Vaping – Success or Disaster?

This month disposable vapes (also known as e-cigarettes) have hit the headlines – this time we have finally woken up to the fact that millions of disposable vapes are being thrown away every week in the UK, and of course in other countries.

Q1: Are vapes being targeted at children, by using candy colours and flavours?

Q2: Are vapes just intended to help smoking cessation?

Q3: How safe is it to inhale vapourised PG and VG, the e-liquids, regularly?

Q4: Can this technology be used to deliver life-saving drugs via the lung?

These £5 sales price products are now significantly cheaper than a pack of twenty cigarettes, and come in many attractive sweet flavours masking the nicotine addiction, some say promoting under-age nicotine addiction. Published US government statistics show that an average of 20% of school children claim to have vaped.

Five million vapes thrown away every week - research

8 September Comments

By Ben King
Business reporter, BBC News

Consumption & Waste	
UK weekly	5,000,000
UK Annual	260,000,000
mAh - typical battery	450
Annual battery waste kAh	117,000
Annual battery waste kWh @3.7V	31,622
85kWh car battery pack equivalents	372
Iphone 13 battery equivalents	2,657,279
Lithium Carbonate equivalent gm	35,100,000
People poisoning potential if in drinking water?	1,404,000

I find it difficult to understand why the vaping market in the UK is unregulated, aside from CE/CA UK marking which is a DIY activity requiring the manufacturer to keep a technical file on their product design and manufacture. Such marking does not prove that a product is safe to use as an inhaler. Indeed the number of cases of lipid (fat deposit) pneumonia related to vaping use are rising, and the FDA in 2019 (four years ago) proposed to put the e-liquid main ingredients on the 'potentially hazardous to inhale' register.

To use a vape as a medical product the technical hurdle would include large scale *in vivo* safety studies firstly in animals and then a human study to prove safety and efficacy. It is my understanding that no vaping product has been registered voluntarily with any regulatory authority. The timescale to do so,

August 2015 – EC's safer for addicts than Tobacco products...

Public Health England

Protecting and improving the nation's health

E-cigarettes: an evidence update
A report commissioned by Public Health England

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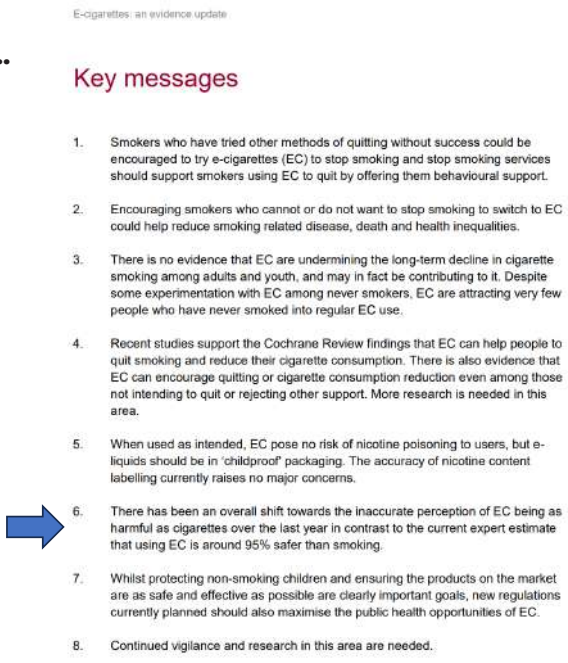

E-cigarettes: an evidence update

Key messages

1. Smokers who have tried other methods of quitting without success could be encouraged to try e-cigarettes (EC) to stop smoking and stop smoking services should support smokers using EC to quit by offering them behavioural support.
2. Encouraging smokers who cannot or do not want to stop smoking to switch to EC could help reduce smoking related disease, death and health inequalities.
3. There is no evidence that EC are undermining the long-term decline in cigarette smoking among adults and youth, and may in fact be contributing to it. Despite some experimentation with EC among never smokers, EC are attracting very few people who have never smoked into regular EC use.
4. Recent studies support the Cochrane Review findings that EC can help people to quit smoking and reduce their cigarette consumption. There is also evidence that EC can encourage quitting or cigarette consumption reduction even among those not intending to quit or rejecting other support. More research is needed in this area.
5. When used as intended, EC pose no risk of nicotine poisoning to users, but e-liquids should be in 'childproof' packaging. The accuracy of nicotine content labelling currently raises no major concerns.
6. There has been an overall shift towards the inaccurate perception of EC being as harmful as cigarettes over the last year in contrast to the current expert estimate that using EC is around 95% safer than smoking.
7. Whilst protecting non-smoking children and ensuring the products on the market are as safe and effective as possible are clearly important goals, new regulations currently planned should also maximise the public health opportunities of EC.
8. Continued vigilance and research in this area are needed.

and cost would make that product many times more costly to buy. It just does not make economic sense to the manufacturers, unless it is mandatory for all to do so. Governments must enforce safety in vaping.

