Short-term effects of urban traffic-related air pollution on blood pressure

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A community based participatory research

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Key Finding

Reduction in traffic-related air pollution (TRAP) exposure attenuated the effects on blood pressure under controlled exposure conditions.
Background & Motivation
• Research has shown associations of adverse cardiovascular indicators and outcomes for both
  • residential proximity to roadways, and
  • short term exposures from time spent on roadways.

• Increased blood pressure (BP) is implicated in adverse cardiovascular outcomes

  • BP can change rapidly in response to environmental stressors
  • An increase as small as 1 mm Hg in usual systolic BP is estimated to increase the risk of CVD deaths by 2-4% (Stamler et al. 1993, Van den Hoogen et al., 2000, NEJM).
  • Proposed as a primary intermediate response for acute PM-related cardiovascular events (Brook et al, 2010 Circulation).
Mechanisms whereby air pollution can trigger BP elevation

You Are What You Breathe: Evidence Linking Air Pollution and Blood Pressure
Brook, Hypertension, 2005
• TRAP exposure may contribute to well-established associations between adverse health and proximity to highways and major roadways.

• Relatively little is known about potential impact of combustion-related TRAP components like ultrafine particles (UFP) and black/elemental carbon on BP.

  • Short-term and long-term exposures to fine (<2.5 μm aerodynamic diameter) ambient particulate-matter (PM) have been related with increased BP in controlled-human exposure and observational studies.

  • 2018 review Magalhaes et al. on UFP and EC/BC association (n = 30 combined); evidence for outdoor UFP exposures was less clear.

• Our research has focused on UFP that are highly elevated near highways.
  • Strong evidence in animal models of susceptible human populations of adverse impacts of UFP on BP (Kleinman et al.)
Study Design
• A crossover trial design i.e., the participants crossed over from one treatment to another during the course of the trial.

• Treatment = Exposure to varying levels of TRAP enriched ambient air pollution that infiltrated indoors
  • rooms were characterized before the sessions

• Randomly assigned to three treatments – high, medium or low exposure as first treatment and received all three.

• One week wash-out period between treatments.

• Overall, 24 sessions per treatment and 77 participants
Inclusion and Exclusion Criterion

Inclusion criteria

-age 40-75 years

Exclusion criteria

-history of a major cardiovascular outcome (including MI, stroke, angina),
-other serious health problems (current asthma or COPD), taking anti-hypertensive medications,
-smoking or living with a smoker,
-cognitive impairment,
-working at a job with high combustion exposure (taxi/truck driver, highway toll collector, cooking in a restaurant, etc.),
-high combustion exposure in the preceding 24 hours (such as driving on the highway),
-not speaking English or Chinese
Exposure Session

• Participants arrived 15-20 minutes prior and surveyed for TRAP exposures in past 24 hours
• Room was already set-up temp was maintained at comfortable levels
• Participant wore noise-cancelling headphones
• BP Monitor was placed on participant’s arm
• Sat quietly for two hours (first 90 minutes of data was analyzed)
• Primary outcome was blood pressure (BP) which was measured intermittently

BP

10 min intervals using Ambulatory Blood Pressure Monitor (Oscar 2, Suntech Medical, NC)
Exposure sessions carried out in close vicinity of busy highways

Somerville (20%)  Chinatown in Boston (80%)
Exposure sessions carried out in close vicinity of busy highways

- Ambient air enriched in TRAP (although there were contributions from other sources too, like, restaurants in vicinity)
- Each session began early in the morning (7-8 AM) to coincide with morning rush hour traffic
- Participants were recruited from neighborhoods close to the rooms where exposure sessions were conducted.
Exposure sessions carried out in close vicinity of busy highways

Traffic-related Air Pollution (TRAP) markers were monitored

- **PNC**
  - Continuous 1 sec using Condensation Particle Counter 3783 (TSI Inc.)

- **BC**
  - Continuous 1 min using Aethalometer 33/16 (Magee Scientific, CA)
HEPA filtration was used and building envelope was modified to generate three exposure treatments

<table>
<thead>
<tr>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Maximum HEPA filtration</td>
<td>• Moderate (~25-50% of max) HEPA filtration</td>
<td>• No HEPA filtration</td>
</tr>
<tr>
<td>• All doors and windows sealed</td>
<td>• Doors and windows closed but not sealed</td>
<td>• Room was cross-ventilated naturally or with a fan</td>
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Results
HEPA filtration and envelope modifications were effective as interventions

We were able to attain:

- **Good exposure contrast**
  - The average contrast between low to medium and low to high was 4.9 (range: 1.4-13.5) and 14.4 (3.9-37.6) for PNC and 3.5 (range: 0.4-16.9) and 8.0 (1.5-28.3) for BC.

- **Stable exposures**
  - Coefficient of variation ~20% (15-23%)

<table>
<thead>
<tr>
<th>Exposure Treatment</th>
<th>PNC particles/cm$^3$ (mean±st.dev.)</th>
<th>BC ng/m$^3$ (mean±st.dev.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>2500±1100</td>
<td>150±90</td>
</tr>
<tr>
<td>Medium</td>
<td>10000±3400</td>
<td>370±170</td>
</tr>
<tr>
<td>High</td>
<td>31000±14600</td>
<td>870±600</td>
</tr>
</tbody>
</table>
HEPA intervention significantly reduced changes in systolic blood pressure

Mean change in systolic blood pressure was:

- 0.6 mmHg for low
- 1.2 mmHg for medium
- 2.5 mmHg for high exposure treatment

linear trend p-value = 0.019
HEPA intervention did not significantly reduce changes in diastolic blood pressure

Magalhaes et al. 2018, Env. Rsch.
HEPA intervention significantly reduced changes in systolic blood pressure

Magalhaes et al. 2018, Env. Rsch.
Strengths and Limitations
Strengths

• Crossover study design & participants were their own controls
• Multiple measures of BP over time, trend & adherence to measurement protocols
• Real-life TRAP exposures

Limitations

• Lack of blinding; difficult to sit quietly for 2-hours and we had to disregard the last 30 minutes of data
• Real-life TRAP exposures
• Can’t infer causality
Questions
Supporting Information
HEPA filtration was used and building envelope was modified to generate three exposure conditions