Smoking & Health Action Foundation/
Non-Smokers' Rights Association

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E-Cigarette Update: Secondhand Vapour

Toxicity and Health Effects

The popularity of e-cigarettes continues to increase, with more Canadians than ever using them indoors and out. The scientific evidence on e-cigarette vapour toxicity and its health effects for both users and bystanders is still emerging and does not yet represent a robust body of knowledge. Unlike the homogeneity of cigarettes, e-cigarettes are available in a wide array of formats, and together with dozens of different e-juice brands and flavours, there are literally thousands of possible combinations to study. Currently, many countries including Canada do not have legislated manufacturing standards in place for vaping products, which means a lack of consistency and quality control adds to the challenges of studying and definitively establishing risk for vaping products. To further complicate matters, some studies on e-cigarette vapour toxicity use machines in laboratories and others use humans vaping under real-use conditions. Laboratory studies may not reflect actual exposures during use because machine vaping may not accurately represent human vaping behaviour and duration, and because many users custom mix their own vaping solutions.

Moreover, many e-cigarette studies have been deemed to be of low quality and there are relatively few studies that have looked at secondhand vapour specifically. As a result, it is difficult to make comparisons between studies and to draw firm conclusions about what is typically present in e-cigarette vapour, let alone what the long-term health effects of exposure to bystanders might be.

This fact sheet summarizes the evidence to date regarding e-cigarette vapour toxicity and its health effects, examines variables associated with vapour toxicity and offers some observations to help guide policy decisions for e-cigarette use in public places, workplaces and multi-unit dwellings.

No combustion = fewer toxic chemicals

Despite all that is still unknown, scientists do agree that because there is no combustion involved with vaping, e-cigarettes do not have the same toxic profile as cigarettes and other combustible tobacco products.

Exposure to e-cigarette vapour is significantly less harmful than exposure to secondhand tobacco smoke.

However, spirited scientific debate continues regarding the degree of reduced harm for vapers and bystanders.

Secondhand vapour: Less harmful than secondhand smoke

Research to date indicates that e-cigarette vapour can contain a variety of potentially toxic constituents, although at levels significantly lower than those found in secondhand tobacco smoke and in one study, at levels comparable with the trace amounts present in a pharmaceutical nicotine inhaler.[i] Whether or not they pose a real health risk to users and bystanders remains to be seen and cannot be confirmed until confidence in the overall quality of e-cigarette research improves. The following table compares the properties of secondhand tobacco smoke with secondhand e-cigarette vapour.

	Secondhand Tobacco Smoke (SHS)	***Secondhand Vapour***
Source	There is both mainstream (exhaled) and sidestream smoke (from the lit end of a cigarette, cigarillo or pipe). Bystanders are exposed to both.	There is no sidestream vapour, as an e-cigarette does not "idle." Bystanders are only exposed to mainstream vapour – that which is exhaled by vapers.
Temperature at which it is generated	~ 600° C - 900° C – the tobacco is combusted and smoke is produced	~ 100° C - 300° C – the e-juice is heated and vapour is produced
Constituents	Well established - over 4,000	31 and counting[ii]
Toxicity	Well established. Of the 4,000 chemicals identified in SHS, 69 are known human carcinogens and 250 are regulated toxins. There is no known safe level of exposure to SHS.	Still under investigation. Studies demonstrate the presence of toxic constituents but typically at much lower levels than SHS, with one study reporting levels 9 – 450 times lower.[iii]
Particulate matter ($PM^{2.5}$)	Mostly solid particles	Mostly liquid droplets
Length of time airborne	~ 19 – 20 minutes	~ 30 seconds (evaporates quickly)
Short-term health effects of exposure	Well established. Eye, nose and throat irritation. Immediate adverse effects on blood and blood vessels, increasing the risk of heart attack.	Still under investigation.
Long-term health effects of exposure	Increased risk of coronary heart disease, lung cancer and respiratory illnesses.	Unknown
Annual mortality	Health Canada reports over 1,000 deaths/year	Unknown

Nicotine – E-cigarettes are nicotine delivery devices so it makes sense that nicotine would be present in e-cigarette vapour. A recent review confirms that exposure to secondhand vapour does produce a measureable absorption of nicotine in bystanders; however, the extent of exposure varies greatly.[iv] One study measuring biomarkers in bystanders in the homes of cigarette smokers versus e-cigarette vapers found no significant difference in nicotine exposure[v] whereas another concluded that passive exposure from e-cigarettes is much lower than that from tobacco cigarettes.[vi] Although a report by the UK Royal College of Physicians concluded that there is no evidence to suggest that passive exposure to exhaled nicotine can cause harm to bystanders,[vii] more recent systematic reviews state that it remains unclear if levels are sufficient to be of biological concern to humans.[viii,ix]