Lithium Salt is a Well-known Poison

Aside from the safety issue of inhalation of e-liquid vapour, I was shocked to find out today that all disposable vaping products contain lithium batteries. To my mind using Lithium-ion batteries only once, in these disposable products, is environmental piracy. Vapes get thrown away in general rubbish and so end up in landfill, with both underground fire risk due to battery crushing at the site, as well as long-term rainwater leachate of the poisonous Lithium salts.

The numbers of disposable vapes, as reported by the BBC and other sources suggest that in the UK alone we are putting up to 35 tonnes of Lithium Carbonate Equivalent into landfill – every year. It will take some years for the battery casing to break down and release the lithium load into rainwater, thus penetrating the soil. So the Lithium experiment is only at the beginning.

25gm of Lithium Carbonate ingested is the toxic limit for a human. A few gm ingested repeatedly will induce nausea and migraine headaches in most people. So every year we are burying enough Lithium from disposable vapes alone to potentially kill 1.4m people, or give 14m (20% of the UK population) lithium induced illnesses.

Typical CE marked 2023 disposable flavoured vape

2015 UK (8 years ago) 'Vapes are 95% safer than cigarette smoking'

Public Health England reported in 2015 (8 years ago) that E-cigarettes (EC's) are '95% safer' for addicts than tobacco products. The report's authors wanted to encourage the use of EC's as nicotine replacement therapies.

In 2019 (four years ago) two of the authors of the 2015 PHE report are named in a clinical study of circa 900 smokers at three smoking cessation centres, demonstrating that 18% of EC users did not revert to tobacco, whereas only 10% of those using replacement therapies were successful in stopping smoking. It was not a safety study for vaping.

Deep-dive tear down of a single typical UK sourced CE and CA UK marked product, bought from a large chain supermarket for £5.

The core technology now includes an inhaled air flow pressure sensor at the distal end to the user's mouth. This e-switch is only Ø6mm by 2.8 mm thick and includes a miniature diaphragm and a packaged control chip for the heating coil. This flow switch could easily be re-purposed for use in an e-haler of any type, or for providing user compliance monitoring by detecting inhalation, or for breathing apparatus as a demand system.

There is also a very small LED (blue in this case) that mimics the first e-cigarette of Ho Lin, a Chinese pharmacist and smoker

August 2019 – of 900 smokers trying to stop, 18% were successful using e-cigarettes compared with 10% on other NRT products

Clinical Trial > Health Technol Assess. 2019 Aug;23(43):1-82. doi: 10.3310/hta23430.

E-cigarettes compared with nicotine replacement therapy within the UK Stop Smoking Services: the TEC RCT

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Affiliations + expand

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Free PMC article

Abstract

Background: Over the past few years, a large number of smokers in the UK have stopped smoking with the help of e-cigarettes. So far, UK Stop Smoking Services (SSSs) have been reluctant to include e-cigarettes among their treatment options because data on their efficacy compared with the licensed medications are lacking.

Objective: The objective was to compare the efficacy of refillable e-cigarettes and nicotine replacement therapy (NRT) products, when accompanied by weekly behavioural support.

Design: A randomised controlled trial comparing e-cigarettes and NRT.

Setting: Three sites that provide local SSSs.

Participants: The participants were 886 smokers seeking help to quit smoking, aged ≥ 18 years, not pregnant or breastfeeding, with no strong preference to use or not to use NRT or e-cigarettes in their quit attempt, and currently not using NRT or e-cigarettes. A total of 886 participants were randomised but two died during the study (one in each study arm) and were not included in the analysis.

Interventions: The NRT arm (n = 446) received NRT of their choice (single or combination), provided for up to 12 weeks. The e-cigarette arm (n = 438) received an e-cigarette starter pack and were encouraged to buy addtional e-liquids and e-cigarette products of their choice. Both arms received the same standard behavioural support. Participants attended weekly sessions at their SSS and provided outcome data at 4 weeks. They were then followed up by telephone at 6 and 12 months. Participants reporting abstinence or at least 50% reduction in cigarette consumption at 12 months were invited to attend for carbon monoxide (CO) validation. Participants/researchers could not be blinded to the intervention.

