fully investigated.

A study published in 2020 in the *New England Journal of Medicine* examined a cluster, in August 1, 2019, of "the first cases of electronic cigarette (e-cigarette), or vaping, product use-associated lung injury (EVALI)" which were reported to the Centers for Disease Control and Prevention (CDC)¹⁰.

5 House of Representatives Standing Committee on Health, Aged Care and Sport, 'Report on the Inquiry into the Use and Marketing of Electronic Cigarettes and Personal Vaporisers in Australia' (Canberra, March 2018), http://parlinfo.aph.gov.au/parlInfo/download/committees/reportrep/024115/toc_pdf/ReportontheInquiryintotheUseandMarketingofElectronicCigarettesandPersonalVaporisersinAustralia.pdf;fileType=application%2Fpdf.

6 Sukhwinder Singh Sohal et al., 'IQOS Exposure Impairs Human Airway Cell Homeostasis: Direct Comparison with Traditional Cigarette and e-Cigarette', *ERJ Open Research* 5, no. 1 (February 2019): 00159–02018, <https://doi.org/10.1183/23120541.00159-2018>.

7 IQOS is a heat-not-burn tobacco device from multinational tobacco company Philip Morris. The device is a hybrid between eCigs and traditional cigarettes. It uses disposable tobacco 'sticks' which are heated to give off an aerosol, but do not burn. To date, most of the studies on IQOS have been conducted by Philip Morris.

8 Centres for Disease Control and Prevention, 2018

9 Matthew C. Madison et al., 'Electronic Cigarettes Disrupt Lung Lipid Homeostasis and Innate Immunity Independent of Nicotine', *The Journal of Clinical Investigation* 129, no. 10 (1 October 2019): 4290–4304, <https://doi.org/10.1172/JCI128531>.

10 Kathleen P. Hartnett et al., 'Syndromic Surveillance for E-Cigarette, or Vaping, Product Use-Associated Lung Injury', *New England Journal of Medicine* 382, no. 8 (20 February 2020): 766–72, <https://doi.org/10.1056/NEJMs1915313>.

A few months prior, the same journal published two letters signed by a number of clinicians which referred to, as described by one of them,

"A surge in cases of severe pulmonary disease associated with the use of electronic cigarettes (e-cigarettes), also called vaping, is emerging across the United States. Clinical presentations include shortness of breath, cough, chest pain, and gastrointestinal symptoms of nausea, vomiting, diarrhea, and abdominal pain. These cases represent a public health threat given the increasing popularity and prevalent use of e-cigarettes, which are marketed as a safer alternative to smoking."¹¹

Vaping is widely assumed to be safer than cigarette smoking, but scientists at the University of North Carolina School of Medicine have uncovered evidence suggesting that vaping promotes the same cellular responses found in smokers who suffer with emphysema. A study published in the *American Journal of Respiratory and Critical Care Medicine* found that the lungs of vapers – like the lungs of smokers – have elevated levels of protease enzymes, a condition known to cause emphysema in smokers. The researchers also found that the nicotine in vaping liquids is responsible for the increase in protease enzymes.¹² These findings may indicate that vaping may not be safer than cigarette smoking in the long term with an indication for a higher risk of emphysema.

b) Injury to the cells that line the airways

A recent University of Adelaide study published in *Respirology*, exposed bronchial epithelial cells – the types of cells that line the airways – to three brands of apple-flavoured vaping liquid both with, and without, nicotine. The researchers found that the vapour from flavoured e-cigarettes can kill the type of cells that line the airways and disrupt the burying of dead cells by the immune system. They found that with prolonged use, the damage can be permanent as *"the vapour was toxic to the cells and could trigger cell death."*¹³

11 Yulin Hswen and John S. Brownstein, 'Real-Time Digital Surveillance of Vaping-Induced Pulmonary Disease', *New England Journal of Medicine* 381, no. 18 (31 October 2019): 1778–80, <https://doi.org/10.1056/NEJMc1912818>.

12 Arunava Ghosh et al., 'Chronic E-Cigarette Use Increases Neutrophil Elastase and Matrix Metalloprotease Levels in the Lung', *American Journal of Respiratory and Critical Care Medicine* 200, no. 11 (7 August 2019): 1392–1401, <https://doi.org/10.1164/rccm.201903-0615OC>.

