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Children and E-Cigarettes: A New Threat to Health

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Abstract

Keywords
e-cigarettes, tobacco, children, secondhand smoke, risk factors

Introduction

Health and exposures to risk factors during childhood establishes a lifetime trajectory of development and health. It is now well established that early life health and development factors are associated with later chronic conditions. For example, the use of antibiotics in young children contributes to increased asthma rates and the use of infant formula predisposes to many conditions.¹,² Similarly, damage to pulmonary endothelium by exposure to air pollutants and particles can begin a pathway to chronic asthma or chronic obstructive pulmonary disease (COPD).³,⁴ Tobacco smoke, direct or secondhand exposure, has detrimental effects on children. Maternal smoking throughout pregnancy is associated with an increased risk of wheeze in children and this may be additive with postnatal secondhand smoke exposure.⁵ Maternal and paternal smoking reduces breastfeeding initiation and duration, exposing the infant to further risks.⁶,⁷

The advent of e-cigarettes has meant that new assessments of risk are required. E-cigarettes contain a variety of solvents and flavors and tobacco, which can be ignited or heated. Vapor is exhaled by the user and potentially can expose children to chemical and particulate matter. The argument in favor of e-cigarettes is that e-cigarettes present a lower health risk than tobacco cigarettes and may even assist tobacco addicts in quitting. Human studies show that smokers who change to e-cigarette use experience substantial reductions in blood or urinary biomarkers of tobacco toxicants.⁸ They represent a harm reduction strategy for adult smokers in a similar fashion to harm reduction programs for other addictions. However, with the use of e-cigarettes, there may be a risk to others from secondhand vapor. One argument for the use of e-cigarettes by adults is that it can reduce exposure of children to secondhand tobacco smoke where the parents cannot quit smoking. However, substituting tobacco smoking with e-cigarettes may not be without harm.

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from inhaled vapor through contributions to indoor air pollution and even from the toxicity of the
device itself.9 It represents only a reduction of risk to children and not an elimination of risk. The
major promoters of “vaping” are the large tobacco manufacturers, and because of their record of
decades of dishonest promotion tobacco, which still continues in our region, their advocacy of
e-cigarettes as a safe solution needs to be taken with a “grain of salt.” The debate is continuing
and will be addressed in other commentaries in this issue of the journal.10 For children, e-ciga-
rettes could be a potential public health hazard in several ways. These include direct exposure if
children themselves take up “vaping,” exposure to secondhand smoke, or even the accidental
ingestion of e-cigarette chemicals.

In 2015, there were 1273 articles on e-cigarettes available on PubMed, of which 135 are
reviews and only 85 included the terms “e-cigarette” and “lung.”11 By the end of 2017, this num-
ber had increased to 2976 and included 171 articles on e-cigarettes and children. The objective of
this article is to provide a review and public health perspective on the effects of e-cigarettes on
children. There are 4 public health questions to be answered:

1. Are e-cigarettes and replenishing fluids toxic on accidental ingestion?
2. If children smoke e-cigarettes, is this harmful?
3. Does exposure to secondhand vapor from e-cigarettes cause harm to children?
4. Are children or adolescents who use e-cigarettes more likely to begin smoking conven-
tional cigarettes?

**Toxicity of Ingestion of E-Cigarette Fluids**

Vaping devices and refills may be left in places accessible to children. In 2017 (up to November
30), there were 2229 reported exposures to e-cigarette fluids and liquid nicotine in the United
States, and 50% were below 6 years of age.12 In Europe, 277 exposures, mainly ingestion, were
reported from 10 centers, and again the majority were children.5 The most common
symptoms were vomiting and nausea, and while not commonly reported, cardiovascular effects
of nicotine are possible.13 Cigarette ingestion can cause cardiovascular symptoms and fatalities
have been reported.14 In the case of e-cigarettes, if a child ingests 10 mL of nicotine-containing
fluid, it could be fatal.15

**Smoking of E-Cigarettes by Children**

Children like to explore and try out new things, and older children may experiment with e-cigarettes
as publicity materials suggest that they are safe to use. The lung provides a large surface area for
absorption of at least 140 m², and toxic aerosols and particles can readily be absorbed.16 Schweitzer
et al have demonstrated that the pulmonary endothelium can be damaged by both cigarettes and
e-cigarettes.17 E-cigarette exposure caused alterations in gene expression in in vitro exposure exper-
iments and this may reflect the effects experienced in vivo by e-cigarette users.18

In the United Kingdom, the Committees on Toxicity, Carcinogenicity and Mutagenicity of
Chemicals in Food, Consumer Products and the Environment have issued a toxicological evalu-
ation of novel heat-not-burn tobacco products.19 They concluded,

There would likely be a reduction in risk for conventional smokers deciding to use heat-not-burn
tobacco products instead of smoking cigarettes. However, stopping smoking entirely would lead
to the greater reduction in risk. A reduction in risk would also be experienced by bystanders
where smokers switch to heat-not-burn tobacco products. The Committees were concerned over
the potential for non-smokers including children and young people, who would not otherwise
start to smoke cigarettes, to take up using these products, as they are not without risk. There was
also concern over whether the use of these products would lead to cigarette smoking by non-smokers.\textsuperscript{19}

