E-cigarettes: Are we renormalizing public smoking? Reversing five decades of tobacco control and revitalizing nicotine dependency in children and youth in Canada

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An electronic cigarette (e-cigarette) is a battery attached to a chamber containing liquid that may (or may not) contain nicotine. The battery heats the liquid and converts it into a vapour, which is inhaled, mimicking tobacco smoking. The e-cigarette does not rely on tobacco as a source of nicotine but, rather, vaporizes a liquid for inhalation. E-liquids are often flavoured and may contain nicotine in various concentrations, although actual amounts are seldom accurately reflected in container labelling. The deleterious effects of nicotine on paediatric health are well established. The use of e-cigarettes in the paediatric age group is on the rise in Canada, as are associated nicotine poisonings. E-devices generate substantial amounts of fine particulate matter, toxins and heavy metals at levels that can exceed those observed for conventional cigarettes. Children and youth are particularly susceptible to these atomized products. Action must be taken before these devices become a more established public health hazard. Policies to denormalize tobacco smoking in society and historic reductions in tobacco consumption may be undermined by this new 'gateway' product to nicotine dependency.

Key Words: *Healthy public policy; Heavy metal exposure; Nicotine dependency; Nicotine poisoning; Normalization; Smoking; Vaping*

La cigarette électronique : renormalisons-nous le tabagisme en public? Anéantir cinq décennies de lutte contre le tabac et revitaliser la dépendance à la nicotine chez les enfants et les adolescents du Canada

La cigarette électronique (vapoteuse) est une batterie fixée à un réservoir rempli d'un liquide qui peut (ou non) contenir de la nicotine. La batterie réchauffe le liquide et le convertit en vapeur, qui est inhalée afin d'imiter le tabagisme. La source de nicotine de la vapoteuse ne provient pas du tabac, mais le dispositif vaporise un liquide en vue de son inhalation. Ces e-liquides, souvent aromatisés, peuvent contenir de la nicotine sous diverses concentrations, mais leur quantité réelle est rarement bien indiquée sur l'emballage. Les effets délétères de la nicotine sur la santé sont bien établis dans le groupe d'âge pédiatrique. Le vapotage est en hausse au sein de ce groupe au Canada, de même que les intoxications à la nicotine qui y sont associées. Les vapoteuses produisent de grandes quantités de particules fines, de toxines et de métaux lourds, à des taux qui peuvent dépasser ceux de la cigarette conventionnelle. Les enfants et les adolescents sont particulièrement susceptibles à ces produits atomisés. Il faut agir avant que ces dispositifs deviennent un danger mieux établi en santé publique. Cette nouvelle « porte d'accès » à la dépendance à la nicotine pourrait saboter les politiques visant à « dénormaliser » le tabagisme dans la société, ainsi que les réductions historiques de consommation du tabac.

THE PRODUCTS

Smoking a conventional cigarette made from tobacco quickly delivers a psychoactive substance throughout the body. It takes only 10 s to 20 s for nicotine to pass from a burning cigarette to the brain.(1) Cigarette tobacco contains additives that maximize the speed of delivery such as ammonia (which increases the pH of smoke, accelerating the delivery of free nicotine) and theobromine (which dilates the airways, facilitating inhalation).(2)

By contrast, an electronic cigarette (e-cigarette) is a battery attached to a chamber containing a liquid. The energy from the battery heats the liquid and converts it into a vapour, which users draw into their mouth and lungs, mimicking the action of a conventional cigarette.(3) The solution in the heated chamber, known as 'e-liquid' or 'e-juice' by users, contains propylene glycol, sometimes glycerol and other compounds, as well as various flavouring agents (eg, watermelon, cherry cheesecake, lemon/lime, even tobacco). E-liquid solutions may also contain between 0% and 2.4% nicotine.(3) Flavouring of the product does not reflect the nicotine content. The e-cigarettes used today reflect significant technological advances since two products, 'Premier' and 'Eclipse', were introduced in the early 1990s. The mechanisms used in these prototypes heated rather than burned the tobacco they contained, ostensibly to reduce toxin production compared with conventional smoking. However, despite significant investment by industry, neither brand gained wide consumer acceptance.(4) The current e-cigarette has not only evolved from previous industry efforts but is being continually refined to meet various aftermarket demands.(5)

One important modification has been a nondisposable 'tank' system, which makes devices larger and more likely to resemble a cigar, small flashlight or fountain pen.(3) Previous disposable e-cigarettes were patterned after conventional cigarettes. In newer designs, an often transparent reservoir filled with e-liquid (which may or may not contain nicotine) is heated using high-voltage batteries, such that thick plumes of vapour and, if present, significant doses of nicotine are generated. A wide range of product modifications instigated by retailers and users are currently in use (detailed descriptions, including pictures of different e-devices, can be found in Figure 1 of the article by Grana et al [3]).