13 'Flavoured E-Cigarettes Can Kill Lung Cells, Even without Nicotine: New Study', *The New Daily*, 22 September 2019, sec. Wellbeing, <https://thenewdaily.com.au/life/wellbeing/2019/09/23/e-cigarettes-health-effects/>.

14 Won Hee Lee et al., 'Modeling Cardiovascular Risks of E-Cigarettes With Human-Induced Pluripotent Stem Cell-Derived Endothelial Cells', *Journal of the American College of Cardiology* 73, no. 21 (4 June 2019): 2722–37, <https://doi.org/10.1016/j.jacc.2019.03.476>.

15 Karena D. Volesky et al., 'The Influence of Three E-Cigarette Models on Indoor Fine and Ultrafine Particulate Matter Concentrations under Real-World Conditions', *Environmental Pollution* 243 (1 December 2018): 882–89, <https://doi.org/10.1016/j.envpol.2018.08.069>.

However, the study found e-cigarettes are less harmful than cigarettes, while still emphasising significant and as yet not fully understood risks.

c) Cardiovascular problems

The impact of e-cigarettes on the cardiovascular system is an emerging area of research. In a June 2019 study, published in the *Journal of the American College of Cardiology*, researchers exposed human endothelial cells – which line the blood and lymphatic vessels – to six e-liquid flavours with different levels of nicotine. They discovered that the e-liquid damaged the cells, exacerbating *"endothelial dysfunction, which often precedes cardiovascular diseases."* They found that acute exposure to flavoured e-liquids or e-cigarette use exacerbates endothelial dysfunction, which often precedes cardiovascular diseases.¹⁴

It has also been found that e-cigarettes emit microscopic particles that have been linked to heart attacks, high blood pressure, and coronary artery disease. Even when vapour is nicotine-free, it may carry other heart health risks. The heating element in e-cigarettes emits tiny particles, sometimes including metals, which can lodge themselves deep into the lungs and get absorbed into the body's circulatory system. This can lead to potential cardiovascular toxicity.

One recent study demonstrated that using e-cigarettes increases concentration of these microscopic pollutants in indoor environments. Researchers don't yet know what risks e-cigarette aerosol particles carry, but these tiny particles have been studied extensively in the context of air pollution and tobacco smoking. In those studies, researchers have linked exposure to small particles with a range of bad cardiovascular outcomes, including heart attacks, high blood pressure, and coronary artery disease.¹⁵ This may also have implications for 'second hand' inhalation.

d) e-Cigarettes may contain heavy metals

One study has found that all that vaping products may produce an unhealthy by-product (aside from the possible risks already suspected of some e-cigs): a medley of heavy metals with links to cancer, lung disease, gastrointestinal disorders, and other maladies. Researchers examined six popular tank-style electronic cigarettes and screened their aerosols for 19 metals. They found the aerosols from all of the e-cigs contained some of the metals, which appeared to originate in the atomising units.¹⁶

Eleven metals in particular were linked to components of the e-cigarettes: aluminium, calcium, chromium, copper, iron, lead, magnesium, nickel, silicon, tin, and zinc. The more metal parts in the e-cigarette, the more heavy metals were found in the vapours produced. The researchers noted that concentrations of some elements (e.g. lead) increased in aerosols as voltage/power increased.

Tank-style e-cigarettes operate at higher voltage and power, resulting in higher concentrations of metals; such as lead, nickel, iron, and copper; in their aerosols. Most of the metals in e-cigarette aerosols likely come from the nichrome wire, tin solder joints, brass clamps, insulating sheaths, and wicks, which are all components of the atomiser unit.

Some of the metals found in this study have significant health risks:

- Chromium, lead, and nickel are known carcinogens.
- Prolonged exposure to lead can trigger cardiovascular problems, and can potentially lead to brain disorders which affect memory, processing speed and learning ability.
- Chromium is linked to gastrointestinal symptoms, respiratory distress and lung cancer.
- Nickel is linked to lung disorders, nasal cavity damage, and other issues.

