Effect of HEPA filtration air purifiers on blood pressure: A *pragmatic* randomized crossover trial

Doug Brugge, Misha Eliasziw, Vedaant Kuchhal, Chermaine Morson, Teresa Vazquez-Dodero, Amy Mertl, Pratham Tallam , Sangita Kunwar, Linda Sprague Martinez, Kiran Sing-Smith, Hunter Gates, Sharly Palma, Mohan Thanikachalam, Warren Goldstein-Gelb, Shir Ginzburg, Scott Oakley Hersey, Wig Zamore, Francesca Majluf

UConn Health & Storrs, Tufts, Wellesley, The Welcome Project, Olin, Somerville Transportation Equity Partnership, Massachusetts College of Pharmacy and Health Sciences

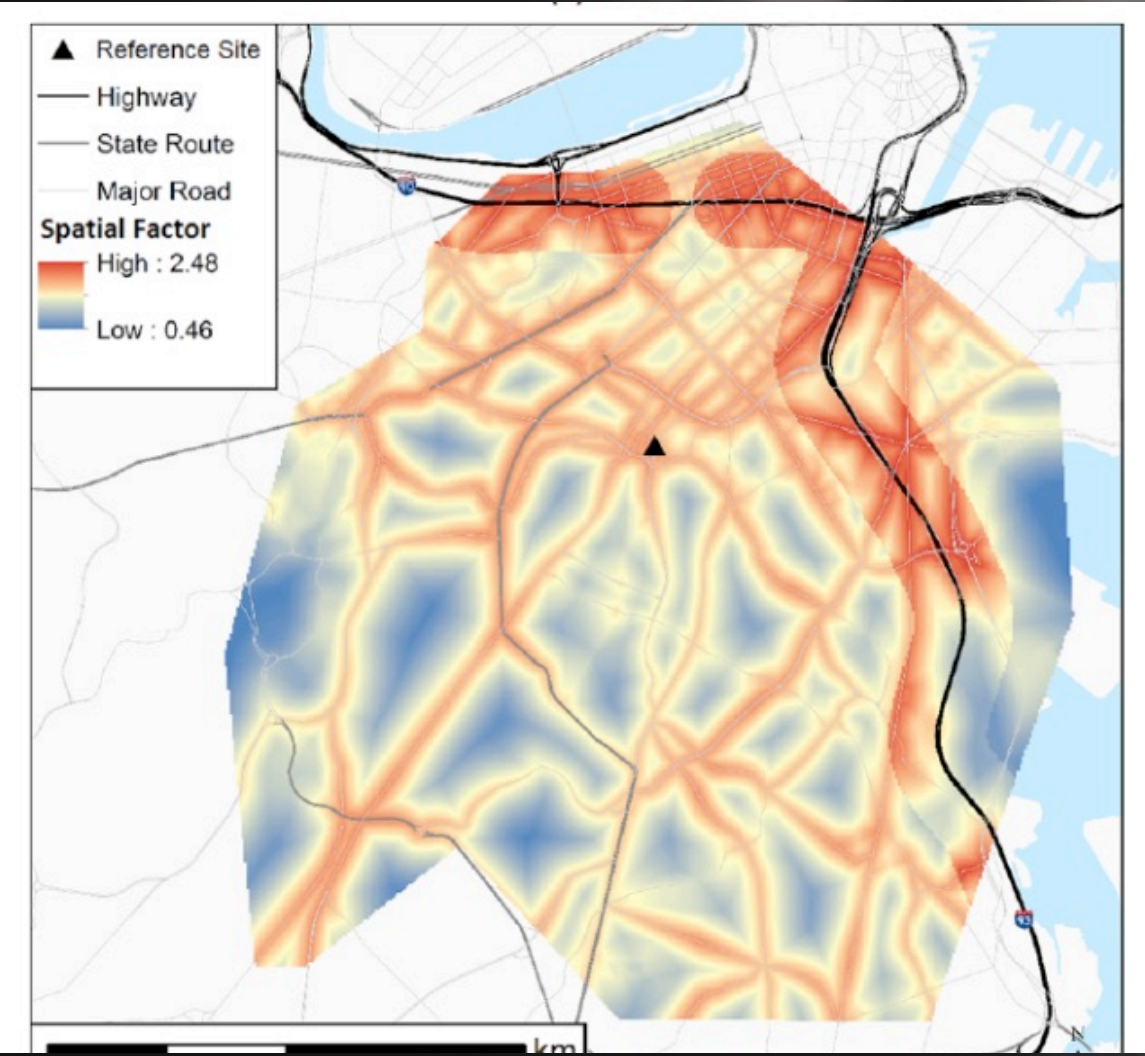
JACC JOURNALS

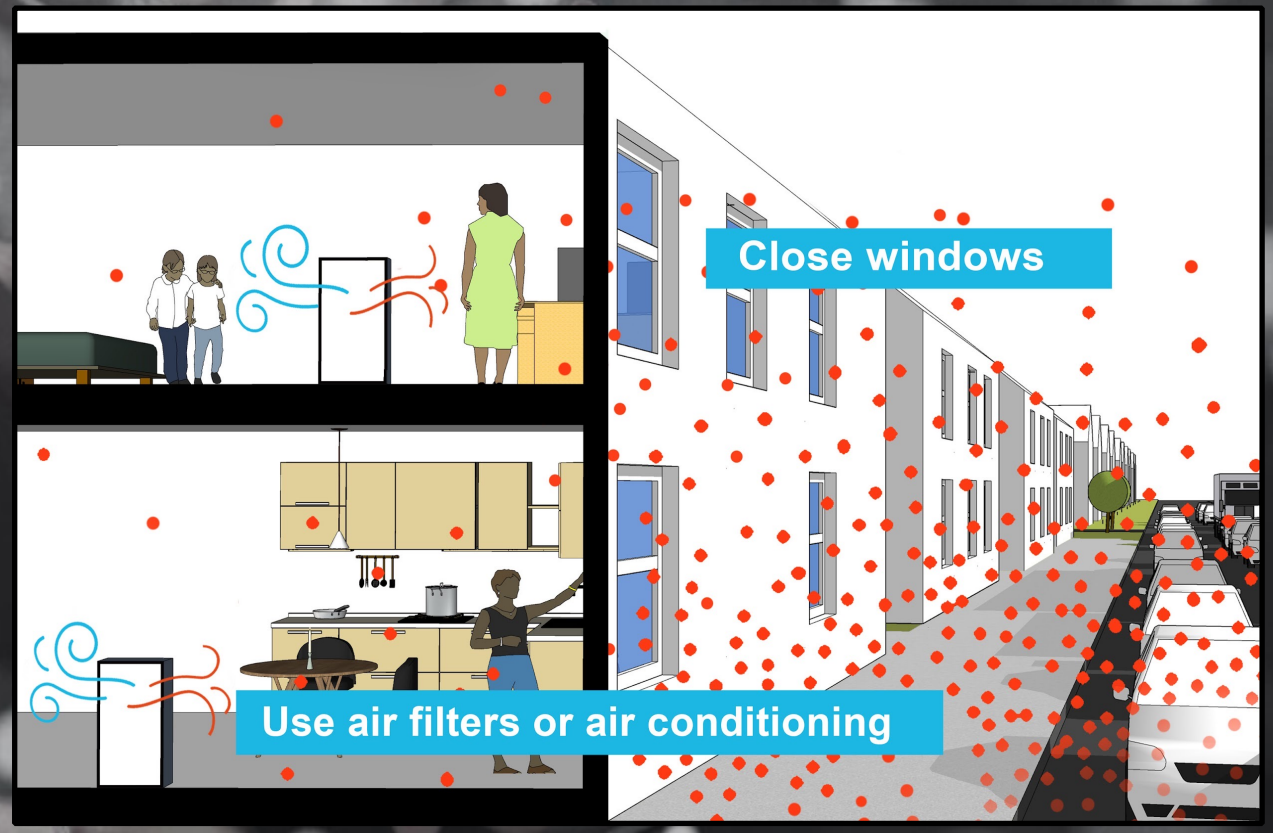
The #1 cause of morbidity globally

Leading risks 2021	95% UI for Ranking	Percentage of total DALYs, 2021	Percentage change in number of DALYs, 2000–2021	Percentage change in age-standardised rate of DALYs, 2000–2021
1 Particulate matter pollution	(1 to 2)	8·0 (6·7 to 9·4)	−17·2 (−25·9 to −6·2)	−41·9 (−47·2 to −35·6)
2 High systolic blood pressure	(1 to 2)	7·8 (6·4 to 9·2)	34·3 (26·7 to 42·3)	−24·3 (−28·4 to −20·0)
3 Smoking	(3 to 6)	5·7 (4·7 to 6·8)	10·8 (3·2 to 19·9)	−34·8 (−39·2 to −29·7)
4 Low birthweight and short gestation	(3 to 6)	5·6 (4·8 to 6·3)	−32·4 (−41·2 to −22·3)	−33·0 (−41·6 to −22·8)
5 High fasting plasma glucose	(3 to 6)	5·4 (4·8 to 6·0)	88·2 (80·5 to 96·4)	7·9 (3·3 to 12·9)
6 High body–mass index	(3 to 10)	4·5 (1·9 to 6·8)	96·5 (87·1 to 105·8)	15·7 (9·9 to 21·7)
7 High LDL cholesterol	(7 to 10)	3·0 (1·9 to 4·2)	27·0 (20·8 to 33·6)	−26·1 (−29·6 to −22·4)
8 Kidney dysfunction	(6 to 10)	3·0 (2·6 to 3·4)	49·5 (42·7 to 57·0)	−12·4 (−16·5 to −7·9)
9 Child growth failure	(6 to 14)	2·6 (1·4 to 3·5)	−69·8 (−77·5 to −62·4)	−71·5 (−78·8 to −64·4)
10 High alcohol use	(7 to 11)	2·5 (2·1 to 3·1)	12·4 (2·6 to 20·9)	−25·8 (−32·0 to −20·4)
11 Unsafe sex	(11 to 17)	1·5 (1·4 to 1·7)	−35·0 (−44·6 to −20·1)	−52·4 (−58·9 to −42·3)
12 Diet low in fruits	(11 to 22)	1·5 (0·6 to 2·3)	22·5 (15·5 to 34·0)	−26·6 (−30·9 to −20·5)
13 Unsafe water source	(11 to 24)	1·5 (0·8 to 2·0)	−60·1 (−67·1 to −53·2)	−66·3 (−72·0 to −60·2)
14 Diet high in sodium	(8 to 36)	1·4 (0·3 to 3·2)	27·6 (1·3 to 41·2)	−26·8 (−40·9 to −19·1)
15 Diet low in whole grains	(12 to 23)	1·4 (0·6 to 2·1)	30·1 (24·0 to 36·6)	−23·3 (−26·9 to −19·5)
16 Secondhand smoke	(11 to 26)	1·2 (0·6 to 1·8)	−16·0 (−22·0 to −6·5)	−45·3 (−48·9 to −40·3)

