Electronic Cigarettes in the Indoor Environment

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Protecting Worker Health
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Courtesy of John P. (Jack) Springston Jr., MS, CIH, CSP
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Thanks, Jack!
Anatomy of an E-Cigarette

**LED**
Lights up when inhaled to simulate a lit cigarette. It also lets you know if the battery is working or running low.

**Battery**
Most kits come with two rechargeable lithium 3.7 volt batteries. The battery is what makes the device work by charging the atomizer to produce the vapor.

**Cartridge**
Holds the liquid, that comes in different strengths and flavors, in the tip of the vaporizer.

**Metal Mesh Dome**

**How it works**

**The Atomizer**
When a user inhales the personal vaporizer, the rechargeable battery in the device creates a solid contact with positive and negative wires inside the metal casing of the atomizer that turns it on to produce the vapor in the metal mesh dome. It then pulls the liquid from the cartridge to produce the vapor. The virtually odorless vapor that simulates smoke quickly dissipates in the air when exhaled.
First Generation ECs (‘cigalikes’)

- Disposable
- Re-chargeable with pre-filled cartridges
Second Generation ECs

- Refillable with liquids
Third Generation ECs (‘mods’)
Statistics

• More than 460 different e-brands currently on the market*
• Over 7,700 unique e-cigarette flavors*
  * As of January 2014
• China produces approximately 90 percent of the world’s e-cigarettes
• Chinese manufacturers are expected to ship more than 300 million e-cigarettes to the US and Europe this year


Statistics

• E-cigarette sales in the U.S. were estimated at $2.2 billion in 2014
• Sales expected to grow nearly 50% per year through 2018
• In 2014, an estimated 2.5 million middle and high school students used e-cigarettes
• In 2015, this number increased to more than 3 million
Statistics

• There is some evidence that e-cigarette use is prospectively associated with increased risk of combustible tobacco use initiation during early adolescence.

• An estimated 16% of U.S. tenth graders have tried e-cigarettes, of whom 43% have never smoked combustible cigarettes (August, 2015).

• Among high school students that were electronic nicotine delivery system (ENDS) users, 25% went on to be conventional tobacco product users, compared with 9% in the population that had never used an ENDS.


Primary Components

- Propylene Glycol/Vegetable Glycerin
- Nicotine
- Flavorings

- Typical makeup is 70%v VG, 30%v PG, 20 mg/mL nicotine, non-flavored

Propylene Glycol/Vegetable Glycerin

- Used in theatrical fog
  - Exposure may contribute to both acute and chronic health issues, such as asthma, wheezing, chest tightness, decreased lung function, respiratory irritation, and airway obstruction*

Propylene Glycol/ Vegetable Glycerin

- Pyrolysis/heating glycerin forms acrolein, formaldehyde and acetaldehyde in the vapors


Uchiyama, S., K. Ohta, Y. Inaba, & N. Kunugita. (2013). Determination of carbonyl compounds generated from the e-cigarette using coupled silica cartridges impregnated with hydroquinone and 2,4-dinitrophenylhydrazine, followed by high-performance liquid chromatography. *Analytical Sciences, 29* (12), 1219-1222
Formaldehyde

- A known degradation product of propylene glycol and glycerin
- Found in vapor and in small amounts in some studies of some liquids
- Higher airborne concentrations with higher voltage second and third generation units
- Known human carcinogen
Acrolein

- Causes irritation to the nasal cavity, damage to the lining of the lungs and is thought to contribute to cardiovascular disease in cigarette smokers
- Found in vapor only (formed as a result of heating process)
Nicotine

- **Health Effects**
  - Addictive
  - Teratogenic
  - Increases heart rate, respiratory rate, blood pressure, and level of alertness

- **E-Cig Labeling**
  - Some cartridges labeled as containing no nicotine did, in fact, contain detectable levels of nicotine
  - Concentration and delivery inconsistencies

- **Nicotine found in the vapor, but lower than found emitted from conventional cigarettes**
Poison center calls involving e-cigarettes

215 Calls per Month

1 Call per Month

September 2010 to February 2014
The first reported child’s death from accidently ingesting e-liquid was in early December of 2014 involving a 1-year old in Fort Plain, New York.
Flavorings

- BANANA NUT BREAD
- BLACK MAMBO
- BLU SPOT
- BLUEBERRY COBBLER
- BLUE RAZ COTTON CAN
- BUBBLE GUM
- CHERRY LIMEADE
- CHOCO LOCO TOBACCO
- FROZEN LIME DROP
- FRESH STRAWBERRY
Other Additives

Other Additives
Generally Recognized as Safe (GRAS)?
Bronchiolitis obliterans and consumer exposure to butter-flavored microwave popcorn: a case series.