The presence of heavy metals, including some known carcinogens, in e-cigarette aerosols is concerning, as with prolonged exposure they could cause serious adverse health effects. Clearly, more research is required in this area.

e) e-Cigarette use may contribute to seizures

It is known that seizures can be a symptom of nicotine poisoning, which happens when people are exposed to high levels of the compound. The U.S. Food and Drug Association is investigating a possible link between e-cigarettes and seizures after reports that some people who use e-cigarettes have experienced seizures, with most reports involving youth or young adult users. Seizures or convulsions are known potential side effects of nicotine toxicity and have been reported in the scientific literature in relation to intentional or accidental swallowing of e-liquid. However, recent voluntary reports of adverse experiences with tobacco products that mention seizures occurring with e-cigarette use (e.g. vaping) signal a potential emerging safety issue. The FDA notes that some e-cigarettes have designs that allow users to obtain high levels of nicotine very quickly.¹⁷

f) No conclusive evidence for e-cigarettes as a smoking cessation aid

"In Britain, e-cigarettes are seen as central to the fight against smoking, but many experts believe the evidence is contradictory."¹⁸

The World Health Organisation (WHO) has come out with the position that there is 'insufficient evidence' to support claims of the effectiveness of e-cigarettes in assisting smokers trying to quit conventional cigarettes.¹⁹ A few randomized clinical trials examining the use of e-cigarettes as a cessation tool have shown mixed results. While some trials, including a recent one published in the *New England Journal of Medicine*²⁰ demonstrate a significant increase in cessation success (from 9.9% to 18%), people using e-cigarettes

16 Olmedo Pablo et al., 'Metal Concentrations in E-Cigarette Liquid and Aerosol Samples: The Contribution of Metallic Coils', *Environmental Health Perspectives* 126, no. 2 (21 February 2018): 027010, <https://doi.org/10.1289/EHP2175>.

17 Center for Tobacco Products, 'Some E-Cigarette Users Are Having Seizures, Most Reports Involving Youth and Young Adults', Government, U.S. Food & Drug Administration (blog) (FDA, 20 December 2019), <http://www.fda.gov/tobacco-products/ctp-newsroom/some-e-cigarette-users-are-having-seizures-most-reports-involving-youth-and-young-adults>.

18 Jamie Doward, 'After Six Deaths in the US and Bans around the World – Is Vaping Safe?', *The Guardian*, 15 September 2019, sec. Society, <https://www.theguardian.com/society/2019/sep/15/how-safe-is-vaping-e-cigarettes-deaths-bans>.

19 World Health Organisation, 'WHO Report on the Global Tobacco Epidemic 2019: Offer Help to Quit Tobacco Use', 26 July 2019, <https://apps.who.int/iris/bitstream/handle/10665/326043/9789241516204-eng.pdf?ua=1>.

20 Peter Hajek et al., 'A Randomized Trial of E-Cigarettes versus Nicotine-Replacement Therapy', *New England Journal of Medicine* 380, no. 7 (14 February 2019): 629–37, <https://doi.org/10.1056/NEJMoa1808779>.

were much more likely to remain dependent on nicotine as compared to those using more traditional nicotine replacement products, such as nicotine patches, gum and nasal spray. Another study found that:

"Vaping more than one year after quitting smoking was associated with smoking relapse at 12-month follow-up in a nationally-representative sample."²¹

In short, whether, how, and to what extent e-cigarettes have potential as a cessation tool is not yet settled and further studies are needed to evaluate whether this is the case. Ilona Jaspers, Professor of Pediatrics, Microbiology and Immunology, and Environmental Sciences and Engineering at the University of North Carolina at Chapel Hill makes the important point that:

"While it is too early to say whether or to what extent e-cigarettes can be used to support smoking cessation, one conclusion can already be drawn: Vaping is not without health effects."²²

g) e-Cigarettes and young people

There is increasing evidence that e-cigarettes may act as a gateway to traditional cigarette smoking among youth. Reporting on the health impact of e-cigarettes, the National Academies of Sciences, Engineering, and Medicine assessed ten high-quality studies on this gateway question, and they all pointed to the same effect. The report concluded that young people who had never smoked were more likely to take up smoking after vaping.²³

The evidence base is large enough, consistent enough and strong enough to conclude that there's an association between e-cigarette use and use of combustible tobacco – cigarettes – but what isn't clear is whether young people are more likely to only try cigarettes after vaping, or whether they then go on to become long-term smokers. Given that youth smoking rates have dropped significantly in recent years, the question of e-cigarettes leading to cigarette smoking in young people is one that needs thorough investigation.

