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Air monitoring at large public electronic cigarette events

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ABSTRACT

Background: Electronic cigarette (e-cigarette) conventions bring hundreds to thousands of e-cigarette users together socially regularly across the world. E-cigarette secondhand exposures to chemicals in this environment, likely the public setting with the highest concentration of e-cigarette secondhand aerosol, have not been characterized.

Methods: Air sampling for formaldehyde, acetaldehyde, acrolein, nicotine, and propylene glycol was conducted at three e-cigarette conventions and one smaller event from April 2016 to March 2017 in three states in the Southeastern United States. Volunteers attended the events as members of the public and wore backpacks containing air sampling pumps. Control sampling was conducted when venues were crowded for non-e-cigarette events. Additional control sampling was conducted in two venues when they were empty.

Results: Formaldehyde and acetaldehyde concentrations during e-cigarette events were comparable to background concentrations. The median formaldehyde concentrations during events, crowded control events, and empty control events were 12.0, 10.5, and 12.5 $\mu\text{g}/\text{m}^3$, respectively. The median acetaldehyde concentrations during events, crowded control events, and empty control events were 9.7, 15.5, and 3.5 $\mu\text{g}/\text{m}^3$, respectively. Propylene glycol and nicotine were not detected during control sampling. The median nicotine concentration during events was 1.1 $\mu\text{g}/\text{m}^3$. The median propylene glycol concentration during events was 305.5 $\mu\text{g}/\text{m}^3$.

Conclusion: Results indicate e-cigarette secondhand exposures are sources of elevated nicotine and propylene glycol exposures. Secondhand exposures to e-cigarettes did not contain consistently elevated concentrations of formaldehyde or acetaldehyde. Additional research is needed to characterize exposures via inhalation to propylene glycol at concentrations measured in this study.

1. Introduction

Electronic cigarettes (e-cigarettes) are electronic devices that deliver nicotine to a user in a manner similar to traditional cigarettes, but e-cigarettes do not burn tobacco (AIHA, 2014). E-cigarettes are rapidly increasing in popularity and are currently the most commonly used tobacco product among American youth (U.S. Department of Health and Human Services, 2016). E-cigarettes are often excluded from smoke-free laws and policies (Tobacco Control Legal Consortium, 2015).

Characterizing secondhand, or passive, e-cigarette exposures is an urgent public health priority. Passive exposures to traditional cigarettes expose bystanders to a mixture of smoke from the burning end of a

cigarette and smoke exhaled by a cigarette smoker (Nelson, 2001). By contrast, e-cigarettes do not use a burning mechanism and do not produce such sidestream smoke. Passive exposures to e-cigarettes are restricted to the aerosols exhaled by the e-cigarette users and are not fully understood (Schripp et al., 2013; U.S. Department of Health and Human Services, 2016).

Research regarding secondhand e-cigarette exposures is inconsistent (Hess et al., 2016). Most studies agree nicotine, propylene glycol, and/or glycerin are present in e-cigarette aerosol. However, the available literature does not consistently report to what extent e-cigarettes produce volatile organic compounds (VOCs) (i.e. formaldehyde, acetaldehyde, and acrolein). If present in e-cigarette aerosol, these chemicals could cause adverse health effects in those exposed to secondhand

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Table 1
Sampling Characteristics.

	Event 1	Event 2	Event 3	Event 4
E-Cigarette Event Details				
Location	Daytona Beach, Florida	Athens, Georgia	Chattanooga, Tennessee	Atlanta, Georgia
Date	April 2016	August 2016	October 2016	March 2017
Estimate number of attendees	1000	300	150	1500
Number of backpacks with air sampling pumps	5	7	6	4
Venue Characteristics				
Venue type	Convention	Concert	Convention	Exhibition/Tradeshow
Site (ft ²)	42,146	5100	36,000	205,000
Estimated Ceiling Height (ft)	45	35	30	13
Air Sampling^a				
Sampling Day	Saturday	Friday	Sunday	Saturday and Sunday ^b
Sampling Hours	12:39–18:20	18:20–00:00	13:00–17:40	12:30–18:00 (Saturday) 11:30–1700 (Sunday)
Sampling duration (mean ± SD) (minutes)	313 ± 37	337 ± 8	279 ± 1	329 ± 2 (Saturday) 324 ± 16 (Sunday)
Empty Venue Control Sampling				
Sampling Month	April		December	
Sampling Day	Friday	N.A. ^c	Monday	N.A. ^c
Sampling Hours	10:55–16:58		13:00–17:30	
Sampling duration (mean ± SD) (minutes)	297 ± 58		262 ± 15	
Crowded Venue Control Sampling				
Estimate number of attendees	1000	800	500	1000
Sampling Month	April	October & February	December	March
Sampling Day	Saturday	Tuesday and Wednesday ^d	Sunday ^e	Saturday
Sampling Hours	12:32–18:33	19:13–22:50 (Tuesday) 19:30–22:30 (Wednesday)	12:00–17:00	12:00–17:40
Sampling duration (mean ± SD) (minutes)	355 ± 3	208 ± 11 (Tuesday) 179 ± 1 (Wednesday)	295 ± 8	333 ± 16

