Intrusion of Electronic Cigarette Aerosol into Neighboring Shops - an Occupational Focus

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Introduction

Electronic cigarettes (EC) are battery operated devices that evaporate a solution of Propylene Glycol (PG), Vegetable Glycerin (VG), nicotine and flavorings using heat. Below is a depiction of their evolution over the past decade. The latest ECs digitally control by voltage, power or temperature and no longer look like tobacco cigarettes.

1st gen 2nd gen 3rd gen

With more powerful, user customizable devices on the market we have seen a ground swell of EC retail shops (vapor stores) that embrace high power vaping and indoor use. Most vapor stores offer employee perks such as free e-juice and promote competitions like cloud blowing.

55 people attended this cloud competition. Picture on left is not the same event from above, just a similar event

With heavy vaping occurring indoors, we sought to characterize the airborne particulate levels in vapor stores, their shop neighbors and across the street control shops to assess employee exposure and aerosol spill over.

Methods and Materials

All known vapor stores (VS) within a 25 mile radius of Oklahoma City were considered for this study. Only VS with at least one adjoining shop and an across the street control shop, resulting in 56 qualifying VS. 35 of these shops were approached in a randomized order; 14 consented to participate. At these locations, 8 adjacent shops (AS) and 10 control shops (CS) consented to participate.

The manager, owner, or shift leader of each VS was interviewed using a questionnaire obtaining basic commercial demographics such as shop size, sales, number of employees, e-juice perks, daily volume of e-juice consumed, devices used, and other aspects to assess how much e-juice was vaporized in this indoor space on a regular basis. During the interview, a field portable aerosol spectrometer was used to measure thes particle size distribution and count concentration within the VS for at least 15 minutes (15-60 min). Similarly, particle size distribution and count concentration were measured in each AS and CS, providing a basis for assessing potential "cloud spill over" from the VS to AS. CS served as the local background control

Results

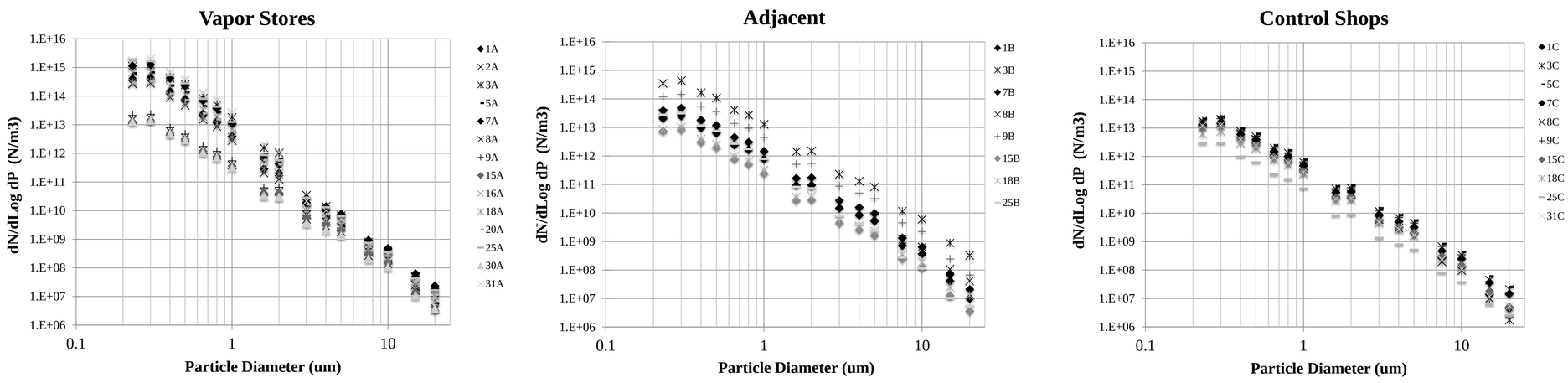

Figure 1: particle size distributions of all samples collected in VS, AS and CS. A clear trend is observed that VS have elevated ultrafine and fine PM while CS have ~100fold lower ultrafine and fine PM. Interestingly, AS appears to be evenly spread across the range of VS and CS, suggesting that aerosol intrusion occurs in some locations but not others.