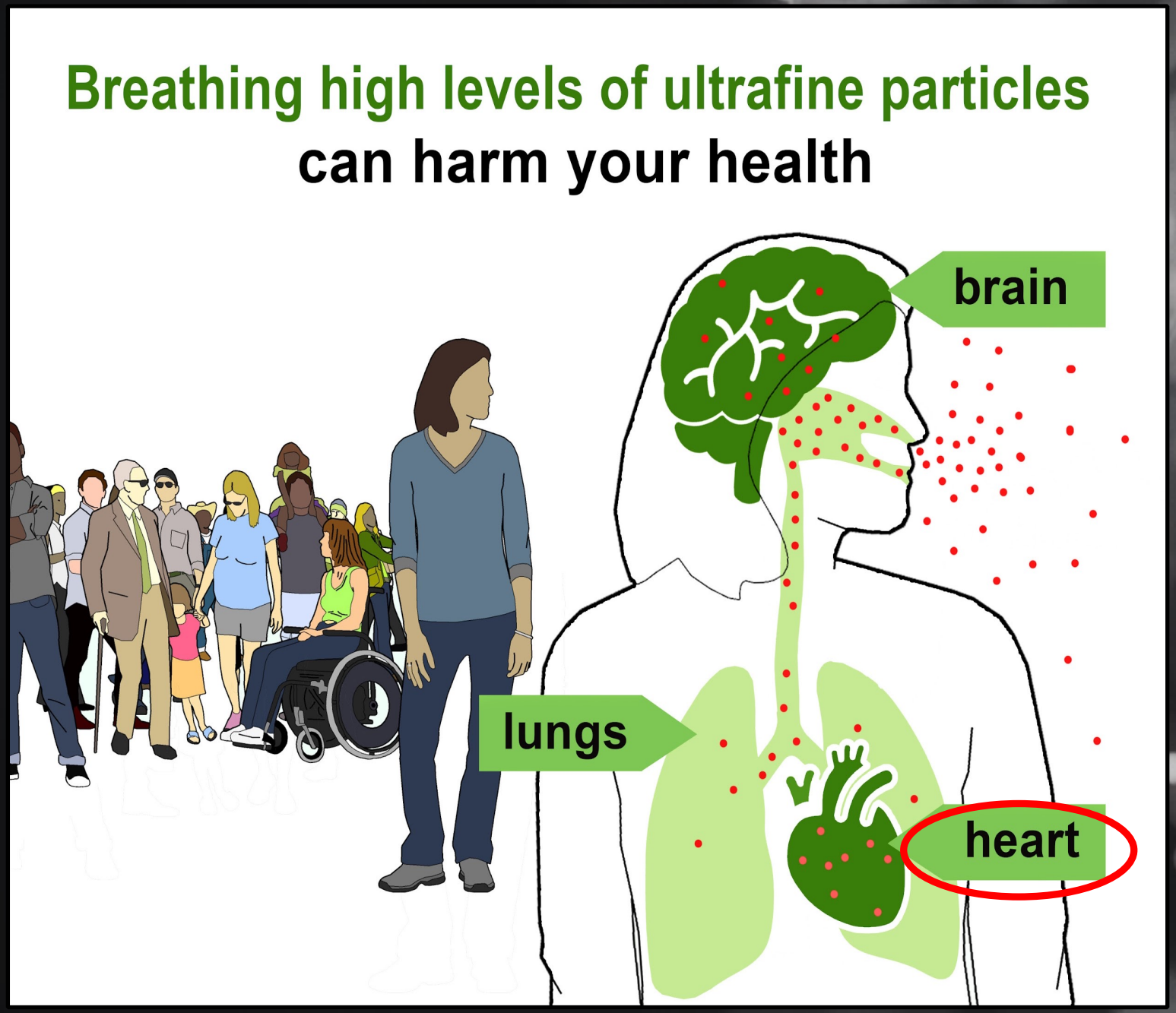
Lancet 2024; 403: 2162–203

Particulate matter (UFP/PNC, BC) air pollution near busy roads and highways



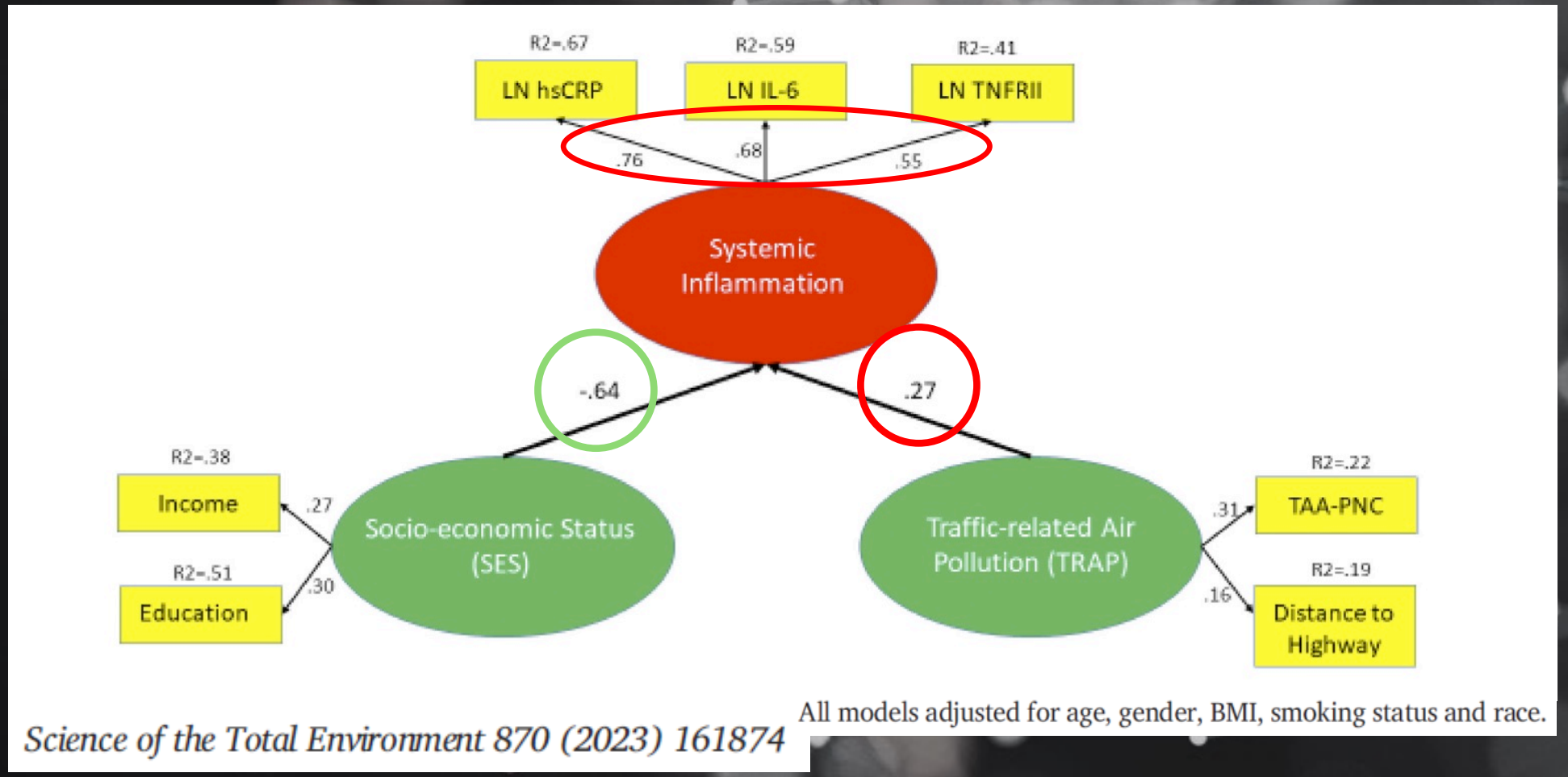


Environ. Sci. Technol. 2020, 54, 1677−1686



Our focus has been effects in the cardiovascular system

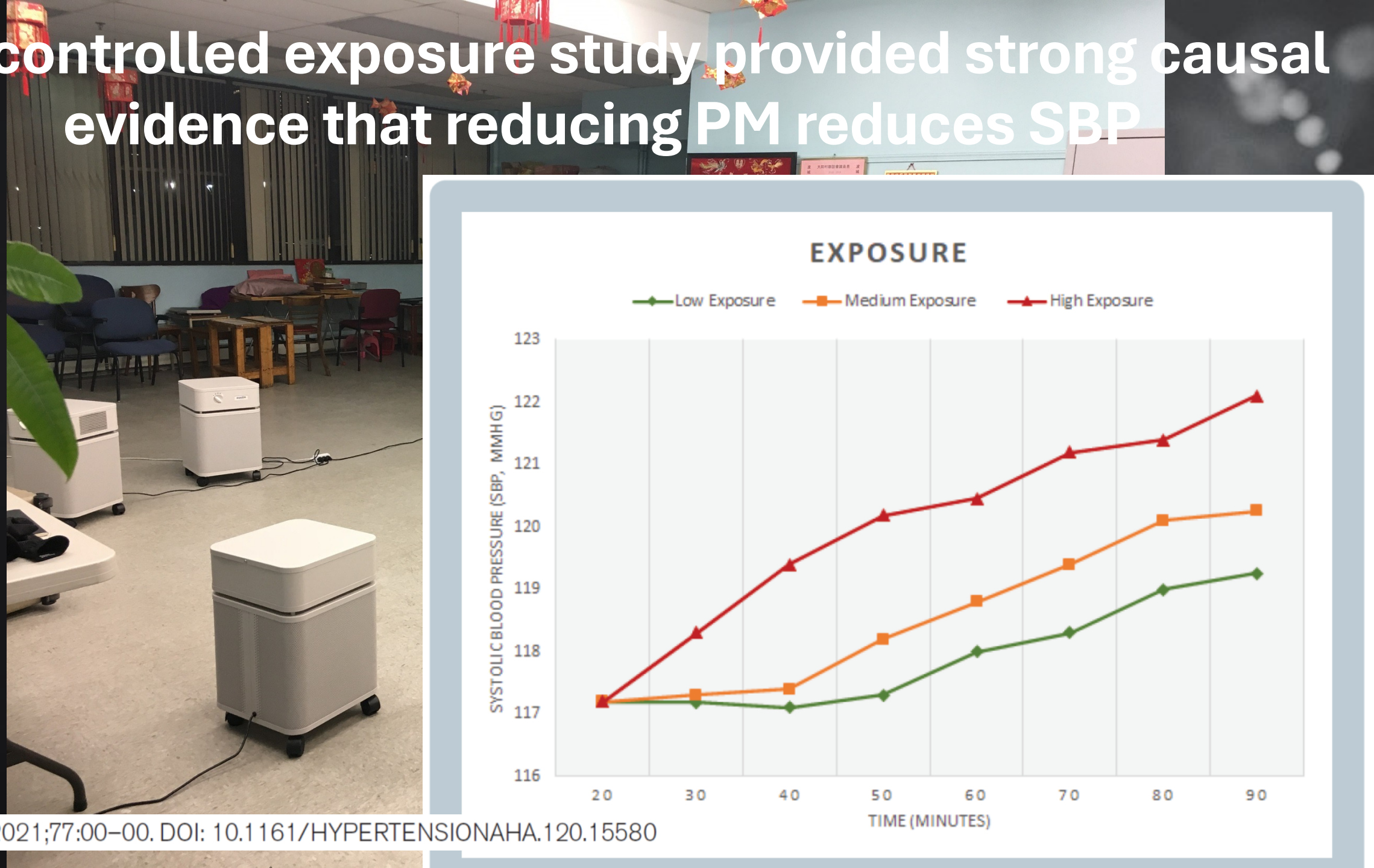
