Identifying E-Cigarette Person and Session Types Using Real-World Puff Topography

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Conflicts of interest
- The authors have no conflicts of interest

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Researchers examine combustible cigarette topography (frequency and intensity of puffing behavior) but comparatively little is known about e-cigarette topography.

E-cigarette topography impacts nicotine delivery and contents of aerosol emissions.

Critical to examine users’ behavior in naturalistic rather than lab settings.

Need to characterize both puff and session characteristics because user behavior and device functionality can change during a session (e.g., as coil heats up).
Purpose

- Characterize person- and session-level puffing patterns for second generation e-cigarettes in a naturalistic setting

- Consider implications of findings for aerosol testing protocols and understanding exposure to chemicals in e-cigarette aerosol
Methods
Participants & Procedures

- Experienced adult e-cigarette users (n = 34) recruited in 2016 in Rochester, NY
- Two-week testing period with wireless personal use monitor (wPUM) attached to second generation “vape pen”
- Randomly assigned to flavor: tobacco for 1 week and menthol/mint or berry for 1 week (order of weeks also randomly assigned)
- Nicotine concentration was matched to participant’s usual level (6, 12, or 18 mg/ml)
- Online surveys at enrollment and completion plus brief daily and weekly behavioral assessments

Figure 1. Portable Use Monitor (wPUM) on an e-cigarette
Measures

- Puff characteristics
  - Puff duration in seconds (s)
  - Puff interval (time between puffs) in seconds (s)
  - Puff volume in milliliters (ml)
  - Puff flow (outflow of vapor calculated as volume divided by duration) in ml/s

- Session characteristics
  - Day of week
  - Time of day
  - Number of puffs per session
Sample Characteristics

Total Sample: N=34 current pen-style e-cigarette users

- **Sex**
  - Males: 32 (94%)
  - Females: 2 (6%)

- **Reported Usual Nicotine Concentration**
  - Low 6 mg/ml: 20 (60%)
  - Med 12 mg/ml: 7 (20%)
  - High 18 mg/ml: 7 (20%)

- **Age**
  - Age Range: 18-63 years old
  - Mean Age: 27 years old
Analyses

- Multilevel latent profile analysis (MLPA) to characterize classes of person and session
- Classes based on average puff duration, volume, and flow and average puffs per session
- Total of 957 sessions across participants
- Iterative MLPA models added classes of person and session until no improvements in model fit
- Model parameters:
  - Person-class membership probabilities
  - Session-class membership probabilities
  - Conditional means of puff characteristics across session classes
- Included dummy indicators for flavor, time of day, and day of week in multinomial logistic regression simultaneously with class membership modeling
Results
Model Fitting

- Started with base model of 2 person-classes and 2 session-classes (“2,2”)

<table>
<thead>
<tr>
<th>Person Classes</th>
<th>Session Classes</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td>38309</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>38049</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>38313</td>
</tr>
</tbody>
</table>

- Number of person-classes
  - Superior model fit when increased to 3 classes
  - Model fit further improved for >3 but solutions inadmissible
    - too many parameters and lack of variability within classes

- Number of session-classes
  - 3 class model had worse fit

- Final model = 3 person-classes and 2 session-classes (“3,2”)
Session Classes

Session class 1 = **Light**
- Low puff flow and puff volume
- Average puff duration ~2 seconds

Session class 2 = **Heavy**
- Higher puff flow (almost 2x) and puff volume (almost 5x)
- Average puff duration ~4 seconds

<table>
<thead>
<tr>
<th>Session Class</th>
<th>Number of Puffs</th>
<th>Mean Puff Duration (sec X 100)</th>
<th>Mean Puff Volume (ml)</th>
<th>Mean Puff Flow (ml/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>16.7</td>
<td>203</td>
<td>59.9</td>
<td>14.7</td>
</tr>
<tr>
<td>Heavy</td>
<td>441</td>
<td>290.9</td>
<td>71.5</td>
<td>28.7</td>
</tr>
</tbody>
</table>

**Session Classes (2-Class Model)**
Person Classes

- Defined by relative proportions of session types:
  - Class 1 = predominantly heavy sessions
  - Class 2 = almost exclusively light sessions
  - Class 3 = predominantly light sessions

<table>
<thead>
<tr>
<th>Person Class</th>
<th>N (%) of sessions that are “Light”</th>
<th>N (%) of sessions that are “Heavy”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person Class 1 (n = 2)</td>
<td>13 sessions (39.3%)</td>
<td>20 sessions (60.7%)</td>
</tr>
<tr>
<td>Person Class 2 (n = 20)</td>
<td>640 sessions (98.0%)</td>
<td>13 sessions (2.0%)</td>
</tr>
<tr>
<td>Person Class 3 (n = 12)</td>
<td>196 sessions (75.3%)</td>
<td>64 sessions (24.7%)</td>
</tr>
</tbody>
</table>
Other Effects on Session Type

- **Flavor**
  - No differences by flavor in probability of session class occurrence

- **Time of day**
  - In the afternoon/evening (12 pm–6 pm), more likely to observe “heavy” sessions than “light” sessions ($b = .615 (.323)$, $t = 1.906$, $p = .057$)

- **Day of week**
  - More “light” sessions on Thursdays than on Saturdays (reference day) ($t = 2.896$, $p = .004$)
Discussion
Discussion

- There are different, classifiable types of e-cigarette users who engage in distinct puffing patterns.
- Engaging in more “heavy” sessions (greater puff duration and volume) could result in greater exposure to harmful emissions for some users.
- Benefits of this study over previous studies include:
  - A naturalistic setting
  - Multiple weeks of observation
  - Standardized devices and e-liquids were used to avoid confounding.
- Limitations include that the study:
  - May not generalize to more advanced vaping devices
  - Did not collect data on cigarettes smoked per day or CO levels
  - Used a non-representative sample, mostly young adult male college students
  - Had limited sample size for analyzing person-level characteristics, such as smoking status or demographics.
Future Directions

- Results can
  - Inform our understanding of variations in user behavior
  - Suggest how variations in behavior could result in variations on exposure to harmful emissions

- Future studies might
  - Compare device types, including advanced “mods”
  - Examine how characteristics of users (e.g., age, smoking history), products (e.g., e-liquid type, device brand), or the environment (e.g., location) might influence puffing behavior

- Regulatory implications
  - Variation in user behavior could influence individual- or population-level health effects.
  - Regulation of products and public education efforts may benefit from improved understanding of variation in user behavior.
Questions?

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