

# Electronic cigarette explosion and burn injuries, US Emergency Departments 2015–2017

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Received 22 May 2018

Revised 25 July 2018

Accepted 17 August 2018

## ABSTRACT

**Background** Electronic cigarette (e-cigarette) battery failure can result in explosions and burn injuries. Previous attempts to quantify these events has been limited to compilations of case studies, federal agency reports and media reports. Although e-cigarette explosions and burn injuries are thought to be rare, current surveillance methods likely underestimate actual occurrences.

**Methods** Analyses were conducted on cross-sectional data from the US Consumer Product Safety Commission's (CPSC) National Electronic Injury Surveillance System (NEISS). A keyword search of case narrative text was used to identify e-cigarette-related explosion and burn injuries presenting to US emergency departments from 2015 to 2017. Sampling weights were applied to make conservative national incidence estimates.

**Results** From 2015 to 2017, there were an estimated 2035 e-cigarette explosion and burn injuries presenting to US hospital emergency departments (95% CI 1107 to 2964).

**Conclusions** There are more e-cigarette explosion and burn injuries in the USA than estimated in the past reports. Improved surveillance of e-cigarette injuries and regulation of e-cigarette devices is urgently needed. NEISS could be a valuable resource for e-cigarette injury surveillance.

## INTRODUCTION

Electronic cigarettes (e-cigarettes) are devices that use an electric heater to aerosolise a liquid often containing propylene glycol, vegetable glycerin, nicotine and chemical flavorants for user inhalation.<sup>1</sup> E-cigarettes are commonly powered via a lithium-ion battery contained in the device.<sup>2,3</sup> Since 2009, studies and media reports have documented instances of e-cigarettes overheating, igniting, and/or exploding.<sup>4,5</sup> These events appear to result from lithium-ion battery failures in which the battery overheats to the point of catching fire or exploding, a phenomenon referred to as 'thermal runaway'.<sup>2,3,6</sup> Thermal runaway is thought to be a function of the materials, design, quality of manufacturing and handling.<sup>2,3,6</sup> One way this is thought to occur is by e-cigarette batteries short circuiting when they are in contact with metal objects, for example, keys or coins.<sup>7</sup>

E-cigarette-caused fires and explosions have resulted in severe injuries including: loss of body parts (eg, eye, tongue, teeth), hole blown through the roof of mouth and third degree burns to the face, legs and hands.<sup>5</sup> In May 2018, an e-cigarette explosion wound to the head was determined by a medical examiner's office as the cause of death for a

male in his 30s.<sup>8</sup> Although e-cigarette explosion and burn injuries are considered 'rare',<sup>3,5,7-9</sup> they have not been well monitored. The US Food and Drug Administration (FDA) Center for Tobacco Products (CTP) has used media sources, information from federal agency reports and incidents recorded in the peer-reviewed research literature to attempt to estimate injuries caused by e-cigarettes.<sup>4</sup> Using these methods, CTP noted 92 explosions/fires that injured 47 people between 2009 and September of 2015.<sup>4</sup> A report by the US Fire Administration that included media reports through 2016 identified 195 separate explosion/fire incidents involving e-cigarettes, 133 of which resulted in acute injuries and one-half of which occurred in the year 2016 alone.<sup>5</sup> This rapid increase in incidents and injuries in a single year suggests that e-cigarette fire and explosion injuries have become more common in recent years.

However, because many e-cigarette injuries may not be described in a published case report, covered by the media, or reported to the FDA, current surveillance reports likely underestimate the number of injuries caused by e-cigarettes. Currently, there is no national surveillance system charged with monitoring e-cigarette caused explosion and burn injuries. However, utilisation of existing surveillance systems in novel ways may provide better estimates of the number of e-cigarette explosion and fire injuries in the USA. For example, researchers from the CTP recently analysed data from the Consumer Product Safety Commission's (CPSC) National Electronic Injury Surveillance System (NEISS) to estimate the number of e-cigarette burn injuries presenting to US hospital emergency departments (EDs) in 2016.<sup>10</sup> We conducted similar analyses using NEISS data from the years 2015 to 2017.

