



## Short Communication

# Do you vape? Leveraging electronic health records to assess clinician documentation of electronic nicotine delivery system use among adolescents and adults



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## ABSTRACT

Use of electronic nicotine delivery systems (ENDS) has increased substantially over the past decade. However, unlike smoking, which is systematically captured by clinicians through routine screening and discrete documentation fields in the electronic health record (EHR), unknown is the extent to which clinicians are documenting patients' use of ENDS.

Data were gathered from medical visits with patients aged 12 and older ( $N = 9,119$ ; 55% male) treated in a large, integrated healthcare system. We used natural language processing to assess the incidence rates of clinician documentation of patients' ENDS use in unstructured tobacco comments in the EHR, and the words most frequently documented in relation to ENDS, from 2006–2015.

ENDS documentation in the EHR increased dramatically over time (from 0.01 to 9.5 per 10,000 patients,  $p < 0.0001$ ), particularly among adults aged 18–24 and 25–44. Most prevalent were “e-cig,” “electronic cigarettes,” and “vape,” with much variation in spelling and phrasing of these words. Records of adolescent and young adult patients were more likely to contain the word “vape,” and less likely to have “e-cig” and “electronic cigarette” than records of adults ( $ps < 0.0001$ ). The relatively low observed number of patients with ENDS terms in the EHR suggested vast under documentation.

While healthcare providers are increasingly documenting patients' use of ENDS in the EHR, overall documentation rates remain low. Discrete EHR fields for standard screening and documentation of ENDS that reflect the language used by patients would provide more complete longitudinal population-level surveillance of ENDS use and its association with short- and long-term health outcomes.

## 1. Introduction

Electronic nicotine delivery systems (ENDS), including e-cigarettes, have become increasingly popular since entering the US market in 2007 (Singh et al., 2016; King et al., 2015). While there is some evidence that ENDS may be safer nicotine delivery products than combustible cigarettes (Farsalinos and Polosa, 2014; McRobbie et al., 2014; Farsalinos et al., 2016; Nolan et al., 2016) and may help some people quit smoking (Hartmann-Boyce et al., 2016), their long-term safety and potential for harm and harm reduction are unknown. To be able to assess the long-

term population health effects associated with ENDS use, researchers need the means to accurately identify the incidence and prevalence of ENDS use across the lifespan.

ENDS surveillance is limited in that many nationally representative surveys are conducted infrequently with a substantial lag between time of data collection and publication of results (Ayers et al., 2016). Tracking ENDS use through routine documentation within healthcare visits could yield important surveillance data for studying population-level harm and harm reduction effects. National guidelines strongly recommend that tobacco screening in healthcare settings be expanded

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to include ENDS questions as part of standard health examinations (American Heart Association, 2016; The American Academy of Pediatrics Issues Sweeping Recommendations on Tobacco and E-Cigarettes, 2015), and healthcare providers are increasingly discussing ENDS use with patients (Nickels et al., 2016; Steinberg et al., 2015; Brown-Johnson et al., 2016). Routine clinician screening and documentation of ENDS use in the EHR could be linked to other healthcare data for retrospective and prospective analyses essential to assessing ENDS' safety and harm reduction effectiveness.

Currently, healthcare system surveillance of ENDS is limited because few healthcare systems have discrete EHR fields for ENDS documentation, clinicians receive little training on ENDS screening, and in general, clinicians inconsistently document use in free-text comment fields (Winden et al., 2015). Qualitative research has demonstrated differences in ENDS terminology by consumer age group and product type, suggesting that screening questions should reflect the range of terms used by patients (Alexander et al., 2016). These challenges currently limit the ability of healthcare systems to systematically screen for, detect, and monitor this key emerging health behavior.

To better guide the development of ENDS surveillance in healthcare systems, we sought to: 1) describe trends in how clinicians document ENDS use in the free-text comments of the EHR in a large integrated healthcare system from 2006 to 2015, stratified by patient age, and 2) compare the terms used to document ENDS use among adolescents and adults.

## 2. Methods

### 2.1. Data source

Data were gathered from medical visits with patients aged 12 and older within Kaiser Permanente Northern California (KPNC) between 2006 and 2015. KPNC is a nonprofit healthcare delivery system serving 4 million members. KPNC provides integrated medical and behavioral health treatment to a racially and socioeconomically diverse patient population that is representative of the geographic catchment area (Gordon, 2006). To construct our sample, we identified KPNC members with any text in the tobacco comments section of the EHR from 2006 to 2015.

