Measuring Aerosol Particle Emissions from Cannabis Vaporization and Dabbing

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SUMMARY
Cannabis smoke contains many of the same carcinogens and chemicals found in tobacco smoke (Moir, Rickert et al. 2008, Wei, Alwis et al. 2016). Exposure to secondhand cannabis smoke can impair endothelial function, which increases the risk of cardiovascular disease (Wang, Derakhshandeh et al. 2016). However, US data show that the perceived health risks of marijuana use are, in fact, declining among adults (Compton, Han et al. 2016). We measured the concentrations of airborne fine particles ($PM_{2.5}$) and cannabinoids at an indoor cannabis event where dabbing and vaporizing were the only cannabis emissions. We found average particle concentrations of 200-600 micrograms per m^3 and peak concentrations over 1,600 micrograms per m^3. Particle concentrations this high are seen in extreme air pollution events like wildfires (Landis, Edgerton et al. 2018, Li, Han et al. 2018) and severe industrial pollution (Nagar, Singh et al. 2017, Li, Han et al. 2018). Exposure at these concentrations can cause cardiovascular and respiratory disease (Zheng, Ding et al. 2015, Li, Fan et al. 2016). We show that dabbing and vaporizing cannabis can create levels of indoor air pollution that are hazardous to human health, in the absence of actual combustion.

KEYWORDS
Cannabis, Vaping, Dabbing, Environmental Cannabis Pollution, Particulate

INTRODUCTION

Study of the health and environmental effects of cannabis is complicated by diverse preparations and routes of administration. Cannabis can be purchased as dried flowers, mechanically separated trichomes (hash), concentrates, tinctures, and edible and topical preparations. The dried flowers can be smoked using a cigarette (Ramo, Liu et al. 2012), a blunt, or a pipe (Golub, Johnson et al. 2006). Cannabis, hash and cannabis concentrates can also be consumed by “vaporizing” (Gieringer 2001, Gieringer, St. Laurent et al. 2004, Malouff, Rooke et al. 2014, Pepper and Brewer 2014, Walker 2014). To vaporize whole cannabis, dried flowers from female plants are ground finely and heated to between 180° and 300° C, and the resulting aerosol is inhaled. Vaporizers are being popularized among medicinal cannabis users as a way to reduce exposure to toxins (Malouff, Rooke et al. 2014), however, there is little known about the chemical composition of vaporizer aerosols. Cannabis concentrates are made by extracting cannabis plant material with organic solvents or liquid carbon dioxide. Pure cannabis concentrates can be “dabbed”. Dabbing uses a surface heated to 300-750° C to flash-vaporize concentrates. At the higher temperatures, combustion can occur.

Because cannabis research has been strictly limited in the U.S., academic and public health researchers have little experience studying it. To meet this research gap, we have conducted field experiments at public events in the San Francisco Bay Area where people use cannabis. We present aerosol particle data from a single experiment conducted at a farmers’ market sales event conducted on December 16th, 2017. The event took place in two rooms in a retail space. In room one, vendors were providing samples of cannabis concentrates using six electrically-powered dabbing instruments and one vendor was providing samples of vape pens that contained cannabis. In room two, people were providing samples of cannabis flowers using two electrically-powered vaporizers. The dabbing equipment and the vaporizers were provided by the retailer and all vendors used the same type of equipment in each category.

METHODS

We measured $PM_{2.5}$ concentrations in real time with three laser photometers (two model AM510, one model 8532 (Dusttrak), TSI, Shoreview, MN), fitted with 2.5 μm impactors to exclude larger particles. For gravimetric aerosol particle measurements, we used 5 air pumps (GilAir-3, Sensidyne L.P., St. Petersburg, FL) were fitted with filters (Pallflex, EMFAB, Pall Corporation, Cortland, NY). The air pumps were calibrated a flow rate of 2.0 LPM for the Gillian pumps and photometers were calibrated to 1.7 LPM, with a soap bubble spirometer (Gilibrator 1, Sensidyne L.P, St. Petersburg, FL). The laser photometer data reported have been adjusted using a calibration factor of 0.30 (Jiang, Acevedo-Bolton et al. 2011).