Furthermore, a recent study by Funhee Park et al found that with the legalisation of cannabis in many American states:

"State-level policies were potential risk factors for using cannabis in e-cigarette devices among youth. Cannabis legalization policy and e-cigarette MLSA [minimum legal sales age] laws at 19 or 21 years were positively associated with cannabis use in e-cigarettes... Even more problematic, tobacco use was highest among cannabis in e-cigarette ever users across every tobacco product assessed..."

"For public health programs seeking to minimize harms from substance use among youth in a rapidly evolving policy and tobacco product landscape, innovations in tailored prevention and education programs that acknowledge the potential combined influences of cannabis and tobacco laws are needed."²⁴

5. SUGGESTED ACTIONS

a) Regulation of the e-cigarette industry

Given the rapid growth of the e-cigarette industry, the increase in the unregulated manufacturing of e-liquids in various countries and their questionable impact on health, there is significant concern about the need to regulate even flavoured vaping liquids (which don't contain nicotine) and paraphernalia. Should nicotine-based e-cigarettes become legal in Australia they must be regulated in line with traditional tobacco products. Furthermore, according to Brown and Cheng:

Although e-cigarettes share a basic design, engineering variations and user modifications result in differences in nicotine delivery and potential product risks. e-Cigarette aerosols may include harmful and potentially harmful constituents.

Battery explosions and the risks of exposure to the e-liquid (especially for children) are also concerns. Additional research will enhance the current understanding of basic e-cigarette design and operation, aerosol production and processing, and functionality.

21 Hongying Dai and Adam M. Leventhal, 'Association of Electronic Cigarette Vaping and Subsequent Smoking Relapse among Former Smokers', *Drug and Alcohol Dependence* 199 (1 June 2019): 10–17, <https://doi.org/10.1016/j.drugalcdep.2019.01.043>.

22 Ilona Jaspers, 'Vaping Likely Has Dangers That Could Take Years for Scientists to Even Know About', *The Conversation*, 11 September 2019, <http://theconversation.com/vaping-likely-has-dangers-that-could-take-years-for-scientists-to-even-know-about-123051>.

23 The National Academies of Sciences, Engineering, and Medicine, *Public Health Consequences of E-Cigarettes* (National Academies Press (US), 2018), <https://doi.org/10.17226/24952>.

24 Eunhee Park et al., 'Adolescent E-Cigarette Use Trajectories and Subsequent Alcohol and Marijuana Use', *Addictive Behaviors* 103 (1 April 2020): 106213, <https://doi.org/10.1016/j.addbeh.2019.106213>.

A standardised e-cigarette testing regime should be developed to allow product comparisons.²⁵

Regulations need to be put in place to balance the risks of e-cigarettes with their potential benefits, and achieve key aims of reducing smoking and continuing to avoid uptake of e-cigarettes by non-smokers. This requires keeping them under regular review and evaluating their impact.²⁶

Suggested regulations include:

- Restrictions on their sale to minors.
- A ban on vaping in public places.
- Testing and labelling requirements.
- Restrictions on advertisements and online selling.
- Regulation and standardisation of flavourings, which are not identified on labels, and can be a combination of volatile and potentially toxic chemicals.

b) Evaluation of e-cigarettes

e-Cigarettes haven't been thoroughly evaluated in scientific studies and there is currently not enough existing data on their safety, how the health effects compare to traditional cigarettes and if they are helpful for people trying to quit smoking.

One problem in evaluating e-cigarettes is that they can vary greatly in their design, nicotine concentration (ranging from none to relatively high levels), flavourings, and other compounds emitted. Currently, it is assumed that the levels of potentially toxic chemicals emitted are lower than those from tobacco cigarettes, but this is not clear as there is so much variability and the extent of risk reduction is presently unknown.

Another problem with evaluation of e-cigarettes is the lack of corroborating evidence; there is no long-term evidence, because e-cigarettes are relatively new in the market; and there is inconsistency in the quality of research, especially regarding industry-lead research which gives consistently and deceptively positive results.

25 Christopher J. Brown and James M. Cheng, 'Electronic Cigarettes: Product Characterisation and Design Considerations', *Tobacco Control* 23, no. suppl 2 (1 May 2014): ii4-10, <https://doi.org/10.1136/tobaccocontrol-2013-051476>.

