E-cigarettes and Vaping: Chemistry and Toxicology Considerations

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Disclosure

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What are e-cigarettes?

- “Cig-a-like” (~2007)

- Version 1

- Version 2

- Version 3

- Version 4
What are e-cigarettes?

*“Cig-a-like”* (~2007)
Tank system
Mod
E-cigarette
E-pipe
E-hookah

- Nicotine liquid
- Heating element
- Power source

How many U.S. adults are using e-cigarettes?

- 23% of all people
- 25% of all men
- 19% of all women

Hu et al. Prev Chronic Dis 2019;16:180362
There are more e-cigarette users than smokers

Percentage of adult e-cigarette users who are also cigarette smokers

Percentage of adult e-cigarette users who never smoked tobacco cigarettes
E-cigarette use among youth is on the rise

Are there harmful consequences from e-cigarettes?

Harm from smoking is due to toxic and cancer-causing chemicals in cigarette smoke
What is in e-cigarettes?

Nicotine is almost always present in e-cigarettes

How nicotine works

Nicotine is almost always present in e-cigarettes

• Typically 6 – 24 mg/mL
• Nicotine is mostly in harsh form
• High levels of nicotine are hard to inhale

• Up to 65 mg/mL
• Nicotine is present as salt
• High levels of nicotine are easy to inhale

How nicotine works

Receivers: Normal acetylcholine and receptors

New Smoker: Too much activity at acetylcholine receptors

Addicted Smoker: Less acetylcholine and fewer receptors

Quitting Smoking: Not enough acetylcholine and receptors
Reasons behind JUUL popularity among youth

- Advertising
- High nicotine content
- JUUL and other “pods”


Effects of nicotine on adolescents

- Brain vulnerability to the neural remodeling from nicotine exposure
- Alterations in cognition (memory, attention, auditory processing) and behavior (impulsivity, anxiety)
- Greater susceptibility to the addictive effects of nicotine
- Potential predisposition to other substances of abuse
Are e-cigarettes safe?

Other chemicals in e-liquids:

- Nicotine
- Propylene glycol (PG)
- Vegetable glycerin (VG)
- Contaminants
- Flavoring chemicals

*It is not just nicotine and water!*

- more than 7,000 unique flavors in 2014

Zhu et al. Tob Control 2015;24:5-3.
Aerosols are more complex than liquids

- Nicotine
- Propylene glycol (PG)
- Vegetable glycerin (VG)
- Flavouring agents
- Contaminants

Aerosols

- Nicotine
- Propylene glycol (PG)
- Vegetable glycerin (VG)
- Volatile organic chemicals
- Metals
- Ultrafine particles
- Other

E-liquids produce harmful chemicals during “vaping”

Decomposition of solvent components (propylene glycol and vegetable glycerin):

- Irritants
- Respiratory toxicants
- Carcinogens

Carcinogens Can Alter DNA

- ADDUCT
- Formaldehyde
- Acetaldehyde
Levels of harmful chemicals in e-cigarette aerosols depend on device characteristics

Container type
• Volume, material, refillable or disposable (accumulation of toxicants on the wick material, leaching of toxicants)

Power settings
• Higher voltage affects nicotine delivery and formation of toxicants

Heating element characteristics
• Coil resistance is associated with the temperature and also affects nicotine delivery and toxicant formation

E-cigarette, or vaping, product use-associated lung injury (EVALI)

• As of January 21, 2020, a total of 2,711 hospitalized EVALI cases or deaths have been reported to CDC.
• Vitamin E acetate, an additive in some THC-containing e-cigarette products is the likely cause.
• Vitamin E acetate was found in lung fluid samples from 48 of 51 EVALI patients.

Formation of a cancer-causing chemical in e-cigarette users

- Nitrate (diet)
- Nitrite (can also be present in diet)
- Nornicotine
- Endogenous nitrosation
- Bacteria (natural oral microflora)
- Acidic environment

- NNN Can cause cancer of the mouth and esophagus

Bustamante et al. Chemical Research in Toxicology, 2018
Is there anything good about e-cigarettes?

Exposures to many harmful chemicals are lower from exclusive use of e-cigarettes than from cigarettes

Biomarker-based studies

Exposures to many harmful chemicals are lower from exclusive use of e-cigarettes than from cigarettes

Relative levels of biomarkers

- Acrolein
- Crotonaldehyde
- Benzene
- NNK

Hecht et al. Nicotine & Tobacco Research 2014
Complete switching is necessary to reduce exposures!

Exposure to a tobacco-specific lung carcinogen NNK

Exposure to acrolein

E-cigarettes may help adult addicted smokers

- E-cigarettes may help non-pregnant adult smokers if used as a complete substitute for all cigarettes and other smoked tobacco products
- E-cigarettes are not currently approved by the FDA as a quit smoking aid

Fetal effects of nicotine

Prenatal nicotine/tobacco exposure negatively affects:

- Fetal brain and neuronal development
- Arousal and hypoxic stress response
- Stress hormone regulation
- In utero lung development (decreased pulmonary function)
- Auditory processing
- Cognitive development
What is the bottom line?

Harmful

Potentially helpful

Regulation of contents is necessary!

Research is needed:
- Effects of long-term use
- Effects of dual use
- Effects in people with various health issues

It depends who is using e-cigarettes, and where they are getting the product

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