The Health Effects of E-Cigarette Use
LEARNING OBJECTIVES

At the end of this session, participants will be able to:

• Describe the link between e-cigarettes and future initiation of cigarette use
• Understand that youth are uniquely susceptible to nicotine addiction
• Name common safety risks of e-cigarettes
• Discuss the science related to long-term health risks
**A Note about Risks**

• While there is growing evidence of the health effects of e-cigarette use, more research is needed and ongoing

• The symbol “▲” indicates that the presented data is emerging and will be updated as new evidence is published
Known and potential risks

- **Risks**
  1. Initiation of combustible tobacco products
  2. Nicotine addiction
  3. Safety risks
  4. E-cigarettes are not a cessation device
  5. Long term health risks
Link to Future Initiation of Combustible Tobacco Products
Cigarette Smoking Initiation

Association Between Initial Use of e-Cigarettes and Subsequent Cigarette Smoking Among Adolescents and Young Adults

Soneji, et al. JAMA Pediatrics 2017

- Meta-analysis of 7 longitudinal studies of youth
- “Strong and consistent evidence” of an association between e-cigarette use and future cigarette use
- E-cigarette users are 3.5 times more likely to initiate cigarette use than non-users
Conclusion 16-1: There is substantial evidence that e-cigarette use increases risk of ever using combustible tobacco cigarettes among youth and young adults.²
Nicotine Addiction
**What is Nicotine?**

- Nicotine is considered a toxin
- Nicotine is the primary psychoactive ingredient in tobacco
- Nicotine is commercially available almost exclusively from the *Nicotiana tabacum*, commonly known as the tobacco plant
- There are e-cigarette solutions that claim no nicotine
MEASURING NICOTINE DEPENDENCE

• When assessing a teen’s readiness to quit, it may be helpful to show the teen that they are addicted to nicotine

• Pediatricians can consider using a practice tool to assess an adolescent’s level of dependence on nicotine

• Some options:
  – **Hooked on Nicotine Checklist** (tailored for e-cigarettes or traditional tobacco products)\(^3\)
  – **E-Cigarette Dependence Scale**\(^4\)
  – **Modified Version of the Fagerstrom Tolerance Questionnaire (mFTQ)**\(^5\)
  – **DSM-5** for tobacco use disorder\(^6\)
**Nicotine Effects: “The Good”**

- Decreases the appetite
  - For this reason, the fear of weight gain affects some people's willingness to stop smoking
- Boosts mood
- May relieve minor depression
- Many people feel a sense of well-being
- Stimulates memory and alertness
  - People who use tobacco often depend on it to help them accomplish certain tasks and perform well
- Re-dosing prevents withdrawal
NICOTINE EFFECTS: “THE BAD”

Toxic Effects:
- Nausea and vomiting
- Excessive salivation
- Abdominal pain
- Sweating
- High blood pressure
- High heart rate
- Balance problems
- Tremor
- Headache
- Dizziness
- Muscle twitching
- Seizures
NICOTINE WITHDRAWAL: “THE UGLY”

- Irritability
- Frustration
- Increased Appetite
- Anger
- Anxiety
- Depression
- Difficulty Concentrating
- Tremors
- Insomnia
NICOTINE ADDICTION

The adolescent brain is uniquely vulnerable to the rewarding effects of nicotine. \(^7\)
NICOTINE ADDICTION

Youth who use e-cigarettes are at risk for nicotine-induced neural and behavioral alterations, including:  

• A strong desire or sense of compulsion to take the substance
• A persistent desire or unsuccessful efforts to reduce or control substance use
• A physiological withdrawal state when use is reduced or ceased
• Use of the same (or closely related) substance with the intention of relieving or avoiding withdrawal symptoms
• Tolerance to the effects of the substance
• Preoccupation with substance use
• Persistent substance use despite clear evidence of harmful consequences
NICOTINE ADDICTION

E-cigarettes can deliver higher levels of nicotine than traditional cigarettes.\(^9\)

Pod system e-liquids (including JUUL):

63% Of JUUL users do not know that the product always contains nicotine.\(^{10}\)
Nicotine dependence, indicated by craving, starts *prior* to daily or regular use. Interventions may be delivered at any stage.
NICOTINE SALTS

• Designed to deliver more nicotine and with less throat irritation, compared to closed system devices\textsuperscript{12}
• Contribute to more frequent use, increasing potential for addiction
• All salt-based e-juice and liquid contains nicotine (ie, JUUL)
Nicotine salts allow high levels of nicotine to be inhaled more easily.