Observational findings of associations with inflammation



All models adjusted for age, gender, BMI, smoking status and race.

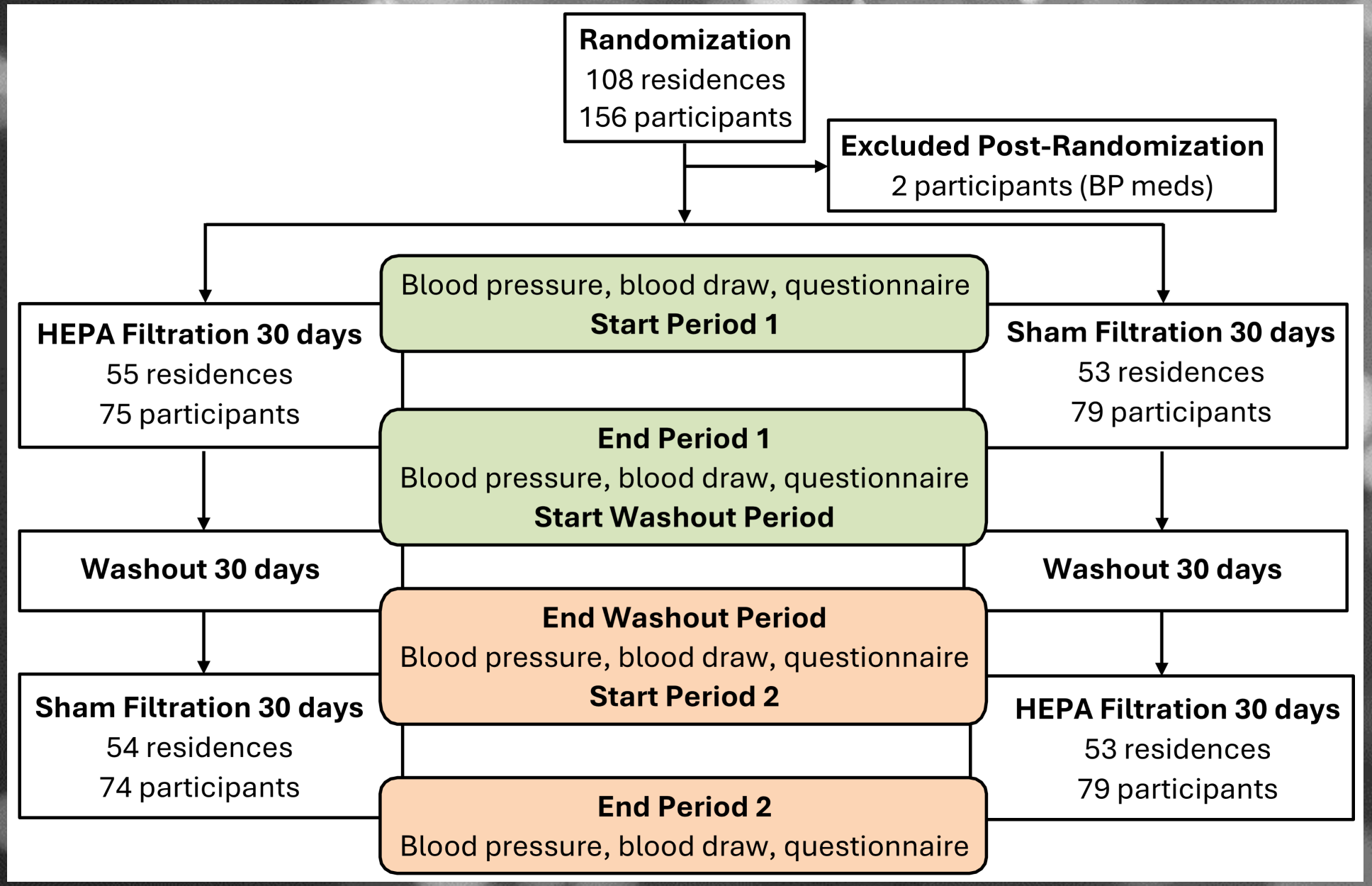
Science of the Total Environment 870 (2023) 161874

Our controlled exposure study provided strong causal evidence that reducing PM reduces SBP



