Exposure-response functions relating intensity and duration of ambient traffic-related air pollution to systolic blood pressure

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Background and Importance

- Exposure to traffic-related air pollution (TRAP) is associated with adverse health outcomes, including elevated blood pressure (BP).
- BP can change rapidly in response to environmental stressors.
- An increase as small as 1 mmHg in systolic BP is estimated to increase the risk of cardiovascular deaths by 2-4%.
- However, the nature of the exposure-response functions for combustion-related TRAP components like ultrafine particles (UFP; i.e., < 100 nm) and black carbon (BC) is not well established.

<u>Aim</u>: Derive exposure-response functions that include both intensity and duration of UFP and BC concentration.

Source of Data for the Present Analysis

- We recently published a three-exposure, three-period crossover trial.
- We used portable high-efficiency particulate air (HEPA) filters to reduce indoor infiltration of TRAP.
- The results showed significantly effective prevention of short-term increases in systolic blood pressure (SBP).

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Crossover Trial Design

- Sessions were conducted in rooms immediately adjacent to highways in Boston MA, USA.
- Low, medium, and high exposures were attained by varying the degree of air exchange and amount of HEPA filtration in the room.
- Total of 77 participants.
- Aged 40-75 years without hypertension diagnosis.
- Participants sat quietly and wore noise-cancelling headphones for two hours.

Measurements Recorded

- **Indoor particle number concentration (PNC)**
  - Continuous 1-second resolution.
    Condensation Particle Counter (TSI Inc, model 3873).
    - averaged into 10-minute intervals for analyses.

- **Indoor black carbon (BC) concentration**
  - Continuous 1-minute resolution.
    Aethalometer (Magee Scientific, model AE16).
    - averaged into 10-minute intervals for analyses.

- **Blood pressure (BP)**
  - 10-minute intervals.
    Ambulatory BP Monitor (SunTech Medical, Oscar).

Description of Sample and Analysis

- Total of 1470 SBP measurements from 77 participants.

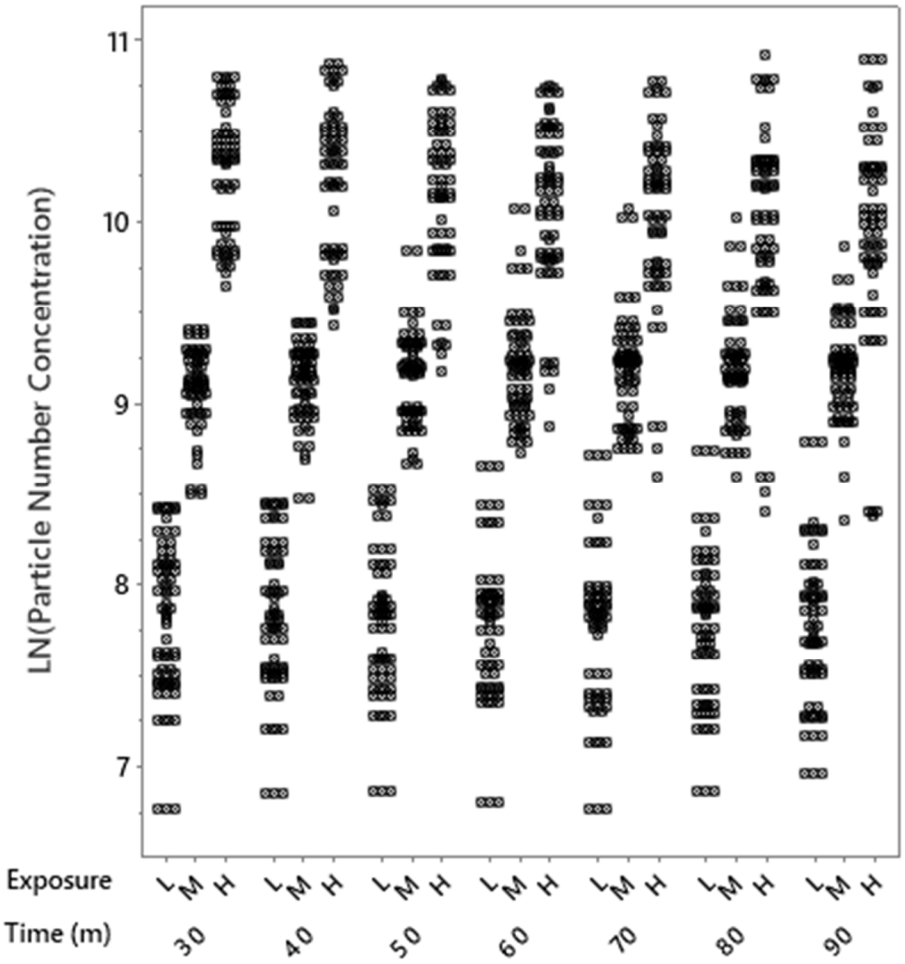
- Average age 60 years, 79% female, 77% Asian, 17% White.

