Evaluation of Chemical Exposures at Two Vape Shops in Texas

Leonard M. Zwack, ScD
Sophia Chiu, MD, MPH
Ryan F. LeBouf, PhD, CIH

HHE Report 2016-0120-3307
May 2018

Centers for Disease Control and Prevention
National Institute for Occupational Safety and Health

Contents

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation. Photo by NIOSH.

Highlights of this Evaluation

The Texas Department of State Health Services asked the Health Hazard Evaluation Program to evaluate employees' potential exposure to vaping chemicals in two shops.

What We Did

- We visited the vape shops in July 2016.
- We collected air samples for flavoring chemicals (diacetyl, 2,3-pentanedione, 2,3-hexanedione, and acetoin), nicotine, volatile organic compounds, and formaldehyde.
- We took wipe samples for nicotine and metals on commonly touched surfaces.
- We interviewed employees about their work and health.

What We Found

- Employees vaped at work.
- Concentrations of flavoring chemicals in our air samples were below occupational exposure limits.
- Nicotine was detected on commonly touched surfaces throughout both shops.
- All employees wore chemical protective gloves when they were mixing e-liquids and working with concentrated nicotine solutions.
- Some employees reported liquid nicotine coming into contact with their skin or eyes while handling liquid nicotine or vaporizers.
- None of the employees reported symptoms consistent with either nicotine toxicity or exposures to flavorings in the past 4 weeks.

We evaluated exposures to vaping-related chemicals in two vape shops. Exposures to flavoring chemicals (diacetyl, 2,3-pentanedione) were all below occupational exposure limits. Exposure to formaldehyde, other volatile organic compounds, and nicotine were also low. We found evidence of residual nicotine on commonly touched surfaces throughout both vape shops.

What the Employer Can Do

- Implement a policy prohibiting vaping in the shop with e-liquids that contain diacetyl and 2,3-pentanedione. These chemicals are often found in dairy flavorings, brown flavorings such as butterscotch and caramel, and some fruit flavorings.
- Place a spill tray or drip pan under the large carboys to prevent liquid nicotine from spilling onto the counter during transfer from the large carboys to the transfer bottles.
- Inspect and replace broken caps and droppers on the bottles containing the liquid flavorings and nicotine.

What Employees Can Do

- Wear nitrile gloves whenever handling liquids that contain nicotine.
- Wear nitrile gloves whenever handling customers' vaporizers.
- Wear nitrile gloves, a long-sleeve laboratory coat, and goggles when working with concentrated nicotine solutions.
- Clean workstations and other commonly touched surfaces throughout the day.

Abbreviations

μg/m^3	Micrograms per cubic meter
μg/sample	Micrograms per sample
ACGIH®	American Conference of Governmental Industrial Hygienists
CFR	Code of Federal Regulations
FEMA	Flavor and Extract Manufacturers Association of the United States
mg/mL	Milligrams per milliliter
mL	Milliliter
ND	Not detected
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
ppb	Parts per billion
PPE	Personal protective equipment
REL	Recommended exposure limit
STEL	Short-term exposure limit
TLV®	Threshold limit value
TWA	Time-weighted average
VOC	Volatile organic compound

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Introduction

The Texas Department of State Health Services requested assistance from the Health Hazard Evaluation Program. They asked us to evaluate employees' exposures to chemicals associated with vaping at two vape shops. We visited the two shops in July 2016. We met with employer and employee representatives, measured employees' exposures to vaping-related chemicals, and interviewed employees about their work and health.

Background

Vaping is the process in which liquid is heated by an atomizer housed in an electronic nicotine delivery system or "e-cigarette." The liquid becomes an aerosol of liquid droplets in air (commonly referred to as vapor) that the user inhales. The liquid (known as e-liquid or e-juice) is typically comprised of propylene glycol, vegetable glycerin, nicotine, and flavoring chemicals. Formaldehyde can also be generated as a breakdown product of propylene glycol. Other chemicals that have been associated with vaping include flavorings, nicotine, glycols, glycerin, other volatile organic compounds (VOCs), metals, and ultrafine particles composed of these chemicals, among others [AIHA 2014]. Diacetyl and its substitute, 2,3-pentanedione, are widely used flavoring chemicals. Serious respiratory disease and decreased lung function have been reported in employees exposed to diacetyl [NIOSH 2016]. Other flavoring chemicals that can be used in e-liquid such as acetaldehyde and acetoin can also have adverse respiratory health effects [NIOSH 2016]. A laboratory study has shown that diacetyl and 2,3-pentanedione are present in the heated vapor that e-cigarettes produce [Allen et al. 2016]. A previous health hazard evaluation of exposures at a vape shop found detectable levels of flavorings in the air of the shop [NIOSH 2017]. Other studies have directly measured exposures to vaping-related chemicals in well-characterized rooms and chambers, though they often did not sample for flavoring chemicals [Czogala et al. 2014; Maloney et al. 2016; Schober et al. 2014; Schripp et al. 2013].

At the time of our visit, the same company operated two vape shops (shop A and shop B) and had 17 total employees. Both shops sold e-cigarettes and the e-liquids used in e-cigarettes. The shops were open from 10 a.m. to 8 p.m. Monday through Saturday. On Sunday, they were open from 12 p.m. to 5 p.m. The employer estimated that shop A was approximately 2,000 square feet and included retail space, a lounge, an attached warehouse, and some offices. We observed shop B to be substantially smaller than shop A, containing retail space, a lounge, and some office space. The lounge area was a place for customers to congregate and vape. Shift lengths were variable, with most employees working up to 10 hours, depending upon the day. Generally, we observed approximately five employees working in shop A at any one time. Shop B typically had two or three employees working.

These vape shops purchased premixed e-liquids from a supplier and resold them to customers. They also hand mixed custom e-liquid blends according to customers' tastes and nicotine, propylene glycol, and vegetable glycerin preferences. Hand mixing of chemicals potentially exposed employees to concentrated levels of liquid nicotine. All counter employees generally performed the same tasks each day. The primary task was hand mixing of e-liquids for customers at a counter. Employees used liquid droppers to transfer the flavoring chemicals into various sized bottles of e-liquid that the customers purchased. In both shops, employees also refilled small bottles of nicotine, propylene glycol, and vegetable glycerin solutions from large carboys located in a separate room (Figure 1).

