

TO VAPE OR NOT TO VAPE IS THE QUESTION

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ABSTRACT

To answer this vexatious question, currently available medical and scientific information to be considered comprise the following:

1. To vape or not to vape is the question
2. Tobacco vs eCigarettes
3. Tobacco smoking vs vaping - emissions and health risks
4. What we know so far from United Kingdom(**UK**),United States of America (**USA**) and Australia.

The answer to my question is "YES" from the perspective of harm minimisation medical and scientific evidence but "NO" from the ideological point of view that both smoking and vaping are bad habits and should be discouraged. Hopefully, the information I have presented will facilitate informed decision making in rational policy formulation.

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Dr Wan (KC) is a specialist in occupational and environmental medicine in private practice as a consultant occupational physician in OccuMED and Medical Legal Consultants of Australia (**MLCOA**) in Perth, Western Australia.

KC was President of the Occupational Health Society of Australia in Western Australia (**OHSAWA**)1993 to 1996 and is currently a committee member. He was Chairman Australian New Zealand Society of Occupational Medicine Western Australian branch (**ANZSOMWA**)1987-1989 and emeritus member. From 1992 to 1999 he was a member of the Australasian Faculty of Occupational & Environmental Medicine (**AFOEM**)Western Australia Committee.

From 1985 to 2001 he worked as Worksafe Western Australia, Chief occupational health physician and inspector. He was the Health Department and Mines Department of Western Australia occupational health physician from 1979 to 1985.

He was the medical member on the Western Australia Workers' Compensation and Rehabilitation Commission from 1987 to 1991 and Industrial Diseases Medical Panel (**IDMP**) member/chairman from 1979 to date.

KC held appointments as Adjunct professor occupational medicine from 1997 to 2011 at Curtin University and 1996 to 2014 at Edith Cowan University in Western Australia.

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I am a specialist in occupational and environmental medicine from Perth, Western Australia. I have been invited by Professor Somchai to speak on what we know so far about electronic cigarettes commonly known as eCigarettes and vaping.

TO VAPE OR NOT TO VAPE

My question sounds like the question "To be or not to be is the question" in the play Hamlet by the renowned playwright William Shakespeare that it is a vexatious question.(1)

I am presenting historical, scientific and medical information that should be considered for informed decision making by policy makers.

TOBACCO SMOKING VS eCIGARETTES

The toxicological components emitted by tobacco smoking will be compared with eCigarettes/vaping in assessing the associated hazard and risk.

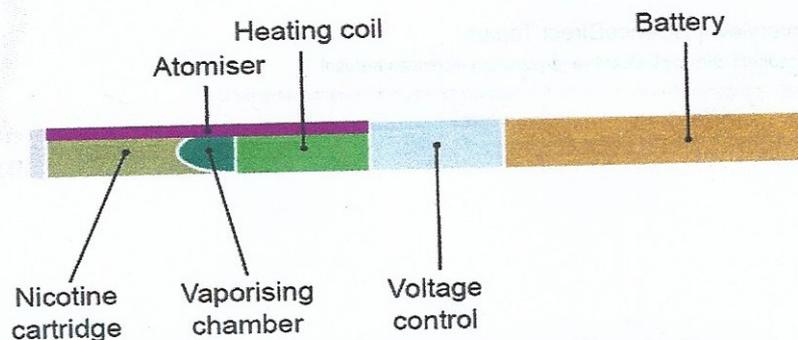
Tobacco smoking is the practice of smoking tobacco and inhaling tobacco smoke consisting of particle and gaseous phases. This is believed to have begun in 5000 BC in mesoamerica and south america. German scientists identified a