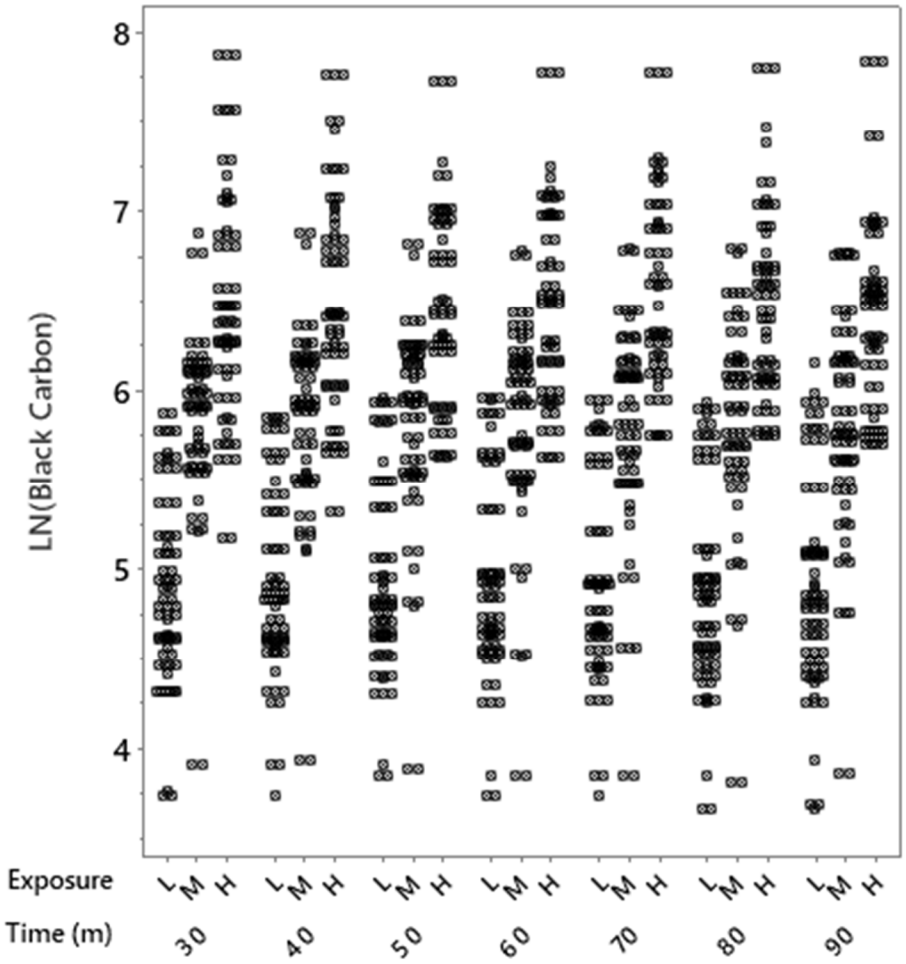
- Average PNC = 13,000 particles/cm^3 (range 860 to 56,000).
- Average BC concentration = 430 ng/m^3 (range 38 to 2700).
- Average SBP = 120 mmHg.

- **Linear mixed models**
  - Natural logarithmic relationship between PNC and SBP.
  - Natural logarithmic relationship between BC and SBP.

  - Models included:
    (1) 'time from study entry' as a measure of exposure duration.
    (2) random intercept to account for the interdependence of multiple SBP measurements from each participant.