## METHODS

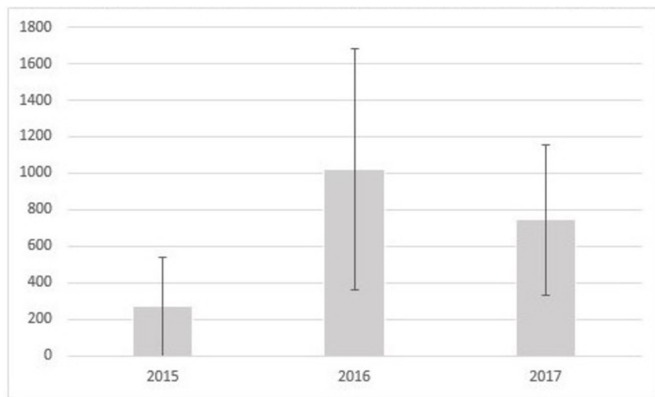
### Data

The CPSC regulates the manufacturing and sale of most consumer products in the USA<sup>11</sup> To guide their efforts, the CPSC uses NEISS data to monitor consumer product-related injuries. NEISS data are collected from a probability sample of approximately 100 of the more than 5000 hospitals in the USA with at least five beds and an ED.<sup>12</sup> These data are designed to be weighted to provide national estimates of consumer product-related injuries treated in EDs.<sup>13</sup> NEISS data include information about the patient and their injury and a unique code that specifies which consumer product(s) were involved in the injury.



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**To cite:** Rossheim ME, Livingston MD, Soule EK, et al. *Tob Control* Epub ahead of print: [please include Day Month Year]. doi:10.1136/tobaccocontrol-2018-054518



**Figure 1** E-cigarette explosion and burn injuries, US emergency departments, 2015–2017.

Tobacco products currently are not within the CPSC's regulatory jurisdiction<sup>14</sup>; they are regulated federally by the FDA CTP.<sup>15</sup> Thus, NEISS data do not contain a specific code for e-cigarette injuries.<sup>16</sup> However, NEISS data include brief case narrative texts describing how each patient was injured.<sup>17</sup>

### Identification of cases

To identify e-cigarette injuries in the NEISS data, case narratives were searched using the following 27 keywords and roots: e-cig\*, e cig\*, ecig\*, \*nic cig\*, \*niccig\*, \*ette batt\*, \*cig batt\*, vape\*, vapor\*, vapour\*, vaping, digital cig\*, \*hooka\*, iqos, usb char\*, adapter\*, adaptor\*, atomiz\*, cartridge\*, delivery sys\*, glycol, nico\*, liquid nic\*, e-juice\*, ejuice\*, \*ette juice\*, \*cig juice\*. Most search terms did not identify any e-cigarette injuries (eg, \*hooka\*, delivery sys\*, or atomiz\*). Some terms identified only cases of child ingestion (eg, nico\*, liquid nic\*, or \*cig juice\*). The six search terms that successfully identified cases of e-cigarette explosion and burn injuries were e-cig\*, e cig\*, \*nic cig\*, \*ette batt\*, vape\* and vapor\*.

As done in previous studies using NEISS data to identify cases without specific product codes, two investigators worked independently to search and review the narrative texts.<sup>10 18 19</sup> A total of 256 narratives were identified and reviewed. Both investigators reviewed the narrative texts independently and identified 52 cases that were explosion or burn injuries obtained from e-cigarettes. To be included in the analyses, both investigators needed to identify a case narrative as an e-cigarette caused explosion or burn injury. E-cigarette injuries that were not explosion-related or burn-related, such as from liquid ingestion or being struck with an e-cigarette, were not included in the sample. The narrative text for each case included in this study is provided in the online Supplementary appendix.

### Statistical analyses

Sampling weights were applied to generate nationally representative estimates of the number of e-cigarette explosion and burn-related injuries presenting to US hospital EDs. Descriptive statistics and corresponding CIs were estimated using PROC SURVEYFREQ in SAS (V.9.4) to account for the complex survey design of the NEISS. This study was exempt from human subjects review because NEISS data were publicly available and did not contain personally identifiable information.

### RESULTS

From 2015 to 2017, there were an estimated 2035 (95% CI 1107 to 2964) e-cigarette explosion and burn injuries presenting

to US hospital EDs. As shown in figure 1, there were an estimated 269 ED visits in 2015 (95% CI 0 to 542), 1022 visits in 2016 (95% CI 363 to 1680) and 745 visits in 2017 (95% CI 334 to 1156). Patients admitted for injuries from e-cigarette explosions and burns were primarily young (median age: 26, 95% CI 22 to 30) and male (94% male, 95% CI 85% to 100%). Among admissions with available race data (62%), patients were primarily white (87%, 95% CI 72% to 100%).