Nicotine Salts

Free Base Nicotine

Benzoic Acid

Acidic

Neutral

Alkaline

Slide adapted with permission from Centers for Disease Control and Prevention
SAFETY RISKS

• Poisonings
  – Can occur via ingestion or transdermal
  – 8,269 liquid nicotine exposures reported in children from 2012-2017\textsuperscript{13}
  – Child-resistant packaging laws associated with decreasing exposure

• Symptoms of nicotine poisoning:
  – Vomiting
  – A fast heartbeat
  – Jittery and unsteady appearance
  – Difficulty breathing
  – Increased saliva
NICOTINE TOXICITY

- E-cigarette solutions have a range of nicotine strengths
- Mid-range: 36mg/ml of nicotine
  \[\downarrow\]
  15 ml (1 tablespoon) = 540 mg nicotine
- Ingestion of 0.8 mg/kg can induce mild GI symptoms
- Ingestion of 1.4-1.9 mg/kg may induce severe toxicity
- The lethal dose has been estimated as between 0.8-13 mg/kg\textsuperscript{14}

A teaspoon of liquid nicotine can be fatal to a 10 kg child.
SAFETY RISKS

• **Burns**
  - 2,035 explosion and burn injuries seen in US Emergency Departments from 2015-2017\(^1\)
    - Patients were primarily young (median age 26 years)
    - 94% of patients were male
    - Severity varied:
      - ~ 69% treated and released
      - ~ 26% admitted/held for observation
    - Location varied:
      - ~ 61% upper leg
      - ~ 25% hands/fingers
Long-Term Health Risks
E-CIGARETTE EMISSIONS

Conclusion 5-1: There is **conclusive** evidence that in addition to nicotine, most e-cigarette products **contain and emit** numerous potentially toxic substances.²
LONG TERM HEALTH IMPACT

• The health effects are not completely understood
• There is evidence that completely switching to e-cigarettes from cigarettes reduces exposure to toxicants and carcinogens\textsuperscript{4}
• However... “safer” does not mean safe!
• Concerns with:
  – Inhalation of ultrafine particles deep into the lung
  – Exposure to heavy metals in e-cigarette aerosol (nickel, lead, tin)
  – Exposure to volatile organic compounds
There are known and unknown harms from inhaling the chemicals in e-cigarettes:

- Impact on the delivery of chemicals varies based on the device and e-juice characteristics

- We know that some of the compounds found in e-cigarette aerosol are also found in tobacco smoke and are known to be harmful:¹⁶,¹⁷
  - Aldehydes, including acrolein and formaldehyde: ranked as one of the most significant cardiovascular toxins found in cigarette smoke
  - Diacetyl: associated with bronchiolitis obliterans, or “popcorn lung”
Conclusion 11-5: There is limited evidence of adverse effects of e-cigarette exposure on the respiratory system from animal and in vitro studies.²
LONG TERM HEALTH IMPACT

Studies reveal links to cancer, respiratory effects:

  - Mice exposed to e-cigarettes sustained significant DNA damage to lungs, heart, bladder
  - Over a four-year period:
    - 23% developed lung cancer
    - 58% developed precancerous lesions on the bladder

  - Measurable adverse effects on lung health, function, and development
  - Increased risk of respiratory symptoms

  - Adolescent e-cigarette users had increased rates of chronic bronchitic symptoms
HEALTH RISKS

Conclusion 11-4: There is moderate evidence for increased cough and wheeze in adolescents who use e-cigarettes and an association with e-cigarette use and an increase in asthma exacerbations.²
LONG TERM HEALTH IMPACT

Exposure to e-cigarette aerosols during adolescence and early adulthood can result in significant lung impairments:

- McGrath-Morrow et al (2015)— in *PLoS ONE*\(^\text{21}\)
  - Neonatal exposure to aerosol from nicotine-containing e-cigarettes was associated with:
    - Diminished alveolar cell proliferation
    - Impairment in postnatal lung growth