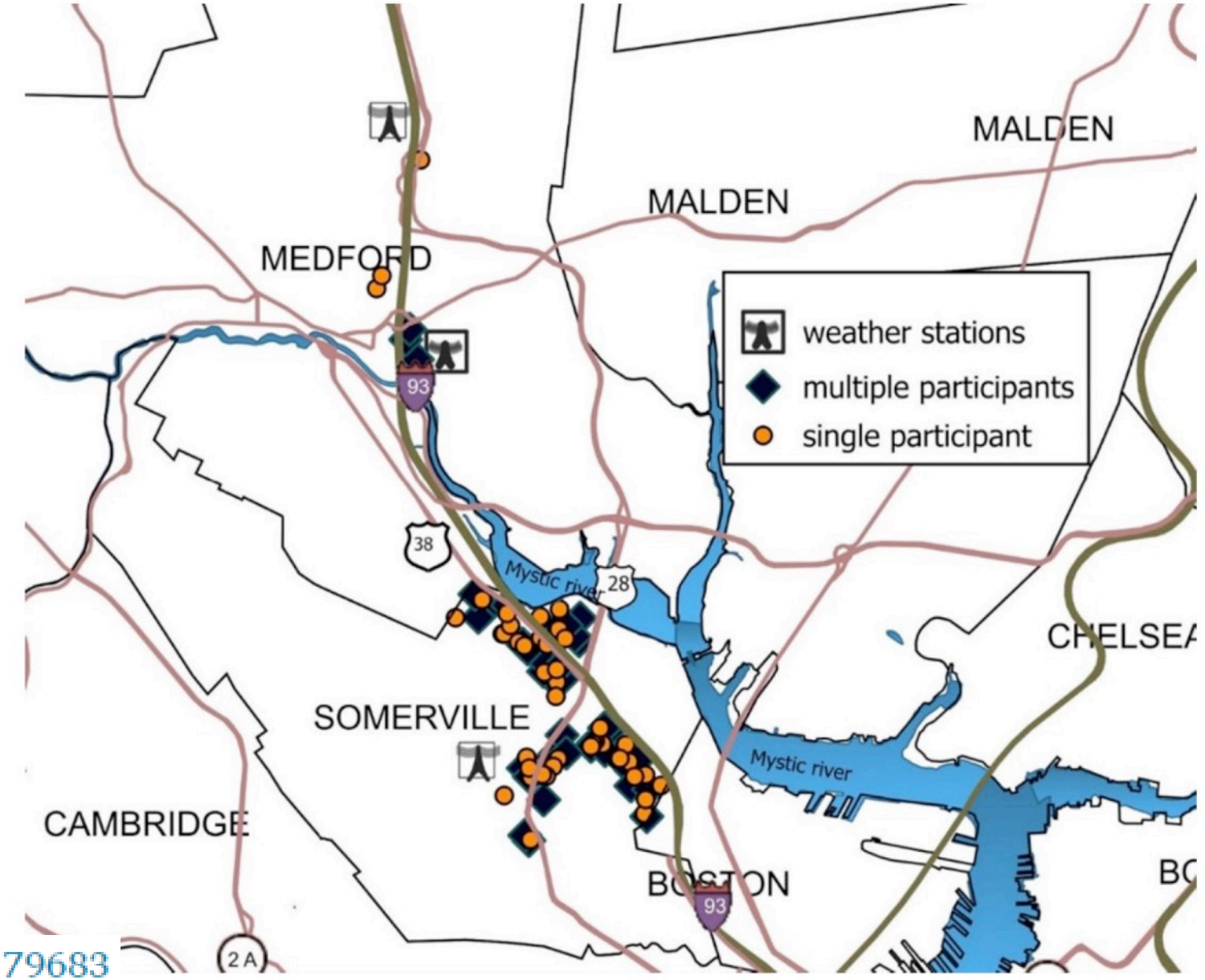
Hypertension. 2021;77:00–00. DOI: 10.1161/HYPERTENSIONAHA.120.15580

Study design and participants



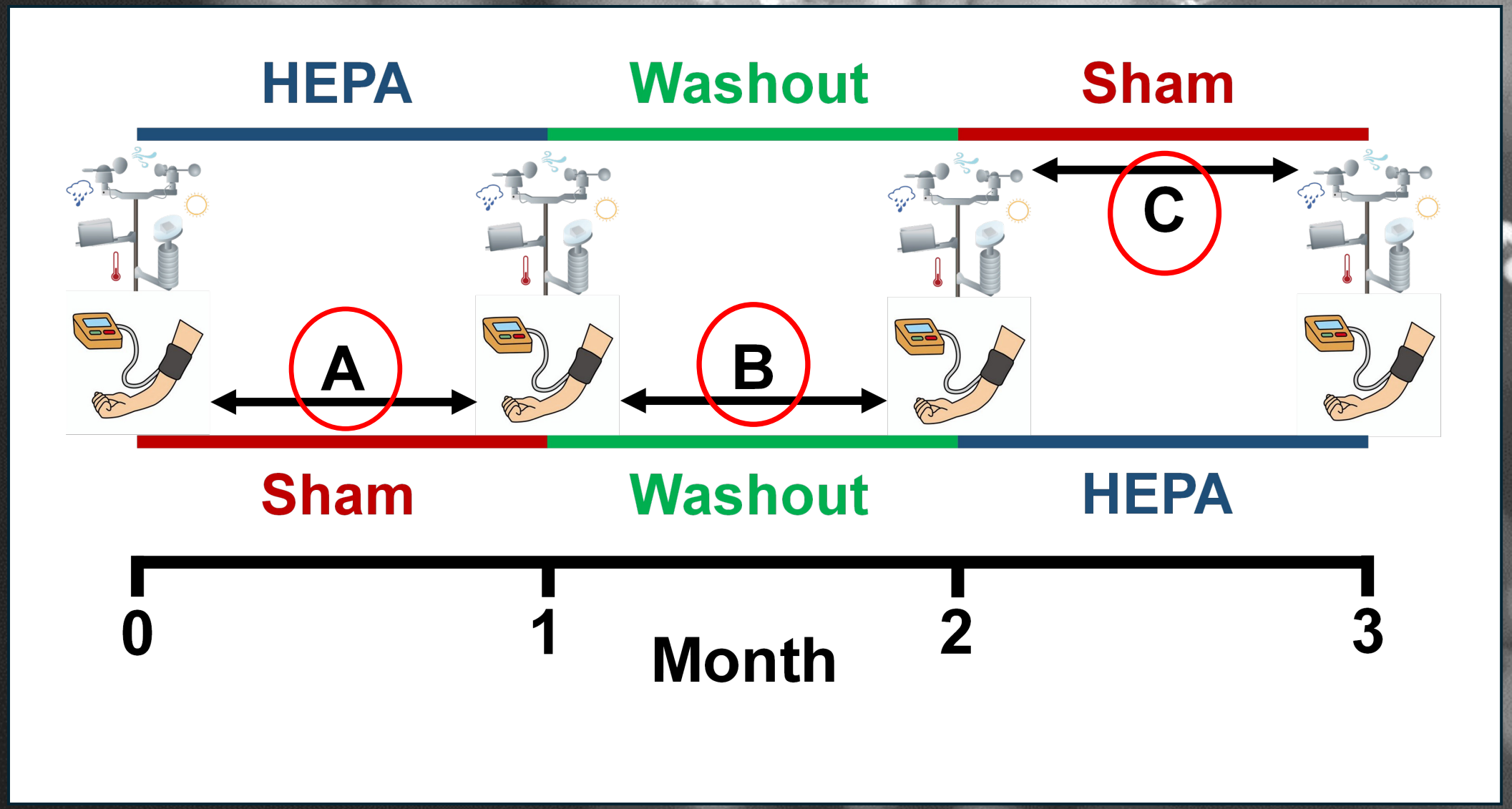
The study area

Figure 1. Location of study participant residences relative to highways.



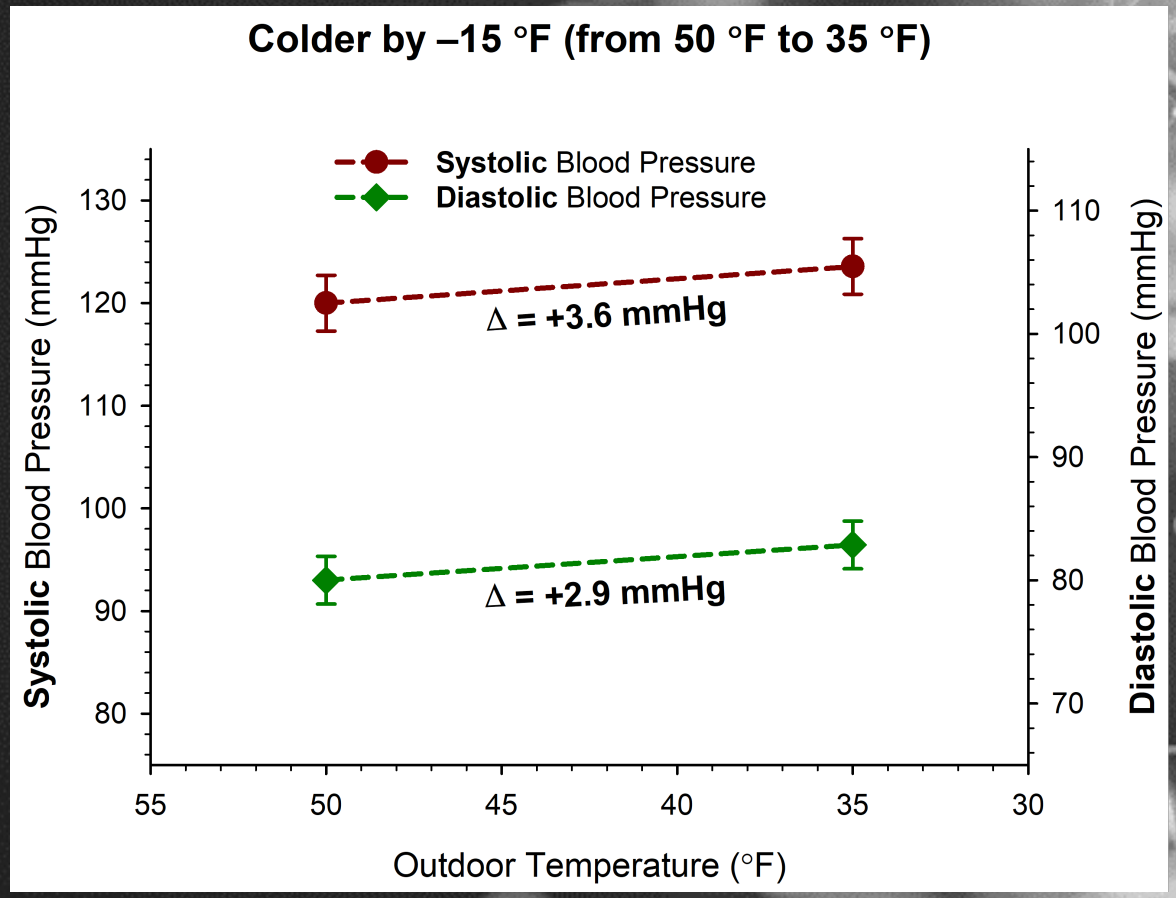
Science of the Total Environment 982 (2025) 179683

