Electronic Smoking Devices and Secondhand Aerosol

Electronic smoking devices (or ESDs), which are often called **e-cigarettes**, heat and vaporize a solution that typically contains nicotine. The devices are metal or plastic tubes that contain a cartridge filled with a liquid that is vaporized by a battery-powered heating element. The aerosol is inhaled by the user when they draw on the device, as they would a regular tobacco cigarette, and the user exhales the aerosol into the environment.

"If you are around somebody who is using e-cigarettes, you are breathing an aerosol of exhaled nicotine, ultra-fine particles, volatile organic compounds, and other toxins." Dr. Stanton Glantz, Director for the Center for Tobacco Control Research and Education at the University of California, San Francisco.

Current Legislative Landscape

- As of January 2, 2017, **589 municipalities and 10 states include electronic smoking devices** as products that are prohibited from use in smokefree environments.

Constituents of Secondhand Aerosol

Electronic smoking devices (ESDs) do not just emit "harmless water vapor." **Secondhand aerosol (incorrectly called vapor by the industry) from ESDs contains nicotine, ultrafine particles and low levels of toxins** that are known to cause cancer.

- ESD aerosol is made up of a high concentration of ultrafine particles, and the particle concentration is higher than in conventional tobacco cigarette smoke.[1]
- Exposure to fine and ultrafine particles may exacerbate respiratory ailments like asthma, and constrict arteries which could trigger a heart attack.[2]
- ESD aerosol particles are smaller than 1000 nanometers, which is a similar size to tobacco smoke and diesel engine smoke, and bystanders can be exposed to this aerosol. "The exact size distribution depends on the chemical composition of the electronic cigarette liquid, the e-cigarette device operation, and user vaping preferences."[3]
- At least 10 chemicals identified in ESD aerosol are on California's Proposition 65 list of carcinogens and reproductive toxins, also known as the Safe Drinking Water and Toxic Enforcement Act of 1986. The compounds that have already been identified in mainstream (MS) or secondhand (SS) ESD aerosol include: **Acetaldehyde (MS), Benzene (SS), Cadmium (MS), Formaldehyde (MS,SS), Isoprene (SS), Lead (MS), Nickel (MS), Nicotine (MS, SS), N-Nitrosonornicotine (MS, SS), Toluene (MS, SS).**[4,5]
- **ESDs contain and emit propylene glycol**, a chemical that is used as a base in ESD solution and is one of the primary components in the aerosol emitted by ESDs.
    - Short term exposure causes eye, throat, and airway irritation.[6]
    - Long term inhalation exposure can result in children developing asthma.[7]
- Even though propylene glycol is FDA approved for use in some products, the inhalation of vaporized nicotine in propylene glycol is not. Some studies show that heating propylene glycol changes its chemical composition, producing small amounts of propylene oxide, a known carcinogen.[8]

- There are **metals in ESD aerosol, including chromium, nickel, and tin nanoparticles**.[9]

- FDA scientists found detectable levels of carcinogenic tobacco-specific nitrosamines in ESD aerosol.[10]

- People exposed to ESD aerosol absorb nicotine (measured as cotinine), with one study showing levels comparable to passive smokers.[11]

- **Diethylene Glycol**, a poisonous organic compound, was also detected in ESD aerosol.[12]

- **Exhaled ESD aerosol contained propylene glycol, glycerol, flavorings, and nicotine, along with acetone, formaldehyde, acetaldehyde, propanal, diacetin, and triacitine.[13]**

- Many of the elements identified in the aerosol are known to **cause respiratory distress and disease.** The aerosol contained particles >1 µm comprised of tin, silver, iron, nickel, aluminum, and silicate and nanoparticles (<100 nm) of tin, chromium and nickel. The concentrations of nine of eleven elements in ESD aerosol were higher than or equal to the corresponding concentrations in conventional cigarette smoke.[14]

- ESDs cause exposure to different chemicals than found in conventional cigarettes and there is a need for risk evaluation for both primary and passive exposure to the aerosol in smokers and nonsmokers.[15]

- Short term use of ESD has been shown to increase respiratory resistance and impair lung function, which may result in difficulty breathing.[16]