Figure 1. Carboys containing nicotine, propylene glycol, and vegetable glycerin in the back room of a shop. One of the carboys appeared to be leaking, as indicated by fluid on the counter surface below the carboy nozzle and shown inside the yellow circle drawn on the figure. Photo by NIOSH.

Methods

Our primary objective was to evaluate employees' potential exposures to chemicals associated with vaping in the shop. Our work involved (1) sampling air for specific flavoring chemicals associated with respiratory disease; (2) sampling air for nicotine, formaldehyde, and other VOCs; (3) sampling work surfaces for metals and nicotine; (4) observing work practices; and (5) conducting confidential medical interviews with employees.

Air Sampling for Vaping-related Chemicals

We collected personal air samples for specific flavoring chemicals and formaldehyde on employees during their full work shifts. For shop A, we sampled five employees on days 1 and 2. For shop B, we sampled two employees on day 1 and three employees on day 2. We selected two locations in each shop to sample general room air (referred to as "area" air samples). Area samples were collected for nicotine, flavoring chemicals, VOCs, and formaldehyde. For shop A, one set of area air samples was collected directly at the end of the mixing counter. The other was taken in the back of the shop, near an employee who mixed e-liquids to fill internet orders. For shop B, one set of area air samples was collected at the end of the mixing counter, while the other set was collected behind the mixing counter.

Flavoring Chemicals

We measured flavoring chemicals using two air sampling methods, silica gel tubes and evacuated canisters. The silica gel tube method was developed by the Occupational Safety and Health Administration (OSHA) for measuring flavoring chemicals in the air. The evacuated canister method is experimental and still undergoing validation by the National Institute for Occupational Safety and Health (NIOSH).

We collected full-shift personal and area air samples for acetoin, diacetyl, 2,3-pentanedione, and 2,3-hexanedione using sets of two silica gel sorbent tubes in series with pumps calibrated to a flow rate of 50 cubic centimeters per minute. We collected samples at both shops and at both area sampling locations over 2 days. These samples were analyzed for flavoring chemicals in accordance with OSHA Method 1013 [OSHA 2008] and OSHA Method 1016 [OSHA 2010a]; however, an alternate detector (mass spectrometer) was used to increase method sensitivity [LeBouf and Simmons 2017]. The analytical limits of detection were as follows: acetoin, 0.04 micrograms per sample (µg/sample); diacetyl, 0.03 µg/sample; 2,3-pentanedione, 0.03 µg/sample; and 2,3-hexanedione, 0.04 µg/sample. The limits of quantitation were as follows: acetoin, 0.14 µg/sample; diacetyl, 0.088 µg/sample; 2,3-pentanedione, 0.094 µg/sample; and 2,3-hexanedione, 0.13 µg/sample.

We used evacuated canisters to collect personal and area air samples for diacetyl, 2,3-pentanedione, 2,3-hexanedione, and acetaldehyde. The evacuated canister sampling setup consisted of a 450-milliliter (mL) evacuated canister equipped with a restricted flow controller set to collect a 9-hour air sample. The canister air samples were analyzed using a preconcentrator/gas chromatograph/mass spectrometer system according to a published method validation study [LeBouf et al. 2012] with the following modifications: the preconcentrator was an Entech Instruments Model 7200, and four additional chemicals, acetaldehyde, diacetyl, 2,3-pentanedione, and 2,3-hexanedione, were included in the analysis. The limit of detection of the sampling and analytical method is the lowest mass that can be currently measured. The limit of quantitation is the lowest mass that can be reported with acceptable precision. The analytical limits of detection were as follows: acetaldehyde, 0.3 parts per billion (ppb); diacetyl, 0.3 ppb; 2,3-pentanedione, 0.4 ppb; 2,3-hexanedione, 0.6 ppb. The limits of quantitation were as follows: acetaldehyde, 0.89 ppb; diacetyl, 0.86 ppb; 2,3-pentanedione, 1.2 ppb; 2,3-hexanedione, 2.1 ppb. These detection and quantitation limits were multiplied by the individual sample pressure dilution factors to obtain the minimum detectable and quantifiable concentrations displayed in the results table footnotes. At present, this canister method is partially validated [LeBouf et al. 2012] and not considered the standard method.

Formaldehyde in Air

We collected full-shift personal and area air samples for formaldehyde using SKC UMEx 100 passive badges. The air samples were collected and analyzed in accordance with OSHA Method 1007 [OSHA 2005].

Nicotine in Air

We collected area air samples for nicotine using XAD-4 tubes with pumps calibrated to a flow rate of 200 cubic centimeters per minute. The air samples were analyzed in accordance with NIOSH Method 2551 [NIOSH 2018].

Volatile Organic Compounds in Air

The personal and area canister sampling described above was also able to quantify 16 target VOCs. Additional compounds were tentatively identified using the National Institute of Standards and Technology 2011 mass spectral library (NIST/EPA/NIH Mass Spectral Database NIST11, Scientific Instrument Services, Ringoes, NJ).

Surface Sampling for Elements and Nicotine

We collected wipe samples for elements (minerals and metals) from several surfaces in the vape shop that employees commonly touched during their work. These samples were collected using premoistened Palintest® Dust Wipes following NIOSH Method 9102 [NIOSH 2018]. We used a disposable template to collect each wipe sample over an area of 100 square centimeters. The wipe samples were analyzed according to NIOSH Method 7303 [NIOSH 2018].

We collected surface wipe samples for nicotine using sterile cotton swabs (ITW Texwipe Model STX705W) that were wetted with ethyl acetate and 0.01% triethylamine. Most samples were collected using a disposable template, covering an area of 100 square centimeters. The wipe samples were analyzed according to NIOSH Method 2551, which was modified to incorporate the use of cotton swabs [NIOSH 2018].

Confidential Employee Interviews

We invited all employees working in both shops during our visit to participate in confidential interviews. During the interviews, we discussed workplace exposures, work history and practices, medical history, and employees' experiences with vaping.