link between smoking and lung cancer in the late 1920s and in 1950, Richard Doll published research in the British Medical Journal (**BMJ**) showing a close link between smoking and lung cancer. Cigarettes, cigars and pipe tobacco are made from dried tobacco leaves. Tobacco is often mixed with other substances for flavour and additives such as potassium and nitrates to enhance combustion. In the United States, there are 599 additives in cigarettes. Burning changes the properties of chemicals. Of the more than 7000 chemicals in tobacco smoke, at least 250 are known to be harmful, including nicotine, hydrogen cyanide, formaldehyde, lead, arsenic, radioactive elements such as uranium, benzene, nitrosamines carbon monoxide, polycyclic aromatic hydrocarbons (**PAH**) and ammonia. Radioactive materials are in the tobacco leaves used to make cigarettes and cigars. These radioactive materials are given off in the smoke when tobacco is burned. Among the 250 known harmful chemicals in tobacco smoke, at least 69 can cause cancer. Because of the ageing process to make cigars, cigar tobacco has high concentrations of nitrates and nitrites. When the fermented cigar tobacco is smoked, these compounds give off several highly potent carcinogenic tobacco specific nitrosamines (**TSNAs**). The cigar wrapper is less porous than a cigarette wrapper so it does not burn as completely resulting in higher concentrations of toxic nitrogen oxides, ammonia, carbon monoxide and tar. Tobacco smoke is a complex mixture of over 5000 identified chemicals of which 98 are known to have specific toxicological properties. The most important chemicals causing cancer are those that produce DNA damage since such damage appears to be the primary underlying cause of cancer. The seven most important carcinogens in tobacco smoke are acrolein, formaldehyde, acrylonitrile, 1,3 butadiene, acetaldehyde, ethylene oxide and isoprene. Cigarette smoking has also been associated with sarcopenia - the age related loss of muscle mass and strength. The World Health Organisation (**WHO**) estimates that tobacco smoking caused 100 million deaths over the course of the 20th century and the cost for lost productivity and health care expenditures combined for cigarette smoking was at least US\$193 billion and over US\$10 billion for secondhand smoke. Cigarette smoking is the leading cause of preventable death. In 2007, the WHO attributed 4.9 million deaths to tobacco and in 2017 it caused 1 in 10 deaths worldwide.(2)& (3).

Electronic cigarettes (**eCigarettes**) also known as Electronic Nicotine Delivery System (**ENDS**) or personal vaporiser (**PV**) work by heating a solution of water, flavouring, propylene glycol(or vegetable glycerine) and typically, nicotine to generate an aerosol to create a vapour that the user inhales.

There is also an electronic delivery system that heat tobacco but not burn to deliver nicotine known as Heated Tobacco System (**HTS**) that has been permitted for sale by the United States Food and Drug Administration (**FDA**) recently in April 2019. Those not containing nicotine are referred to as Electronic Non-Nicotine Delivery System (**ENNDS**) The liquid in the e-cigarette is called e-liquid or e-juice and may not contain nicotine. The act of using an e-cigarette is known as **vaping**. The device used comprises a cartridge or refillable tank containing the liquid solution and an atomiser that vapourises the solution when heated. (4)& (5) The temperature at the tip of the burning tobacco cigarette is 600 degrees Celsius and 800 degrees Celsius during a puff whereas the temperature in the heated system is 360 degrees Celsius and onset of combustion is at 400 degree Celsius. At 310 degrees Celsius, organic material is converted by pyrolysis and oxidation into volatile organic compounds, hydrocarbons and carbonized gas..

The components of an e-cigarette



Source: [E-cigarettes: Frequently Asked Questions](#), Scottish Parliament Information Centre (SPICe), November 2014

It generates an aerosol called a "**vapor**" that the user inhales. An **aerosol** is a suspension of fine solid particles or liquid droplets in air or another gas. Aerosols can be natural such as fog, dust, geyser steam or anthropogenic such as haze and smoke.(6) Vaping is the act of inhaling and exhaling the aerosol which is produced by an e-cigarette or similar device. (7) The composition of the vapor varies but the majority of toxic chemicals found in tobacco smoke are absent in e-cigarette aerosol. Those present are mostly below 1% of the corresponding levels in tobacco smoke. The aerosol can contain toxicants and traces of heavy metals at levels permissible in inhalation medicines and potentially harmful

chemicals not found in tobacco smoke permissible by workplace safety standards. However, chemical concentrations may exceed the stricter public safety limits. A graphic demonstration of the difference is shown in the video on instagram (8) at <https://www.instagram.com/p/Bv6fE9sn0ph/>

