FACTORS GOVERNING THE DISPERSION OF EXHALED PARTICLES DURING VAPING OF AN E-CIGARETTE

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Background:
- Electronic cigarettes (e-cigarettes) are rapidly increasing in the market as an alternative to conventional tobacco cigarettes.
- E-cigarettes are battery-powered devices that deliver an aerosol to users from an e-liquid. E-liquids typically contain propylene glycol and glycerol in varying proportions as the aerosol formers and may contain nicotine and flavourings.
- E-cigarettes do not contain tobacco, do not require combustion and do not generate side-stream smoke.
- There is little data available on the properties of exhaled e-cigarette “particles” in the scientific literature and as a result there is a growing discussion amongst the public health community as to whether the “particles” exhaled following use of such products has potential implications for indoor air quality and bystanders.

Aim:
- To investigate the impact of different factors on the dispersion of exhaled e-cigarette particles at a bystander’s position, namely vaping topography, distance from bystander and room ventilation rate, following use of a commercial e-cigarette.

Methods:
- A room-simulating chamber was developed (Fig. 1).
- An occupant bystander was represented by a seated heated “dummy”.
- The ventilation air supplied to a chamber was treated with three steps of filtration.
- Variables: three experienced e-cigarette volunteers; ventilation rates of 0, 1 and 2 ACH; distance 0.5, 1.0, and 2.0 metres from the bystander.
- Highly time-resolved aerosol samples were analysed at the bystander’s position using a Fast Mobility Particle Sizer (FMPS) and an Electrical Low Pressure Impactor (ELPI+).
- Chemical composition of exhaled e-cigarette particles were also analysed.

Results:
- The distance and the vaping topography exhibited the highest influence on dispersion of exhaled particles (Fig. 2).
- A greater distance between e-cigarette user and a bystander resulted in lower maximum particle concentrations (median value: 0.5 m - 4.4*10^6, 1.0 m – 2.1*10^6, 2.0 m – 7.4*10^6).
- Even at a close distance the decay of particle concentrations was very rapid.
- Vaping topography may be related to physiological differences and e-cigarette use behaviours amongst the volunteers which influenced significant differences between PNC.
- The ventilation rate did not significantly influence particle size distributions or maximum particle concentrations (most of the exhaled particles evaporated immediately after exhalation).
- The chemical composition of the exhaled particles was shown to be largely composed of water (~96% water + ~4% glycerol) (Table 1).

Table 1. The chemical composition of the exhaled particles during vaping of e-cigarette

<table>
<thead>
<tr>
<th>Vaper</th>
<th>Propylene Glycol</th>
<th>Glycerin</th>
<th>Nicotine</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>95.80%</td>
<td>0.01%</td>
<td>4.15%</td>
</tr>
<tr>
<td>2</td>
<td>95.60%</td>
<td>0.03%</td>
<td>4.35%</td>
</tr>
<tr>
<td>3</td>
<td>97.20%</td>
<td>0.06%</td>
<td>2.69%</td>
</tr>
</tbody>
</table>

Conclusion:
- This study shows for the first time exhaled e-cigarette particles are liquid droplets that evaporate rapidly upon exhalation.
- The results presented here may have a positive implication for continued use of e-cigarettes in indoor areas.

Fig. 1. Room-simulating chamber with heated “dummy” and controlled ventilation. 1 – FMPS; 2 – ELPI; 3 – SMPS; T, V – temperature and VDCs sensors

Fig. 2. Particle number concentration growth (A) and decay (B) rates (min⁻¹) during a puff (Kruskal-Wallis ANOVA, significant if p<0.05)