RESULTS

Unlike a burning cigarette, dabbing equipment and vaporizers do not emit aerosol constantly. Emissions are episodic and depend on the device design and the intensity of use. A dabbing rig consists of a heated surface, and a trap or cover that captures the aerosol so it can be inhaled. Dabbing-associated aerosol emissions occurred in three phases:

1. When the concentrates were applied to the heated surface, before the aerosol trap was put over the surface
2. When the customer exhaled
3. When the trap was removed and the remaining concentrate was "burned off."

The Volcano vaporizer used a fan below the heating plate to blow cannabis aerosol into a plastic bag that was then removed from the vaporizer and held or given to a customer to inhale. Several bags would be filled from a single load of cannabis and then held for use by customers. Vaporizer-associated aerosol emissions occurred in four phases:

1. When the bag was removed from the vaporizer
2. When the customer exhaled
3. When the unused aerosol was pressed out of the bag so it could be refilled for a new customer
4. When the spent cannabis flowers were removed from the vaporizer.

Because the aerosol emissions were not constant, we found we had to increase the observation time for a given area from 1 to 5 minutes to properly count emission activities. We were not able to observe correlations between the emission phases described above and the continuous particle concentrations observed because there were multiple sources in both rooms.

We sampled for ~6 hours. The battery of one pump died at 4 hours. The mean particle concentrations measured gravimetrically at four different locations in room one (dabbing) sampled over the same six hour time span were 445, 578, 582 and 654 μg/m^3. The average laser photometer measurements collected at two of the same locations in room one, during the same time period, were 297 and 242 μg/m^3. The mean particle concentration measured gravimetrically at one location in room two (vaping) was 354 μg/m^3 and the corrected average laser photometric measurement collected at the same location was 939 μg/m^3.

We do not have chemical analyses of these aerosols to report at this time. However, it was possible to distinguish the aerosols in the two rooms by smell. The aerosol in the dabbing room smelled acrid and more like smoke. The aerosol in the vaporizing room smelled more like unheated cannabis.

DISCUSSION

Our main finding is that dabbing and the use of a Volcano vaporizer can cause high levels of $PM_{2.5}$ in indoor air. Our gravimetric data show that average concentration in the dabbing room over 6 hours was 564 μg/m^3. The laser photometer data from both rooms shows a pattern of high mean levels with brief peaks of 3-5 times higher concentrations. The people who worked in these rooms were exposed to aerosol particle concentrations that are recognized as hazardous by the US Environmental Protection Agency and by the World Health Organization (World Health Organization 2006, US Environmental Protection Agency 2015). Specifically, the US EPA national ambient air quality standards state that the 24-hour average outdoor $PM_{2.5}$ concentration should not exceed 35 μg/m^3. A 6-hour exposure to 564 μg/m^3 creates a 24-hour average of 142 μg/m^3, even if the $PM_{2.5}$ concentration is 2 μg/m^3 for the remaining 18 hours of the day. Using the US EPA air quality index calculator, a PM2.5 concentration of 142 μg/m^3 is associated with "increased aggravation of heart or lung disease and premature mortality in persons with cardiopulmonary disease and the elderly; increased respiratory effects in general population"(US Environmental Protection Agency 2018). While the chemical composition of dabbing aerosol emissions is not yet known and may not be as toxic as the combustion aerosols that are a primary constituent of outdoor $PM_{2.5}$ in most areas, it is unlikely that exposure to concentrations this high are without health consequences.

Our secondary finding is that the relationship between the gravimetric and laser photometric measurements of dabbing aerosol did not follow the relationship normally seen with tobacco cigarette smoke, where the gravimetric mass is equal to the laser photometer mass x ~0.30 (Jiang, Acevedo-Bolton et al. 2011). For the vaporization aerosol, where the gravimetric value is less than the photometric value, this may be due to evaporation of volatiles from the gravimetric samples. For the dabbing aerosols, the gravimetric values are higher than the photometric values, so loss of volatiles is unlikely to be the cause of the discrepancy. It may be necessary to derive specific calibration factors for cannabis dabbing aerosol and vaporizer aerosol.

