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Electronic Cigarette Refill Liquids: Child-Resistant Packaging, Nicotine Content, and Sales to Minors^{1,2}

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Purpose: To determine the accuracy of the labeled quantity of the nicotine content of the e-liquids sold in unlicensed vape stores, whether the packaging of e-liquids sold within the vape stores was child-resistant, whether minors were present within vape stores, and whether sales to minors occurred. This study was conducted across North Dakota prior to implementation of a new e-cigarette state law and provided a baseline assessment before enactment of the new legal requirements.

Design and Methods: We tested samples of e-liquids and performed observations in 16 stores that were selling e-cigarettes but were not legally required to be licensed for tobacco retail. The e-liquids were analyzed for nicotine content using a validated high-performance liquid chromatography method for nicotine analysis.

Results: Of the 70 collected e-liquid samples that claimed to contain nicotine, 17% contained more than the labeled quantity and 34% contained less than the labeled quantity by 10% or more, with one sample containing 172% more than the labeled quantity. Of the 94 e-liquid containers sampled, only 35% were determined to be child-resistant. Minors were present in stores, although no sales to minors occurred.

Conclusions: Mislabeling of nicotine in e-liquids is common and exposes the user to the harmful effects of nicotine. The lack of child-resistant packaging for this potentially toxic substance is a serious public health problem. E-cigarettes should be included in the legal definition of tobacco products, child-resistant packaging and nicotine labeling laws should be enacted and strictly enforced, and vape stores should be licensed by states.

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Electronic cigarettes (e-cigarettes) are one type of electronic nicotine delivery system that is experiencing rapid growth in the United States, with sales more than doubling from 2012 to 2013 (Giovenco, Hammond, Corey,

Ambrose, & Delnevo, 2015). E-cigarette makers increased yearly advertising spending from \$6.4 million in 2011 to \$18.3 million in 2012, including marketing on television, where regular cigarette advertising is banned (King, Patel,

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Nguyen, & Dube, 2015). From 2013 to 2014, e-cigarette use by U.S. teenagers tripled, with e-cigarettes now used more than any other tobacco product, including conventional cigarettes (Arrazola et al., 2015; Centers for Disease Control and Prevention [CDC], 2015a). Use among high school students increased from 660,000 students (4.5%) in 2013 to 2 million students (13.4%) in 2014 (CDC, 2015a). E-cigarette use more than tripled among middle school students, from 120,000 students (1.1%) in 2013 to 450,000 students (3.9%) in 2014 (CDC, 2015a). From 2010 to 2013, adults who have used an e-cigarette increased from 3.3% to 8.5%; current and former cigarette smokers who have ever used an e-cigarette increased from 9.8% to 36.5% and from 2.5% to 9.6%, respectively (King et al., 2015).

E-cigarettes include disposable and reusable products. At its most basic, e-cigarettes include a container of liquid that is often, but not always, a nicotine solution; a battery or other power source; an aerosol generator that heats the nicotine and other chemicals; and a flow sensor (Brown & Cheng, 2014). The aerosol generator turns the liquid into an aerosol that is inhaled by the user. Of interest to this study was the e-cigarette liquid refill solution (e-liquid; Pepper & Eisenberg, 2014). E-liquids can be purchased separately from the e-cigarette and typically contain nicotine, flavors, and solvent chemicals, including polyethylene glycol and vegetable glycerin, but may also contain contaminants, such as diethylene glycol, heavy metals, and potential carcinogens, such as nitrosamines (Cheng, 2014; Orellana-Barrios, Payne, Mulkey, & Nugent, 2015). This study did not assess substances, legal or illegal, added by consumers after purchase.

Public health officials are concerned that e-cigarette use among youth will become a gateway to regular cigarettes and other tobacco products. E-cigarettes often have attractive packaging and flavored liquids that appeal to youth. Nicotine negatively affects fetal lung development and fetal and adolescent brain development (England, Bunnell, Pechacek, Tong, & McAfee, 2015). The aerosol released from e-cigarettes contains particulate matter and is not considered as safe as clean air (California Department of Public Health & California Tobacco Control Program, 2015; CDC, 2015b). Additionally, federal regulation and oversight of e-cigarettes and e-liquids are lacking (Orellana-Barrios et al., 2015). A systematic literature search showed several studies in which the labeling of the nicotine content on e-liquid containers varied significantly from the measured actual content; of the six studies that analyzed “refillable solutions,” one reported a range of $\pm 100\%$ deviation from the label (Cheng, 2014). Davis, Dang, Kim, and Talbot (2015) reported that 35 of 54 nicotine fluids varied by more than $\pm 10\%$ from the labeled amount. Hutzler et al. (2014) reported that seven of 10 liquids with claims that they were nicotine free contained 0.1 to 15 mg/mL of nicotine.

A study by the Salt Lake County Health Department (2014) in Utah showed that the advertised nicotine content of e-liquids was not consistent with the actual nicotine content; 61% of the e-liquids that did not list a nicotine amount of

zero differed by at least 10% of the labeled nicotine content. The difference ranged from 88% less to 840% more than advertised. Additionally, 28% of the samples that had listed amounts of nicotine did not have child-resistant caps. E-liquids are not federally required to have child-resistant packaging (Orellana-Barrios et al., 2015).

In North Dakota (ND), legislation enacted August 1, 2015 (NDCC § 12.1-31-03.2.1), prohibits the sale of e-cigarettes to minors and requires child-resistant packaging for liquid nicotine containers per federal standards (North Dakota Legislative Council, 2015; Sixty-Fourth Legislative Assembly of North Dakota, 2015). The number of calls to U.S. poison centers related to human exposure to e-cigarettes (exposure calls) has dramatically increased, from one in September 2010 to 215 in February 2014, representing a 47% proportionate increase in e-cigarette exposure calls within the total e-cigarette and conventional cigarette exposure calls (Chatham-Stephens et al., 2014). From September 2010 to February 2014, 2405 e-cigarette exposure calls occurred. Slightly more than half involved children younger than 5 years of age. E-cigarette-related poisoning can occur through ingestion, inhalation, or absorption through the skin or eyes, commonly resulting in nausea, vomiting, and eye irritation. The American Association of Poison Control Centers (2014) supports federal legislation to require child-proof packaging for liquid nicotine because of the death of a 1-year-old, possibly due to ingestion of liquid nicotine (Hugher, 2014).

The purposes of this study were to determine the accuracy of the labeled quantity of the nicotine content of the e-liquid containers sold in unlicensed vape stores; to determine whether the packaging of e-liquids sold in vape stores was child-resistant; and to assess for the presence of minors within vape stores. We also assessed for any sales to minors of e-cigarettes, e-liquid, or other tobacco products within the vape store.

Methods

The settings for this cross-sectional study were 16 unlicensed vape stores across ND prior to implementation of the state’s e-cigarette law. Data collection occurred from June 9, 2015, to June 16, 2015, between 10:00 am and 2:30 pm. The data collection form was based on questionnaires used by the Salt Lake County Health Department and the North Dakota Center for Tobacco Prevention and Control Policy questionnaires, which were modified with permission. The study was determined to be exempt by the appropriate institutional review board.

We included stores that sold e-cigarettes but did not have a license to sell tobacco products. When the study was conducted, a state license was not required for stores that sold e-cigarettes because they were not considered a tobacco product (ND State Attorney General’s Office, personal communication, May 2015). We evaluated these stores because they were comparatively new and were considered unlikely to be compliant with the prohibition against the sale

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