The severity of injury varied. For example, 69% (95% CI 47% to 91%) of patients were treated/examined and then released in the same visit. Approximately, 26% (95% CI 5% to 47%) were either treated and then either transferred to another unit, admitted or held for observation, with 5% (95% CI 0% to 15%) having left without being seen. Almost all injuries were burns (97%, 95% CI 93% to 100%). The majority of injuries occurred on the upper leg (61%, 95% CI 45% to 77%) or hand/fingers (25%, 95% CI 9% to 42%).

### DISCUSSION

This study demonstrates that past reports of e-cigarette explosion and burn injuries likely represent substantial underestimations of the actual number of these events. The current study estimated that 2035 e-cigarette explosion and burn injuries presented to US hospital EDs from 2015 to 2017 (95% CI 1107 to 2964), more than 40 times the number of injuries reported by the FDA from 2009 to 2015 and 15 times the number of injuries reported by the US Fire Administration from 2009 to 2016. Moreover, the estimates from the current study in all likelihood underestimate total US e-cigarette explosion and burn injuries because people who obtain less severe injuries are less likely to present to an ED and are therefore under-represented in NEISS data. Despite being conservative, the injury estimates provided here are on a much larger scale than previously reported using data compiled from media sources, federal agency reports and the research literature. Moreover, the 2016 injury estimates presented in this study (1022; 95% CI 363 to 1680) were very similar to those identified in the recently published study by CTP researchers that also utilised NEISS data (1007; 95% CI 357 to 1657). The slight difference is from our inclusion of the search term \*ette batt\* which identified one additional case where 'electronic cigarette battery' was spelled out. Due to the imprecise estimates available, it is not advisable to use the current data to make inferences about trends between years. Regardless, the data strongly support that there are a substantial number of e-cigarette explosion and burn injuries presenting to US EDs.

Improved surveillance of e-cigarette injuries is needed. Although currently outside of the CPSC's regulatory jurisdiction,<sup>14</sup> NEISS data already has a code for cigarettes, cigars, pipes or tobacco as well as a catchall code for other drugs or medications that includes e-cigarettes.<sup>16</sup> A unique e-cigarette code would improve on this classification system and improve the monitoring of these injuries.

Until 2016, efforts to prevent e-cigarette explosion and burn injuries fell outside of FDA regulatory authority.<sup>20</sup> However, with the passing of the Final Deeming Rule in 2016, FDA's regulatory authority was extended to include all tobacco products, including e-cigarettes.<sup>15</sup> As a result, the CTP now has the authority to regulate all e-cigarette components including e-cigarette batteries.<sup>15</sup> The CTP currently provides some tips to consumers regarding how to prevent e-cigarette explosions, such as only using batteries recommended for the device and not exposing them to extreme temperatures.<sup>9</sup> However, to date, the CTP has not put any regulations on e-cigarette batteries.<sup>15 21</sup>

There is some concern that working to improve regulations on e-cigarette devices may distract from the CTP's general tobacco prevention and control efforts that have the potential for a much greater positive impact on public health, such as working towards lowering the nicotine levels in combustible cigarettes and the removal of flavours from all tobacco products.<sup>20 21</sup> For this reason and because of their experience and expertise in regulating similar types of consumer products, the CPSC may be a valuable stakeholder that could contribute to the development of regulatory policies to prevent e-cigarette-related injuries.<sup>20</sup> However, federal law currently prohibits the CPSC from regulating tobacco products.<sup>14</sup> Thus, congressional action would be needed to grant the CPSC this authority.<sup>20</sup>

### What this paper adds

- ▶ From 2015 to 2017, there were an estimated 2035 e-cigarette explosion and burn injuries presenting to US hospital emergency departments (95% CI 1107 to 2964).
- ▶ The number of injuries in the USA caused by e-cigarette explosions and burns likely exceed estimates from past reports.

**Contributors** MER conceptualised the study, created the database and drafted the introduction, methods and discussion sections. MDL conducted the statistical analyses and drafted the results section. MER and HAZ searched and reviewed NEISS narrative texts. All authors contributed to reviewing and revising drafts of the article and approved the final article.

**Funding** ES's effort was supported by the National Institute on Drug Abuse of the National Institutes of Health under Award Number P50DA036105, the Center for Tobacco Products of the U.S. Food and Drug Administration. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health or the U.S. Food and Drug Administration.

**Competing interests** None declared.

**Patient consent** Not required.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Data sharing statement** NEISS data are publicly available.

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