Results

Workplace Observations

Employees and customers vaped inside the shop. During the site visit, employees reported that the air inside the shop could get "cloudy" or hazy when many people were vaping simultaneously. However, we did not observe haziness or lingering vapor clouds in shop A. In shop B, we noticed some minimal haziness during the second day of sampling. On the days of our visits, we observed that employees did most of the vaping inside the shop. Customers would sometimes vape while sampling flavors or waiting to be helped by a staff member, but this practice was relatively infrequent compared to the employees' vaping. When customers did sample flavors, they stood directly across from employees working at the counter.

Ventilation in shop A was provided by two air handling units attached to the ceiling that delivered ducted supply air to the entire shop. Employees in the shop reported that they periodically changed the air handling unit filters. We were not able to look at the air handling units in shop B because they were located above the suspended ceiling tiles. However, we observed that supply air vents in the ceiling provided conditioned air. Employees stated that they did not have control over the air handling units in this shop, and that the building owner maintained it.

Employees reported that they cleaned floors, counters, displays, and the counter with cleaning agents including Clorox® wipes and sprays, Pine-Sol® surface cleaner, and glass cleaners. While we were at the shops, we observed employees cleaning the mixing counter multiple times throughout the day.

At a mixing station in the back of shop B, we observed a transfer bottle of nicotine solution that appeared to be leaking. We also observed older bottles of flavoring chemicals that appeared to be damaged. We did not observe this mixing station to be in use during our 2 days in this shop. This mixing station was located in the same room where employees ate lunch. At both shops, we observed that the flavoring chemicals and nicotine used at the mixing counters were stored in secondary containers. This included both glass vials (flavorings, nicotine) as well as plastic carboys (nicotine). None of these containers was labeled as required by the OSHA hazard communication standard [1910.1200]. This standard requires that all hazardous chemicals stored outside of their original container have a label that contains, at a minimum, the identity of the hazardous chemical and the hazards present.

At the nicotine mixing station in the back of shop A, we observed that one of the large carboys had a small leak (Figure 1). The shop did not have any secondary containment in place, such as a spill tray or drip pan to catch liquids leaking from carboys and accumulating on the counter below the carboy.

Personal Protective Equipment

The company provided employees with nitrile gloves for use when mixing e-liquids and when working with chemicals. We observed that employees always wore gloves during these tasks, as required by company policy. When wearing gloves, employees generally used a new pair for each bottle of e-liquid they were mixing and did not reuse gloves between e-liquid mixing tasks. Sometimes, employees would change their gloves multiple times when working with one customer. Employees transferring nicotine from the large carboys to the smaller transfer bottles wore gloves during this process.

Air Sampling Results

Flavoring Chemicals

Table 1 presents the personal air monitoring results for flavoring chemicals using silica gel tubes and analyzed using the modified OSHA methodology. The results of the experimental evacuated canister sampling are presented in Appendix A. The conclusions and recommendations presented in this report for the flavoring chemicals are based on the data collected using the OSHA sampling methodology, and not on the experimental canister data.

None of the personal air samples for the flavoring chemicals were above any 8-hour time-weighted average (TWA) occupational exposure limit (OEL). The lowest OEL for these chemicals was the NIOSH recommended exposure limit (REL) of 5 ppb for diacetyl and 9.3 ppb for 2,3-pentanedione. OELs for 2,3-hexanedione and acetoin have not been established. Appendix B describes these and other OELs in more detail.

Table 1. Personal air sampling results for flavoring chemicals (ppb)*

Employee	Date	Sample duration (minutes)†	Diacetyl	2,3-pentanedione	2,3-hexanedione	Acetoin
Shop A						
1	Day 1	449	[0.4]	[1.3]	ND	ND
1	Day 2	461	ND	1.4	ND	ND
2	Day 1	377	ND	0.8	ND	ND
3	Day 1	358	[0.3]	1.5	ND	ND
4	Day 1	367	ND	[1.3]	ND	ND
4	Day 2	363	ND	1.3	ND	ND
5	Day 1	373	ND	1.4	ND	ND
5	Day 2	527	[0.3]	1.4	ND	ND
6	Day 2	529	ND	1.7	ND	[1.8]
7	Day 2	558	[0.3]	1.5	ND	ND
Shop B						
8	Day 1	432	ND	ND	ND	ND
8	Day 2	508	ND	ND	ND	ND
9	Day 1	507	ND	ND	ND	ND
10	Day 2	521	ND	ND	ND	ND
11	Day 2	520	ND	[0.4]	ND	ND
ACGIH TLV			10	—	—	—
NIOSH REL			5.0	9.3	—	—
OSHA PEL			—	—	—	—

ACGIH TLV = American Conference of Governmental Industrial Hygienists threshold limit value

OSHA PEL = OSHA permissible exposure limit

ND = Not detected

[ ] = Estimated concentration; this concentration was between the minimum detectable and minimum quantifiable concentrations.

*The minimum detectable concentration range was 0.3–0.4 ppb for diacetyl and 2,3-pentanedione, 0.4–0.6 ppb for 2,3-hexanedione, and 1.4–1.9 ppb for acetoin. The minimum quantifiable concentration range was 1.0–1.3 ppb for diacetyl and 2,3-pentanedione, and 4.7–6.4 ppb for acetoin.

†Employee shift lengths varied. For each employee sampled, we sampled for the entire shift.

The results for the area air samples taken over the entire work day in two shops using silica gel tubes are presented in Table 2. In shop A we found detectable levels of diacetyl and quantifiable levels of 2,3-pentanedione. In shop B, we did not find detectable concentrations of any of the flavoring chemicals measured.

