

Public Health Consequences of E-Cigarettes

Committee on the Review of the Health Effects of
Electronic Nicotine Delivery Systems

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Injuries and Poisonings

There is no question that sources of morbidity and mortality from e-cigarettes are the injuries related to malfunctioning of the devices, leading to burns and projectile injuries, and injuries related to intentional or unintentional consumption of e-liquids. There are no epidemiological studies of these events, but the literature does contain numerous case reports, case series, and reports from passive surveillance systems, such as poison control centers. The committee briefly reviews this evidence. The committee notes that in recognition of these injuries, Congress and the Food and Drug Administration (FDA) have taken action. In 2016, Congress directed the Consumer Product Safety Commission to require special packaging (similar to child-resistant packaging) for e-liquid bottles that contain nicotine.¹ FDA's Center for Tobacco Products recently held a public workshop to discuss battery safety (HHS, 2017). Finally, in recognition of the risks, FDA's recently released comprehensive nicotine strategy includes provisions for setting product standards "to protect against known public health risks such as electronic nicotine delivery systems (ENDS) battery issues" and for "concerns about children's exposure to liquid nicotine" (HHS, 2017).

¹ Child Nicotine Poisoning Prevention Act of 2015, Public Law 114-116 § 142, 114th Cong. (September 29, 2017).

BURNS AND EXPLOSIONS

Most of the information regarding the malfunction of e-cigarettes and injuries comes from case reports, case series, and retrospective reviews of burn center reports. No prospective observational studies have been identified. Although these events are infrequent and the true rate is not known, when they do occur they have the potential to cause great harm. Serious burns from exploding e-cigarette batteries have been reported in the literature. Overheating and explosions of lithium ion batteries in e-cigarettes are most frequently the cause of burns in e-cigarette users. The quality of the components and design of the device, including user modifications, may influence the likelihood of malfunction and explosions in e-cigarettes. The committee reviewed 46 case reports published in the literature as solo case reports or case series documenting burns to the face, chest, abdomen, genitalia, and thigh, with burns to the thigh area most frequently reported. The majority ($n = 25$) of the cases of burns to the thigh are from devices stored in pants pockets (Bauman et al., 2016; Bohr et al., 2016; Colaianni et al., 2016; Herlin et al., 2016; Jiwani et al., 2017; Kumetz et al., 2016; Nicoll et al., 2016; Serror et al., 2017; Sheckter et al., 2016; Treitl et al., 2016; Walsh et al., 2016). Some explosions are documented to occur when the device could have come into contact with metals, such as coins and keys, in the pocket.

There have also been reports of injuries caused by projectiles following an e-cigarette explosion. Vaught and colleagues (2017) reported facial trauma from such an explosion. Another case reported that an 18-year-old suffered oral trauma and tooth avulsion following an e-cigarette explosion while using the device (Rogér et al., 2016). Paley and colleagues (2016) reported two cases of severe corneal injuries, in addition to other facial injuries that occurred in an adult and adolescent when their e-cigarettes exploded, resulting in decreased visual acuity.

Several groups have published summaries of reported explosions causing harm, based on reports from general hospitals or burn treatment centers (Arnaout et al., 2017; Brownson et al., 2016; Hassan et al., 2016; Rudy and Durmowicz, 2016). For example, Ramirez and colleagues (2017) found that 29 people were referred between February 2015 and July 2016 to three regional burn treatment centers in California for burn-related injuries from e-cigarettes. In addition, Arnaout and colleagues (2017) reported on 12 people who were treated for e-cigarette injuries in two burn centers in the United Kingdom, between October 2015 and July 2016. In their study, the thigh region was the most common area for a burn. Another study from California found that 25 patients were treated for burns caused by e-cigarettes at a regional burn center, between November 2015 and March 2017 (Toy et al., 2017). The majority of patients were male and most injuries resulted from the e-cigarette device exploding in

a pocket, with thigh and genital areas being most commonly affected. Malfunctions of the lithium battery in the e-cigarettes have been blamed for many of these injuries, but Serror and colleagues (2017) reported on a patient who had a full-thickness thigh burn due to overheating of a resistor component of the e-cigarette, in the absence of the device catching fire or exploding.

INTENTIONAL AND UNINTENTIONAL EXPOSURE TO E-LIQUID

Ingestion of nicotine-containing e-cigarette solutions can result in serious health effects, including death, due to nicotine toxicity. Many of the commercially available e-cigarette solutions contain high concentrations of nicotine. The committee identified 19 case reports (documented in 16 publications) in the literature of poisonings from exposure to e-liquid via oral or dermal routes. Twelve of these incidents are reported as intentional (sometimes associated with a suicide note) (Bartschat et al., 2015; Chen et al., 2015; Christensen et al., 2013; Eberlein et al., 2014; Garat et al., 2016; Lam et al., 2016; Schipper et al., 2014; Sommerfeld et al., 2016; Thornton et al., 2014; You et al., 2016), and six as unintentional (Eggleston et al., 2016; Gill et al., 2015; Gupta et al., 2014; Jamison and Lockington, 2016; Noble et al., 2016; Seo et al., 2016). Fatalities have been reported (Eggleston et al., 2016; Thornton et al., 2014; You et al., 2016). The medical consequences of the non-fatal cases include vomiting, lactic acidosis (Garat et al., 2016), and other outcomes. Several of these unintentional cases involved young children who apparently accessed e-liquid vials in the household (Eggleston et al., 2016; Gill et al., 2015; Gupta et al., 2014).

Further evidence of the consequence of ingestion of e-liquid is found in reports from poison control centers and other passive surveillance systems (Anonymous, 2015; Cantrell and Clark, 2014; Chatham-Stephens et al., 2014, 2016; De La Oliva Urieta and Conejo Menor, 2014; Forrester, 2015; Kamboj et al., 2016; Lovecchio and Zoph, 2015; Ordonez et al., 2015; Thomas et al., 2014; Vakkalanka et al., 2014; Valentine et al., 2016; Weiss et al., 2016). For example, between January 2010 and June 2014, poison control centers in Texas received 203 reports of ingestion by children age 5 or younger (Forrester, 2015). Between January 2013 and April 2014, 64 cases of e-liquid exposure were reported to Spain's poison centers, 28 percent of which were in children younger than 2 years of age (De La Oliva Urieta and Conejo Menor, 2014). Between September 2010 and February 2014, poison control centers in the United States recorded 2,405 calls regarding e-cigarette exposures (Chatham-Stephens et al., 2014). Children age 5 and younger accounted for 51 percent of those calls. In the United States, the number of calls to poison centers for e-cigarette exposures increased 1,492.9 percent between January 2012 and April 2015

(Kamboj et al., 2016). E-cigarette exposures were also more likely to result in a health care admission and a more severe outcome than an exposure related to cigarettes.

Although the committee identified no epidemiological studies about injuries and poisonings, the type of evidence that supports other conclusions in this report, the committee viewed the case studies as sufficient basis for several conclusions.

*Conclusion 14-1. There is **conclusive evidence** that e-cigarette devices can explode and cause burns and projectile injuries. Such risk is significantly increased when batteries are of poor quality, stored improperly, or modified by users.*

*Conclusion 14-2. There is **conclusive evidence** that intentional or accidental exposure to e-liquids (from drinking, eye contact, or dermal contact) can result in adverse health effects including but not limited to seizures, anoxic brain injury, vomiting, and lactic acidosis.*

*Conclusion 14-3. There is **conclusive evidence** that intentionally or unintentionally drinking or injecting e-liquids can be fatal.*

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