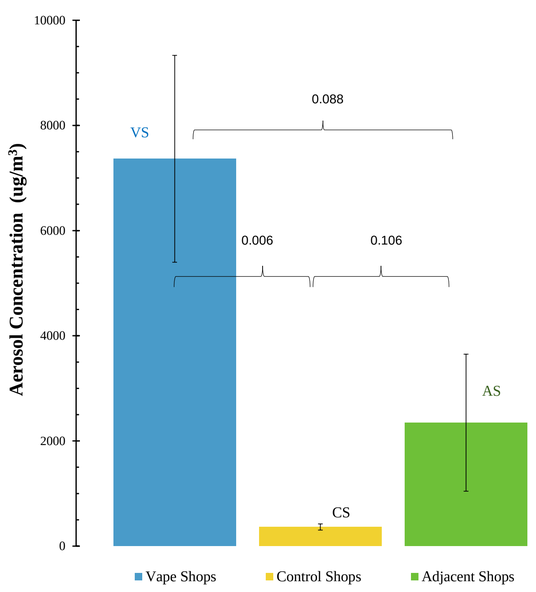

Figure 2: Total Particulate Matter (TPM) data was summarized for each location type (VS, AS, CS) and compared. AS is not statistically different from CS or VS suggesting aerosol intrusion.

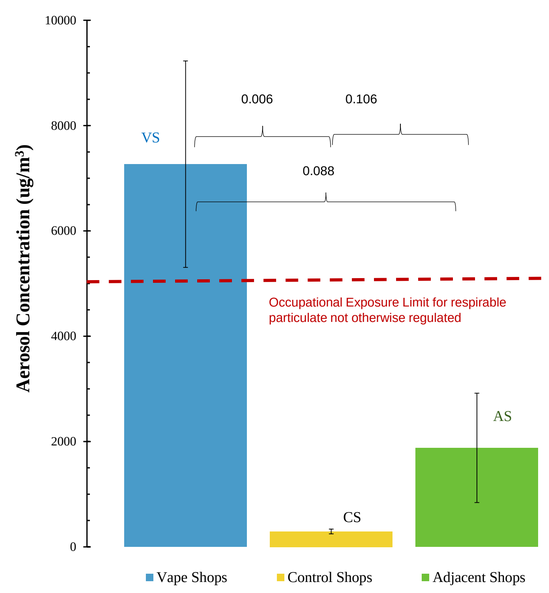

Figure 3: Respirable Particulate Matter (respirable PM) data was compared across each location type (VS, AS, CS) and compared to the OSHA exposure limit to respirable particulates. Mean VS exceeded the OSHA PEL (red dashed line). AS is not statistically different from CS or VS, further suggesting aerosol intrusion.

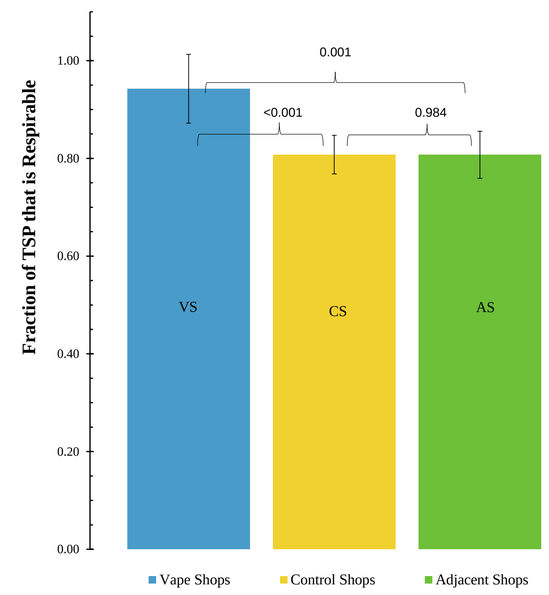

Figure 4: Respirable Fraction of Total Particulate Matter was calculated for each location type (VS, AS, CS) and compared. VS was significantly greater than AS and CS, no difference was found in the respirable fraction of AS and CS.