In 2015, e-cigarettes were the most commonly used tobacco product among middle and high school students in the United States, with 16\% of high school students identifying as active users (up from 1.5\% in 2011).\textsuperscript{20} Where children and adolescents use e-cigarettes they have increased rates of respiratory symptoms, although it is not yet known if longer term use will also result in increased rates of cancer and cardiovascular disease. A study of 44,662 Grade 7 (12 years of age) in Hong Kong found that approximately 2500 had been or were current users of e-cigarettes.\textsuperscript{21} These children had an increase in respiratory compared to nonsmokers, adjusted odds ratio (aOR) = 1.39 (confidence interval [CI] = 1.14–1.70). These results were adjusted for sex, age, perceived family affluence, secondhand smoke exposure, and school clustering effects. A similar increase in bronchitic symptoms has been found in other studies.\textsuperscript{22}

**Secondhand Smoke and Indoor Air Pollution From E-Cigarettes**

Indoor air pollution is a major global cause of morbidity and mortality.\textsuperscript{23–25} The World Health Organization estimates that more than 4 million people die prematurely from illness, including stroke, ischemic heart disease, and COPD, attributable to the household air pollution, mainly from cooking with solid fuels.\textsuperscript{26} More than 50\% of premature deaths due to pneumonia among children under 5 years of age are associated with particulate matter (soot) inhaled from household air pollution. It is estimated that 90\% of the world’s population live in places where the atmosphere does not meet the World Health Organization standards. Conventional tobacco and e-cigarettes increase air pollution, but are far more significant to those located near the source.

A study showed that the indoor secondhand particulate matter exposure levels from e-cigarettes for nonsmokers can be as high as in an environment where combustible cigarettes are smoked.\textsuperscript{27} Chapman et al summarize some of the contents of e-cigarette vapor as containing “nicotine, carbonyls, metals, organic volatile compounds, besides particulate matter, and putative carcinogenic polycyclic aromatic hydrocarbon and the high concentrations of nanoparticles in vape,” despite their small mass, may have significant toxicological impact.\textsuperscript{28} Children in households with e-cigarette smokers are exposed to inhaled toxins, but not in as great concentrations as from conventional cigarettes. Long-term studies in children are not yet available, but extrapolation from animal studies suggests that secondhand vapor exposure is a public health problem.\textsuperscript{29}

**E-Cigarettes and the Onset of Tobacco Smoking in Adolescents**

Shields et al reported that in the United States, the rates of e-cigarette use among youth are now higher than cigarette use.\textsuperscript{8} In 2015, the prevalence of never-smokers using e-cigarettes was as high as 19\% among youths. About 5\% of college students who have never smoked are now using e-cigarettes.\textsuperscript{8} A cohort study of 3757 college students in the United States was followed-up after 12 months. Among participants reporting never smoking at the first interview, those who had ever tried e-cigarettes or were currently using e-cigarettes (at least one use in past 30 days) were more likely to have tried cigarettes by the second interview when compare to those who had not used e-cigarettes, aOR = 3.37 (CI = 1.91–5.94).\textsuperscript{30} A further study by Bold et al (n = 808), found that over time the e-cigarettes were associated with later conventional cigarette use.\textsuperscript{31} A systematic review and meta-analysis of 9 longitudinal studies (n = 8936) found consistent and strong evidence that e-cigarette use is associated with increased odds of subsequent cigarette smoking initiation, aOR = 3.62 (CI = 2.42–5.41).\textsuperscript{32} The data were adjusted for demographic, psychosocial, and behavioral risk factors.
The accumulating evidence indicates that e-cigarette increases the probability of later conventional tobacco use in adolescents, and Bold et al recommend restricting e-cigarette availability as a way of reducing tobacco use by children.31

Conclusion

Studies to date show that e-cigarettes are toxic, damage pulmonary endothelium, and increase short-term morbidity. It appears that the damage they cause is less than conventional tobacco smoking. However, no studies of long-term effects, such as carcinogenesis and COPD, are yet available, but the vaping products of e-cigarettes are known to contain established carcinogens. The US Surgeon General undertook a comprehensive review of e-cigarettes and concluded:

Comprehensive tobacco control and prevention strategies for youth and young adults should address all tobacco products, including e-cigarettes. Further, reductions in tobacco use and initiation among youth and young adults are achievable by regulating the manufacturing, distribution, marketing, and sales of all tobacco products—including E-cigarettes, and particularly to children—and combining those approaches with other proven strategies.33

In answer to the questions posed above, e-cigarettes contain toxic substances and can cause harm on ingestion or on direct inhalation. The public health conclusion is that secondhand vapor exposure can have deleterious effects on children. Evidence is now available that older children who use e-cigarettes are more likely to begin conventional tobacco smoking. More long-term monitoring and research is needed into chronic effects of e-cigarette vaping, including carcinogenesis and the development of COPD.

Because of this accumulating evidence of harm to children, great caution should be exercised in widening their public promotion and usage. To avoid a repeat of the public health disaster of tobacco smoking, the advertising and marketing of e-cigarettes needs careful regulation and restriction. Children should avoid any contact with e-cigarettes or their vapor.

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