NZASE resource

The science of vaping

Image by Vaping360, Flickr, CC BY 2.0.

Vaping is becoming more prevalent among teenagers. A 2021 survey of Y10 students in Aotearoa New Zealand showed that 40% have tried it, including the 10% who vape daily (compared with 1.3% who reported smoking daily).[1] And more than 20% of rangatahi Māori vape daily. While much is still unknown about vaping, some of the science is already clear. Science Communicator Mike Stone summarises what is known.

The problem with smoking

Vaping was invented to help smokers quit, so to understand vaping, we also need to talk about smoking.

Traditional cigarettes burn dried, crumbled tobacco leaves which contain nicotine and are infused with agricultural chemicals. Cigarettes also include flavourings and additives to improve the processing, shelf life, moisture and combustion of tobacco.

The combustion process generates cigarette smoke containing more than 4,000 different chemical compounds, as solids, liquids and gases (some are listed here).

Some of these substances are toxic and at least 60 are known carcinogens, mostly found in cigarette smoke condensate or tar which settles in the lungs. As well as causing lung and throat cancer, this tar can also lead to emphysema by destroying the cilia that move mucus out of the lungs.

Vaping devices

While individuals and tobacco companies had been experimenting with aerosol generation since the 1960s, Chinese pharmacist Hon Lik is credited with making the first commercially successful e-cigarette, in 2003. He wanted a device to help him stop smoking after his father died from lung cancer.

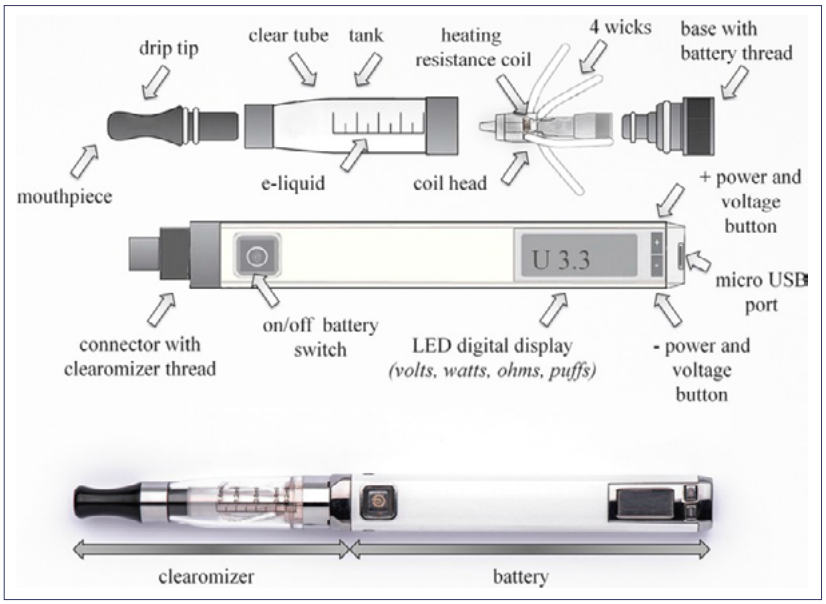
Vapes, or e-cigarettes, now come in many forms; some look like cigarettes and others have a tank. They all need electricity; some can be charged while others are disposable. Many are made by tobacco companies.

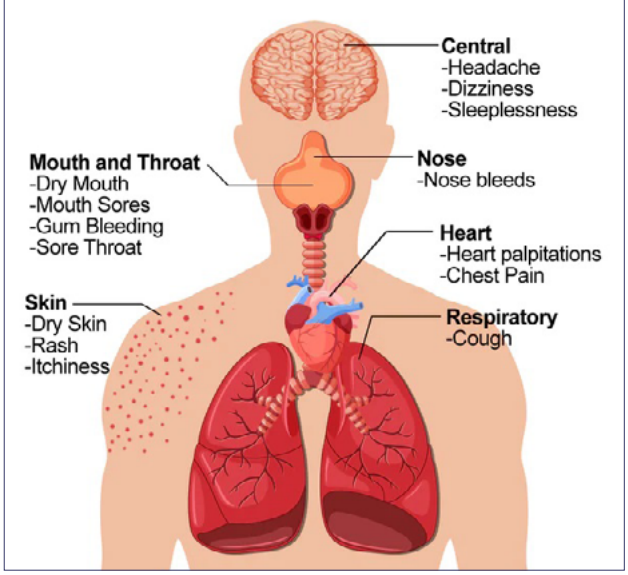
All such devices tend to have four parts:

- A cartridge or reservoir which holds a liquid solution (vape juice).
- A nichrome heating element (inside the atomiser).
- A power source (usually a battery).
- A mouthpiece.

Inside the atomiser, a wire coil is wrapped around liquid-soaked wicks. Electric current from the battery heats the coil, which heats the solution in the wicks until it vaporises, at 200-250°C. This vapour is inhaled by the user.