- In VS (vapor shops), fine and ultrafine particulates were elevated 20-100 fold over CS (control shops)
- In AS (adjoining shops), we see an even spread of fine and ultrafine particulates spanning from background levels to near VS levels.
- Size distribution plots show that VS have notably greater count of fine and ultra fine particulates (here covered by the "respirable" designation)
- Total Particulate Matter (TPM) was not statistically different between VS and AS ($p = 0.088$) but was statistically different from CS ($p = 0.006$)
- Respirable particulate matter (PM) exceeded the OSHA limit for respirable particulates not otherwise regulated. This is a designation used for nuisance dusts and particulates with no known adverse health affects
- Respirable PM was significantly elevated over CS ($p = 0.006$) but not AS ($p = 0.106$). These results do not prove that intrusion was occuring, but definitely indicates this is a possibility.
- In one location, aerosol was visibly intruding into the adjoining shop via the shared ventilation system.
- Respirable fraction of TPM was significantly greater in VS than both AS ($p < 0.001$) and CS ($p < 0.001$), confirming that the size distribution of particulate within VS is significantly different thatn AS or CS.
- Environmental EC aerosol is widely dispersed with approximately 94% respirable (<4 um), this demonstrates significant risk to pulmonary tissues.

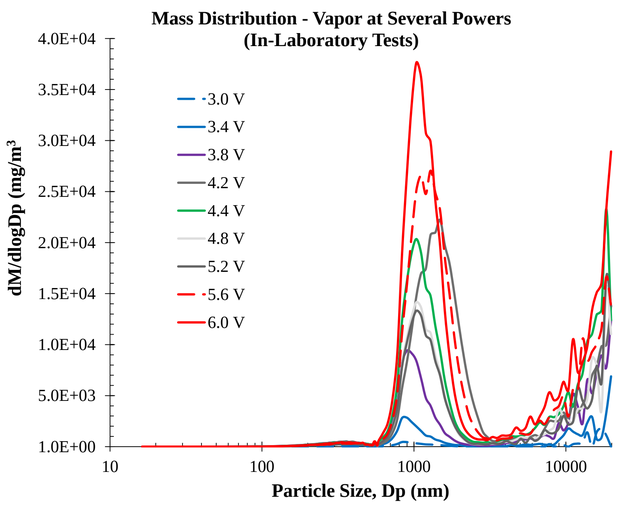

Fig. 5 - Mass Distribution of vaping aerosol produced with a lab power supply. As power increases the mass of e-cig aerosol around 900 nm increases dramatically.

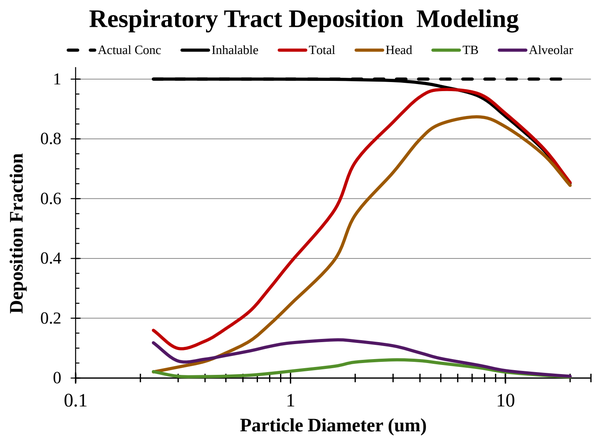

Figure 5: Respiratory tract deposition modeling for the particle size data obtained with the spectrometer. This represents what fraction is expected to deposit in the respiratory tract (total) and the relative deposition in each region of the respiratory tract (Head, TB, Alveolar).

Conclusions

In this study we see limited quantitative evidence that EC aerosol can intrude into adjoining spaces, moreover we actually observed EC aerosol intrusion at one location. The OSHA PEL for Respirable Particulates NOR was exceeded in the majority of vapor shops and the mean for the VS group was well above the 5000 ug/m^3 limit. Until further evidence is collected on the health effects of 2nd and 3rd hand vapor, indoor EC use should be treated the same as indoor tobacco use and spill-over strictly prevented

Acknowledgments

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For further information

Please contact Evan-Floyd@*ouhsc.edu* for more information on this and related projects.

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