Plain language summary

Alarge number of smokers in the UK have stopped smoking with the help of e-cigarettes, but it is not known if e-cigarettes are as helpful as stop smoking medications that are provided by the UK Stop Smoking Services (SSSs). This information is needed to decide whether or not SSSs should include e-cigarettes among their treatment options. A total of 886 smokers who were seeking help with quitting and did not mind whether they would use nicotine replacement therapy (NRT), such as nicotine patches, or e-cigarettes were recruited at three SSSs. The smokers were randomly allocated (by chance) to receive weekly behavioural support and either a NRT of their choice (a single NRT product or product combinations) (n = 447) or a starter pack of e-cigarettes (n = 439). The trial ran from May 2015 to February 2018. The participants were followed up for 1 year to see how many stopped smoking in each group. Smokers using e-cigarettes suffered less cigarette withdrawal discomfort early on and had higher quit rates at all time points. At 1 year, 10% of participants in the NRT trial arm had been abstinent for the whole year, compared with 18% in the e-cigarette arm; regarding abstinence for at least 6 months, the figures were 12% in the NRT arm and 21% in the e-cigarette arm. Of interest, coughs and phlegm production also reduced more in people quitting with e-cigarettes than those quitting with NRT. This supports previous reports suggesting that an ingredient in e-cigarettes (i.e. propylene glycol) may protect vapers from airborne infections. E-cigarette starter packs cost much less than NRT and so, if SSSs provide them, their use is likely to boost the success rates and reduce the costs of SSSs.

Conflict of interest statement

Peter Hajek received research funding from, and provided consultancy to, manufacturers of stop smoking medications (Pfizer Inc., New York City, NY, USA). Hayden J McRobbie received a grant from the National Institute for Health Research Health Technology Assessment programme; he also received honoraria for speaking at smoking cessation meetings and attended advisory board meetings organised by Pfizer Inc. and Johnson & Johnson (New Brunswick, NJ, USA). Dunja Przulj received a research grant from Pfizer Inc. Maciej Goniewicz provided consultancy to Johnson & Johnson. Lynne Dawkins reports personal fees from attorneys at law outside the submitted work. Jinshuo Li reports grants from the National Coordinating Centre for Health Technology Assessment (NCCHTA) during the conduct of the study.

(2003). His invention had a large red LED on this distal end to encourage a tobacco smoker by mimicking the combustion product.

It is reported that Schenzen in China is the global centre for making vapes, so Ho Lin has helped generate considerable profit for his country over the last twenty years.

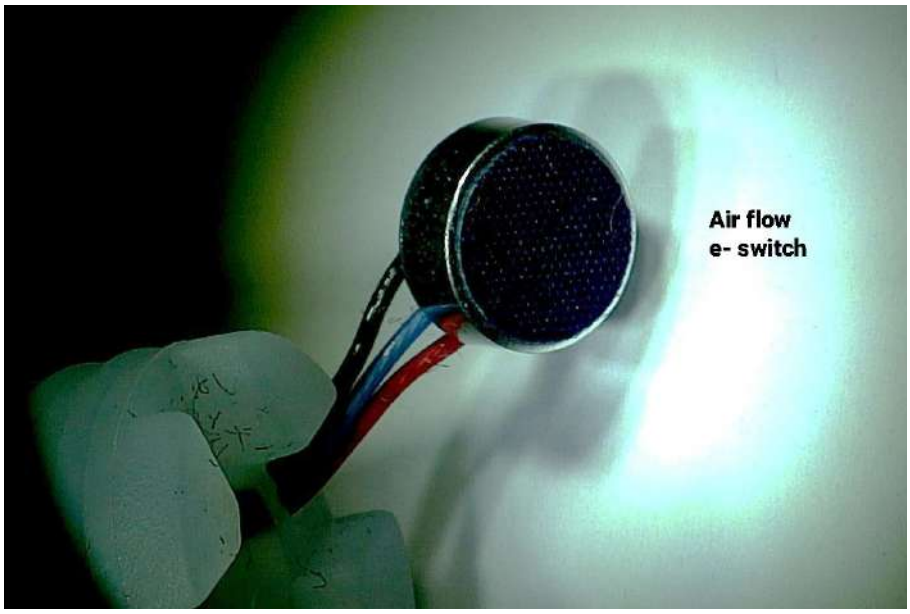
Inside the mouthpiece of this used vape can be seen a white foam oil collector than has been discoloured by the flavoured orange oil that has leeched from the reservoir next to the oil catcher. My understanding is that the oil, which contains nicotine, is toxic if ingested, so this oil catcher is a safety feature of some sort.