- Sussan et al (2015) – in *PLoS ONE*\(^\text{22}\)
  - Exposure to e-cigarette aerosol for 2 weeks produced significant increases in oxidative stress and impaired pulmonary bacterial clearance

- Laube et al (2017) – in *Inhalation Toxicology*\(^\text{23}\)
  - Daily exposure to propylene glycol and nicotine slowed mucociliary clearance compared with exposure to propylene glycol alone
E-CIGARETTE OR VAPING ASSOCIATED LUNG INJURY (EVALI)²⁴

Demographic and laboratory findings among hospitalized patients, Aug 2019 – Jan 2020:

• **2,668** hospitalized cases or deaths in all 50 states, the District of Columbia, and two US territories (Puerto Rico and US Virgin Islands).

• **60** confirmed deaths in 27 states and the District of Columbia (age range 13-85)
  • More under investigation

• The majority of EVALI patients are male, White, and under 35 years old

• Laboratory data support findings that vitamin E acetate is closely associated with EVALI
  • Vitamin E acetate is used as an additive, most notably in THC-containing e-cigarette, or vaping, products

  • When inhaled, vitamin E acetate may interfere with normal lung functioning
17-year-old male hospitalized for EVALI: shows bilateral consolidations in bilateral lower lungs
16-year-old male hospitalized for EVALI: 
X-ray shows pneumomediastinum and extensive perihilar and lower lobe opacities
E-cigarette or Vaping Associated Lung Injury (EVALI) ²⁴

• CDC recommendations for the public:
  – People should not use vaping products that contain THC
  – People should consider refraining from using vaping products that contain nicotine
  – Youth, young adults, pregnant women, or people who do not currently use tobacco products should never use vaping products

• Recommendations for health care providers:
  – Report possible cases of EVALI to state health department and to the FDA via the online Safety Reporting Portal
  – Take a detailed history of substances used, sources of products, frequency of use
  – Follow guidelines from updated CDC guidance for health care professionals, December 2019

For in-depth information: www.cdc.gov/lunginjury
E-Cigarettes Are Not A Cessation Device
E-cigarettes are not FDA-approved cessation devices: 25,26,27

• Nicotine replacement therapies (NRT) must undergo a rigorous approval process before being made publicly available, including animal and human clinical trials

• This process ensures that products are safe and effective

• E-cigarette companies can go through the FDA-approval process to test their efficacy for tobacco cessation. To date, no e-cigarette company has done so
E-cigarettes are not a Cessation Device

Studies show that using both e-cigarettes and traditional cigarettes during the quitting process is problematic:

- Many cigarette users try to quit by switching to e-cigarettes, but end up continuing to use both products

- With dual use, potential health benefits are reduced, and cardiovascular risks associated with smoking remain the same\(^{28}\) or increase\(^{29}\)

- E-cigarettes may stop individuals from overcoming their nicotine addiction\(^{26,30}\)
E-CIGARETTES ARE NOT A CESSATION DEVICE

There is no conclusive evidence that e-cigarettes are safe or effective for tobacco cessation:

• The US Preventive Services Task Force determined there is insufficient evidence to recommend e-cigarettes as a smoking cessation tool\textsuperscript{31}

• No evidence from randomized control trials that e-cigarette use helps adult smokers quit at a higher rate than smokers who do not use these products\textsuperscript{2,26,32}
Secondhand Exposure to E-Cigarettes
Data about secondhand exposure to e-cigarette aerosol are limited

- Secondhand aerosol from e-cigarettes contains nicotine, propylene glycol, flavorings, and other chemicals\(^{33}\)
- Nonsmokers who are exposed to cigarettes and e-cigarettes have similar cotinine levels, indicating that they take in similar levels of nicotine\(^ {34}\)
- Further research is needed to fully understand the health impacts of secondhand exposure to e-cigarette aerosol\(^ {35}\)
**Key Points**

- E-cigarette use increases youth risk of using combustible cigarettes in the future
- Youth are highly susceptible to nicotine addiction from using e-cigarettes
- E-cigarettes present immediate safety risks, such as burns and poisonings
- Data on the long-term health effects of e-cigarettes are limited, but scientists are concerned about the impacts on respiratory health and potential links to cancer
REFERENCES


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