Particulate matter ($PM^{2.5}$) – Particulate matter is frequently reported in e-cigarette vapour. One recent indoor air quality study at a vaping event recorded $PM^{2.5}$ levels at dangerously high concentrations similar to those observed in hookah cafés and bars where smoking is still permitted.[x] Another study looking at the size and composition of e-cigarette vapour particles reported the presence of nanoparticles—ultrafine particles an order of magnitude smaller than $PM^{2.5}$. The authors of that study theorized that the greater surface area per unit mass of nanoparticles, compared with larger particles of the same chemistry, renders them more biologically active, meaning their toxicity could be higher.[xi] However, others emphasize that unlike solid secondhand smoke particles that cause damage when they become lodged deep in lung tissue, e-cigarette vapour is comprised of liquid droplets that do not maintain their shape and size. Thus, it is argued that the $PM^{2.5}$ metric is irrelevant in terms of any potential harm caused by e-cigarette vapour—it is the chemistry of the particles that is of concern.[xii]

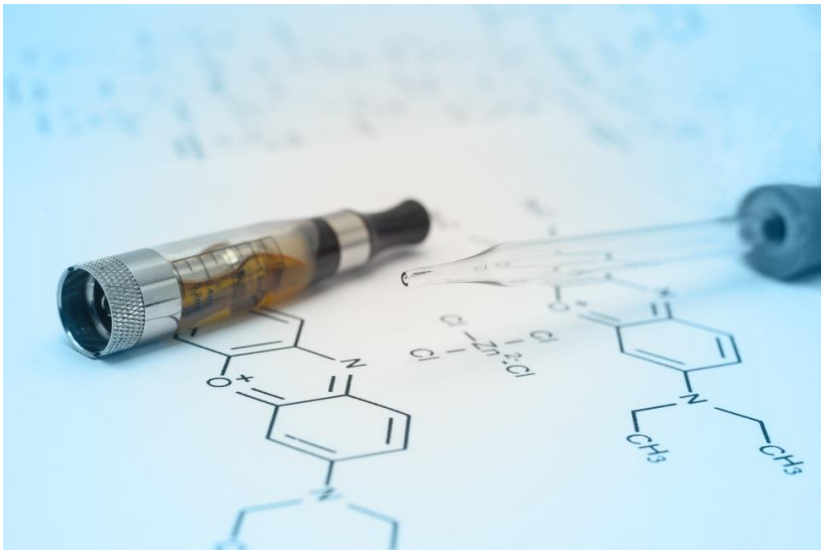
Carbonyl compounds (formaldehyde, acetaldehyde & acrolein) – These chemicals are all powerful respiratory and eye irritants; formaldehyde is a known human carcinogen and acetaldehyde is recognized as a possible human carcinogen.[xiii] Researchers think carbonyls are formed when propylene glycol and/or vegetable glycerin (PG/VG, the main ingredients in e-juice) decompose with heating, although the role of flavouring compounds in carbonyl formation has recently also been called into question. It is important to keep in mind that experimental design and conditions of usage seem to play a significant role in their formation. Laboratory studies using machine vaping can heat e-juice to temperatures that create a "dry puff" scenario—high levels of toxic constituents are formed under conditions that are not typically tolerated by human vapers. However, it has been noted that the presence of acid in e-juice allows for lower decomposition temperatures, meaning that carbonyls can also form under normal human vaping conditions.[xiv] Mouth and throat irritation are the most frequently reported side effects among users; more research is needed to confirm how they are formed and the risk of harm to both vapers and bystanders.

Tobacco-specific nitrosamines (TSNAs) – TSNAs are potent cancer-causing compounds and have been detected in trace amounts in some vapour studies. More research is warranted to establish their relationship with e-juice and to understand under what conditions they are formed.

Heavy metals – Some studies have detected trace amounts of heavy metals in e-cigarette vapour including cadmium, nickel, zinc and lead—all which have a variety of known adverse health effects including brain damage and cancer. Although they have been measured in trace amounts, their presence could be problematic if they are traveling deep into lung tissue in liquid nanoparticles.

Volatile organic compounds (VOCs) – VOCs are emitted as gases from certain solids or liquids, and include a wide variety of chemicals, some of which have short- and long-term adverse health effects including eye, nose, and throat irritation, headaches, allergic skin reactions, loss of coordination, nausea, liver damage and cancer. In the better quality vapour studies, VOCs were either not detected at all or were detected at negligible levels. However, more research is needed: one study involving "direct dripping," an e-cigarette hack in which users drip e-liquid directly on the heating element to increase clouds of vapour and improve the flavour, recorded emissions of three VOCs at levels exceeding those of regular cigarettes.[xv]

Variables affecting e-cigarette vapour toxicity



Temperature – Intuitively this makes sense: the hotter the e-juice becomes, the greater the chance the ingredients will degrade instead of vaporize. E-cigarette temperature is a function of the power output, or voltage, of a device's battery. Once more is understood about the formation of toxic constituents under specific heating conditions, manufacturing standards can be established to minimize health risks.