CONCLUSIONS

Although there is reason to believe that vaporizing and dabbing cannabis may create aerosols that contain lower concentrations of toxins than are found in cannabis smoke, these activities can still create high concentrations of $PM_{2.5}$ indoors. Chemical analysis of these aerosols will allow an accurate assessment of the health risks of these behaviors.

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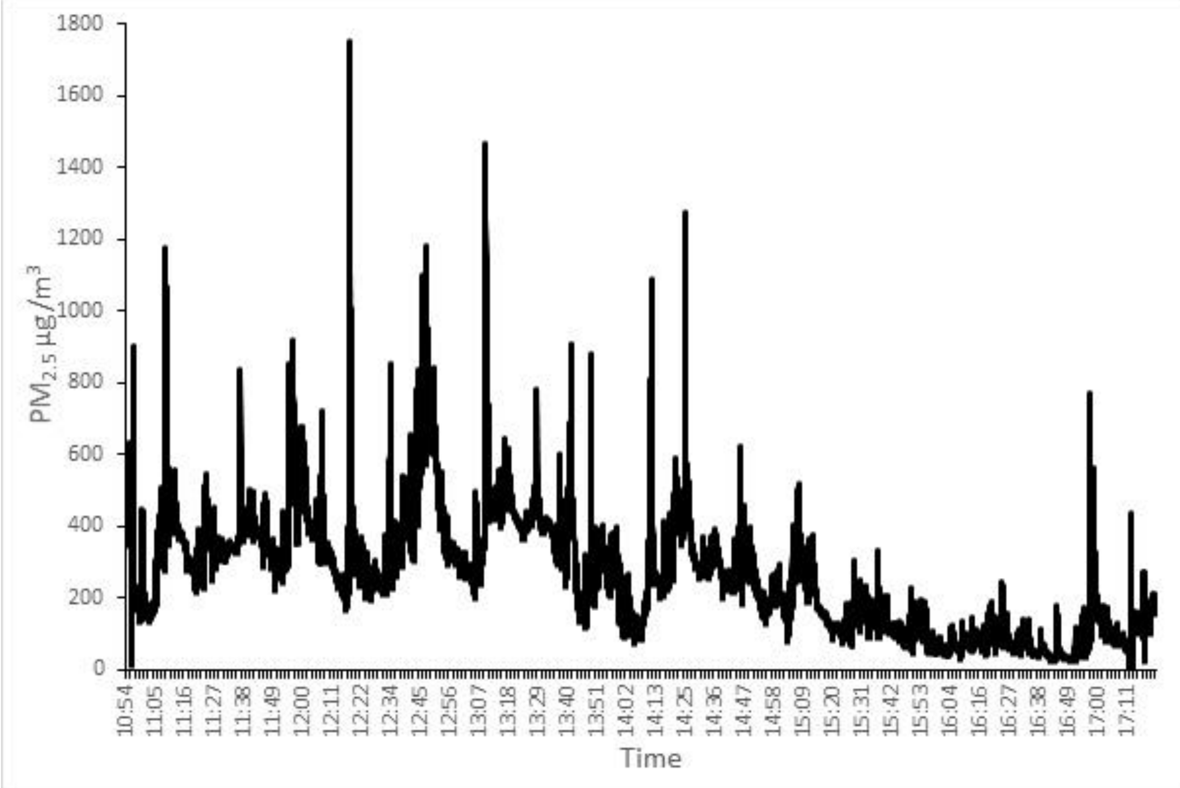
Figure 1: Aerosol Particle (PM2.5) Concentrations From Cannabis Vaporization



Data are values from a factory-calibrated laser photometer, corrected for biomass smoke. (Dusttrak model 8532, TSI Inc, Shoreview, MN)

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