^a Sampling times only reflect samples included in analysis.

^b Sampling on Sunday was only for nicotine and propylene glycol.

^c Not Available (N.A.) – venue was not open to the public when venue was empty.

^d Initial control sampling was on a Wednesday night. Formaldehyde and acetaldehyde control concentrations were abnormal. Researchers repeated sampling for these two chemicals on a Tuesday night.

^e Sampling was conducted on the previous Saturday, but due to logistical difficulties, the length of the sampling was not sufficiently representative of the event. Therefore, sampling was repeated on Sunday.

e-cigarette aerosol. Formaldehyde and acetaldehyde are Group 1 (carcinogenic to humans) and Group 2 B (possibly carcinogenic to humans) carcinogens, respectively (IARC, 1999, 2006). Acrolein is a potent irritant and cardiopulmonary toxicant estimated to account for ~90% of the noncancer hazard index of tobacco smoke (ATSDR, 2007; Hausmann, 2012).

Secondhand exposures to VOCs, nicotine, and propylene glycol from e-cigarettes have been studied on a small scale (i.e. 1–10 e-cigarette users in a chamber or chamber-like environment) (Czogala et al., 2014; Long, 2014; Melstrom et al., 2017; Schober et al., 2014; Schripp et al., 2013), in a home (Ballbe et al., 2014), and using a smoking machine (Czogala et al., 2014; Geiss et al., 2015; Goniewicz et al., 2014; Kosmider et al., 2014; McAuley et al., 2012; Pellegrino et al., 2012; Schripp et al., 2013; Uchiyama et al., 2013). Research on e-cigarette secondhand exposures to these chemicals under real-use conditions in a public environment is limited.

This study aimed to characterize secondhand e-cigarette exposures in public e-cigarette conventions and events. E-cigarette conventions have been described previously as social events designed to bring together users, manufacturers, and sellers of e-cigarettes and e-cigarette accessories (Johnson et al., 2018; Williams, 2015). Hundreds to thousands of attendees come to the events and use e-cigarette devices. The thick haze of e-cigarette aerosol present inside e-cigarette events (Williams, 2015) indicate a large portion of attendees are active e-cigarette users during the events. In this study environmental samples of nicotine, propylene glycol, formaldehyde, acetaldehyde, and acrolein were collected at three e-cigarette conventions and a fourth similar but smaller event in three states across the Southeastern United States. Air sampling was conducted for a length of time representative of a work shift to simulate occupational exposures because concession workers at

e-cigarette conventions and employees at e-cigarette stores/shops may have high exposures. Control sampling was also conducted on days with no e-cigarette exposures.

2. Methods

2.1. Study locations

The study was conducted at four separate e-cigarette events that occurred in Daytona Beach, Florida (Event 1), Athens, Georgia (Event 2), Chattanooga, Tennessee (Event 3), and Atlanta, Georgia (Event 4). Data collection occurred from April 2016 to March 2017. Event 1, 3, and 4 were e-cigarette conventions held in large, open venues. Event 1 and 4 had an estimated 1000–1500 attendees. Event 2 was a social gathering of an estimated 300 e-cigarette users in a concert venue. Event 3 was smaller and had an estimated 150 attendees. These events were chosen because they were within driving distance of The University of Georgia (UGA) in Athens, GA and researchers expected the events to draw a large crowd of e-cigarette users based on the events' social media presence.

2.2. Participant recruitment and selection

Study subjects were recruited from UGA students and staff or friends and family members of the researchers. All subjects gave written informed consent and completed a screening questionnaire to determine their eligibility. The UGA Institution Review Board reviewed and approved this study. Participating subjects could elect to wear backpacks containing 2–4 active air sampling pumps while attending the e-cigarette event.

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