

Electronic Cigarette Toxicity

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Journal of Primary Care & Community Health
2017, Vol. 8(2) 100–102
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DOI: 10.1177/2150131916668645
journals.sagepub.com/home/jpc



Abstract

Electronic cigarettes (e-cigarettes) are often advertised as a healthier product when compared with traditional cigarettes. Currently, there are limited data to support this and only a threat of federal regulation from the US Food and Drug Administration. Calls to poison control centers about e-cigarette toxicity, especially in children, and case reports of toxic exposures have increased over the past 3 years. This research letter reports the frequency of hazardous exposures to e-cigarettes and characterizes the reported adverse health effects associated with e-cigarette toxicity.

Keywords

electronic cigarettes, toxicity, poison, suicide, nausea, vomiting

Electronic cigarettes (e-cigarettes) have been sold in the US market since 2007.¹ These devices are designed to simulate smoking by heating a nicotine-containing solution producing an inhaled aerosol. Sales are steadily increasing, and regulation of these devices is locale dependent with no standard policy in place. With their increasing popularity, reports of toxic exposure from e-cigarettes have also increased, especially in children. This research letter summarizes the available information on the frequency of hazardous exposures to e-cigarettes and the adverse health effects associated with e-cigarette toxicity based on reports from poison control centers. A PubMed and Embase search was performed for articles related to e-cigarette toxicity with a total of 326 articles reviewed.

To date, data from 5 poison control center databases have been published (Table 1). Between September 2010 and February 2014, the number of e-cigarette exposures in all reports was 2405 total calls with calls increasing from 1 per month to 215 per month.^{2,3} Forty-two percent of the calls involved children younger than 5 years, and 27.4% involved adults aged 20 to 39 years.^{2,3} Calls in children <6 years old rose from 14 per month in January 2012 to 223 per month in April 2015.⁴ Calls to California and Texas poison control centers were studied individually and showed a wide population range with many calls involving children <5 years old.^{5,6} Studies have examined pediatric (<6 years old) accidental poisoning from ingestion of tobacco products and found that children <1 were at the highest risk, accounting for >70% of ingestions.^{7,8} Forrester⁹ reported that 32% of the calls to Texas poison control centers involved <1 one-year-old children and that 42% involved 1- to 2-year-old children. Kamboj et al⁴ recently reported an increase of 1493% in e-cigarette exposures in children <6

years old from January 2012 through April 2015 with children younger than 2 years accounting for 44.1% of the total. The majority of the calls concerned accidental ingestion of e-liquid in children and reported relatively mild toxicity.⁷ In 4 poison control center studies vomiting was the most frequent symptom with an average of 16%,^{3,5,7} in 3 studies nausea was reported 3% of the time,^{3,5,7} and in 3 studies eye irritation accounted for 3% of the calls.⁵⁻⁷

Several case reports describe suicide attempts. Two decedents had very high levels of nicotine in their venous circulation after intravenous injection or ingestion.^{10,11} Two other cases involved individuals ingesting nicotine in much higher quantities than the Immediately Dangerous to Life or Health Concentration (IDLH) level who did not die.^{12,13} E-cigarettes can increase the heart rate and blood pressure and have the potential to cause cardiac events and arrhythmias in persons with or at risk for cardiac disease.¹⁴ Most of the presumed cardiac effects are secondary to the nicotine delivered by e-cigarettes and not the other components in the solution.¹⁵

The nicotine cartridges and solutions used in smoking e-cigarettes come in varying volumes and concentrations and frequently contain large doses of nicotine and other potentially hazardous chemicals. The Centers for Disease Control and Prevention reports that the IDLH for nicotine is 5 mg/m³. This IDLH for nicotine is based on acute oral toxicity data in humans. There are no toxicity data available on

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Table 1. Call Center Reports.

Study Author(s)	Number of Exposures	Period Observed	Data Source	Most Frequent Age Group	Effects
Chatham-Stephens et al ²	2405 total exposures	September 2010 through February 2014	US poison centers	E-cigarette exposures were mostly in persons aged 0-5 years (51.1%) and >20 years (42.0%). Cigarette exposures were primarily in persons aged 0-5 years (94.9%)	The most common adverse health effects in e-cigarette exposure calls were vomiting, nausea, and eye irritation. One suicide death from intravenous injection of nicotine liquid was reported
Vakkalanka et al ³	1700 total exposures	June 2010 through September 2013	US poison centers	The most frequent age groups were children ≤5 years with 717 (42.2%) exposures and adults aged 20-39 years with 466 (27.4%) exposures	The majority of patients who were followed reported that they had only minor effects
Cantrell ⁵	35 total exposures	2010 through 2012	California poison centers	Age range 8 months to 60 years	Reported symptoms were mild and transient. Five patients were evaluated in an emergency department but none admitted
Ordonez et al ⁶	225 total exposures	January 2009 through February 2014	Texas poison centers	53% (n = 119) occurred in individuals aged <5 years old, 41% (n = 93) occurred in individuals aged >20 years old, and 6% (n = 13) occurred in individuals aged 6-19 years	The clinical effects reported most often were vomiting (20%), nausea (10%), headache (4%), ocular irritation (5%), dizziness (5%), and lethargy (2%)
Kamboj et al ⁴	4138 exposures in children <6 years old	January 2012 to April 2015	US poison centers	44.1 % children <2 years old	

which to base an IDLH for inhaled nicotine. The concentrations of nicotine in these products can put people at risk for accidental overdose. Nicotine has both muscarinic (salivation, vomiting, diarrhea, and bronchial constriction) and nicotinic (fasciculations, hypertension, tachycardia, and muscle cramps) effects. Treatment of these toxic effects is largely supportive.

There are very few controlled studies investigating acute toxicity associated with e-cigarettes. Exposure to the primary ingredient of the e-liquid, propylene glycol, is generally considered safe, but this chemical can cause irritation to the upper and lower respiratory tract. When heated, it produces acetaldehyde and formaldehyde which are both toxic.¹⁶ Vardavas et al¹⁷ studied the effect of using an e-cigarette for 5 minutes on exhaled nitric oxide levels and lung function. Nitric oxide decreased and respiratory flow resistance and overall peripheral airway resistance increased acutely after this short exposure.¹⁷ Carnevale et al¹⁸ measured oxidative stress, nitric oxide availability, and flow-mediated dilation in subjects who smoked either 1 tobacco cigarette or 1

e-cigarette. Oxidative stress increased, and nitric oxide and vasodilation decreased after these exposures. These 2 studies demonstrate that electronic cigarettes rapidly alter vascular function with the reduction of nitric oxide synthesis and small airway function with an increase in airway resistance.

In summary, the current increase in e-cigarette availability has resulted in many individuals using these devices without knowledge about possible adverse consequences. Health care providers should educate users about the risk associated with accidental exposure, especially in children. New Food and Drug Administration regulations beginning on August 8, 2016 have the potential to reduce the risk of toxic exposure with regulation of both devices and components.¹⁹ Common strategies to reduce exposure used in chemical and pharmaceutical industry include education, child safety containers, and warning labels. Health care providers should familiarize themselves with the effects of toxic exposure and treatment options.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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