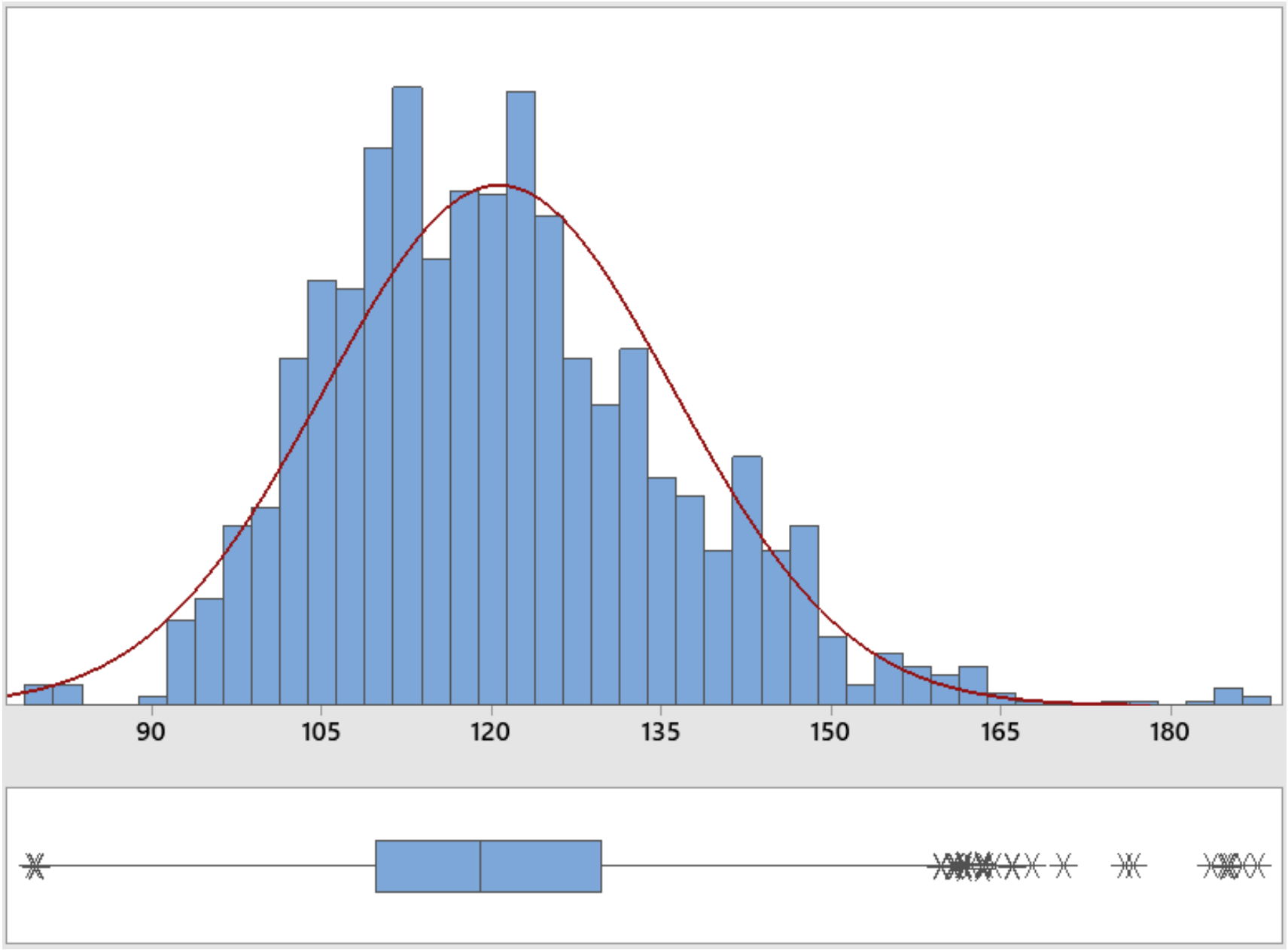
Distribution of ln(PNC) and ln(BC) over Time