The earliest e-cigarette can be traced to Herbert A Gilbert who in 1963 patented a smokeless non tobacco cigarette that involved replacing burning tobacco and paper with heated, moist flavoured air. Gilbert said in 2013 that today's e-cigarettes follow the basic design set forth in his original patent. The modern e-cigarette was invented in 2003 by chinese pharmacist Hon Lik and as of 2015 most e-cigarettes are made in China. Since first sold in 2004, their global use has risen exponentially. By 2013, there were several million users globally with sales in excess of US\$7 billion. In 2014 in France 1.1 to 1.9 million use eCigarettes on a daily basis of which 67% used them to reduce or quit smoking and 84% credited eCigarettes as essential in quitting. According to Action on Smoking and Health (**ASH**) in the United Kingdom (**UK**) in 2017, the number of people using eCigarettes had risen to 2.9 million(5.8% of the population)compared to 2.6 million in 2015 and 700,000 in 2012. Of the 2.9 million vapers, 1.5 million (52%) were ex-smokers, 1.3 million (45%) continued to smoke tobacco alongside eCigarettes and only 3% were never smokers. Public Health England(**PHE**) reported in 2015 that best estimates show that eCigarettes are 95% less harmful to your health than normal cigarettes and that there was no current evidence to show that they were renormalising smoking or increasing the uptake of tobacco cigarettes. (9)

VAPING VS TOBACCO SMOKING - EMISSIONS AND HEALTH RISKS

The National Academies of Science, Engineering and Medicine (**NASEM**)United States of America (**USA**) in the 2018 consensus study on the Public Health Consequences of eCigarettes reported that there is conclusive evidence on the following aspects:

1. that eCigarette use increase airborne concentrations of particulate matter and nicotine in indoor environments
2. that nicotine from eCigarettes is highly variable and depends on product characteristics (including device and e-liquid characteristics) and how the device is operated
3. that in addition to nicotine, most eCigarette products contain and emit numerous potentially toxic substances
4. that other than nicotine, the number, quantity, and characteristics of potentially toxic substances emitted from eCigarettes are highly variable and depend on product characteristics (including device and e-liquid characteristics) and how the device is operated
5. that eCigarettes can explode and cause burns and projectile injuries. Such risk is significantly increased

when batteries are of poor quality, stored improperly or modified by users

6. that intentional or accidental exposure to e-liquids from drinking, eye or dermal contact can result in adverse health effects but not limited to seizures, anoxic brain injury, vomiting and lactic acidosis and that intentional or unintentional drinking or injecting e-liquids can be fatal

7. that completely substituting eCigarettes for combustible tobacco cigarettes reduces users' exposure to numerous toxicants and carcinogens present in tobacco cigarettes.(10)

Cancer Research UK-funded scientists found that people who swapped smoking cigarettes for eCigarettes or nicotine replacement therapy (**NRT**)for at least 6 months, had lower levels of toxic and cancer causing substances in their body than people who continued smoke tobacco cigarettes. According to PHE, eCigarettes are the most popular quitting tool in the country with more than 10 times as many people using them than using local stop smoking services although using local stop smoking services is by far the most effective way to stop.

WHAT WE KNOW SO FAR FROM UK, USA AND AUSTRALIA

The British Royal College of Physicians agreed that eCigarettes is the most effective way of getting smokers to quit. Something like half of the 2.8 million current users of eCigarettes are no longer smoking tobacco. The Royal Australasian College of Physicians (**RACP**)policy on electronic cigarettes was published in 2018 May and expressed concern that there remains a lack of clear and robust evidence to inform policy makers , clinicians and the public about eCigarettes. ECigarettes are likely to be less harmful than tobacco cigarettes due to lower level of potentially toxic substances in eCigarettes compared to tobacco cigarettes. The RACP acknowledged that eCigarettes may have a potential in tobacco harm reduction and smoking cessation for smokers unable or unwilling to quit.(11)