- The first study to look at exposure to aerosol from ESDs in real-use conditions found that non-smokers who were exposed to conventional cigarette smoke and ESD aerosol absorbed similar levels of nicotine.[17]

- The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) has concluded that ESDs emit harmful chemicals into the air and need to be regulated in the same manner as tobacco smoking. The "E-cigarettes do not produce a vapor (gas), but rather a dense visible aerosol of liquid sub-micron droplets consisting of glycols, nicotine, and other chemicals, some of which are carcinogenic (e.g., formaldehyde, metals like cadmium, lead, & nickel, and nitrosamines)."[18]

- ESD aerosol is a source of high doses of particles being deposited in the human respiratory system.[19]

- ESD exposure damages lung tissues. Human lung cells that are exposed to ESD aerosol and flavorings—especially cinnamon—are show increased oxidative stress and inflammatory responses.[20]

- Concentrations of formaldehyde are higher than concentrations of nicotine in some samples of ESD aerosol. Formaldehyde is created when propylene glycol and glycerol are heated to temperatures reached by commercially available ESDs operating at high voltage.[21]

- Flavorings are a largely unrecognized potential hazard of ESDs. Diacetyl and acetyl propionyl are present in many sweet-flavored ESDs, and are approved by the FDA for food use (ingestion), but are not evaluated and approved for heating and inhalation, and are associated with respiratory disease when inhaled.[22] High doses of diacetyl, used to flavor buttered popcorn, have been shown to cause acute-onset bronchiolitis obliterans, a severe and irreversible obstructive lung disease when inhaled by workers exposed to particulate aerosolized flavorings containing diacetyl.[23] Therefore, these chemicals cannot be deemed "generally recognized as safe" for inhalation.

- Nanoparticles in ESD aerosol are much smaller than the particles in tobacco smoke and are present in much higher concentrations. Toxic chemicals attached to nanoparticles may have greater adverse health effects than when these toxins are attached to larger tobacco smoke particles.[24] Nanoparticles are more easily and deeply breathed into the lungs of the user and bystander.

- ESD aerosols contain carbonyls at levels which can have cardiovascular toxicity. While ESD aerosol has lower levels of toxins than tobacco smoke, toxins from the aerosol may still have a significant cardiovascular impact because cardiovascular disease has a nonlinear dose-response, which means that high risk is possible with relatively low exposure.[25]

- Human lung cells exposed to ESD aerosol and copper nanoparticles show signs of inflammatory stress and DNA fragmentation.[26]

- ESDs that operate using a single-coil heating element produce much higher levels of toxins than double-coil devices across different e-liquids. Double-coil devices produce aerosol at lower temperatures while single-coil devices produce aerosol at higher temperatures.[27]

- There is a risk of thirdhand exposure to nicotine released from ESD aerosol that deposits on indoor surfaces.[28]

- Overall, ESDs are a new source of **Volatile Organic Compounds (VOCs) and ultrafine/fine particles in the indoor environment,** thus resulting in "passive vaping."[29]

- The World Health Organization (WHO) recommends that ESDs not be used indoors, especially in smokefree environments, in order to minimize the risk to bystanders of breathing in the aerosol emitted by the devices and to avoid undermining the enforcement of smokefree laws.[30]

- The National Institute for Occupational Safety and Health (NIOSH) 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."[31]

- The American Industrial Hygiene Association (AIHA) also recommends that ESDs be included in smokefree laws: "***Because e-cigarettes are a potential source of pollutants (such as airborne nicotine, flavorings, and thermal degradation products), their use in the indoor environment 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 room occupants.***"[32]

- The American Public Health Association adopted a resolution, "Supporting Regulation of Electronic Cigarettes," that outlines seven action steps including, "States and municipalities [should] enact and enforce laws…prohibiting the use of e-cigarettes in all enclosed areas of public access and places of employment. These standards should be incorporated into existing clean indoor air laws."[33]

- The American Association for Cancer Research and the American Society of Clinical Oncology supports prohibiting the use of ESDs in smokefree spaces until the safety of second- and thirdhand aerosol exposure is established.[34]

ESD aerosol is a new source of pollution and toxins being emitted into the environment. We do not know the long-term health effects of ESD use and although the industry marketing of the product implies that these products are harmless, the aerosol that ESD emit is not purely water vapor.

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