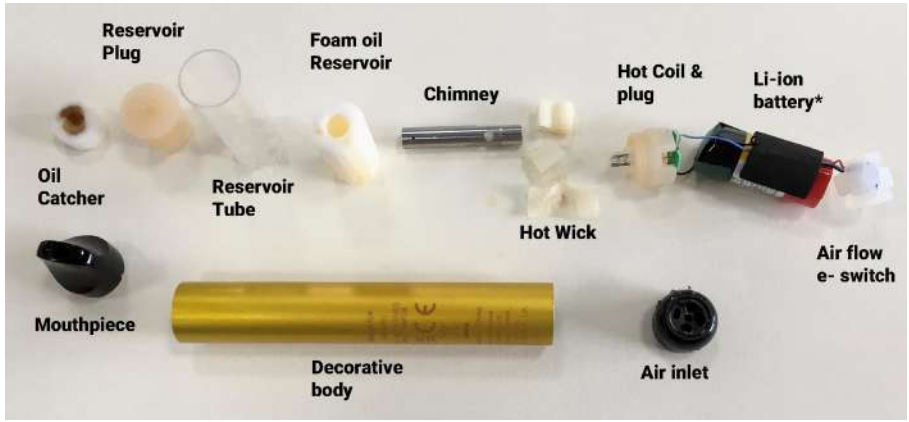
This vape has 21 individual components, much like a state-of-of-the art complicated inhaler used to treat asthma or COPD*. Single-use Lithium batteries are not common in any products, but their ability to generate high currents is helpful when using a hot element to vapourise the PG and VG.

Lithium battery fires are fairly well known, following crushing or just shock damage. When combusting acutely poisonous gases are released by the batteries, so I was a little surprised to see that in this case the lithium battery was directly in the air stream leading to the user's mouth. Although the likely hood of battery combustion during inhalation is low – the outcome could be death of the user from hydrogen fluoride gas and hydrofluoric acid vapour. For this reason in a medical device the use of a lithium battery in the drug path or air path would not be advisable, and not approvable by most regulatory authorities.

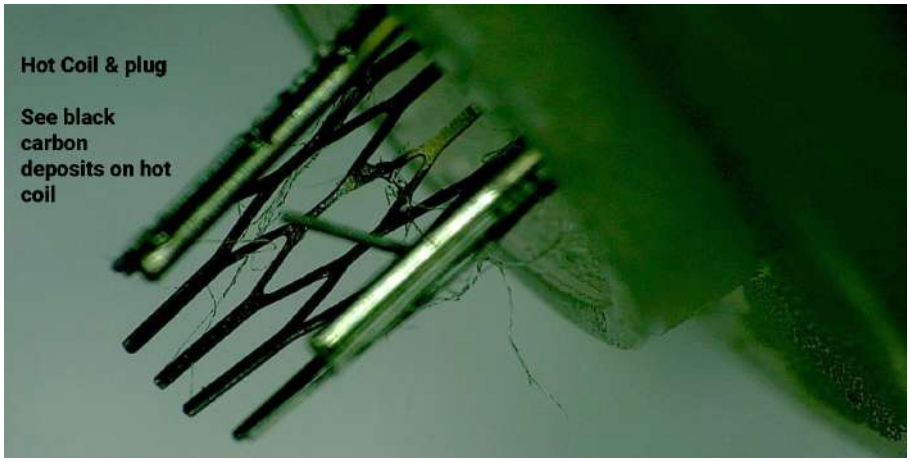
The majority of the product weight is in the aluminium tube and battery (62%) with the majority of remaining weight in hard and soft plastics and foam. The only unusual pieces are the steel chimney found in the centre of the product, and the very small steel structure wire mesh used to vapourise the polypropylene glycol (PG) 'oil' and vegetable glycerine (VG).

These products vary in weight by is we use 25gm as a typical weight when used, then the UK landfill sites will receive 6,500 tonnes of them per year – assuming no re-cycling occurs. Perhaps some 250 bin lorries full of vapes, every year.