Table 2. Area air sample concentrations (ppb) of flavoring chemicals*

Location	Date	Sample duration (minutes)	Diacetyl	2,3-pentanedione	2,3-hexanedione	Acetoin
Shop A						
Back mixing station	Day 1	519	[0.4]	[1.2]	ND	ND
Back mixing station	Day 2	542	ND	1.4	ND	ND
End of counter	Day 1	518	[0.4]	1.3	ND	ND
End of counter	Day 2	537	ND	1.4	ND	ND
Shop B						
Behind counter	Day 1	539	ND	ND	ND	ND
Behind counter	Day 2	541	ND	ND	ND	ND
End of counter	Day 1	551	ND	ND	ND	ND
End of counter	Day 2	546	ND	ND	ND	ND

*The minimum detectable concentration ranged from 0.3–0.4 ppb for diacetyl and 2,3-pentanedione, from 0.4–0.6 parts ppb for 2,3-hexanedione, and from 1.4–1.9 for acetoin. The minimum quantifiable concentration for ranged from 1.0–1.3 ppb for diacetyl and 2,3-pentanedione.

[ ] = Estimated concentration; this concentration was between the minimum detectable and minimum quantifiable concentrations.

Table 3 presents the personal air sampling results for formaldehyde. All sample results were below the OSHA PEL for formaldehyde. Two employees in shop A had formaldehyde exposures at or just above the NIOSH REL of 16 ppb. None of the other employees we monitored in shop A and none of the employees at shop B had exposures to formaldehyde at or above OELs. In general, personal formaldehyde concentrations in shop A were slightly higher than concentrations in shop B.

Table 3. Personal air sample results for formaldehyde

Employee	Date	Location	Sample duration (minutes)*	Formaldehyde (ppb)
1	Day 1	Shop A	447	14
1	Day 2	Shop A	502	14
2	Day 1	Shop A	406	12
3	Day 1	Shop A	501	11
4	Day 1	Shop A	493	15
4	Day 2	Shop A	443	3.6
5	Day 1	Shop A	485	17
5	Day 2	Shop A	562	5.9
6	Day 2	Shop A	549	7.1
7	Day 2	Shop A	543	16
8	Day 1	Shop B	565	3.3
8	Day 2	Shop B	570	6.8
9	Day 1	Shop B	563	4.9
10	Day 2	Shop B	575	6.2
11	Day 2	Shop B	571	6.3
NIOSH REL				16
OSHA PEL				750

*Employee shift lengths varied. For each employee sampled, we sampled for their entire shift.

Table 4 presents the area air sample results for formaldehyde. For both shops, concentrations of formaldehyde in the air were generally low and similar to those found in the personal air samples.

Table 4. Area air sample results (ppb) for formaldehyde

Location	Date	Sample duration (minutes)	Formaldehyde (ppb)
Shop A - Back mixing station	Day 2	521	16
Shop A - End of counter	Day 2	516	17
Shop B - Behind counter	Day 1	385	3.4
Shop B - Behind counter	Day 2	545	6.1
Shop B - End of counter	Day 1	385	4.9
Shop B - End of counter	Day 2	546	6.1

Nicotine in Air

Table 5 presents the results for the nicotine area air samples. With the exception of one nondetectable sample in shop B, all of the airborne nicotine concentrations were detectable, but below the minimum quantifiable concentration.

Table 5. Area air sample results for nicotine

Location	Date	Sample duration (minutes)	Nicotine (micrograms per cubic meter [μg/m^3])*
Shop A - Back mixing station	Day 1	520	[1.4]
Shop A - Back mixing station	Day 2	532	[3.7]
Shop A - End of counter	Day 1	524	[2.1]
Shop A - End of counter	Day 2	522	[3.5]
Shop B - Behind counter	Day 1	563	[0.8]
Shop B - Behind counter	Day 2	562	[1.8]
Shop B - End of counter	Day 1	557	ND
Shop B - End of counter	Day 2	545	[1.1]

[ ] = Estimated concentration; this concentration was between the minimum detectable and minimum quantifiable concentrations.

*The minimum detectable concentration range was 0.5–0.6 μg/m^3, while the minimum quantifiable concentration range was 11–13 μg/m^3.

Volatile Organic Compounds in Air

Laboratory analysis of the personal air samples collected using evacuated canisters indicated the presence of multiple chemicals. Quantifiable concentrations of ethanol (220–4,000 ppb), acetone (ND–60 ppb), isopropyl alcohol (100–400 ppb), limonene ([3.3]–32 ppb), and benzene (ND–3.7 ppb) were identified in some of the samples. Detectable, but not quantifiable, concentrations of toluene, ethylbenzene, m,p-xylene, o-xylene, and alpha-pinene were also identified. Employees' exposures to all of the compounds identified were well below OELs.

For the area samples, we identified quantifiable concentrations of acetone (ND–49 ppb), benzene (ND–11 ppb), limonene (ND–21 ppb), ethanol (160–1,400 ppb), ethylbenzene (ND–4.9 ppb), isopropyl alcohol (90–2,300 ppb), m,p-xylene (ND–6.4 ppb), methyl methacrylate (ND–15.5 ppb), o-xylene (ND–3.6 ppb), and toluene (ND–5.8 ppb). Detectable, but not quantifiable, concentrations of methylene chloride were also identified.

In addition to the VOCs quantified, 41 other chemicals were tentatively identified in the personal and area canister air samples. This included substances on the Flavor and Extract Manufacturers Association of the United States (FEMA) list of substances that "may pose potential respiratory hazards when improperly handled" [FEMA 2012]. We tentatively identified benzaldehyde, furfural, and isobutyraldehyde in our samples. FEMA classifies these chemicals as "high priority" substances. Pyridine, ethyl acetate, isoamyl acetate, dimethyl disulfide, and isobutyl acetate were also tentatively identified. FEMA classifies these as "low priority" substances. These priority levels were assigned by FEMA based on "available inhalation exposure data in animals and humans, chemical structure, volatility, and volume of use."

Elements on Surfaces

We took surface wipe samples for minerals and metals throughout both vape shops over 2 days of sampling in each shop. This included surfaces that employees or customers touched and included the employee and patron sides of the mixing counters, top of the repair counters, and breakroom lunch tabletops. Quantifiable concentrations of aluminum, calcium, chromium, copper, iron, lithium, magnesium, manganese, nickel, potassium, silver, strontium, tin, and zirconium were identified in the wipe samples. Detectable, but not quantifiable, concentrations of barium, indium, tellurium, titanium, yttrium, and zinc were also identified in some samples.