THE PROBLEMS

Product perception

While newer e-cigarette products may not produce the same type of inhaled or second-hand smoke as conventional cigarettes, they are essentially nicotine delivery devices. They are neither safe nor harmless in themselves.(3) They 'mimic' pharmaceutically produced nicotine replacement therapies, which are highly regulated and graded medicinally. In Canada, nicotine replacement

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therapies are sold over-the-counter in drug stores. Nicotine-containing gums, patches, mists or inhalers are not, however, promoted for sale to individuals <18 years of age and should only be used in consultation with a medical practitioner.

E-cigarette manufacturers take explicit advantage of other features shared with smoking cessation products such as not staining teeth and fingers (the Nicorette monograph and ads for blu eCigs reference this 'attribute').(6,7) However, unlike pharmaceutical nicotine products, no health benefit can or should be promoted in marketing e-cigarettes. In fact, manufacturers go to great lengths not to tout health benefits (they are forbidden by law to do so in the United States, and e-cigarettes can only be advertised as 'recreational' devices).(8)

As a smoking cessation aid and harm-reduction tool for current adult smokers, e-cigarettes are unproven.(3) They may, in fact, have opposite effects: enticing former smokers back to nicotine dependency, helping to renormalize nicotine dependency in the wider population and representing smoking as a socially acceptable public practice.(9)

Emissions and exposures

The e-liquids used in these devices are not required by law to meet Canadian standards for labelling or nicotine content. Despite indications on the label, solutions may or may not contain nicotine and, when nicotine is present, concentrations vary widely.(10) Also, the dilution of nicotine stated on the label does not necessarily match the actual strength. One recent United States Food and Drug Administration labelling analysis confirmed concerns described in the literature.(11)

Nicotine yields obtained during tests using automated smoking machines suggest that e-cigarettes deliver less nicotine per puff than conventional cigarettes. Clinical studies have also indicated that comparatively modest nicotine concentrations are delivered to the inexperienced e-cigarette user. However, more experienced users are able to intake levels of both nicotine and cotinine, a metabolite of nicotine, in concentrations similar to those produced by cigarette smoking.(12) 'Topographical' or consumption behaviour studies found that compared with conventional cigarettes, the average puff duration was significantly longer for e-cigarettes and required stronger suction.(13)

A practice known as 'dripping', in which users trickle drops of a nicotine-containing fluid directly onto the heating element, is associated with tank systems. While generating a more potent vapour, the intense heat alters the chemical composition of e-liquids, creating new compounds. Changes in chemical structure affect the liquid nicotine, filler ingredients and any flavouring(s) that are present. The stronger the battery, the higher the temperature, making chemical reactions more complete.(14)

One significant potential danger of large boluses of nicotine, as generated by tank technology, is their potential for acute cardiac events. A hypercoagulable state may be produced, which can, in turn, promote thrombosis. This phenomenon has been observed with nicotine inhalation from cigarette smoking and is a theoretical but significant risk with e-devices.(15) Also, the high nicotine concentrations generated by tank apparatuses increase second-hand exposure risks for nonusers, particularly children.(16)

Exposure to fine particulates in the aerosol generated by e-smoking may impair respiratory function in users and bystanders. E-cigarettes produce copious amounts of fine particles, at times in excess of conventional cigarette levels.(3) Young people could be particularly vulnerable to particulate affects, which may cause or worsen pre-existing breathing problems such as asthma and bronchitis.(17) Moreover, the deleterious impacts of nicotine on the developing brain are well documented, and the potential for entrenched dependency is already an empirical concern.(10,18,19)

Aside from nicotine, e-cigarette aerosols may also contain propylene glycol and glycerol/glycerin as filler materials, flavourings and other chemical compounds. Aerosolized propylene glycol and glycerol are known to produce mouth and throat irritation, and dry cough; chronic exposure in any form is discouraged by the chemical industry.(3,16)

Structurally, e-cigarettes may include various metals, rubber and ceramics, constituents that can also become aerosolized during operation and cause adverse health effects.(3,5) Heavy metal levels in e-cigarettes have been documented, sometimes at levels exceeding those associated with conventional cigarettes.(3) Batteries have exploded on occasion, and exposures to the e-liquid by breathing, contact with skin or from oral ingestion carry significant health risks, especially for children.(5) Nicotine poisonings from e-liquids and discarded cartridges among children are increasing,(20) with observed toxic effects to rival those of conventional cigarettes.