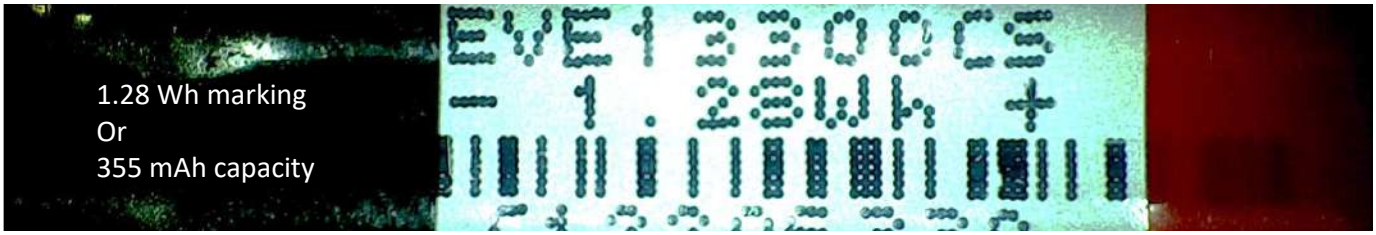




*'If a lithium-ion battery combusts, it will produce Hydrofluoric acid and hydrogen fluoride gas, an acute poison than can permanently damage our lungs and eyes'



	Description of component	Manufacturing Process	Most likely bulk Material	Weight gm	% overall weight
1	Outer coloured & printed body tube	Aluminium, anodised & tampo printed	Aluminium	8.052	32.4%
2	Lithium-ion battery- re-chargeable 356mAh	Complex - poisonous chemical	Lithium Salt	7.327	29.5%
3	Proximal reservoir plug	Injection moulding	Elastomer	1.727	7.0%
4	Distal reservoir plug	Injection moulding	Elastomer	1.363	5.5%
5	Mouthpiece	Injection moulding	ABS	1.327	5.3%
6	Reservoir foam tube - some liquid	Foamed tube	Polyester	0.994	4.0%
7	Reservoir tube	Extruded	Polycarbonate	0.939	3.8%
8	Metal chimney - coil to mouth	Stainless tube laser cut	Stainless 302	0.852	3.4%
9	Flow sensor holding plug	Injection Moulding	Elastomer	0.759	3.1%
10	Air inlet cap	Injection moulding	ABS	0.68	2.7%
11	Flow sensor, coil switch & LED	Multiple station automated	Plastic & Aluminium	0.258	1.0%
12	Mouthpiece back catcher	Foamed tube	Polyester	0.165	0.7%
13	Printed circuit board - coil	Glass fibre board - metal flashing	Glass fibre board	0.16	0.6%
14	Hot wick in contact with coil	Folded Fibre glass sheet	Glass fire weave	0.113	0.5%
15	Green insulating tab	Punch sheet	Card & foam	0.063	0.3%
16	Expanded mesh heating coil	Nickel Chromed steel	Steel	0.034	0.1%
17	Battery anti-rattle wrap	Punch sheet	Foam & Adhesive	0.023	0.1%
18	Brown wire		Aluminium & plastic		0.0%
19	Black wire		Aluminium & plastic		0.0%
20	Purple wire		Aluminium & plastic		0.0%
21	Blue wire		Aluminium & plastic		0.0%
Overall 'empty' weight typical disposable £5 retail vape - grammes				**24.836**	



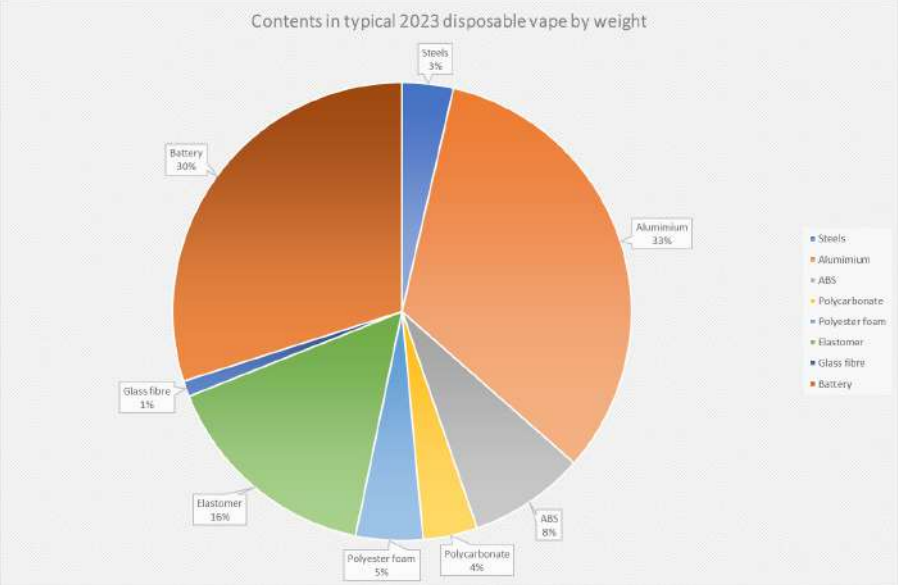
This pie chart shows that the aluminium, battery and plastics have roughly equal shares of product. Manual disassembly is needed to recover the internal battery and aluminium tube body. The rest could be perhaps used as part of the fuel of a combined heat and power plant for a town – a rare item in the UK, but more common in Scandinavia.