Nicotine on Surfaces

We took surface wipe samples for nicotine throughout both vape shops over 2 days of sampling in each shop. For both shops, we sampled surfaces at the nicotine mixing area, on the mixing counter, the online mixing counter in the back of the shop, the break room mixing bar, the repair counter, and the table used by customers. The laboratory was not able to achieve an adequate recovery for the sampling media we used and was not able to calculate a limit of quantitation for these data. All but one of the surfaces sampled had detectable levels of nicotine at concentrations greater than 0.1 micrograms per 100 square centimeters. The table used by customers had a nondetectable level of nicotine on it. There are no OELs for dermal exposure to nicotine.

Confidential Employee Interviews

Of 16 employees working during the dates of our visit, 15 participated in the interviews and one employee declined. Fourteen were male, and one was female. The median age was 31 years (range: 21–44 years).

Employees worked at this company for a median of 17 months (range: 1–56 months). Ten employees worked at shop A, four worked at shop B, and one worked at both shops. Two employees had previously worked at another vape shop. Employees reported working a median of 42.5 hours per week (range: 36–50 hours).

Of 15 employees, 13 reported mixing e-liquid as part of their job duties. Table 6 shows the types of tasks and personal protective equipment (PPE) used while mixing e-liquids that employees reported. All 13 employees reported 100 milligrams per milliliter (mg/mL) as the highest concentration of nicotine that they had handled.

Table 6. Type of job duties and reported PPE use when mixing e-liquids (n = 13)	
Type of job duty or PPE	Number (%) of employees
Cleaning equipment	12 (92)
Cleaning work surfaces	12 (92)
Gloves, always	13 (100)
Closed toe shoes, always	13 (100)
Long pants	
Always	8 (62)
Sometimes	5 (38)

Table 7 presents the number of employees who reported receiving training on various safety topics. All interviewed employees reported receiving training on how to handle liquid nicotine safely. Most reported having received training related to liquid nicotine or flavorings.

Table 7. Health and safety training received by interviewed employees (n = 15)

Type of training	Number (%) of employees
How to handle liquid nicotine safely	15 (100)
How to clean up spills of liquid nicotine or e-liquid	14 (93)
Types of PPE required for job duties	14 (93)
What to do if liquid nicotine or e-liquid gets into eyes, mouth, or skin	12 (80)
Health risks related to work with liquid nicotine	12 (80)
Health risk related to work with flavorings	14 (93)

Six of 13 employees who mix e-liquid reported ever having liquid nicotine or e-liquid coming into contact with their skin, eyes, or mouth while mixing e-liquid. Four employees reported they had two to five episodes of contact within the past month. We asked for details about these recent incidents. All four employees reported wearing gloves, but the liquid nicotine or e-liquid came into contact with their wrist or forearm above the glove. Three employees reported the contact occurred when there was dripping when they were trying to quickly transfer liquid from the dropper. One employee reported splashing liquid nicotine onto the forearm while pouring from one bottle to another without using a funnel. All four employees reported that they were able to wash the affected area right away and did not have any symptoms associated with coming into contact with liquid nicotine or e-liquid.

Four employees reported liquid nicotine or e-liquid coming into contact with their skin or eyes during other job tasks. One employee reported spilling concentrated nicotine (100 mg/mL) on his arm while filling a container more than a year ago. He reported sweating and feeling “jittery” after the incident. One employee reported liquid nicotine coming into contact with his wrist above the glove when he was handling a leaking bottle of liquid nicotine. One employee reported hot e-liquid splashing into his eye while he was inspecting a customer’s nonfunctioning e-cigarette. He was not wearing safety glasses at the time. He washed his eye in a sink for 3 minutes. He experienced eye burning and redness for approximately 30 minutes, with no changes in his vision. Another employee reported contact with e-liquid on multiple occasions. He reported getting e-liquid on his ungloved hands approximately 75%–80% of the time when inspecting customers' e-cigarettes. He also reported e-liquid splashing into his ear twice in the past month when he held an e-cigarette tester next to his ear to listen for a popping sound that indicated it was ready for customer use.

Fourteen of the 15 interviewed employees reported vaping every day at work. One employee is a former vaper. Employees reported using a median of 10 mL (range: 4–30 mL) of e-liquid at work, which corresponds to approximately 60% (range: 40%–100%) of their daily e-liquid use. Ten employees reported demonstrating how to vape for customers by actually vaping themselves. Thirteen employees reported that it gets cloudy or hazy when others are vaping around them at work. None of the employees reported currently smoking.

One employee reported eye irritation when working with cinnamon or menthol flavorings in the past 4 weeks. None of the employees reported symptoms related to nicotine toxicity, such as nausea, vomiting, racing or irregular heartbeat, dizziness, and increased salivation in the past 4 weeks. None of the employees reported respiratory symptoms such as cough, shortness of breath, chest tightness, or wheezing in the past 4 weeks that might raise suspicion for flavorings-related disease. One employee reported currently having asthma that was diagnosed by a healthcare provider, but asthma symptoms were not worse while at work.

Discussion

None of the airborne concentrations of the specific flavoring chemicals we measured were above applicable OELs using the OSHA sampling methodology. In addition to the OSHA sampling methodology, we also tested the use of the evacuated canisters to measure flavoring compounds in the air. At present, this canister method is partially validated [LeBouf et al. 2012] and not considered the standard method. Some employees wore a silica gel tube and an evacuated canister at the same time. The concentrations measured by the evacuated canister tended to be higher than corresponding concentrations measured by the OSHA silica gel tube method (Table A1). In the area samples collected, we similarly observed that the canisters measured higher concentrations of the flavoring chemicals than did the OSHA silica gel tube method (Table A2).