The Australian Medical Association (**AMA**)position on tobacco smoking and E-cigarettes was issued on 16 December 2015. The AMA reported that although smoking rates in Australian have declined but 16% or 2.8 million people in Australia continue to smoke. Each year 15,000 Australian die as a result of tobacco smoking and two in three smokers (1.8 million people) will die from smoking. Passive (involuntary) smoking is a cause of lung cancer in people who never smoked and in Australia 136 cases of lung cancer per year are attributable to second hand smoke exposure. The Australian National Health and Medical Research Council (**NHMRC**) and Australian Therapeutic Goods Administration (**TGA**) and WHO currently do

not recognise eCigarettes as smoking cessation aids and there are concerns that eCigarettes normalise the act of smoking.(12)

The AMA statement on E-cigs: a help or harm dated 4 April 2016 reported on the objections to the AMA's position on eCigarettes by tobacco treatment specialist Dr Colin Mendelsohn of The Sydney Clinic who has no commercial or other relationship with any tobacco or electronic cigarette companies. Dr Mendelsohn is of the opinion that there is growing evidence to support their effectiveness and safety for smoking cessation and harm reduction. ECigarettes are a potentially game changing technology and could save millions of lives. Three meta-analyses and a systematic review suggest that eCigarettes are effective for smoking cessation and reduction. In the UK, eCigarettes are now the most popular quitting method and are used in 40% of quit attempts.(13)The results of a randomized clinical trial by Hazek p, Phillips-Waller, Przulj D, et al published in the New England Journal of Medicine in January 2019 concluded that eCigarettes were more effective for smoking cessation than nicotine replacement therapy.

A landmark study published on 25 January 2019 in the Journal of the National Cancer Institute USA found no evidence that vaping is a gateway to smoking among youth. The data came from the Population Assessment of Tobacco and Health (**PATH**) study which is the largest longitudinal study of youth smoking initiation that included 2 waves of observations on nearly 12,000 youths in the United States.(14)

On 11 April 2018, the AMA reported that the Parliamentary Committee backs AMA on eCigarettes. Electronic cigarettes containing nicotine will remain banned in Australia. Nicotine is a Schedule 7 poison under TGA and while it is legal to buy vaping devices, it is not lawful to buy, sell or use devices containing nicotine.(15) It is illegal to possess nicotine liquid for vaping in Australia without a prescription from a doctor although smokers can readily purchase higher risk tobacco cigarettes.

According to the McKell Institute in March 2019, tobacco prices in Australia are now the highest in the world. A 20 pack costs A\$28.55 or A\$10420 per year for a pack a day smoker when compared to A\$9.78 in USA and A\$1.51 in Vietnam. Despite the high cost of smoking and best practice treatment of professional counselling and stop smoking medication, quit rates are low - 75% are still smoking a year later. Smoking rates in Australia have been declining steadily since the 1970s but have recently slowed in spite of Australia having the highest cigarette price in the world, plain packaging and

strict tobacco control laws. For the first time in decades there was no statistically significant fall in the rate of smoking in 2 consecutive national surveys covering the period 2013-2016 and 2014/5-2017/8. Smoking rates are now declining faster in many other countries where tobacco harm reduction strategies are available such as UK and USA. Smoking rates have fallen dramatically in Sweden, Norway, Iceland, Japan and South Korea where increasing numbers of smokers have switched to vaping or heated tobacco products. Cigarette sales in Japan decreased by an unprecedented 27% during 2017-2018 after heated tobacco products were introduced.(16)

The **precautionary principle** cautions policy makers from implementing policies where there is still substantial uncertainty and therefore a potential risk of adverse effects. However, surveys in many countries have found that vaping by young adult non-smokers is rare - usually less than 1%. The substantial risk reduction associated with vaping is due to the fact that most of the harm from smoking is caused by the tar, carbon monoxide and 7000 toxic chemicals produced by burning tobacco. In contrast, the aerosol inhaled by vaping devices contains a fraction of the chemicals and those present are mostly at concentrations less than 1% of that in tobacco smoke. Substituting eCigarettes for combustible tobacco cigarettes reduces users' exposure to numerous toxicants and carcinogens in tobacco smoke.