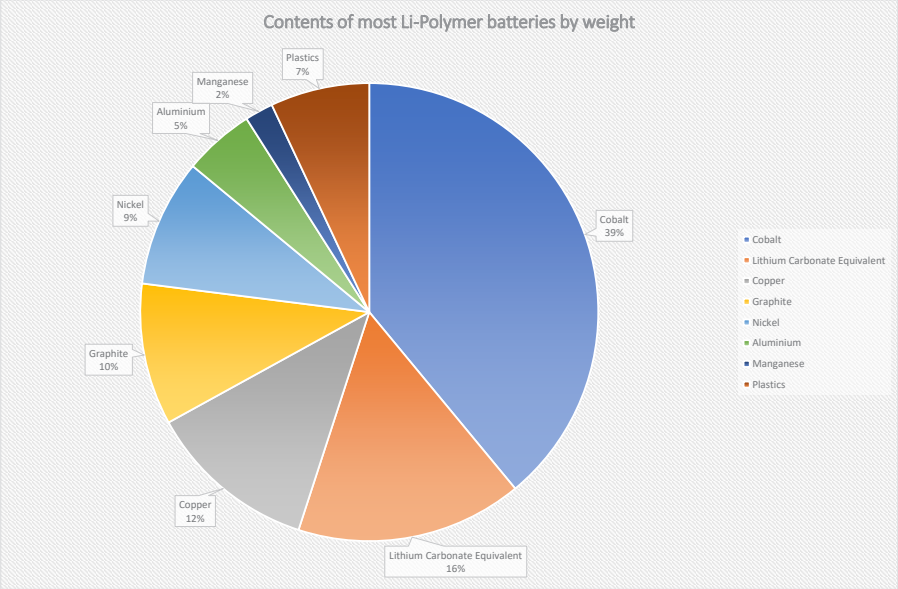
It would seem that the economic return of such re-cycling work is low, unless there is a use for millions of 400 to 500mWh lithium batteries to power other products? LED head torches perhaps, made in developing countries, re-purposing vape batteries?

The pie chart shows 39% of a Lithium battery is Cobalt, which is undesirable in rainwater leachate. The data was sourced from a 'Green' site, and 16% seems slightly high for LCE.

*Chronic Obstructive Pulmonary Disease (COPD) is generally considered a tobacco related disease, when lung function is impaired after longer-term exposure to smoke and the other tobacco contents.

There is not common medical name yet for those adversely affected by vape inhalation – but the chronic symptoms are of lipid pneumonia due to a sticky substance blocking the lung. By 2019 there had been 42 deaths reported in the US considered related to lung disease due to vaping – but reports suggest that most individuals had used THC in their vape, so vape issues are not proven beyond doubt, at the time of writing.





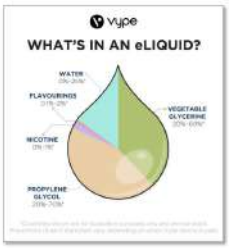
2019 – Canada Physicians high-light the FDA proposal to identify PG and VG as hazardous. There is scant clinical data to support inhalation of PG and VG as safe – vapers are doing the trials.

Propylene glycol & vegetable glycerin

Old and new evidence that these chemicals are not safe to inhale

Propylene glycol (PG) and vegetable glycerin (VG), also known as glycerol, are chemical compounds present in nearly all e-cigarettes and vaping products. Recent reports of acute respiratory disease among some users of vaping products have raised questions about whether these chemicals are safe to inhale.

PG and VG are common chemicals that have been in everyday use for many decades. They have applications in food processing, as food additives and as additives in cosmetics and pharmaceuticals. They are also used in antifreeze and have other industrial applications. For all food applications they are designated by the US Food and Drug Administration as "generally recognized as safe" (GRAS) for ingestion, but not necessarily for other forms of exposure, like inhalation.[1]



Prior to the development of e-cigarettes, propylene glycol and vegetable glycerin were never used in aerosols intended for repeated inhalation. PubChem list dozens of approved uses of glycerol in consumer and industrial products. None of them involve inhalation of the substance.[2] E-cigarette manufacturers were not required to conduct inhalation toxicity testing of these aerosols, and none of them are known to have done so.