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Abstract
Respiratory exposure to diacetyl and diacetyl-containing flavorings used in butter-flavored microwave popcorn (BFMP) causes lung disease, including bronchiolitis obliterans (BO), in flavorings and popcorn manufacturing workers. However, there are no published reports of lung disease among BFMP consumers. We present a case series of three BFMP consumers with biopsy-confirmed BO. We review data relating to consumer exposures, estimate case exposures, and compare them to diacetyl-containing flavoring-exposed manufacturing workers with lung disease. These consumer cases' exposure levels are comparable to those that caused disease in workers. We were unable to identify any other exposures or diseases known or suspected to cause BO in these cases. BFMP poses a significant respiratory risk to consumers. Some manufacturers have substituted diacetyl with other alpha-diketones that are likely to pose a similar risk. Simple consumer practices such as cooling the popcorn bag would eliminate the risk of severe lung disease.

PMID: 22550695 [PubMed - in process]
Diacetyl as a food additive is GRAS, but aerosolized exposures can cause bronchiolitis obliterans.
Diacetyl and Acetyl Propionyl

- Diacetyl and acetyl propionyl are GRAS but are associated with respiratory disease when inhaled
  - The risks associated with inhalation of acetyl propionyl may be as high as from diacetyl based on inhalation studies with rats
- 159 samples purchased from 36 manufacturer and retailers in 7 countries*
- Diacetyl and acetyl propionyl were found in 74.2% of the samples
  - Even found in samples from manufacturers who clearly stated that these chemicals were not present

Flavoring Concerns

• No research on potential health effects of aerosolized vapor exposure
• No research on pyrolysis products of flavorings
• Manufacturing of many flavoring sources are outside the US (China)
Flavoring Concerns

- Benzaldehyde was detected in cherry flavoring, but also in 75% of 145 e-cig refill liquids*
  - Cytotoxic and genotoxic to cell cultures
- Cinnamaldehyde present in 51% of 39 refill liquids*
  - Highly cytotoxic
- Methyl anthranilate was detected in grape flavoring
- 1-hexanol was detected in apple flavoring

Additional Potential Exposures

- Tobacco-Specific Nitrosamines (TSNAs)
- Acetic Acid
- BTEX
- Isoprene
- Diethylene Glycol (antifreeze)*

Tobacco-Specific Nitrosamines (TSNAs)

- Some TSNAs are known human carcinogens and are suspected to contribute to the cancer burden of smokers
- Small amounts of TSNAs have been found in e-liquids and vapor
- Residual nicotine from tobacco smoke has been shown to react with ambient nitrous acid to form TSNAs over time
  - Third-hand exposure?

Additional Potential Exposures

- Tin
- Lead
- Nickel
- Zinc
- Copper
- Chromium
- Silicon fibers
- Nanoparticles
Some Reported Health Effects

- Mouth and throat irritation
- Dry cough
- Nausea
- Dizziness
- Changes in heart rhythm
- Changes in blood pressure

E-cigarette aerosol contains at least 10 chemicals on California’s Prop 65 list of chemicals known to cause cancer, birth defects or other reproductive harm.
Second-Hand Exposure Concerns

- Nicotine (teratogen and addictive)*
- Flavorings (nut and other allergies)
- Formaldehyde (carcinogen)
- Acrolein (listed as a Hazardous Air Pollutant by the EPA)
- Acetaldehyde (possible human carcinogen)
- Fine/ultrafine particles
- Tin, lead, nickel, chromium

*Nicotine levels have been measured in an exposure chamber at levels approximately 10 times below that of traditional cigarette emissions

Cloud Chasing

https://www.youtube.com/watch?v=ZgouBVNIItQA
Second-hand Emissions

- Most vapers don’t go to that extreme, and with stealth vaping, they purposely retain the vapor
- St. Helen et al. determined that systemic retention of nicotine from e-cigarettes is high, averaging 94% (meaning only 6% of the nicotine is emitted) and little to no aerosol is seen when individuals ‘stealth vape’
- Many research protocols use a puffing machine that does not represent what the user emits, but instead, what the device emits
- Be sure to review how the data were collected to understand the implications

Safety Issues

- Several incidents of fires and explosions have been reported from the lithium-ion batteries used to charge e-cigarettes.

- Most common causes of fires have been using incorrect chargers or over-tightening of the screwed connection to the charger, which can damage the battery cells and lead to overheating.

- Many lithium–ion batteries used in e-cigarettes do not have overcurrent or overcharge protection, so if they are left charging, the coil can overheat and cause the battery to explode.
Long Term Public Health Issues?

