Comparative Assessment of Personal Exposure to Nitrogen Dioxide using Spatial Exposure Estimates and Wearable Monitors

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Introduction

- The increasing prevalence of children with asthma living in low-income urban communities is a public health concern. Springfield, MA is one example with 18.2% asthma prevalence in children; asthma prevalence is 12.2% across MA and 8.4% across the US (2015).
- Emergency room use for asthma-related events by Springfield residents is also elevated compared to rates across MA (**Figure 1**).

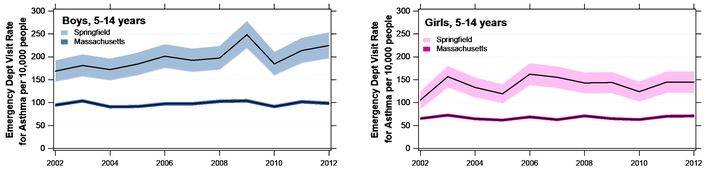

Figure 1. *Emergency room usage for asthma per 10,000 people in Springfield, MA and state-wide from 2002 to 2012 for boys and girls.*

- Nitrogen dioxide (**NO_2**), a marker of tailpipe vehicle emissions, has been positively associated with asthmatic symptoms in children.

The objective of this study was to evaluate ambient NO_2 levels across Springfield, MA as well as the personal NO_2 exposure of children living in this community.

Methods

NO_2 Measurements

- Ogawa passive sampling pads for NO_2 were deployed in custom fabricated PTFE chambers together with sorbent bar for sampling non-polar compounds (**Figure 2A**). These chambers mounted in a Fresh Air wristband for personal exposure assessment (**Figure 2B**) or a Fresh Air clip for stationary site measurements (**Figures 2C,D**).
- NO_2 concentrations were determined using a spectrophotometer following extraction of the Ogawa pad using sulfanilamide and N-(1-naphthyl)-ethylenediamine dihydrochloride.

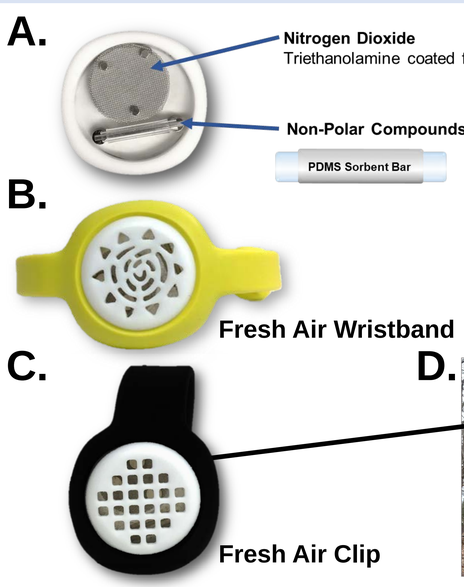

Figure 2. *NO_2 concentrations were measured using Ogawa pads (A). These sampling pads were placed in wristband for personal exposure assessment (B) or in a magnetic clip (C) for sampling at the fixed-site location (D).*

Methods

Spatio-Temporal Exposure Assessment

- NO_2 was measured at 40 sites across Springfield, MA and surrounding regions using Fresh Air Clips. Sampling was conducted over a 5-day period (Monday-Friday) during the winter and summer seasons in 2018.
- An inverse-distance weighting spatial interpolation method was used to predict NO_2 concentration across the study area in ArcMap 10.5.1.

Personal Exposure Assessment

- The study population was comprised of children (n=25) that resided in Springfield, MA and attended the same school. Children completed a questionnaire following study enrollment detailing their commute mode and route to school, home environment (stove type, hood use, pets) and health status.
- The children's personal exposure to NO_2 was evaluated using three approaches:
  - *Fresh Air Wristband*: worn for 5 consecutive days (Monday-Friday) during the winter season
  - *Spatial exposure models*: interpolated concentration at residential address
  - *Community-LINE Source Model* (**C-LINE**, EPA): interpolated concentration at residential address

Results

Spatial and Temporal Variation of NO_2 Across Springfield, MA

- Greater heterogeneity was found across NO_2 concentrations measured in the summer (**Figure 3A**) compared to winter (**Figure 3B**) measurements.
- NO_2 measured during both seasons exhibited similar patterns: elevated concentrations in the western region near the intersection of four major highways and lower levels in suburban areas towards east end of the city.