Early cautions about inhaling propylene glycol and vegetable glycerin

Since glycerol was never intended to be inhaled in a hot aerosol, there is little inhalation toxicology of the substance that predates the appearance of e-cigarettes. Because some of the uses of propylene glycol that involve inhalation do predate e-cigarettes, there is some inhalation toxicological information available for that compound.

No health authority has labelled propylene glycol safe for inhalation. Manufacturers and chemical safety agencies recommend that inhalation be avoided, as shown in the Table 1.

Despite these cautions against inhalation of propylene glycol, its use is common in theatrical fog machines. However, in persons regularly exposed to theatrical fog, glycol-containing fog machines have been observed to produce acute cough, dry throat, increased acute upper airway symptoms and decreased lung function.[3]

Propylene glycol in cigarettes

Although propylene glycol has long been used as an additive in cigarettes, and has been found to produce cancer-causing chemicals when burned,[4] this experience has very little bearing on its potential hazards in e-cigarettes. The chemicals produced by burning will likely be different than the chemicals produced from heating without burning. Moreover, almost all of the propylene glycol used in cigarettes never finds its way into cigarettes, as combustion transforms it into other compounds.[5]

Table1: Selected information about the inhalation of propylene glycol from one commercial and three government agencies

Agency	Selected quotation on effects of inhalation of propylene glycol
Dow Chemical*	"Mist may cause irritation of upper respiratory tract (nose and throat)."
European Chemicals Agency[6]	"Avoid inhalation of hot vapours or extremely high concentrations of aerosols."
Institut national de recherche scientifique (INRS) France[8]	"Le propylène-glycol présente peu de risques dans les conditions normales d'utilisation. Toutefois, des mesures de prévention sont nécessaires dans certaines situations, en particulier si le produit est utilisé à chaud, s'il peut y avoir formation d'aérosols" "En cas d'inhalation de fortes concentrations, retirer le sujet de la zone polluée. Prévenir un médecin en cas de trouble."
ILO/WHO/EU International Programme on Chemical Safety[7]	"Avoid inhalation of mist and vapour. Use ventilation."

Recent concerns about propylene glycol and vegetable glycerin in e-cigarettes

The US Centres for Disease Control provided information on 573 cases of vaping-related illnesses in the USA and concluded that "the specific chemical exposure(s) causing lung injuries associated with e-cigarette product use, or vaping, remains unknown at this time."[10]

Reports of acute illnesses and deaths have increased interest in the health risks of inhaling propylene glycol and vegetable glycerin.

In early August 2019, the United States Food and Drug Administration (USFDA) invited comments on a proposal to add 19 chemicals to the official list of Hazardous and Potentially Hazardous Chemicals (HPHC) in tobacco products (including e-cigarettes).[11] Among the 19 chemicals which the FDA proposes to identify as potentially hazardous are propylene glycol and glycerol.

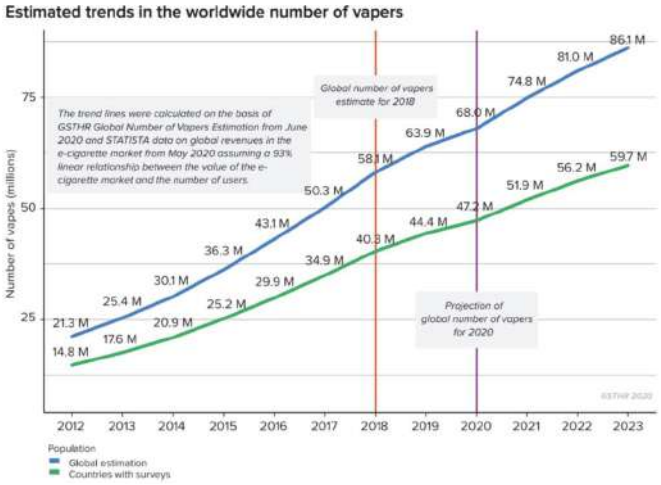
In support of identifying these chemicals as potentially hazardous, scientists at the University of California in San Francisco cited recent and older studies which had linked these compounds to health harms.[12]

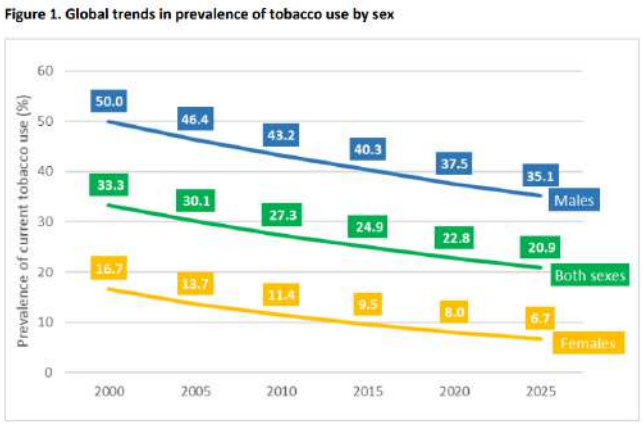
PG and VG can introduce harmful fat to the lungs.