The health risks of eCigarettes are uncertain although they are likely to be less harmful. The long term health effects are not known. However, so far no serious health effects other than throat or mouth irritation, vomiting, nausea and coughing. A systematic review of case reports showed that eCigarettes can have a negative impact on respiratory, gastrointestinal, cardiovascular, neurological and immune systems. Experimental data suggest that eCigarettes can induce lung inflammation.

The concept of **harm minimisation** in the context of nicotine addiction focuses on removing the tobacco related harms to smokers, rather than on people quitting nicotine completely. The public health model of harm minimisation aims to reduce the harmful effects by considering the health, social and economic consequences of addiction on both the individual and the community as a whole.(17) Harm reduction has been successfully employed in other fields such as HIV, road safety, alcohol and illicit drug use. Government programs have addressed high risk behaviour through strategies, education and products to help people change to lower risk behaviour. The same strategies for harm minimisation should be applied to tobacco smoking.

However, there is a need for Regulation of eCigarettes. Ten "nicotine-free" e-liquids purchased online and over the counter from Australian suppliers did not disclose ingredient information. They were analysed quantitatively by gas chromatography (**GC-MS**) which showed that apart from the excipient and nicotine, 16 known chemicals were identified and a further 7 could not be identified. The propylene glycol/glycerine excipient accounted for 91.4-98.8%. Nicotine was detected in 6 e-liquids - the levels in 3 were comparable with those commonly available in nicotine e-liquids (1.3,1.4,2.9 mg/mL). Of the other chemicals, 2-chlorophenol which is classified as acutely toxic by the Globally Harmonized System of Classification and Labelling of Chemicals, was identified in all e-liquids. Probably an excipient contaminant, 2-chlorophenol is commonly used in insecticides, herbicides and disinfectants. There is no Safework Australia exposure standard for 2-chlorophenol but it is known to be a respiratory and dermal irritant. Substances detected such as 2-amino-octanoic, hexadecanoic and octadecanoic acids are relatively benign for humans and commonly used in foodstuffs, soaps and detergents but it is not known whether they affect health when heated and inhaled. Most other substances were flavours (anisaldehyde, menthol, vanillin, ethylvanillin), flavouring precursors (isoeugenol), or solvents (triacetin, benzyl alcohol) that are generally regarded as safe for ingestion or dermal exposure but their effects on health when heated, aerosolised and inhaled are unknown. (18)

E-Cigarettes that do not contain nicotine may be sold in Australia, provided they are not marketed as therapeutic products. Most Australian states and territories regulate the sale of non-nicotine eCigarettes to some extent such as prohibition of sale to minors, advertising and promotion. However, there is no specific regulation of the packaging or labelling and there is no general legal requirement for manufacturers of eCigarettes to list the ingredients on packaging, nor that the packaging be child or spill proof. This is problematic as some e-liquids packaging resemble drinks or confectionary that may appeal to children.(20)

A retrospective analysis of calls to Australian Poisons Information Centres (**PICs**) during 2009-2016 with an overall call volume of about 164,000 per year with a steep increase from 2013 to 2016 of which 126 calls were about the potential side effects of routine use or accidental ingestion or about skin or eye splash exposures. Action is necessary to improve the safety of electronic cigarettes, including labelling, storage and packaging. (20)

CONCLUSION

The Australian Government has recently commissioned the National Centre for Epidemiology and Population Health of Australian National University (**ANU**) to examine the scientific evidence regarding the potential role of eCigarettes in reducing the population harm caused by tobacco.

However, based on the historical, currently available medical and scientific information that I have presented, the answer to my question is "yes" from the perspective of harm minimisation because vaping is at least 10 times less hazardous compared to tobacco smoking. However, the answer is "no" from the ideological perspective as it is a bad habit and should be discouraged although it is not as bad as tobacco smoking.

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To Vape or Not to Vape?

Occupational health consultant **Dr K C Wan** poses the question which is troubling policy makers and doctors alike.

Last year, I was invited to speak at the symposium on Environmental Pollution Harm Reduction in Thailand to report on what we know are the health risks, from current medical and scientific information, of tobacco smoking compared with e-cigarettes and vaping. And to review the outcomes of vaping for harm minimisation in countries such as the UK, US, France, Sweden, Norway, Iceland, Korea and Japan.