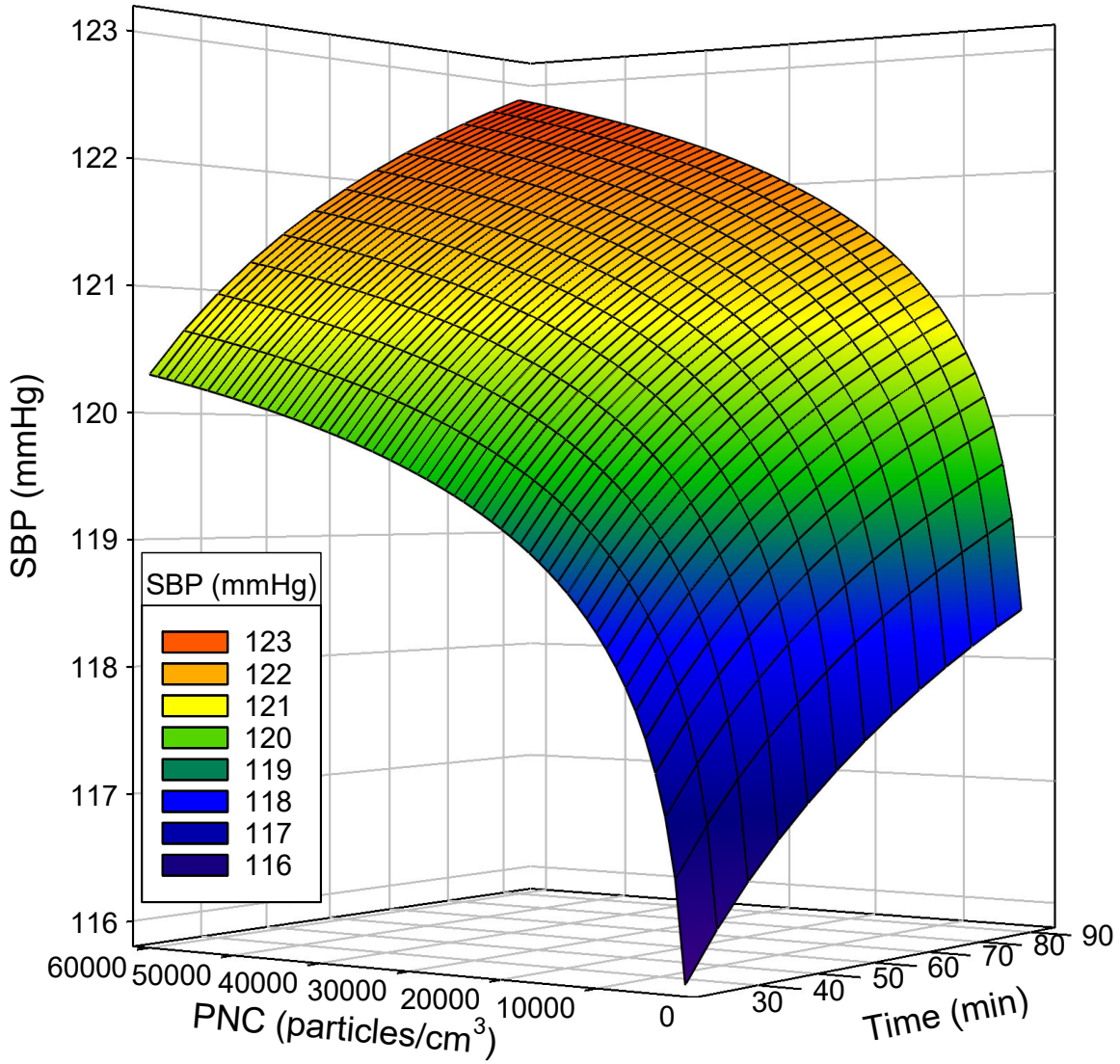


Despite the exposure levels being designated as low, medium, and high for the crossover trial, the ranges of concentrations were quite variable and overlapped the exposure designations, but were relatively stable over time.