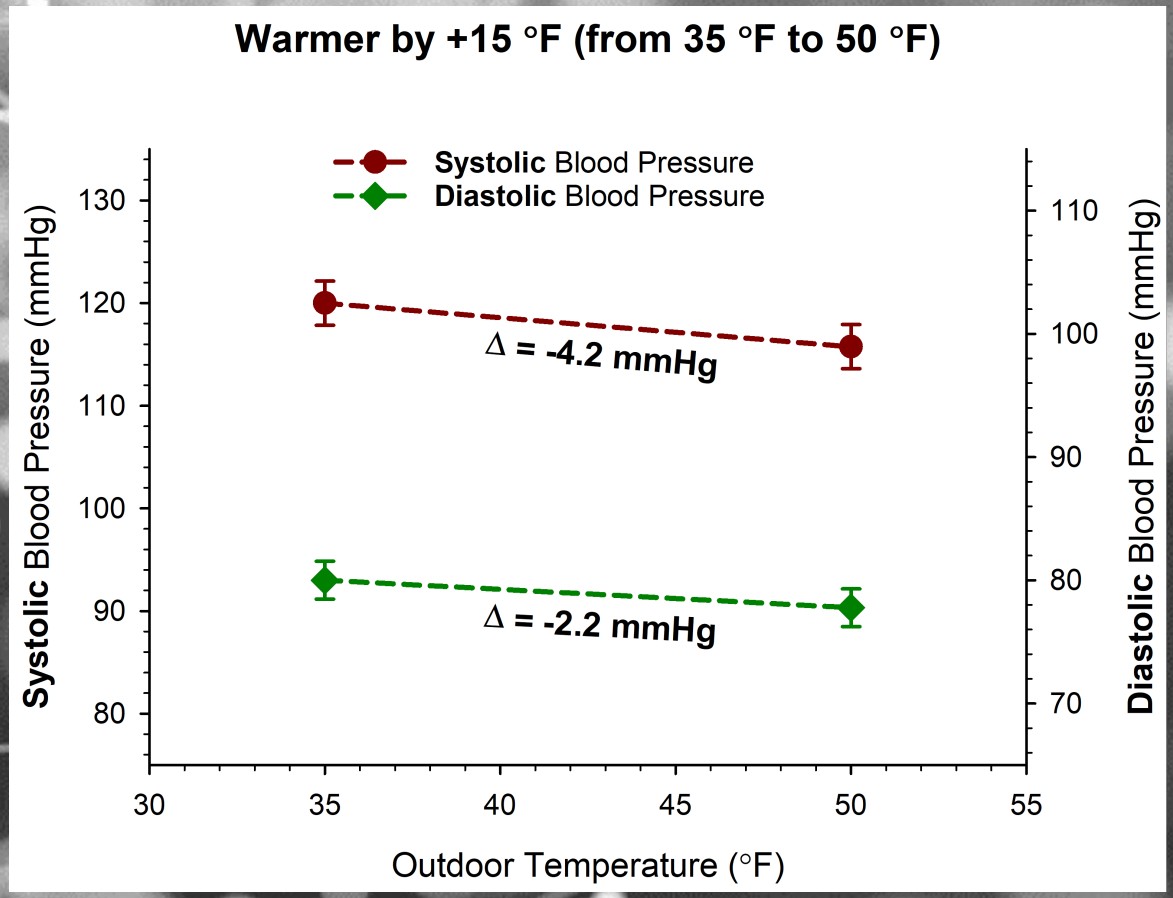
Temperature is associate with changes in blood pressure



Science of the Total Environment 982 (2025) 179683

Colder outdoor temperature was associate with higher blood pressure in our study population





Science of the Total Environment 982 (2025) 179683

The study population is evenly matched on all variables

Table 1. Characteristics of Participants at the Start of the Intervention Period

	HEPA (N = 153)	Sham (N = 152)
Randomized to sequence, n (%)		
HEPA then sham filtration	74 (48.4)	73 (48.0)
Sham then HEPA filtration	79 (51.6)	79 (52.0)
Age in years, mean (standard deviation)	41.1 (9.9)	41.0 (9.8)
Age category, n (%)		
< 40 years	84 (54.9)	85 (55.9)
40 years or older	69 (45.1)	67 (44.1)
Sex, n (%)		
Male	62 (40.5)	61 (40.1)
Female	91 (59.5)	91 (59.9)
Ethnicity and race, n (%)		
Hispanic	29 (19.0)	28 (18.4)
White, non-Hispanic	104 (68.0)	104 (68.4)
Black, non-Hispanic	8 (5.2)	8 (5.3)
Asian, non-Hispanic	12 (7.8)	12 (7.9)
Highest level of education, n (%)		
Grade or high school	17 (11.1)	16 (10.5)
Some college	17 (11.1)	17 (11.2)
College or university degree	43 (28.1)	43 (28.3)
Graduate degree	76 (49.7)	76 (50.0)
Work status, n (%)		
Unemployed	26 (17.0)	26 (17.1)
Part-time working	19 (12.4)	18 (11.8)
Full-time working	108 (70.6)	108 (71.1)
Total annual household income, n (%)		
< $48,000	11 (7.2)	11 (7.2)
$48,000 to $84,999	19 (12.4)	18 (11.8)
$85,000 or greater	95 (62.1)	96 (63.2)
Declined to answer	28 (18.3)	27 (17.8)
Weight status, n (%)		
Healthy	66 (43.1)	66 (43.4)
Overweight	45 (29.4)	45 (29.6)
Obesity	42 (27.5)	41 (27.0)
Time spent inside home (hours per day)	18.7 (3.6)	18.6 (3.6)
Perceived Stress Scale (PSS-4), mean (sd)	3.4 (3.0)	3.3 (3.0)
Peripheral SBP mmHg, mean (standard deviation)	119.1 (13.1)	118.6 (11.9)
Peripheral DBP mmHg, mean (standard deviation)	76.8 (9.4)	76.3 (8.6)
Central SBP mmHg, mean (standard deviation)	109.0 (12.1)	108.4 (11.0)
Central DBP mmHg, mean (standard deviation)	77.5 (9.4)	77.1 (8.6)
Outdoor temperature in Fahrenheit, mean (sd)	44.3 (11.8)	40.9 (12.1)