Exploded view of an e-cigarette with transparent clearomiser and changeable dual-coil head, from a journal article by Christian Giroud et al.





Side effects reported in a survey of 19,000 vapers worldwide, by the US National Institutes of Health. Image: Ruthless Vapor, a vape juice company, 2018.

The vape juice

The solution inside a vape contains many different substances. All vapes contain an oily mixture which is mostly vegetable glycerine, $C_3H_8O_2$, a thick liquid that creates the vapour, and propylene glycol, $C_3H_8O_3$, a thin liquid that binds flavours.

The remaining 10 percent is a mix of flavourings, other additives and, usually, nicotine. The flavourings must meet food standards in the Australia New Zealand Food Standards Code 2002. American research reported more than 15,000 different flavours in 2020.[2]

Some vapes have a very high concentration of nicotine: a disposable vape with a 2 mL tank and 20 mg nicotine/mL contains the same amount of nicotine as a pack of 20 cigarettes. And some vapes marketed as zero nicotine have been found to contain measurable amounts.[3]

The vapour

The vapour inhaled into the lungs is an aerosol, a mixture of fine particles and droplets in air. Although it looks like harmless water vapour, it isn't.

Electronic cigarettes have been marketed as operating at temperatures below combustion, which would make them safer than traditional smoking. Certainly the vapour does not contain smoke or tar.

However, as with cigarette smoke, research shows there are thousands of ingredients in vape products, most of which have not been identified.[4]

Heating the nichrome wire can contaminate the vape juice, and hence the vapour, with traces of heavy metals and harmful substances such as aldehydes.[4] Minute amounts of toxins and carcinogens have also been detected in the vapour.

Side-effects

The common side-effects of vaping come from irritants in the respiratory passages, so are also seen in smokers (see left). However, vapes have not been used long enough for scientists to know the long-term effects – after all, it took decades to prove that smoking caused cancer and other diseases.

Nicotine, $C_{10}H_{14}N_2$, is found in over 90% of vapes and has immediate effects, spiking adrenaline, which raises blood pressure and increases heart rate. It can also affect brain development in babies, children and adolescents. Nicotine use affects how the synapse connections between brain cells are formed, especially in the prefrontal cortex. For adolescents, this can affect mental processes that enable them to plan, focus attention, remember, and juggle multiple tasks – which will affect learning.

As well, nicotine is highly addictive, increasing levels of dopamine, a chemical messenger in the brain which produces a sensation of pleasure. When the vaper tries to stop, this pleasure response is cut off, leading to symptoms of withdrawal – strong cravings, anxiety, irritability, restlessness and difficulties with concentrating, sleeping and hunger. These symptoms alleviate over time.

Is it safe?

Anything you breathe into your lungs that is not just clean air is going to impact the lungs' efficiency in extracting oxygen.

There is no consensus on the risks of vaping. With no tar or smoke, vapers are exposed to fewer toxins than smokers[4]; however, much is unknown. Despite some retailers claiming vaping is 95% safer, there is no evidence available to substantiate these claims, which were based on a judging panel's opinions.[6]

In 2019 there was an outbreak of a condition that came to be known as E-cigarette Vaping Associated Lung Injury (EVALI) in the

USA. Nearly 3,000 vapers were hospitalised and 68 died. Analysis showed that all of these affected people were using vapes that had been modified to contain THC, the active ingredient in marijuana.

The health issues were due to a specific additive, vitamin E acetate. This common dietary supplement is perfectly harmless to eat, but when inhaled it interferes with normal lung functioning.[3]

Dr Kelly Burrowes at the University of Auckland is researching vaping, as she is concerned about the safety of some vape juice additives. She says, "These chemicals are safe for us to eat, but they have not been tested to see if they are safe to inhale."[7]

Much has been made of so-called popcorn lung (a type of bronchiolitis), but reputable vape juice manufacturers stopped using diacetyl to create buttery flavours, so this is no longer a risk.

Although vaping is much less harmful than smoking, it's not harmless[4].

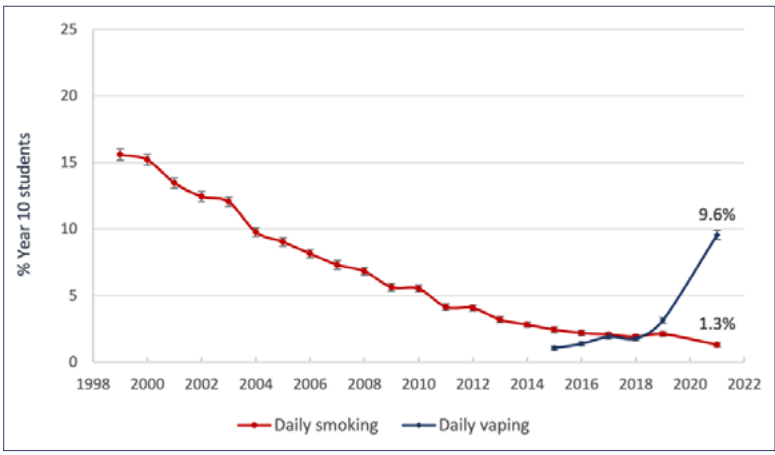
- Vaping helps smokers quit by delivering nicotine, which is addictive. The effect of nicotine on developing brains means that vaping is not harmless for teenagers.
- Inhaled solid and liquid particles irritate the respiratory lining and affect lung function. Research has shown an increased risk of asthma and chronic obstructive pulmonary disease (COPD) from vaping.[8]
- For Māori, and other cultures, the breath or hā is sacred. Vaping may interfere with your hā and the hā of those around you.