Distribution of Systolic Blood Pressures

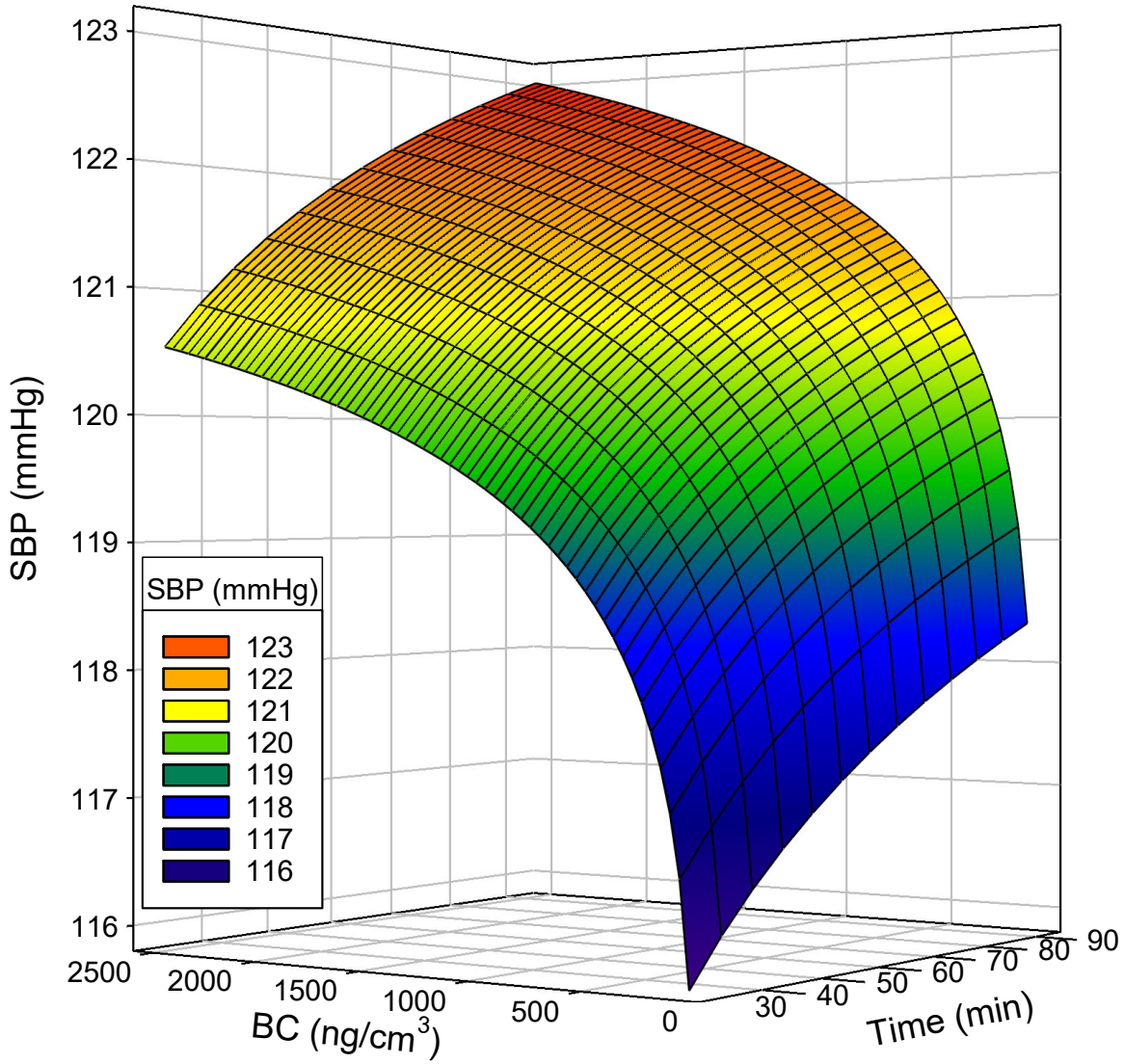


Relationship Between SBP and PNC & Duration of Exposure



$$SBP = 100.59 + 1.08 \log_e PNC + 2.31 \log_e Time \quad (p < 0.001)$$

Relationship Between SBP and BC & Duration of Exposure



$$SBP = 104.11 + 1.13 \log_e BC + 2.23 \log_e Time \quad (p < 0.001)$$

Summary and Conclusions

- Exposure-response functions for PNC and SBP, and for BC and SBP, are logarithmically dependent on intensity and duration.
- The models describe a progressive dampening of the increase in SBP for increasing intensities and durations of exposure.
- Duration of exposure has a greater effect on SBP than intensity:
  - 1 mmHg increase in SBP related to 54% increase in duration.
  - 1 mmHg increase in SBP related to 152% increase in intensity.
- **Strengths**:
  - Continuous recording of both PNC and BC.
  - Measuring BP on the same participant over time permitted an assessment of exposure duration.
- **Generalizability Considerations**:
  - Short duration and not real-life TRAP exposure.
  - No cardiovascular outcomes.