JACC JOURNALS

Indoor & outdoor monitoring of particulate matter

Figure 1A. Hourly $PM_{2.5}$ Concentrations

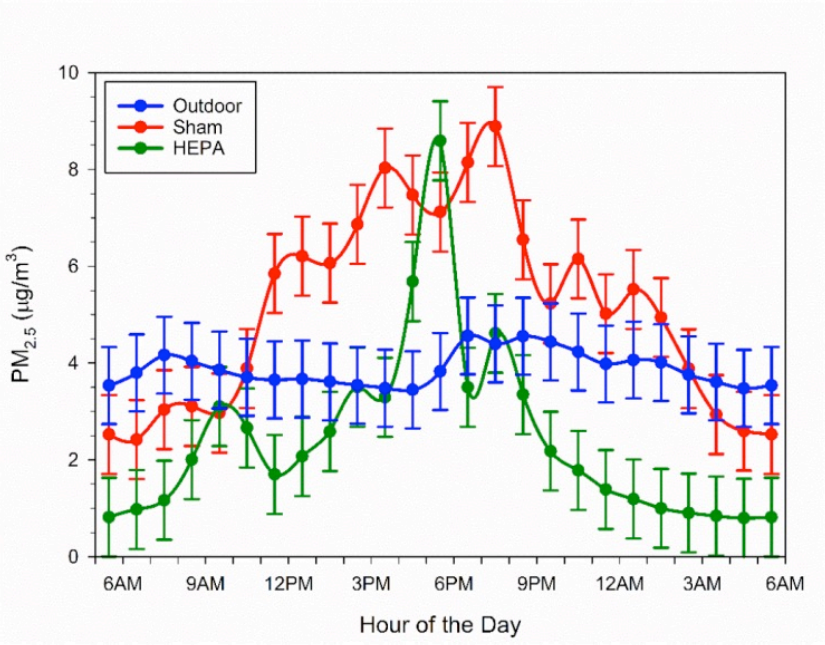


Figure 1B. Hourly Particle Number Concentrations

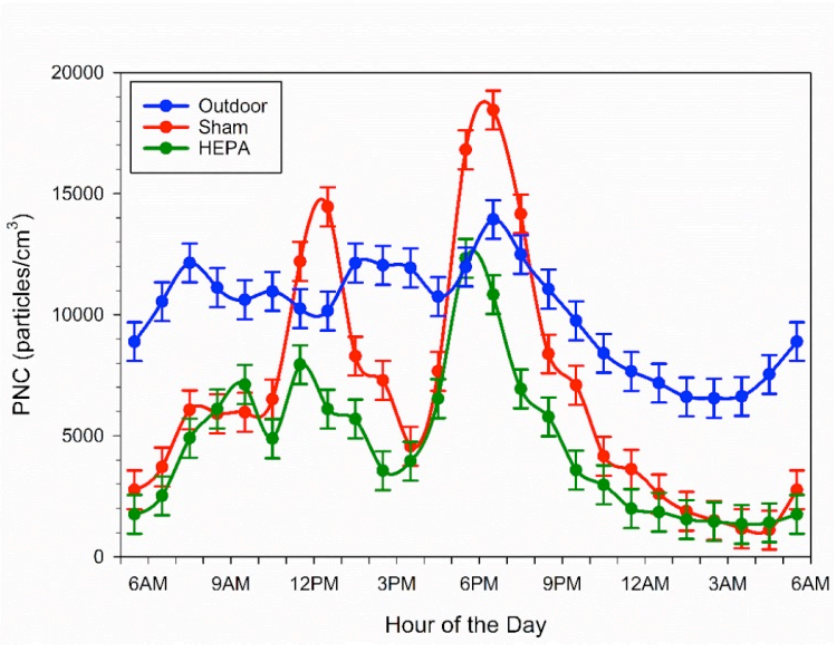


Figure 1C. Hourly Indoor/Outdoor $PM_{2.5}$ Ratios

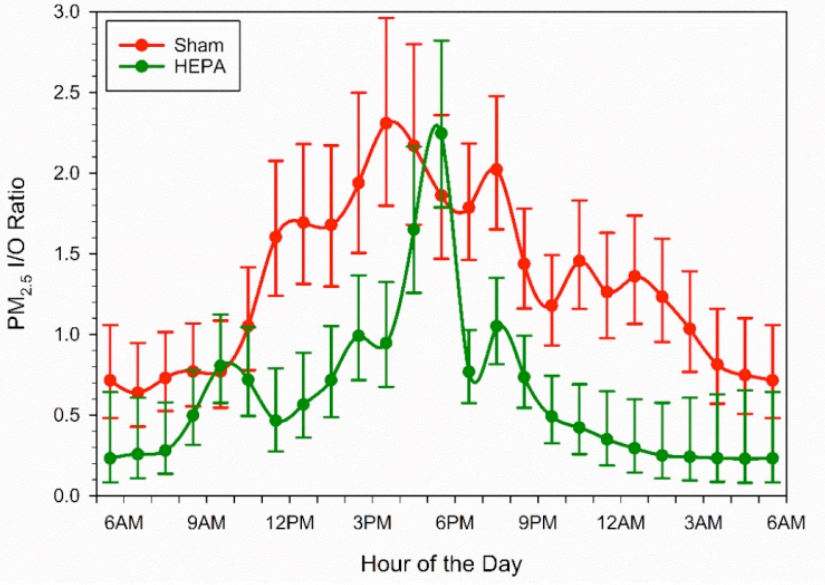
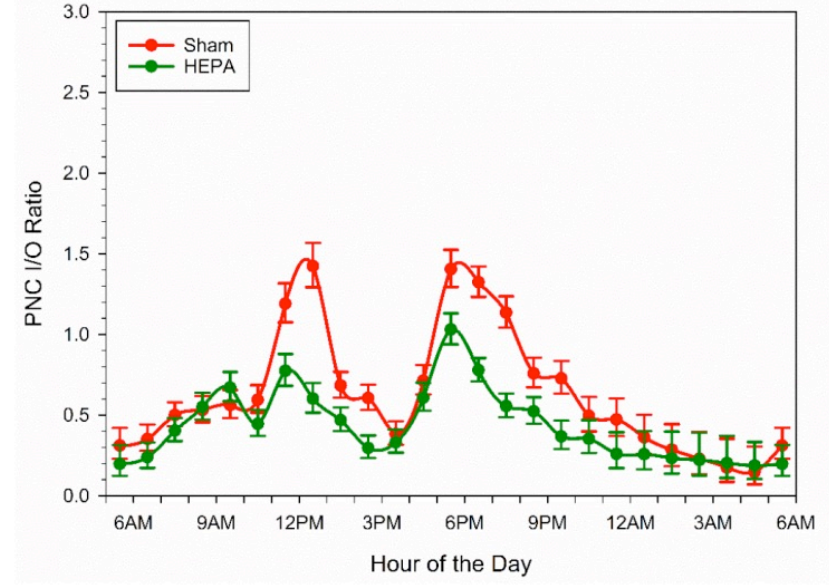
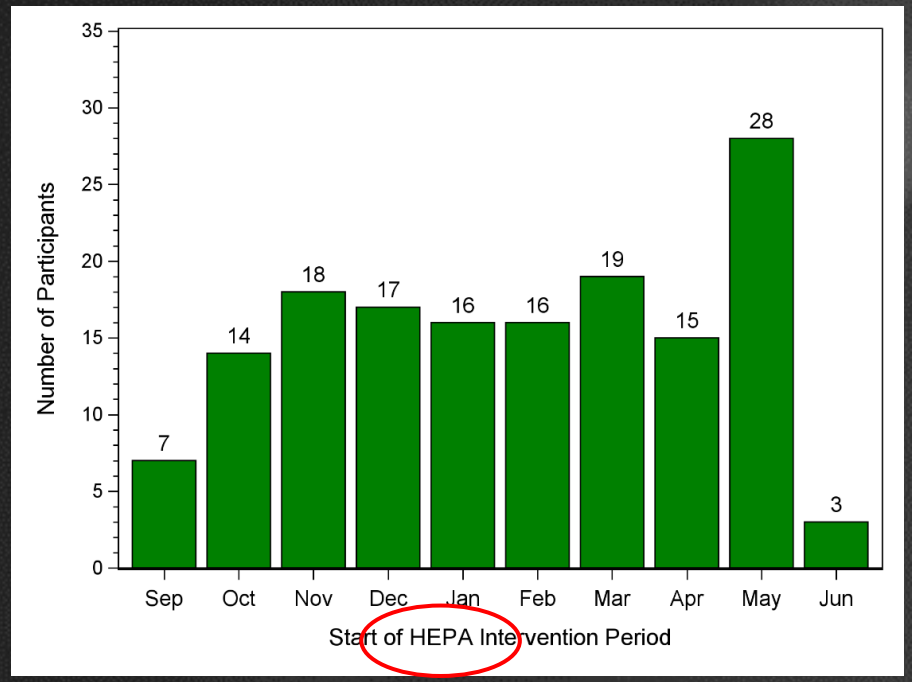
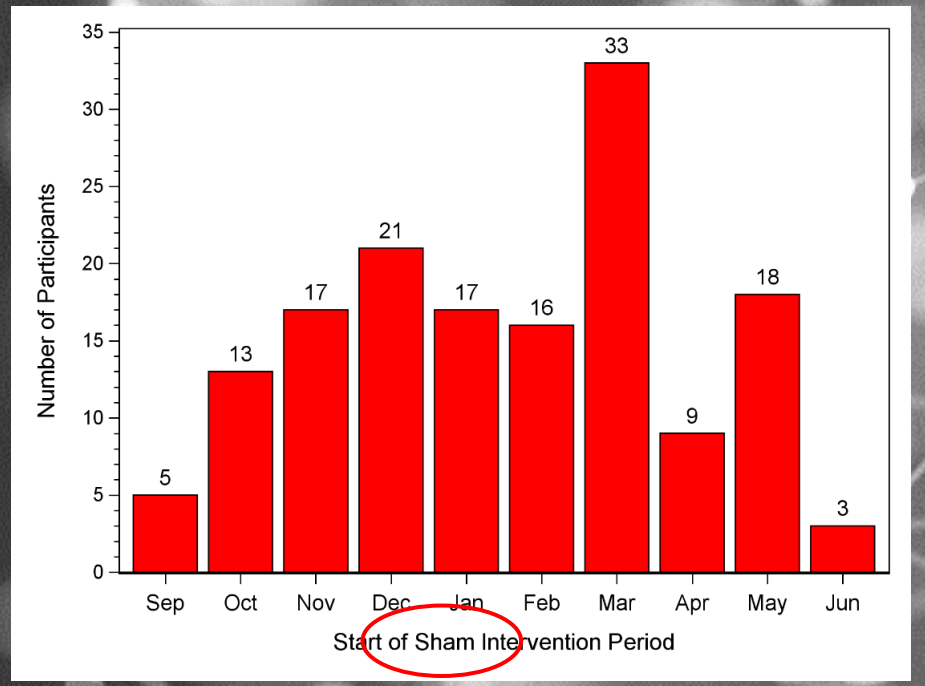