Many of the substances in vape juice and in the vapour produced are unknown, so the long-term harms may not become obvious for a few years.

Other safety issues include fires from defective e-cigarette batteries.

Vaping in Aotearoa/NZ

Vaping is touted as a means to stop smoking, but research evidence is mixed. Some wanting to stop smoking, like Hon Lik, end up both smoking and vaping. So, while the Ministry of Health sees the potential in vaping to help people quit smoking, it has not yet



ASH survey: Youth daily smoking (1999-2021) and daily vaping prevalence (2015-2021).

given it approval as an official stop-smoking medicine. The same is true in other countries. Furthermore, in NZ it is illegal to sell a vaping product (with or without nicotine) while making such a therapeutic claim.

The NZ government has set a goal to have fewer than five percent smoking by 2025. Data suggests this is on target (currently at 8%[10]), but vaping is on the rise.

In NZ it is also illegal to sell or supply vapes to those under 18 and there are controls on the marketing, advertising and promotion of vaping products. Nonetheless it is very easy to buy vapes – there are 1,100 retail outlets, many in dairies and petrol stations.[9]

Our nicotine limit in vapes is currently 50 mg for nicotine salts and 20 mg for free-base nicotine. A recent investigation by *Fair Go* found that some products on our shelves are exceeding the limit. In Australia, vape products with nicotine are now only available on prescription.

Ngā Kupu

Hikareti – Cigarette
Kai paipa – Smoking, to have a smoke
Matū tāoke – Toxic substance
Momi haurehu – Vaping
Nikotini – Nicotine
Pūkahukahu – Lung/s
Tāoke – Toxic
Warawara – Addiction, addicted, addictive
Wairehu – Water vapour
Whakahauā – To harm.

Te Aka Maori Dictionary and *Paekupu*

Footnotes

1 ASH, 2021, Year 10 snapshot survey: Youth smoking and vaping.
2 Henry, T.S. et al., 2020, Imaging findings of vaping-associated lung injury. *American Journal of Roentgenology, 214*, 3, 498–505.
3 Burrowes, K, Beckert, L, & Jones, S., 2020, Human lungs are created to breathe clean air: The questionable quantification of vaping safety "95% less harmful". *NZ Medical Journal*, 133(1517), 100-106.
4 Rosen, 2021, Johns Hopkins researchers find thousands of unknown chemicals in electronic cigarettes & Johns Hopkins University, 2023, Five vaping facts you need to know.
5 Bekki, K., 2014, Carbonyl compounds generated from electronic cigarettes. *International Journal of Environmental Research & Public Health*, 11(11), 11192–11200.
6 Centers for Disease Control, 2020, Questions about EVALI case monitoring.
7 *NZHerald*, 2022, Do you know what's inside your vape?
8 Wills, T. et al (2021). E-cigarette use and respiratory disorder: An integrative review of converging evidence from epidemiological and laboratory studies. *European Respiratory Journal*, 56, 5, 363–380.
9 Hoek, J., Feb 1, 2023, Marketers are targeting teens with cheap and addictive vapes: Nine ways to stem rising rates of youth vaping. *The Conversation*.
10 Verrall, 2022, NZ records lowest smoking rate ever. NZ Government.

Other references

Pellegrino, N., 24 Dec 2022, Up in smoke, *NZ Listener*.
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Health Navigator NZ, 2020, Vaping facts.
US National Institutes of Health, 2020, Vaping devices (electronic cigarettes) drugfacts.
Nordqvist, C., 2019, The science of vaping, *Market Business News*.
My Virtual Medical Centre, 2012, What's in a cigarette?
Johns Hopkins University, Will vaping lead teens to smoking cigarettes?

Other resources

Ministry of Health, Vaping facts: Take the quiz.
Vaping videos (4-8mins), 2019-2020, Dr Murray Winiata and Prof Hayden McRobbie, Health Navigator NZ.
Institute of Human Anatomy, What vaping does to the body (15min video shows cadaver cross-section).
Fair Go, 2022, Investigates how easy it is for kids to buy vapes. (8min video also shows effects of nicotine addiction).
Ministry of Health, 2022, Vapefree schools: Supporting teaching and learning activities.

This article was improved by critique from Sarah Hay and Lian Soh.

Some vape products available locally. Photo: Mike Stone.