- In 10, 20, 30 years, we could have an entire generation of vapers with unforeseen health effects (COPD, asthma, ???)
- Long term public health implications?
WHO

- The World Health Organization (WHO) has recommended that consumers be strongly advised not to use electronic nicotine delivery systems, including e-cigarettes, until they are deemed safe and effective and of acceptable quality by a competent national regulatory body.
Food and Drug Administration (FDA)

- August 8, 2016, the FDA regulation banning the sale of e-cigarettes to minors became effective.
  - Photo ID required
  - Retailers may not hand out free samples
  - No sales in vending machines
- The FDA now requires manufacturers, importers, and retailers to report ingredients and place health warnings on products and advertisements
- Vape shops that mix e-liquids will be regulated as a retailer and a manufacturer
Food and Drug Administration (FDA)

Manufacturers must:
- Stop distributing products that claim it is a modified risk tobacco product
- Register their establishments and submit a list of products, including labeling and advertisements
- Submit tobacco health documents by 2017
- Submit ingredient listing by 2017
- Submit a premarket application for “new” tobacco products
NIOSH

• NIOSH Current Intelligence Bulletin 67 published April 2, 2015 recommends that employers “establish and maintain smoke-free workplaces that protect those in workplaces from involuntary, secondhand exposures to tobacco smoke and airborne emissions from e-cigarettes and other electronic nicotine delivery systems.” (emphasis added)
ASHRAE Standard 62.1 contains requirements for ventilation of spaces that are free of environmental tobacco smoke (ETS).

Also contains requirements for separation of an ETS-free area from any spaces containing ETS.

Addendum c to ANSI/ASHRAE Standard 62.1-2013 clarifies that the definition of ETS “includes smoke produced from the combustion of cannabis and controlled substances and the emissions produced by electronic smoking devices.”

“The existing requirements for separation of ETS-free spaces from ETS spaces remains unchanged.”
ETS-free areas at positive pressure to ETS areas

Solid walls, floors, ceiling, and doors with automatic closing mechanisms to separate ETS areas from ETS-free areas

No recirculation or transfer of air from ETS area to ETS-free area

Signage for ETS areas
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Recommendation:

“E-cigarettes should be considered a source of volatile organic compounds (VOCs) and particulates in the indoor environment that have not been thoroughly characterized or evaluated for safety.”*

*Quoted by NIOSH in the 2015 Current Intelligence Bulletin 67 “Promoting Disease and Injury Through Workplace Tobacco Policies”
Research on e-cigarettes should be conducted in at least the following areas:

1. Health effects from inhaling e-cigarette ingredients that are reported to be generally recognized as safe (GRAS) via ingestion, but which have not yet been evaluated for inhalation toxicity, as well as their thermal degradation products;

2. Effects of second-hand emissions, third-hand exposures, and nicotine addiction from e-cigarettes;

3. Understanding the dynamics of pre- and post-respiration aerosols and their fate in the environment; and

4. Lifecycle and end-of-use issues.*
Life Cycle Issues

• Some are single use or disposable
• Lithium ion batteries
• Nicotine (acute hazardous waste)
  o EPA: “unused (unsold, expired, or returned) nicotine-containing products, including patches, gums, lozenges, inhalers, nasal sprays, and e-cigarettes, are classified as P075 listed acute hazardous wastes when discarded.”

• Some manufacturers offer recycling programs
• There is at least one disposal company that is disassembling the components, recycling the batteries, metal, and plastic components that can be recycled, then disposing of the nicotine by incineration.
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Four areas of regulation relating to the safety of primary users and people exposed to second-hand vapors or e-juice products should be considered:

1. All e-cigarette devices, whether they are used for therapeutic or recreational purposes, should be evaluated for potential physical and/or electrical hazards by a regulatory agency;

2. The health risks and economic consequences of accidental exposure to e-juices by children, adults and pets should be addressed, including proper labeling and child-resistant packaging requirements;
Risk-based regulation recommendations (cont.):

3. All future e-juice components that may be used by consumers should be fully evaluated for any potential hazards (e.g., toxicity, flammability, safety hazards, secondary exposures, etc.) prior to introduction into the marketplace; and

4. As e-cigarettes are a source of pollutants, their use in indoor environments should be restricted, consistent with current smoking bans, until, and unless, research documents that they will not significantly increase the risk of adverse health effects to occupants.
Resources

• AIHA White Paper: *Electronic Cigarettes in the Indoor Environment*
  

• NIOSH *Current Intelligence Bulletin 67: Promoting Health and Preventing Disease and Injury Through Workplace Tobacco Policies*
  

• ANSI/ASHRAE Addenda a, c, j, k, q, r, and s to ANSI/ASHRAE Standard 62.1-2013: *Ventilation for Acceptable Indoor Air Quality*
  
Questions?

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