Passenger Vehicle Secondhand Smoke Particulate Measurements
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Research Questions
• What are the typical and range of fine particle concentrations during and after smoking under various conditions of vehicle speed, window positions and ventilation system status for common vehicle types?
• Do fine particle levels vary spatially inside cars under the various conditions of vehicle speed, window positions, and ventilation system status?
• How do differences in ventilation configurations affect fine particle levels inside vehicles?
• How does particle removal rate vary with different configurations?

Approach
• Each trial consisted of smoking a single cigarette followed by a 25 minute monitoring period and five minute airing out period. The vehicle was driven on either local roads (30 mph) or expressways (60 mph).
• 46 unique trials were conducted for a sedan, minivan, and SUV with variations in season (summer/winter), driving speed (30/60 mph), window position (closed/large open)/driver window open/all open), ventilation (off, recirc, fresh, defrost, heat, both) and cigarette position (normal/towards window/ towards inside).
• The continuous monitoring included photometer PM$_{2.5}$ at 3 to 5 passenger locations and outdoors, CO and CO$_2$ at 3 passenger locations and outdoors, and GPS vehicle speed.
• Computed the average and short duration (5/10/15/30 sec) maximum PM$_{2.5}$ during smoking and entire exposure period. PM$_{2.5}$ exposure = avg PM$_{2.5}$

Results
• The maximum 30 second average PM$_{2.5}$ ranged from 359 to 5,612 µg/m$^3$ (avg = 2,012 µg/m$^3$) when windows were closed. Average drops to 317 µg/m$^3$ with the drivers’ window open 2” and 178 µg/m$^3$ for full-open.
• After smoking stopped, it took from 4 to 25 minutes (avg = 11.5) for the particulate level to decrease to the background level when the windows were closed. The average time reduced to 4.2 minutes with the drivers’ window open 2” and 1.7 minutes for fully-open.
• The average SNS exposure in a vehicle with closed windows was roughly equal to sitting in a typical smoke bar for three hours.
• A multivariate regression found that there was no statistically significant difference in the exposure for the front and rear passenger locations. There was a significant exposure reduction when the smoker held the cigarette and exhaled towards the window compared to towards the inside of the vehicle. The exposure was about 2.3 times higher for the 30 mph driving speed than 60 mph (highly significant).

Background
• The 2013 Minnesota Youth Tobacco and Asthma Survey found that 25.8% of middle school students and 37.1% of high school students surveyed had ridden in a car with someone who was smoking cigarettes in the preceding week.
• The 2014 Minnesota Adult Tobacco Survey found that 95.4% of Minnesotans think that smoking should not be allowed in cars when there are children present.
• Since 2006 7 U.S. states and Puerto Rico have passed laws to prevent smoking in cars when children are present. No law in Minnesota.