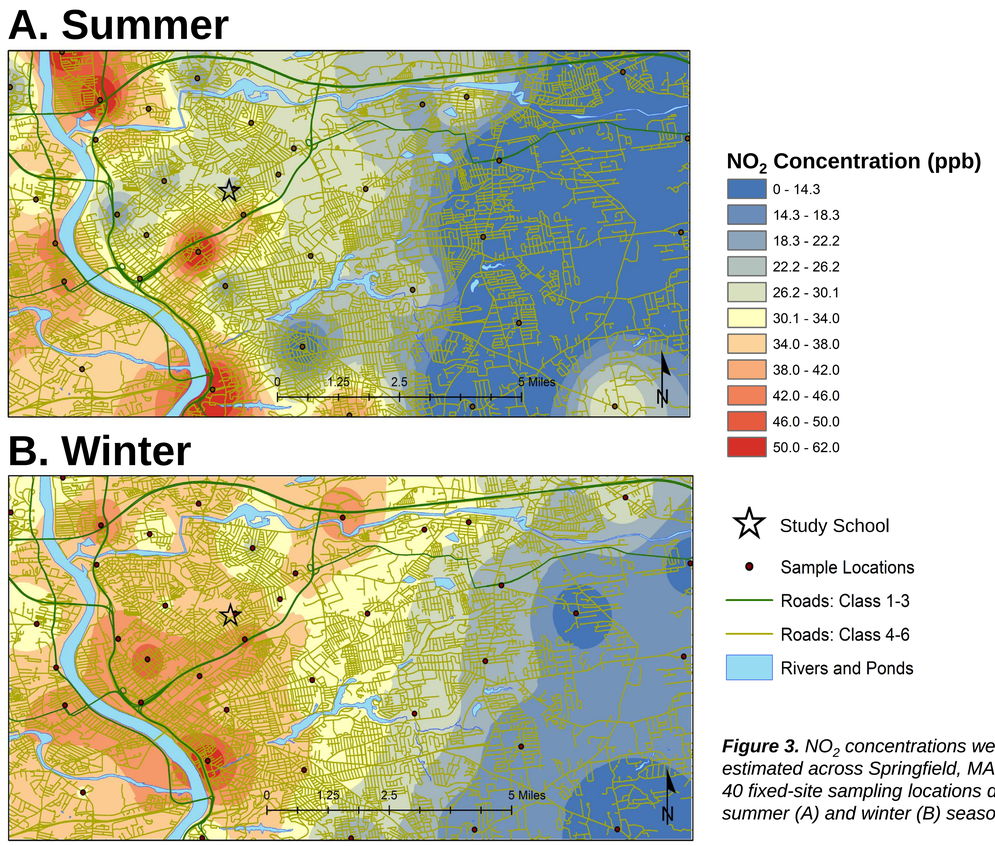

Figure 3. *NO_2 concentrations were estimated across Springfield, MA using 40 fixed-site sampling locations during summer (A) and winter (B) seasons.*

Results

Personal NO_2 Exposure Assessment

- The study population was comprised of 76% females, 28% asthmatics and 52% lived in houses with a gas stove (**Table 1**).
- Winter spatial NO_2 estimates and C-LINE models were correlated but no relationship was found with Fresh Air wristband NO_2 measurements (**Figure 4**).

Table 1. *Selected characteristics of the children included in the present analysis.*

Variable	N (%)
Demographics	
Age (years)	12-13
Girls	19 (76%)
Health Status	
Asthma	7 (28%)
Home Environment	
Pet(s)	16 (64%)
Gas Stove	13 (52%)
Hood Use	15 (60%)

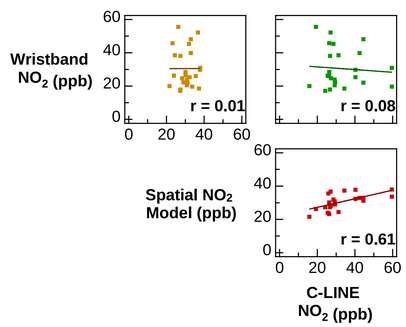

Figure 4. *Relationship between various approaches used to estimate winter NO_2 exposure.*

- Children with asthma had increased concentrations of personal NO_2 exposure measured using the Fresh Air Wristband compared to children without a diagnosis of asthma (**Figure 5**); this difference was not found when estimating NO_2 exposure using the winter spatial surface or C-LINE.
- For children living in houses with gas stoves, decreased NO_2 was found for children who reported use of hood ventilation while cooking (**Figure 6**).

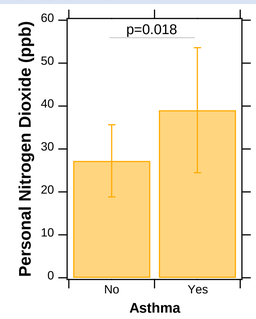

Figure 5. *NO_2 exposure of children with and without asthma.*

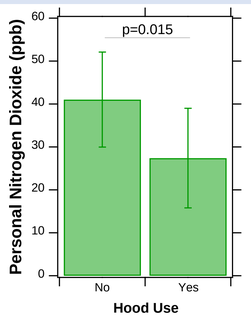

Figure 6. *Comparison of NO_2 levels for children with a gas stove at home, with and without the use of hood ventilation.*

Conclusions

- Study findings suggest a discrepancy between personal NO_2 exposure assessed using a wearable monitor and ambient estimates.
- Additional studies should assess the relationship between ventilation and asthma incidence/ excerbations in homes with gas stoves.

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