Figure 1D. Hourly Indoor/Outdoor PNC Ratios

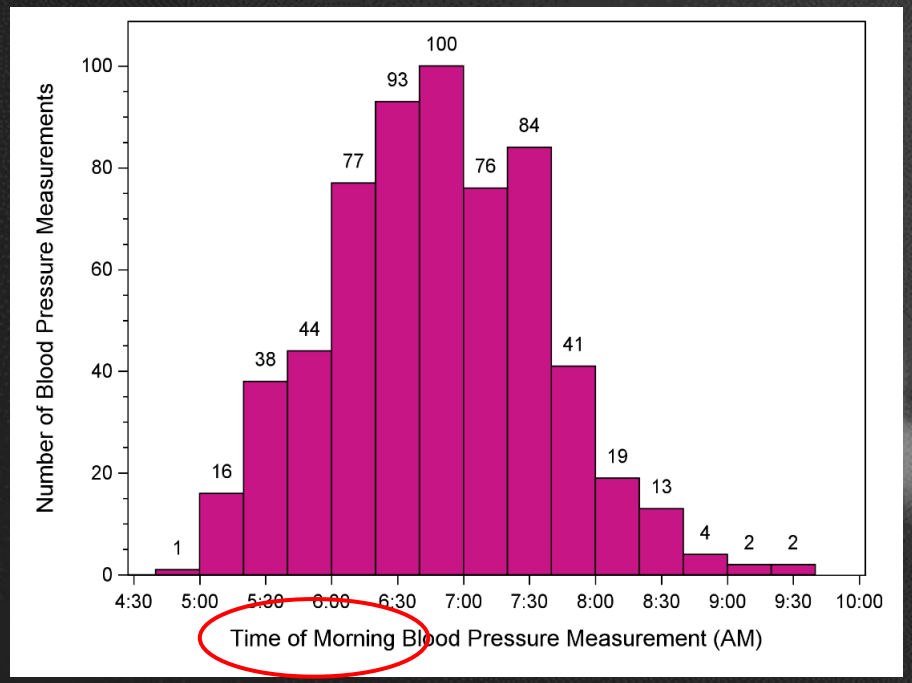


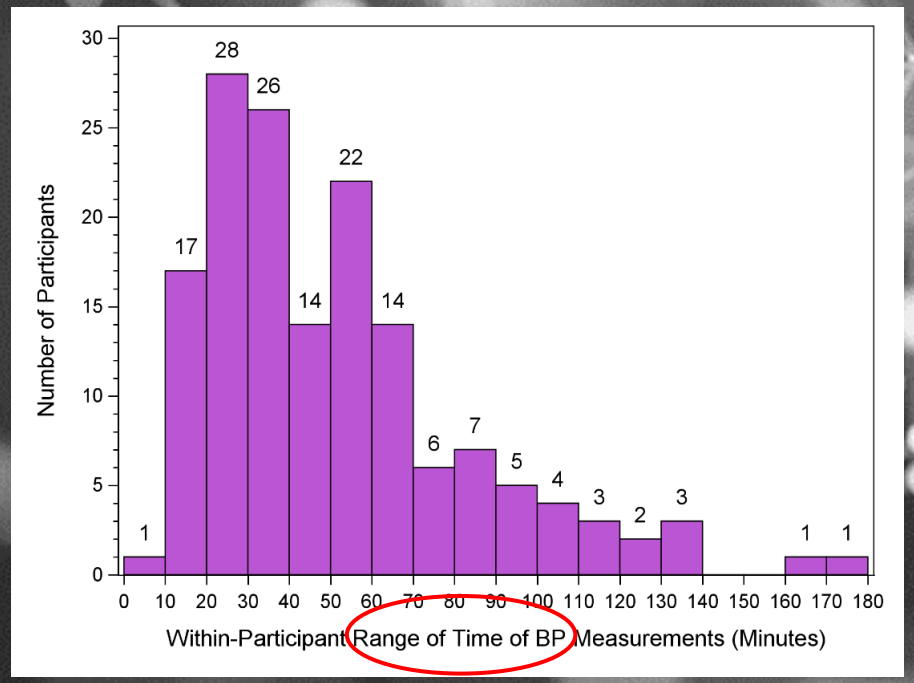
JACC JOURNALS





Month of the year for HEPA and sham and hour of the day and time difference for blood pressure measurements





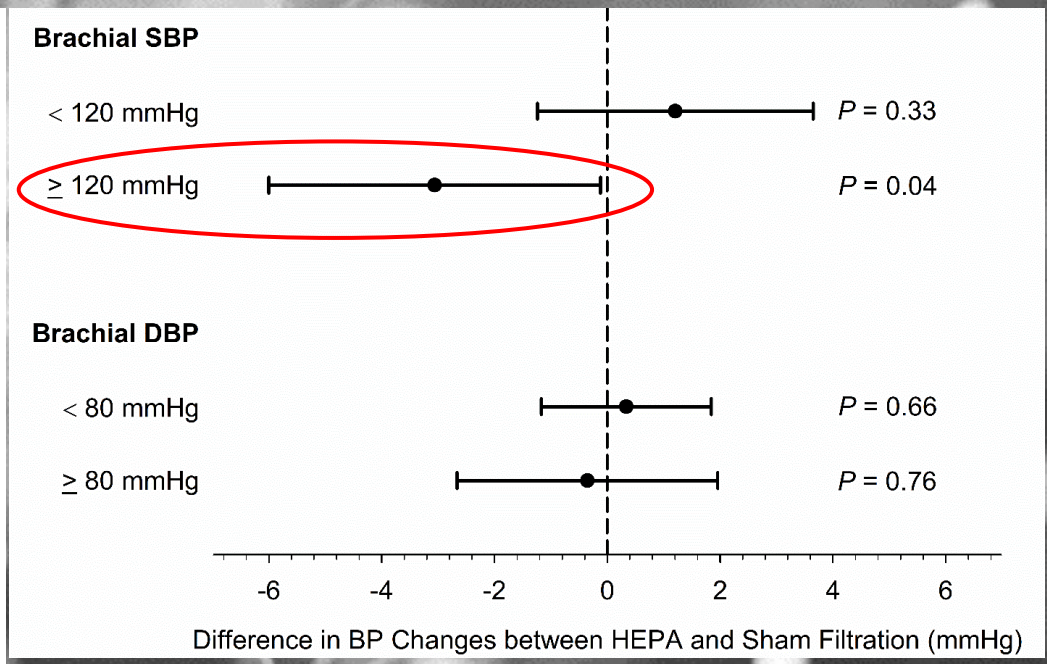
JACC JOURNALS

Benefit, HEPA vs. sham for participants with brachial SBP 120 mmHg or greater

Table 2. Changes in Blood Pressures from the Start of the Intervention Period

	N_{HEPA} , N_{Sham}	HEPA	Sham	Difference	95% CI	P-value
Brachial SBP, mean (se)						
Overall	153 , 152	–1.1 (0.7)	–0.6 (0.7)	–0.5 (0.9)	(–2.4 , 1.3)	0.56
< 120 mmHg	88 , 91	0.1 (1.1)	–1.1 (1.0)	1.2 (1.2)	(–1.2 , 3.6)	0.33
120 mmHg or higher	65 , 61	–2.8 (1.3)	0.2 (1.3)	–3.0 (1.5)	(–6.0 , –0.1)	0.04
Brachial DBP, mean (se)						
Overall	153 , 152	–0.4 (0.5)	–0.5 (0.5)	0.1 (0.6)	(–1.1 , 1.4)	0.81
< 80 mmHg	100 , 109	–0.5 (0.7)	–0.8 (0.6)	0.3 (0.8)	(–1.2 , 1.8)	0.66
80 mmHg or higher	53 , 43	–0.3 (1.0)	0.1 (1.1)	–0.4 (1.2)	(–2.7 , 2.0)	0.76

Results were adjusted for participant's age, sex, and corresponding BP measurement at the start of each intervention period. Results were also adjusted for number of hours per day spent indoors at home a week prior to the BP measurement, and outdoor temperature and Perceived Stress Scale (PSS-4) score at the at the time of the BP measurement.