Flavourings – Flavours used in e-juice have been certified as "generally recognized as safe" for ingestion by the Flavours Extracts Manufacturers Association, but these chemicals were not intended to be inhaled multiple times per day over many months or years. Researchers are discovering that like PG and VG, flavouring compounds can decompose with heat to form carbonyls. In addition, certain flavourings appear to be more toxic than others, and flavouring concentration in e-juice could also be a risk factor.[xvi] This problem is likely easily solved via regulation and manufacturing standards once the science definitively pinpoints certain ingredients and concentration thresholds.

Vaping device manufacturing – With respect to heavy metals, vapour toxicity could be at least partially caused by coil manufacturing inconsistencies such as imprecise application of solder and varied wire resistance.[xvii] Product innovation and the establishment of manufacturing standards will help to minimize health risks. Industry analysts already predict that coil and wick technology will be obsolete in the near future.

"Coil Gunk" – There is evidence to suggest that a build-up of residue on or near the coil(s), known as gunk, and its subsequent heating, is an additional source of toxicity in e-cigarette vapour.[xviii] Regular cleaning, proper maintenance or more frequent replacement of the coil(s) will likely reduce the toxic emissions caused by a build-up of this residue. Given how quickly e-cigarette technology is changing, coil gunk may soon become an historic artifact.

Health risks of exposure to secondhand vapour

No long-term study has yet been conducted to assess long-term health effects of exposure to secondhand e-cigarette vapour, and the discussion on potential harm is mostly focused on more immediate indirect evidence. For example, analysis of complete blood count offers an objective overview of a person's health status: an elevated level of circulating white blood cells is an indicator of low-grade inflammation associated with atherosclerosis. One study that exposed 15 bystanders to secondhand e-cigarette vapour for one hour reported no statistically significant impact on complete blood count for the specific e-cigarettes tested.[xix] Studies on e-cigarette vapour typically demonstrate very low toxicity, and no study to date has directly correlated exposure with long-term adverse health outcomes for bystanders.

Smoke-free enclosed public places and workplaces should also be vape-free

All Canadians enjoy clean, smoke-free indoor air in public places and workplaces. While it is absolutely true that exposure to e-cigarette vapour is less harmful than exposure to SHS, in the context of occupational health and safety it is a false comparison, as virtually all enclosed public places and workplaces are already smoke-free. Smoke-free environments are a globally-recognized best practice that both protect non-smokers as well as help smokers to cut down and even quit smoking. Permitting vaping in these environments would be a step backwards for public health as well as for individual smokers: vapour with unknown long-term health effects would be introduced into otherwise clean indoor environments, and smokers who had otherwise managed to abstain would be free to consume, potentially increasing their net intake of nicotine. E-cigarettes offer a real opportunity for many smokers to quit smoking; however, allowing unrestricted vaping could potentially normalize the behaviour and even help to expand the market.

A recent study surveying exclusive vapers (n=3,960) about their use of e-cigarettes in public places and workplaces found that of the minority who reported being restricted in where they could vape, 88% said it wasn't difficult to refrain, and overall they reported less dependence and less usage compared with vapers who reported unrestricted vaping.[xx] This finding suggests that with time, it becomes easier for people to refrain from vaping in restricted environments.

However, in the context of private homes, including in multi-unit dwellings where people continue to smoke and expose their family members and neighbours to SHS, permitting vaping makes sense—people would be exposed to fewer toxic constituents. It should also be noted that e-cigarette vapour tends to evaporate quickly and that, at present, there is no evidence to suggest that it can travel between units the way SHS can.

Conclusion

Exposure to e-cigarette vapour is significantly less harmful than exposure to SHS, with one study reporting levels 9 - 450 times lower. However, because of the sheer number of variables associated with studying e-cigarettes, together with the overall low quality of evidence, firm conclusions regarding the absolute toxicity and risk profile of secondhand e-cigarette vapour are still premature. Possible factors contributing to vapour toxicity have been identified, many of which can likely be addressed through product regulation and technology innovation. Enclosed smoke-free public places and workplaces should be designated as vape-free to protect indoor air quality and to avoid the risk of e-cigarette use becoming normalized. E-cigarettes hold much promise in terms of smoking cessation but an expansion of the market beyond current smokers is undesirable. More and better research is needed to confirm e-cigarette vapour toxicity and the short- and long-term health effects of exposure for users as well as bystanders.

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[xiv] Goniewicz ML et al. "Levels of selected carcinogens and toxicants in vapour from electronic cigarettes." Tobacco Control 2014; 23:133-139.
[xv] O'Leary R et al. (2017). Clearing the Air: A systematic review on the harms and benefits of e-cigarettes and vapour devices. Victoria, BC: Centre for Addictions Research of BC.
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