- A 2012 American study reported a case of lipoid pneumonia (fat particles in the lung) which resulted from glycerin-based oils in e-cigarettes.[13] Reports on several other U.S. cases were published in 2019,[14,15] as were earlier cases in the United Kingdom.[16]

"As far as WHO is aware, no rigorous, peer-reviewed studies have been conducted showing that the electronic cigarette is a safe and effective nicotine replacement therapy," the World Health Organization wrote in 2008.

US President Trump in his last moments of office in late 2019 was considering a ban on flavoured vapes. Why not just follow Canada and Australia who have always banned all vaping products from the outset, using their poisons legislation?

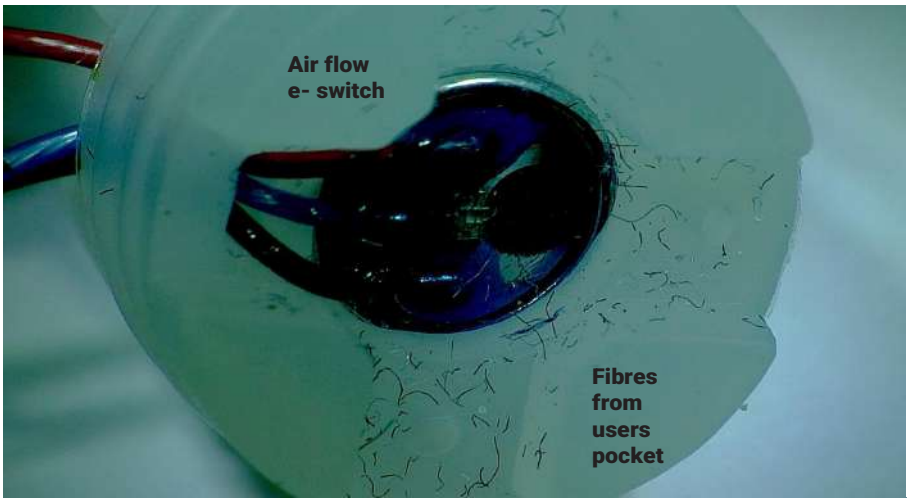




2023 Globally 86m (7%) vapers v 1,300m (100%) tobacco users (WHO report)

Conclusions

- Inhalation of primarily PG and VG vapour by smokers was considered 'safe' by Public Health England in 2015, and '95% safer than smoking'. The 'E-cigarettes – evidence update' PHE report continued to promote the use of vaping for smoking cessation. {A search of the 113-page document using 'safety study' yields no results; 'safety' yields results, but never expressing or agreeing with the concerns or data raised.}
- In 2019 a 3 UK centre ~900 person study was completed that showed e-cigarettes (vapes) helped 18% of smokers to stop using tobacco products, when compared with 10% success with other products. {This was not a safety study, but a promotion/efficacy study of e-cigarettes as NRT's}
- Also in 2019 concerns were raised about 42 US deaths from lung disease in vapers. These concerns have not yet been converted into government led actions to regulate vapes as medicinal products, or even treat the vape inhalers as potential sources of toxins and so require mandatory safety testing before sale.
- In 2023 the free-to-the-vape manufacturers human 'Beagle' experiment continues, but with disposable vape devices under threat of a ban mostly due to the Lithium Batteries underground fire risk in land fill, as well as rainwater leachate of poisons into the soil in the next decade.
- The technology developed to trigger the e-cigarette or vape by inhalation sensing should have many uses in the inhalation field. A very positive result from the experiment.
- With proven safety of the inhaled vapour, then the scope to use this technology for small molecule delivery is potentially disruptive in pharmaceutical use. It seems however than liquids other than PG and VG might well prove more optimal to safe delivery to the human lung.



Bill Treneman

Bill is the Founder and Engineer from UPC Cambridge Limited, UK. Bill has been working continuously for thirty years in the field of inhalation to the lung, as well as parenteral, nasal and diabetes fields. Prior to inhalation Bill specialised in fuel two phase aerosols and engine cooling at LandRover. Bill currently is the Managing Director at UPC Cambridge, a medical system consultancy.