JACC JOURNALS

Individual SBP responses to HEPA filtration

Figure 4A. Lower than 120 mmHg and HEPA Filtration

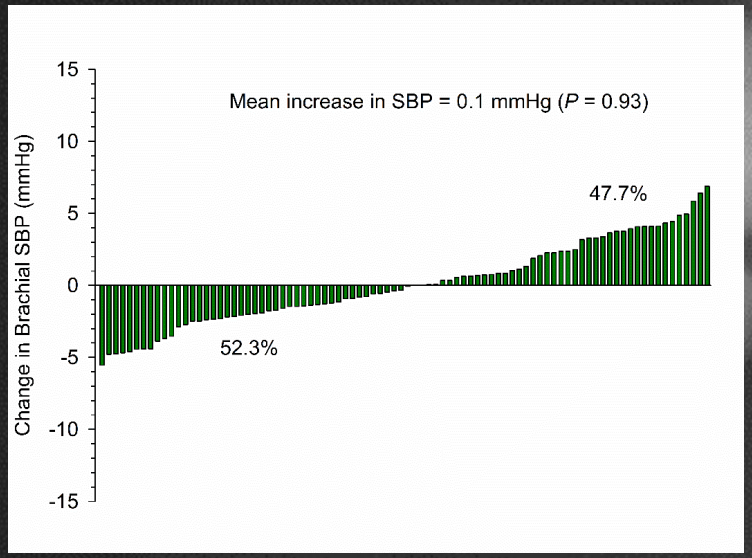


Figure 4B. Lower than 120 mmHg and Sham Filtration

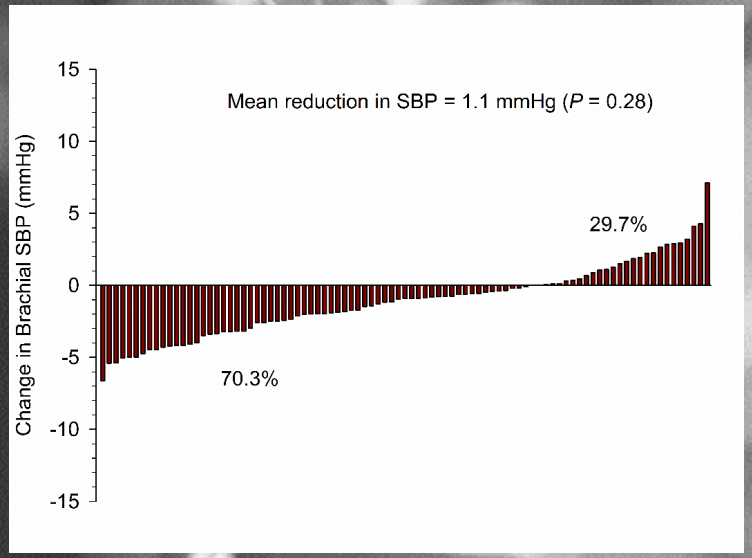


Figure 4C. 120 mmHg or Higher and HEPA Filtration

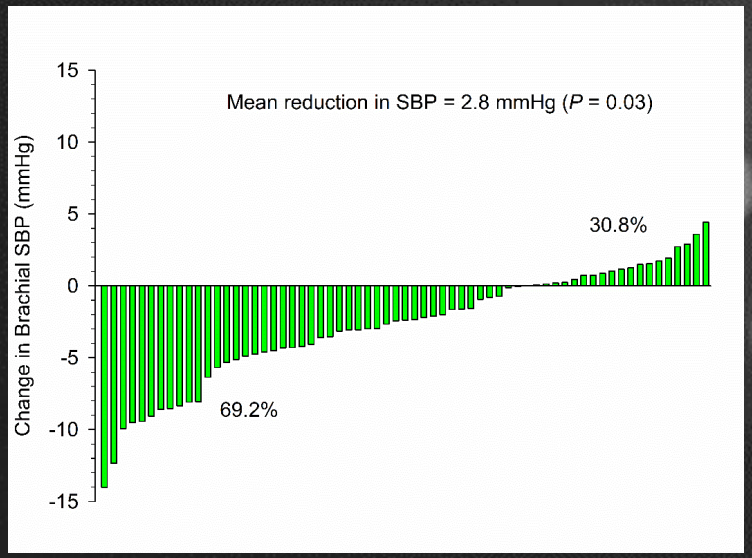
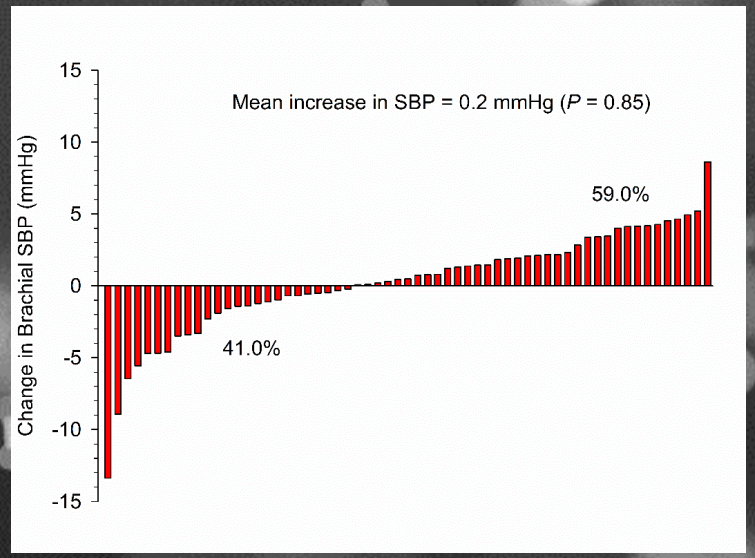


Figure 4D. 120 mmHg or Higher and Sham Filtration



JACC JOURNALS

Clinical significance of 3 mm Hg reduction

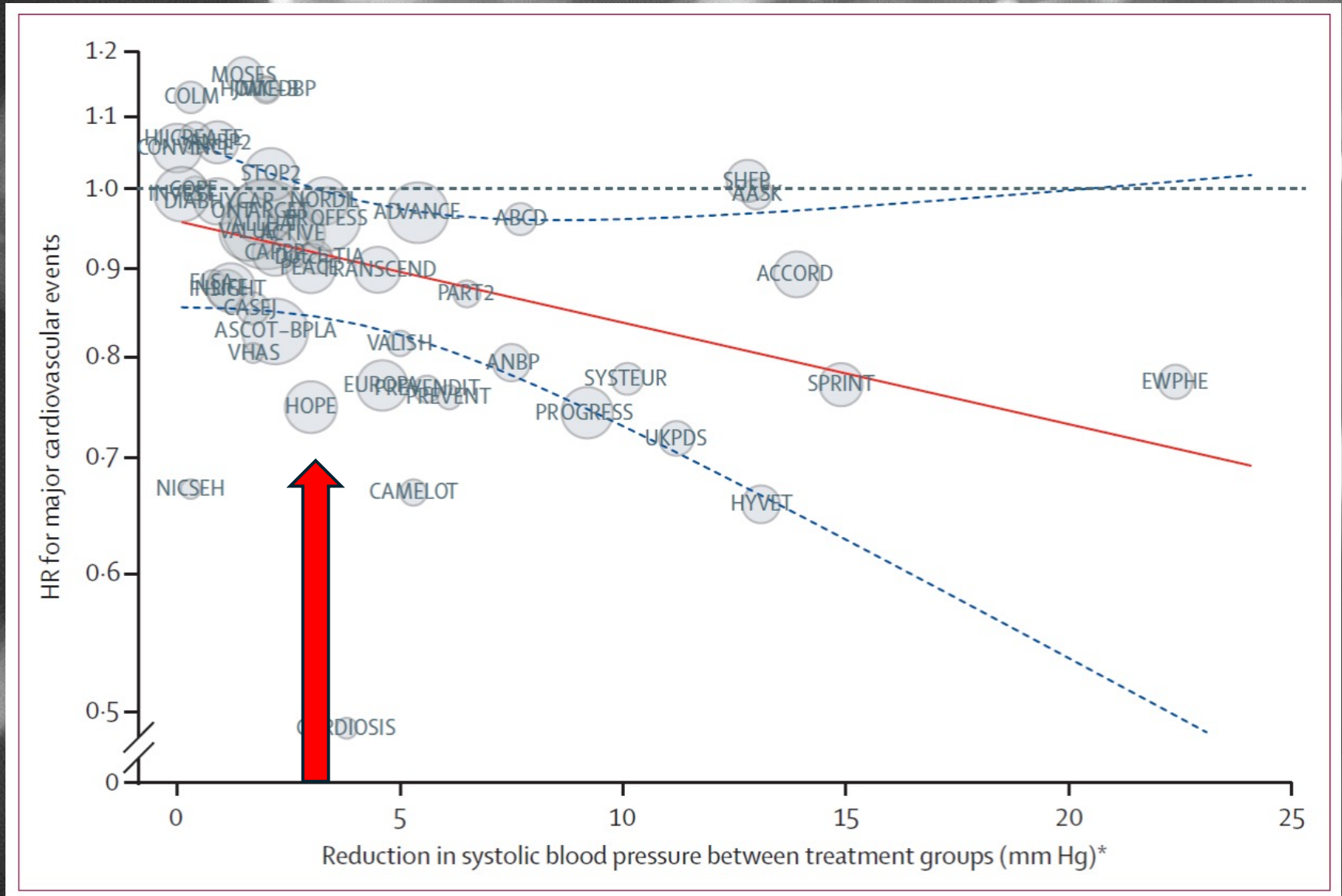


Figure 2: Association between the intensity of blood pressure reduction and relative treatment effects for prevention of major cardiovascular events

Lancet. 2021 May 1;397(10285):1625-1636.

Reaction to at-home air purifiers

* 99% reported **running air purifiers virtually 24 hours.**
* **Electricity use** (N=45) confirmed.
* 80% of participants used the **medium setting**.
* **Tolerance to noise increased** from 30 to 90 days.
* Two thirds reporting **not being bothered** by the noise.
* **Qualitative interviews** (26) yielded similar responses.
* **Size**, **airflow**, and **energy consumption** were concerns.

Singh-Smith *et al. Trials* (2024) 25:551

Take home points:

* BP is likely causally associated with PM exposure.
* Our crossover trial was rigorous and real life.
* I/O PM reduced, but UFP during sham is a question.
* 3 mm Hg reduction in BP only for SBP≥120.
* Clinically significant reduction.
* Maybe more benefit w/ higher PM.
* Individual benefit varied considerably.
* Air purifiers were largely accepted.

Bonus finding, benefit on cognition in >40 years

	N_{HEPA} , N_{Sham}	HEPA	Sham	Difference	95% CI	P-value
Part A seconds, mean (se)						
Overall	112 , 112	–2.8 (0.9)	–2.6 (0.9)	–0.2 (0.7)	(–1.6 , 1.2)	0.76
< 40 years of age	68 , 68	–4.1 (1.1)	–4.6 (1.1)	0.5 (0.9)	(–1.3 , 2.3)	0.59
40 years or older	44 , 44	–0.8 (1.4)	0.5 (1.4)	–1.3 (1.1)	(–3.6 , 0.9)	0.25
Part B seconds, mean (se)						
Overall	112 , 112	–9.1 (2.3)	–7.0 (2.3)	–2.1 (3.1)	(–8.2 , 4.1)	0.51
< 40 years of age	68 , 68	–8.9 (3.0)	–12.0 (3.0)	3.1 (3.9)	(–4.6 , 10.8)	0.43
40 years or older	44 , 44	–9.4 (3.7)	0.6 (3.7)	–10.0 (4.8)	(–19.6 , –0.4)	0.04

Pellegrino, Eliasziw , Brugge et al., in preparation

https://cafeh.squarespace.com/

CAFEH

ABOUT PUBLICATIONS MEDIA RESOURCES
INFOGRAPHICS CONTACT

THE COMMUNITY ASSESSMENT OF FREEWAY EXPOSURE AND HEALTH STUDY

CAFEH serves as the larger umbrella for multiple, related community-based participatory research (CBPR) air pollution studies.

These projects have full participation of the community partners in all aspects of the science including: developing the proposal, leading the study, and collecting, analyzing and interpreting the data.

The CAFEH partnership combines community and academic resources to advance scientific understanding of the health risks of highway pollution. We hope our findings will inform policymakers about the risks of siting new housing, schools or playgrounds next to highways and help to identify measures to reduce exposures.

CAFEH RESEARCH PROJECTS:

- Original CAFEH Study
- Clean Air Project
- Boston Puerto Rican Health Study
- Improving the Health of Near-Highway Communities
- Visualizing Air Pollution (PDF)
- Near-Highway Pollution: From Research to Action
- Animal Model of Autism (PDF)
- Simple Ultrafine Particle (UFP) Factsheet (PDF)

Click here to register for **Indoor Air Quality Webinar #1**