Tank-type devices and the practice of dripping are also responsible for heating the e-liquid with such intensity that levels of formaldehyde and related toxins approach and sometimes exceed concentrations in conventional cigarettes.(14) These chemical transformations affect all constituents of the liquid being heated, including the glycerol/glycerin and propylene glycol.(14,21)

The environmental impacts of improperly discarding used cartridges, which contain residual nicotine, and e-cigarettes, which contain batteries, are comparable with hazards posed by conventional cigarette butts and other batteries not properly disposed of.(21,22)

Public uptake

Industry is well ahead of both researchers and regulators in grasping the potential for this new nicotine delivery system. Both the size and value of the e-cigarette industry are expanding rapidly. Currently estimated to be worth more than $2 billion in the United States alone, e-cigarette sales are forecast to surpass conventional cigarette sales over the next decade.(23) Moreover, the tobacco industry has recently entered the field, with the third-largest tobacco manufacturer in the United States purchasing a leading e-cigarette manufacturer in 2012, while other tobacco companies have launched or are developing their own brands.(3)

Aggressive marketing and weak regulation

Unlike conventional cigarettes, e-cigarettes are being openly used and promoted by dozens of celebrities in a variety of media.(24) Both scripted and (apparently) spontaneous endorsements of these devices in broadcast media run counter to long-established public service announcements on the dangers of smoking from former celebrity smokers, such as Yul Brenner and the 'Marlboro men'.(25,26) Instead, celebrities and late night talk show hosts speak about not having bad breath, the rediscovered comforts of smoking indoors in cold weather, and the ability to 're-choose' smoking after years of restriction.(7,27) The exposure of teens and young adults to e-cigarette advertising on specialty TV channels is already widespread in the United States.(9)

E-cigarettes are readily available in a wide range of venues, notably pharmacies, convenience stores and tobacco shops. There has been some regulatory action in the United States.(3) In 2009, Health Canada issued an advisory that e-cigarettes *with* (emphasis added) nicotine were not authorized for import or sale in Canada, and that their "safety, quality, and efficacy remain unknown".(28) They further stated that e-cigarettes *without* (emphasis added) nicotine could be imported and sold, but warned not to use these products because they "may pose health risks". Also, prospective

manufacturers were notified that, in accordance with the *Food and Drugs Act*, they had to apply to Health Canada for authorization to bring to market any new nicotine-containing device or product with packaging that made any health claim.(28) To date, Health Canada has not approved an e-cigarette product. However, according to proponents, the Act provides an exemption for nicotine "administered orally by means of an inhalation device delivering 4 mg or less of nicotine per dosage". One 'vape' (or dose), from many varieties of e-cigarette cannot deliver this amount of nicotine, an argument being used by some retailers to challenge demand letters from Health Canada advising them to 'cease and desist' the sale of nicotine-related e-cigarette products.(29) Canadian regulatory authorities are silent on after-market modifications or dripping, both of which can raise the dose of nicotine and other inhaled toxins.

Regulatory ambiguity has, understandably, caused public confusion and led some media to view e-cigarette products as operating in a 'grey zone', just beyond the legal reach of Health Canada's "gentle ban".(30)

Implications for children and youth

Our understanding of the negative effects of nicotine has advanced dramatically in the past half-century, since the dangers of tobacco were first raised in seminal British and American reports on smoking. At that time, even the tobacco industry may not have been fully aware of the pathophysiology of addiction, although they played to its risks. One former industry insider, Jeffrey Wigand, observed: "The tobacco companies target underage kids because they know that if they hook them young, they hook them for life".(31) E-cigarettes may be yet another gateway to nicotine dependency.(32) The likelihood that youth will take this gateway is foreshadowed by *snus*, a fermented chewing tobacco product used in Scandinavia. Widely promoted as a 'less harmful' alternative to conventional cigarettes and a smoking cessation aid for adults, it is also associated with increased tobacco uptake in younger age groups.(33)

Our current understanding of nicotine's role in the current epidemic of tobacco-related, chronic and completely preventable diseases should be sufficient warning against future generational addiction and damage to fetal health.(34,35) However, experimentation with e-cigarettes by teenagers is on the rise(3,36,37) and researchers have been slow to make the argument that the addictive and harmful aspects of nicotine in e-cigarettes could have the same deleterious effect on health in this century as tobacco smoking did in the previous century.(10)

Key elements are already in place for a new wave of paediatric nicotine addiction:(38) a cheap, easily accessed supply (in-store or online); high-profile promotion by celebrities who are popular among youth; open and sometimes provocative marketing over social media; and industry sponsorship of public events, including using product-related accessories (eg, T-shirts, ball caps and wrist bands) as giveaways to a generation who have never experienced this type of cigarette-related marketing.(3) Add to the mix the absence of a strong tobacco taste, a wide range of flavourings that mask or integrate tasteless nicotine, and technology with a distinctive 'cool' factor. Finally, in Canada at least, this interplay of product features is unfolding in a regulatory vacuum.