Of the more than 7000 chemicals in tobacco smoke, at least 250 are known to be harmful and at least 69 can cause cancer. Electronic cigarettes (e-cigarettes) work by heating a solution of water, flavouring, propylene glycol (or vegetable glycerine) and, typically but not always, nicotine. The

composition of the resulting vapor varies but the majority of toxic chemicals found in tobacco smoke are absent in ecigarette aerosol. Those present are mostly below 1% of the levels in tobacco smoke.

There is also an electronic delivery system that heats but not burn tobacco to deliver nicotine and less toxic compounds that has been permitted for sale by the United States Food and Drug Administration (FDA) in April 2019.

The modern e-cigarette was invented in 2003 by Chinese pharmacist Hon Lik and as of 2015 most e-cigarettes are made in China. Since first sold in 2004, their global use has risen exponentially.

According to Action on Smoking and Health (ASH) in the UK, in

2017, the number of people using e-cigarettes there had risen to 2.9 million (5.8% of the population). Of this number, 52% were ex-smokers, 45% continued to smoke tobacco alongside e-cigarettes and 3% had never smoked.

Public Health England reported in 2015 that best estimates showed e-cigarettes were 95% less harmful than tobacco and there was no current evidence to show they were renormalising smoking or increasing the uptake of tobacco.

Cancer Research UK-funded scientists found that people who swapped smoking cigarettes for e-cigarettes or nicotine replacement therapy (NRT) for at least six months, had lower levels of toxic and cancer-causing substances in their

body than people who continued to smoke tobacco. The Royal College of Physicians agreed that e-cigarettes were the most effective way of getting smokers to quit.

In 2018, the Royal Australasian College of Physicians' (RACP) expressed concern that there was a lack of clear and robust evidence to inform policy makers, clinicians and the public about e-cigarettes. The RACP acknowledged that e-cigarettes may help in tobacco harm reduction and smoking cessation.

The NHMRC, the TGA and the WHO currently do not recognise e-cigarettes as smoking cessation aids and there are concerns that they normalise the act of smoking. Three meta-analyses and a systematic review suggest they are effective for smoking cessation and reduction.

Nicotine is a Schedule 7 poison under TGA and while it is legal to buy vaping devices, it is not lawful to buy, sell or use devices containing nicotine. It is also illegal to possess nicotine liquid for vaping without a doctor's prescription. However, smokers can readily purchase tobacco cigarettes.

Despite the high cost of smoking and best practice treatment of professional counselling and quit medication, cessation rates are low with 75% still smoking a year later.

Smoking rates in Australia have been declining steadily since the 1970s but have recently slowed, while rates are now declining faster in other countries where tobacco harm reduction strategies are available. Cigarette sales in Japan decreased by an unprecedented 27% during 2017-2018 after heated tobacco products were introduced.

The long-term health effects are not known. A systematic review of case reports showed that e-cigarettes can have a negative impact on respiratory, gastrointestinal, cardiovascular, neurological and immune systems. Experimental data suggest that e-cigarettes can induce lung inflammation.

There is a need for regulation of e-cigarettes. Ten 'nicotine-free' e-liquids purchased online and over the counter from Australian suppliers did not disclose ingredient information. They were analysed quantitatively by gas chromatography (GC-MS)

which showed that apart from the excipient and nicotine, 16 known chemicals were identified and a further seven could not be.

Most Australian states and territories regulate sales, advertising and promotion of non-nicotine e-cigarettes. However, there is no specific regulation for packaging or labelling, nor requirements to list the ingredients and make the packaging child- or spill-proof. This is problematic as some e-liquids resemble drinks or confectionary that may appeal to children.

Action is necessary to improve the safety of e-cigarettes, particularly in view of the recent reports of fatalities from vaping identified by CDC in the US.

Based on the evidence, the answer to my question is "yes" from the perspective of harm minimisation. Vaping is at least 10 times less hazardous than tobacco smoking. However, the answer is "no" from the ideological perspective. Vaping is a habit that should be discouraged. **mf**

- References on request