Personal air sampling results for formaldehyde, a breakdown product of propylene glycol, were well below the OSHA PEL and OSHA action level. Most samples were also below the NIOSH REL, which is much lower than the OSHA PEL. NIOSH recognized formaldehyde as a potential occupational carcinogen in 1981 and, following the NIOSH carcinogen policy in existence at the time, set the REL to the "lowest feasible concentration," which for formaldehyde was defined as the analytical limit of quantification of 16 ppb for up to 8 hours [NIOSH 1981]. Since then, experience has shown that this REL is actually not the "lowest feasible concentration" because formaldehyde in the ambient air can exceed 16 ppb, a fact NIOSH has acknowledged [Lemen 1987]. Area sampling results showed that background formaldehyde concentrations were similar to the personal sampling results and that shop

B generally had lower formaldehyde concentrations than shop A. Low concentrations of formaldehyde exist in many indoor environments because of off gassing from furnishings, clothing, and other materials.

In addition to the specific flavoring chemicals we looked for in the air samples (diacetyl, 2,3-pentanedione, 2,3-hexanedione, and acetoin), we also identified other flavoring chemicals and VOCs in the air of the vape shops. Results from the air samples we collected using evacuated canisters showed very low concentrations of chemicals found in cleaning products (limonene, isopropanol), as well as other chemicals that could be classified as flavoring chemicals. Some of the flavoring chemicals found were on the FEMA list of substances that "may pose potential respiratory hazards when improperly handled." Concentrations of nicotine in the air of the shop were also very low.

Over the 4 days of our evaluation in the two shops, we observed that employees vaped throughout the day. Customers also vaped inside of the shop, though the amount they vaped varied. Our observations indicate that most of an employee's exposure to vaping-related chemicals inside these vape shops was due to direct inhalation of vaping-related chemicals from their personal e-cigarette. They were also exposed to secondhand emissions from coworkers' and patrons' e-cigarettes. This observation was similar to what we observed in a previous health hazard evaluation [NIOSH 2017]. Our air sampling only measured vaping chemicals present in the air from the emissions of e-cigarettes and exhaled breath. We did not measure chemical concentrations directly inhaled from an employee's own e-cigarette. However, the concentrations of vaping chemicals directly inhaled during vaping would likely be higher than the concentrations from secondhand emissions. Although our air sampling results showed very low exposures to vaping chemicals, exposure would have been even lower if employees had not been vaping in the shop.

We detected the presence of metals, such as chromium, copper, and nickel on surfaces in the shop. This finding was not surprising given that these metals have also been measured by other researchers in e-liquids (chromium, nickel) and in vapor from e-cigarettes (chromium, nickel, and copper) [Hess et al. 2017; Williams et al. 2013]. Some of the other elements that we detected on surfaces are found in human sweat (calcium, potassium, magnesium, and phosphorous). It is unknown if their presence on surfaces was from e-cigarettes, people touching surfaces, or both.

Although most employees reported cleaning equipment and work surfaces for mixing e-liquid during the interviews, almost all commonly touched surfaces had detectable levels of nicotine, suggesting that housekeeping processes can be improved. In addition, it is important to use good chemical handling procedures whenever working with nicotine, especially the stock nicotine solution.

Nicotine is a potent and potentially lethal toxin that is quickly absorbed from all routes of entry, including the skin or eyes [Brandon et al. 2015]. Exposure to nicotine can occur by inhalation, skin absorption, and ingestion. If nicotine gets on the skin, employees should immediately wash the affected area with soap and water. Research has shown that it only takes 3 to 5 minutes for nicotine to be absorbed through the skin [Zorin et al. 1999]; after that length of time, nicotine cannot be washed off and remains in the skin where it continues to be absorbed into the body. During interviews, employees reported that nicotine or nicotine-containing e-liquid came into contact with their skin or eyes. All four employees who reported exposures while mixing e-liquid in the last month stated that skin exposure occurred on uncovered wrists or forearms, despite wearing gloves as required. None of these employees reported symptoms consistent with nicotine toxicity; however, an employee reported symptoms consistent with nicotine exposure after skin contact from concentrated nicotine spilling on his arm during an earlier incident. Longer gloves or sleeves covering the arms could minimize the likelihood of this type of skin contact. Most employees reported receiving training on how to clean up spills and what to do if nicotine or e-liquid gets into their eyes, mouth, or skin. Inspecting customers' e-cigarettes without gloves and verifying that an e-cigarette tester was ready for use were identified as other tasks where employees might have skin and eye exposure to nicotine. Ways to reduce nicotine exposures to employees during these tasks include finding another way to tell if an e-cigarette tester is ready and wearing gloves and eye protection.

Few standards define "acceptable" levels of workplace surface contamination. Wipe samples, however, can provide information regarding the effectiveness of housekeeping practices, the potential for exposure to contaminants by skin absorption or ingestion, the potential for contamination of employee clothing and subsequent transport of the contaminant outside the workplace, and the potential for other activities (e.g., sweeping) to generate airborne contaminants. Overall, we found low levels of some surface contaminants during our evaluation.

The health effects associated with vaping are not well understood. According to the U.S. Surgeon General's report on e-cigarette use among youth and young adults, e-cigarette aerosol is not harmless because it contains nicotine, flavorings, other additives, and ultrafine particles [DHHS 2016]. The United States Food and Drug Administration has warned consumers about potential health risks associated with e-cigarettes and has finalized a rule extending their regulatory authority to cover electronic cigarettes [FDA 2013, 2016]. While none of the interviewed employees reported respiratory symptoms in the previous 4 weeks, flavoring chemicals such as diacetyl and 2,3-pentanedione have been associated with serious respiratory disease [NIOSH 2016]. One way to reduce exposure to these chemicals is to not use products containing them. Studies have shown that even flavors that are reported as being free of diacetyl may still contain it [Allen et al. 2016; Rutledge 2015]. The health risks of flavoring chemicals that may be used as substitutes for diacetyl and 2,3-pentanedione may not be known, and precautionary measures such as engineering controls are recommended to protect employees exposed to these substitutes [NIOSH 2016; OSHA 2010b].

This evaluation had limitations that could influence the generalizability of our findings. First, sampling occurred over 2 days in each shop during the summer, and our measurement results may not be representative of all other times or seasons. Over the 2 days we spent in each shop, we observed many employees vaping but we did not observe a large number of customers vaping. Most of the customers we observed were in the shop to purchase liquids, and did not vape much. Moreover, we do not know the chemical composition of the e-liquids employees and customers vaped over the course of our evaluation. The low air concentrations of flavoring chemicals that we measured during our evaluation may occur because the e-liquids employees and customers used contained low levels of the flavoring compounds we measured. Finally, our sampling method for nicotine was not able to capture nicotine that had potentially adsorbed onto particulate matter.