Health advocates have achieved truly historic successes in curbing tobacco use and exposure to the harmful by-products of smoking through a variety of effective public policy interventions.(39) E-cigarettes have the potential to undermine this framework.(3,24)

E-cigarettes are marketed as a nicotine delivery device for recreational use by adults, with no scientifically proven therapeutic effect. Expert opinion is divided as to the value of this product for smoking cessation. However, no logical rationale has been offered by either the product's proponents or its regulators for delaying action to curb the sale of a powerful – if repackaged – psychoactive substance whose harms to children and youth are well established.(24)

Now is the time for action. The government should apply an abundance of caution and place the onus squarely on industry to document the level of risk associated with e-cigarette use *first*, before loosening or lifting precautionary restrictions. The situation at present suggests that these devices may be proven to be a public health hazard before definitive regulatory measures are taken, much as was the case with tobacco smoking.

Fortunately, some communities are pointing the way for regulators. As a first step, >100 communities in the United States(3) – and a handful in Canada – have included e-cigarettes under local clean air/smoke-free bylaws and apply the same limits on e-cigarette use and sales as for conventional cigarettes.

RECOMMENDATIONS

The Canadian Paediatric Society calls on the federal government to curb and control the e-cigarette industry by enacting the following legislation:

1. Expand regulations governing the bilingual marketing, packaging and labelling of conventional tobacco products to include all e-cigarette devices and e-liquids. New regulations must include:
    - Maximum dosage of nicotine in e-liquids, to be strictly enforced.
    - Package warnings on potential and known harmful effects which are equivalent to messaging on cigarette packaging.
    - Complete, accurate labelling for e-liquids, including a full list of ingredients and an exact measure of nicotine concentration.
    - Packaging e-liquids in containers that are child-resistant and carry explicit and appropriate cautionary warnings regarding toxicity.
    - A ban on e-cigarette-related advertising and sponsorship of events and activities intended for young audiences.
    - A ban on marketing e-cigarette-related products using strategies or in venues that attract children and youth in particular, such as 'giveaways' and promotion through social media.
2. Strictly prohibit manufacturers or sellers of e-devices or e-liquids from making *any* positive health claims until industry evidence on product safety and efficacy has been reviewed, evaluated and accepted under Health Canada's *Food and Drug Act*.
3. Restrict Internet sales of e-cigarettes and related products to direct mail only to individuals, and only to individuals identifiable as adults. Such limits would curb development of a 'black' or 'grey' market and facilitate taxation.
4. Make it illegal for anyone under the current federally established legal age to purchase conventional tobacco products to buy, possess or use any form of e-cigarette or other 'vaping' device.

Federal and provincial/territorial governments should tax all e-liquids containing nicotine at levels approaching current levies on other legal, recreational psychoactive substances such as cigarettes and alcohol.

Provincial/territorial or (as appropriate) municipal governments should enact legislation:

1. Making it illegal for anyone under the current provincially established legal age to purchase conventional tobacco products to buy, possess or use any form of e-cigarette or other 'vaping' device.
2. Requiring e-devices and e-liquids to be sold *only* in venues where tobacco is sold legally.
   - Vending machine sales of e-cigarettes should be banned.
   - Retail outlets selling these products to the public would need a license, as they do for conventional cigarettes.
   - Establishments licensed to carry e-devices and e-liquids would *not* be allowed to create so-called 'power wall' displays for these products: the same restrictions governing behind-the-counter sales of conventional cigarettes would apply to all e-cigarette-related products.
3. Expanding all current restrictions on smoking in public spaces or workplaces to apply equally to any form of e-cigarette device.

Provincial/territorial governments must also foster local programs that address the litter generated by e-device use through levies on the purchase price. Such programs should be developed, implemented and maintained like other environmental stewardship programs.

Paediatricians, family physicians and other health care providers must stay informed about research on the risks and effects of e-cigarette smoking. They are encouraged to:

- Educate young patients and their families on the risks and hazards of e-cigarette use and exposure.
- Make counselling on e-devices a segue into broader discussion of tobacco use and smoking cessation.

School boards and provincial/territorial ministries of education must adhere to (or strengthen, as appropriate) all existing restrictions on smoking in places of learning to include any form of e-cigarette device.

- A teaching component on the dangers of exposure to and use of e-cigarettes should be included in an age-appropriate health curriculum.

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