26 Ann McNeill et al., 'Evidence Review of E-Cigarettes and Heated Tobacco Products 2018' (London: Public Health England, 2018).

27 The chemical diacetyl used in many electronic cigarette flavours. This chemical can lead to bronchiolitis obliterans or 'popcorn lung', and some companies which previously used it to flavour microwave popcorn have stopped using it altogether. According to the American Lung Association, using electronic cigarettes or vaping, particularly the flavoured varieties, can cause this condition. Jennifer Huizen, 'Popcorn Lung: Causes, Symptoms, and Treatment', *Medical News Today* (blog), 13 March 2018, <https://www.medicalnewstoday.com/articles/318260.php>.

28 Stephanie Byrne et al., 'E-Cigarettes, Smoking and Health. A Literature Review Update.' (Australia: CSIRO, 22 June 2018).

For policy makers this poses a potential dilemma as making regulatory changes to legalise nicotine e-cigarettes may come with significant risks. Conversely, not making e-cigarettes available deprives smokers of a potentially useful tool to help them quit.

There are a number of questions that have not been fully answered yet, including:

- Do e-cigarettes help reduce the number of people smoking tobacco cigarettes?
- What are the health effects of the long-term use of e-cigarettes?
- Would the legal availability of e-cigarettes act as a gateway to nicotine use for non-smokers?
- Is the use of e-cigarettes really less harmful than the use of tobacco products?
- What are the longer-term success rates of people who use e-cigarettes for quitting compared with other stop smoking treatments?
- Does the uptake of e-cigarettes after quitting prevent relapse back to smoking?
- We need more data examining the number and quantities of some metals in e-cigarette aerosol - is it even greater than that in traditional cigarettes, and/or above accepted health-based limits?
- Although some manufacturers have claimed their flavourings are generally recognised as safe for food additives (i.e. to be used in preparing foods for eating), we need to know about the long-term health effects of inhaling these substances into the lungs (for example, the chemical causing 'popcorn lung'.²⁷)
- What is the level of risk to others from second-hand exposure?

6. SUMMARY

a) In summary, a recent literature review update published by the CSIRO concludes that, based on the current evidence, it is not possible to determine whether e-cigarettes have a positive or a negative effect on health in countries where they are permitted.²⁸ Malas et al. make the point:

While inconclusive due to low quality, overall the existing literature suggests e-cigarettes may be helpful for some smokers for quitting

or reducing smoking. However, more carefully designed and scientifically sound studies are urgently needed to establish unequivocally the long-term cessation effects of e-cigarettes and to better understand of how and when e-cigarettes may be helpful.²⁹

b) There is increasing evidence that e-cigarettes may damage a person's health. Existing evidence shows that e-cigarette aerosol is not merely water vapour as is often claimed in the marketing of these products. The U.S. National Institute on Drug Abuse refers to a number of studies and concludes:

*e-Cigarette use exposes the lungs to a variety of chemicals, including those added to e-liquids, and other chemicals produced during the heating/vaporizing process. A study of some e-cigarette products found the vapor contains known carcinogens and toxic chemicals, as well as potentially toxic metal nanoparticles from the device itself. The study showed that the e-liquids of certain cig-a-like brands contain high levels of nickel and chromium, which may come from the nichrome heating coils of the vaporizing device. Cig-a-likes may also contain low levels of cadmium, a toxic metal also found in cigarette smoke that can cause breathing problems and disease. More research is needed on the health consequences of repeated exposure to these chemicals.*³⁰

c) Vaping electronic cigarettes is increasingly popular with young people, partly driven by the wide range of available flavours. There is some proof that the chemicals used to make the flavours – which are extremely varied and include everything from tobacco-simulating flavours to flavours such as apple, mint, and candy – may not remain stable in e-cigarette liquids and can undergo permutations which can be harmful to health. It has been found that the liquids vaporised by e-cigarettes are chemically unstable and form new chemicals that irritate the airways and may have other toxic effects.