Conclusions

Employees were exposed to low levels of flavoring chemicals in the air while working in the vape shops. Although the measured concentrations were below all applicable OELs, to better protect the health of employees, we recommend that the employer implement a policy prohibiting vaping in the workplace with e-liquids that contain diacetyl and 2,3-pentanedione. Some employees reported liquid nicotine or e-liquid coming into contact with their skin and eyes. Analyzing which work tasks are associated with nicotine exposure to identify PPE needs, training employees on proper chemical handling procedures, and ensuring consistent use of chemical protective nitrile gloves when handling liquids containing nicotine or customers' e-cigarettes will likely reduce employees' work-related exposure to nicotine.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the vape shops to use an employee-employer health and safety committee or working group to discuss our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation at the vape shops.

Our recommendations are based on an approach known as the hierarchy of controls (Appendix B). This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and PPE may be needed.

Elimination and Substitution

Eliminating or substituting hazardous processes or materials reduces hazards and protects employees more effectively than other approaches. Prevention through design, considering elimination or substitution when designing or developing a project, reduces the need for additional controls in the future.

1. Implement a policy prohibiting vaping in the shop with e-liquids that contain diacetyl and 2,3-pentanedione.

Engineering Controls

Engineering controls reduce employees' exposures by removing the hazard from the process or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. Fix the large carboys containing nicotine, propylene glycol, and vegetable glycerin to ensure that they do not leak.
2. Replace the broken and leaking caps on transfer bottles of flavorings, nicotine, and other chemicals so that they do not leak.
3. Install secondary containment underneath the carboys so that if spills or leaks occur,

the chemical can be easily contained and cleaned up. This could consist of a small spill tray or drip pan that will prevent the leaking material from splashing on the counters below the carboys.

Administrative Controls

The term administrative controls refers to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Instruct employees to immediately use soap and water to wash skin that comes into contact with nicotine. Nicotine is absorbed through the skin in only 3 to 5 minutes; after that, the nicotine cannot be washed off [Zorin et al. 1999].
2. Train employees on the potential hazards in the vaping industry such as flavorings, nicotine, and formaldehyde and how to protect themselves. The OSHA hazard communication standard [29 CFR 1910.1200] requires that employees are informed and trained on potential work hazards and associated safe practices, procedures, and protective measures.
3. Instruct employees to clean their stations and other commonly touched surfaces throughout the day to prevent accumulation of nicotine on them.
4. Review current work practices and update current PPE policies to prevent skin exposure to nicotine.
5. Label on all secondary containers used to store flavorings and nicotine. The labels must meet the requirements of the OSHA hazard communication standard, https://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10099.

Personal Protective Equipment

Proper use of PPE requires a comprehensive program and a high level of employee involvement and commitment. The right PPE must be chosen for each hazard. Supporting programs such as training, change-out schedules, and medical assessment may be needed. PPE should not be the sole method for controlling hazardous exposures. Rather, PPE should be used until effective engineering and administrative controls are in place.

1. Train employees and require them to wear chemical protective gloves made out of nitrile whenever working with nicotine. This should include activities such as mixing e-liquids, filling transfer bottles, and handling customers' e-cigarettes. Because nicotine can break through the glove material in as little as 6 to 9 minutes, employees should not reuse gloves and should use a new pair of gloves each time they start a new task involving nicotine.
2. Provide long-sleeved lab coats and goggles or face shields and instruct employees on their use to prevent contact with the eyes, skin, or clothing when handling the stock nicotine solution, such as when transferring from the stock solution container to another container. Gloves with a longer cuff could be used to help protect against nicotine spills on the wrist and forearm for employees mixing e-liquids.

Appendix A: Tables

Table A1. Personal air sampling results for flavoring chemicals using evacuated canisters (ppb)*

Employee	Date	Sample duration (minutes)†	Diacetyl	2,3-pentanedione	2,3-hexanedione	Acetaldehyde
Shop A						
1	Day 1	479	[2.4]	[2.3]	ND	ND
4	Day 1	431	3.3	4.3	ND	ND
5	Day 1	398	[2.9]	[2.8]	ND	ND
5	Day 2	588	[2.3]	[2.6]	ND	ND
6	Day 2	595	[3.7]	[5.1]	ND	ND
7	Day 2	558	4.4	4.7	[3]	ND
Shop B						
8	Day 1	495	[1.4]	[1.4]	ND	ND
8	Day 2	589	[2.5]	[2.1]	ND	ND
9	Day 1	572	[1.5]	ND	ND	ND
10	Day 2	589	[2]	ND	ND	ND
11‡	Day 2	577	ND	ND	ND	ND
ACGIH TLV			10	—	—	—
NIOSH REL			5.0	9.3	—	—
OSHA PEL			—	—	—	—

[ ] = Estimated concentration; this concentration was between the minimum detectable and minimum quantifiable concentrations.

*For employees 1–10, the minimum detectable concentration range was 1–2 ppb for diacetyl and acetaldehyde, 1–3 ppb for 2,3-pentanedione, and 2–5 ppb for 2,3-hexanedione. The minimum quantifiable concentration range was 2.6–6.7 ppb for diacetyl, 3.6–9.3 ppb for 2,3-pentanedione, and 6.4–17 ppb for 2,3-hexanedione.

†Employee shift lengths varied. For each employee sampled, we sampled for their entire shift.

‡Employee 11's minimum detectable concentrations were substantially higher than other samples due to an excess of ethanol in the sample. The minimum detectable concentration was 10 ppb for diacetyl, 2,3-pentanedione, and acetaldehyde, and 20 ppb for 2,3-hexanedione.