### 2.2. Measures

Using natural language processing, we identified provider documentation of ENDS use in the tobacco comments field of the social history section of the KPNC EHR (i.e., free-text comment fields unrelated to tobacco were not included). We created a list of specific keywords appearing within free text fields that refer to ENDS, such as “e-cig”, “electronic”, or “vape” that was informed by commonly used terms in previous ENDS research (Pearson et al., 2017; Cole-Lewis et al., 2015; Myslin et al., 2013), and used the SAS INDEX function (substring match) in an iterative process to identify all variations of these keywords. When we identified a matching text string, we isolated the entire word or candidate text in which the string was embedded. When new potential text strings were found, the full comments were manually reviewed for inclusion, alternative candidate strings, and exclusionary criteria (Appendix A). We only included keywords that referenced ENDS use (e.g., ‘electronic cigarette’ but not ‘electronic signature’). We included the first (earliest) documented reference to ENDS use for each individual in our analyses to estimate the number of *new* documented ENDS users each year. We extracted patient sex, race/ethnicity, age and smoking status (current, former, and never smoker) at the earliest record of documented ENDS use, as well as the department where ENDS was documented, from the EHR.

### 2.3. Analysis

Analyses were performed using SAS® software, version 9.3. We first calculated the annual incidence rate of ENDS use documentation in the EHR (number of newly documented users per 10,000 patients) annually from 2006 to 2015. Next, we fitted Poisson regression models to analyze incidence rates as a function of sex, race/ethnicity, and year, stratified by age group. To calculate the annual percent change in incidence rates and 95% confidence intervals, we exponentiated model coefficients for each year (compared to the previous year), producing adjusted rate ratios. We then plotted annual incidence rates by age to visualize the relative rate increases across different age groups. Finally, we described the cumulative frequencies of distinct keywords during the study period and used chi-square tests to examine differences by age group.

## 3. Results

After removing duplicate comments, we identified 3,049,457 comments in the tobacco comments field of the EHR between 2006 and 2015. Of these, 16,915 comments (0.55%) contained mentions of ENDS use (Appendix A). After selecting the first comment documenting ENDS use for each patient, the final sample consisted of 9119 unique patients aged 12 and older.

The sample was 55% male; 67% White, 12% Asian/Hawaiian/Pacific Islander, 10% Hispanic, 6% African American, and 5% Other. The median neighborhood income of the sample was \$69,000 (IQR = \$36,039); 80% had only a commercial plan, 5% had only Medicaid, 1% had only Medicare, and 14% had more than one type of insurance.

At the time of first documented ENDS use, 1% were aged 12–17, 15% were 18–24, 43% were 25–44, 33% were 45–64 and 8% were > 65; 57% were current smokers, 35% were former smokers, and 8% were never smokers. Compared to the general KPNC population, patients with documented ENDS use were more likely to be male, White, aged 18–44, and current smokers. For patients aged 12–17, ENDS documentation occurred in pediatrics (44%), internal medicine (32%), obstetrics/gynecology (8%), specialty care (14%) and anesthesia (2%). For patients 18 years and older, ENDS documentation occurred in internal medicine (67%), specialty care (16%), obstetrics/gynecology (9%), anesthesia (3%), surgery or transplant (2%), emergency department (2%) and hospital (1%).

The rate of incident documented ENDS use increased exponentially from 2006 to 2015, from 0.01 newly documented users/10,000 patients in 2006 to 9.5 newly documented users/10,000 patients in 2015. Incidence rates at each time point were consistently higher among patients aged 18–24 and 25–65 relative to those aged 12–17 or > 65 (Fig. 1). Using Poisson multivariable regression, we found the largest annual increases occurred from 2011 to 2012 and 2012–2013 for all age groups. Adjusting for annual changes in race and sex distributions, the rate of incident documented ENDS use increased seven-fold (adjusted RR = 6.93, 95%CI = 6.36–7.55) among patients aged 12–17 from 2011 to 2012, six-fold (adjusted RR = 5.93, 95%CI = 5.87–6.00) among patients aged 18–24, and five-fold (adjusted RR = 4.99, 95%CI = 4.96–5.02) among patients aged 25–44 from 2012 to 2013 ( $p < 0.0001$ ). From 2014 to 2015, the incidence of ENDS use increased moderately among patients aged 12–17 (adjusted RR = 1.22, 95%CI = 1.20–1.24) and 18–24 (adjusted RR = 1.11, 95%CI = 1.11–1.12), while ENDS incidence declined for all other age groups ( $p < 0.0001$ ).

The most common keywords used to document ENDS use were variants of “e-cig” (49%), “electronic cigarette” (25%), and “vape” (28%) (Table 1). About half of the documented comments for patients aged 25 and older included “e-cig”, compared to 42% among 12–17 year olds. Patients aged > 65 were more likely to have documented use of “electronic cigarettes” (37%) than those aged 45–64 (28%), 25–44 (22%), 18–24 (18%), and 12–17 (6%). Adolescents were

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