A research collaboration between Duke and the Yale Tobacco Center of Regulatory Science³¹ shows when chemical flavourings for vanilla, cherry,

citrus and cinnamon mingle with solvents such as polypropylene glycol and glycerol, they create compounds called acetals. Contrary to suggestions from vaping advocates who claim low-temperature or temperature-adjustable vaporizers minimize those risks associated with higher vaping temperatures, this study shows chemical changes occur even before the liquids are heated; and even in the absence of heating and combustion, chemical reactions are occurring in e-cigarette liquids and the resulting compounds could be harmful to human airways. In lab tests, researchers found the acetals they created from mixing flavors into e-liquids were effective in triggering molecular receptors involved in lung irritation – the same receptors that maintain irritation and inflammation in people with asthma or those who have inhaled smoke or fumes, the study found. Young people are particularly susceptible to those effects.

d) e-Cigarettes have also been linked to overheating, fire and explosion (OH/F/EXP) events. An article published in 2017 notes that:

ENDS [electronic nicotine delivery systems] OH/F/EXP events are occurring internationally. The scope, causes and trajectory of events in the US remain incompletely defined...

The identified events vary in the involved products, parts, people, device-user interactions, environments, surrounding circumstances, and outcomes, which have included life-threatening injury, permanent disfigurement and disability, and major property damage.

*These findings suggest a need for ongoing surveillance, along with strategies to prevent and mitigate events such as: failure mode analyses; attention to device design; good manufacturing practices; educating consumers, industry and public health professionals about risk, prevention and event reporting; and continued regulatory efforts. Data on ENDS OH/F/EXP may inform clinical counselling, informed consent in clinical research, consumer best practices, product labelling, organisational and public health system policies and regulation.*³²

29 Muhannad Malas et al., 'Electronic Cigarettes for Smoking Cessation: A Systematic Review', *Nicotine & Tobacco Research: Official Journal of the Society for Research on Nicotine and Tobacco* 18, no. 10 (2016): 1926–36, <https://doi.org/10.1093/ntr/ntw119>.

30 National Institute on Drug Abuse, 'Electronic Cigarettes (E-Cigarettes)', accessed 26 November 2018, <https://www.drugabuse.gov/publications/drugfacts/electronic-cigarettes-e-cigarettes>.

31 Stacey Hilton, 'Adding Flavors to E-Cigarette Liquids Changes Chemistry, Creates Irritants', *Duke Anesthesiology* (blog), 24 October 2018, <https://anesthesiology.duke.edu/?p=848829>.

32 Susan F. Rudy and Elizabeth L. Durmowicz, 'Electronic Nicotine Delivery Systems: Overheating, Fires and Explosions', *Tobacco Control* 26, no. 1 (January 2017): 10–18, <https://doi.org/10.1136/tobaccocontrol-2015-052626>.

7. CONCLUSION

There are many reports that have made the case for vaping, especially when compared with the health risks associated with smoking. Many of these studies are funded by e-cigarette firms and should be viewed with caution.

The situation with e-cigarette related deaths in the U.S. has resulted in increased caution around the world, with some places putting bans in place. In Britain, however, e-cigarettes continue to be seen as central to the fight against smoking, even though many experts believe the evidence is contradictory.³³

However, while experts have maintained that vaping poses fewer health risks than smoking cigarettes, there is little is known about the potential toxicology of flavourings, particles, heavy metals and other components used in e-cigarettes. It may take many years to find the full effects of these.

Currently there is increasing concern about e-cigarette flavourings. It is becoming clearer that a number of chemicals used by the flavour industry may be safe when eaten, but may have more negative impacts on the lungs.

There are two final points to be made:

- As a smoking cessation tool, e-cigarettes appear to be more effective than other nicotine replacement tools but only over the short term. e-Cigarettes should therefore only be available for smokers who want to quit over a short period of up to two years. Beyond that timeframe, vaping appears to continue nicotine dependence and can lead to the uptake of tobacco smoking once again. This has implications for provision and monitoring of liquid nicotine, suggesting that rather than being widely available, e-cigarette use as a smoking cessation tool could be managed by a health care worker.
- e-Cigarette flavouring should be avoided, as they are indicated as a significant health risk particularly and there is no current regulation of vaping fluids.

33 Jamie Doward, 'After Six Deaths in the US and Bans around the World - Is Vaping Safe?', The Guardian, 15 September 2019, sec. Society, <https://www.theguardian.com/society/2019/sep/15/how-safe-is-vaping-e-cigarettes-deaths-bans>.

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