Table A2. Area air sample concentrations of flavoring chemicals using evacuated canisters (ppb)*

Location	Date	Sample duration (minutes)	Diacetyl	2,3-pentanedione	2,3-hexanedione	Acetaldehyde
Shop A						
Back mixing station	Day 1	521	5.9	[4.5]	ND	ND
Back mixing station	Day 2	542	[2.9]	[2.9]	ND	ND
End of counter	Day 1	527	[3.5]	[1.8]	ND	ND
End of counter	Day 2	537	12.5	21.2	18	ND
Shop B						
End of counter	Day 1	556	[2.7]	[2.6]	ND	ND
End of counter	Day 2	546	[1.3]	[1.6]	ND	ND
Behind counter	Day 1	554	4.1	[3.9]	ND	ND
Behind counter	Day 2	542	[2.6]	[2.9]	ND	ND

[ ] = Estimated concentration; this concentration was between the minimum detectable and minimum quantifiable concentrations.

*The minimum detectable concentration was 1 ppb for diacetyl and acetaldehyde, 1–2 ppb for 2,3-pentanedione, and 2–3 ppb for 2,3-hexanedione. The minimum quantifiable concentration range was 3.2–4.6 ppb for diacetyl and 4.5–6.4 ppb for 2,3-pentanedione.

Appendix B: Occupational Exposure Limits and Health Effects

NIOSH investigators refer to mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. However, not all employees will be protected if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a pre-existing medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended short-term exposure limits (STEL) or ceiling values. Unless otherwise noted, the STEL is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit should not be exceeded at any time.

In the United States, OELs have been established by federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits; others are recommendations.

- The U.S. Department of Labor OSHA PELs (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits. These limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH RELs are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2010]. NIOSH also recommends risk management practices (e.g., engineering controls, safe work practices, employee education/training, PPE, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects.
- Another set of OELs commonly used and cited in the United States is the ACGIH TLVs. The TLVs are developed by committee members of this professional organization from a review of the published, peer-reviewed literature. TLVs are not consensus standards. They are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2017].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at http://www.dguv.de/ifa/GESTIS/GESTIS-Internationale-Grenzwerte-für-chemische-Substanzen-limit-values-for-chemical-agents/index-2.jsp, contains international limits for more than 2,000 hazardous substances and is updated periodically.

OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970 (Public Law 91–596, sec. 5(a)(1))]. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions. NIOSH investigators also encourage use of the hierarchy of controls approach to eliminate or minimize workplace hazards. This includes, in order of preference, the use of (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) PPE (e.g., respiratory protection, gloves, eye protection, hearing protection). Control banding, a qualitative risk assessment and risk management tool, is a complementary approach to protecting employee health. Control banding focuses on how broad categories of risk should be managed. Information on control banding is available at http://www.cdc.gov/niosh/topics/ctrlbanding/. This approach can be applied in situations where OELs have not been established or can be used to supplement existing OELs.

Diacetyl and 2,3-pentanedione

Diacetyl (2,3-butanedione) and 2,3-pentanedione, a diacetyl substitute, are VOCs with an intense buttery flavor. Exposure to diacetyl is associated with an increased risk for severe lung disease and lung function decline [NIOSH 2016]. Irreversible lung disease, such as obliterative bronchiolitis, has been reported in employees in industries with diacetyl exposures [Kreiss 2007; van Rooy et al. 2007]. Severe airway damage and disease has also been observed in laboratory animals after exposure to diacetyl or 2,3-pentanedione [Hubbs et al. 2008; Morgan et al. 2012]. Because of the potential health effects associated with diacetyl and 2,3-pentanedione exposure, NIOSH has a REL and 15-minute STEL for both of these flavoring chemicals. NIOSH RELs are intended to protect workers exposed to diacetyl or 2,3-pentanedione for a 45-year working lifetime. The REL for diacetyl is based on a quantitative risk assessment which necessarily contains assumptions and some uncertainty. Analytical limitations current at the time were taken into consideration in setting the REL for 2,3-pentanedione. The RELs should be used as a guideline to indicate when steps should be taken to reduce exposures in the workplace. The NIOSH REL is 5 ppb for diacetyl with a STEL of 25 ppb. NIOSH also has an action level of 2.6 ppb for diacetyl. The REL for 2,3-pentanedione is 9.3 ppb, and the STEL is 31 ppb [NIOSH 2016]. The higher REL and STEL for 2,3-pentanedione does not imply that 2,3-pentanedione is of lower toxicity than diacetyl. Rather, the REL and STEL for 2,3-pentanedione are based upon the lowest level at which the substance reliably can be detected using the existing validated analytical method [NIOSH 2016].

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Keywords: North American Industry Classification System (NAICS) 453991 (Tobacco Stores), Texas, Vaping, E-Cigarette, Diacetyl, 2,3-Pentanedione, 2,3-Hexanedione, Formaldehyde, Nicotine, Metals, Propylene Glycol, Acetaldehyde, Acetoin, VOCs, Vape Shop, Flavorings

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The Health Hazard Evaluation Program investigates possible health hazards in the workplace under the authority of the Occupational Safety and Health Act of 1970 (29 U.S.C. § 669(a)(6)). The Health Hazard Evaluation Program also provides, upon request, technical assistance to federal, state, and local agencies to investigate occupational health hazards and to prevent occupational disease or injury. Regulations guiding the Program can be found in Title 42, Code of Federal Regulations, Part 85; Requests for Health Hazard Evaluations (42 CFR Part 85).

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Acknowledgments

Analytical Support: Maxxam Analytics
Desktop Publisher: Shawna Watts
Editor: Ellen Galloway
Industrial Hygiene Field Assistance: Matthew Duling, Stephen Jackson
Logistics: Donnie Booher, Kevin Moore, Emily Hall, Heidi Bojes

Availability of Report

Copies of this report have been sent to the employer and employees at the facility. The state and local health department and the Occupational Safety and Health Administration Regional Office have also received a copy. This report is not copyrighted and may be freely reproduced.

Recommended citation for this report:

NIOSH [2018]. Evaluation of chemical exposures at two vape shops in Texas. By Zwack LM, Chiu S, LeBouf RF. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Health Hazard Evaluation Report 2016-0120-3307, http://www.cdc.gov/niosh/hhe/reports/pdfs/2016-0120-3307.pdf.

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