Microenvironmental Exposure to Particulate Matter and Health Effects In Children with Asthma:
A Pilot Study Utilizing Real-Time Personal Monitoring with GPS Interface
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Supplementary Material

Exposure Assessment Protocol

Personal particulate matter (PM) exposures were assessed through space and time using mobile monitoring backpacks that were worn by students each day. Students were instructed to wear these backpacks as much as possible throughout the day and to place them by their bed at night. Monitoring backpacks contained an aerosol nephelometer (personal DataRAM 1200, or ‘pDR’, Thermo-Fisher Scientific Inc., Waltham, MA) to measure fine particle mass concentration, a global positioning system (GPS) receiver (GPSMap 60Cx, Garmin Inc. Olathe KS) to record geographic position data, and a temperature sensor (Thermo Record TR-52, T and D Inc., Saratoga Springs, NY) to record ambient temperature within the child’s breathing zone. The monitors recorded data at 10-second intervals. A time integrated filter sample (Teflo 37mm, Pall Inc., Ann Arbor, MI) was also collected immediately downstream of the nephelometer each day. Flow through the sampling train was maintained with a calibrated personal sampling pump (6.8 L/min flow, Omni Personal Pump, BGI Inc., Waltham MA); a size selective cyclone (1.5 μm size cut, Model GK2.05, BGI Inc., Waltham MA) was placed at the inlet to limit the measurement to fine PM. Particulate mass collected on the filter was weighed to the nearest
microgram; this measurement was used to standardize the instrument’s readings, as recommended to improve instrument accuracy (1).

The total weight of the backpack apparatus was 3.2 kg (7 lbs). The air sampling inlet was positioned 2 inches above the top surface of the backpack, slightly to the rear of the child’s left shoulder. This inlet location was chosen to capture a breathing zone sample, defined as the envelope around the head that is considered to have the same concentration of pollutant as the air breathed in by the person. An image of the sampling backpack and associated equipment is shown in Figure 1. The rear pockets on each backpack contained the sampling equipment (Figure 1, right panel); the intermediate and front pockets of each backpack (Figure 1; left panel) were made available for students to carry books and school supplies.

The following steps were performed to prepare the sampling apparatus for use each day: 1) A pre-weighed filter was placed downstream of the pDR sensor chamber; 2) pump flowrate was calibrated; 3) the GPS receiver was powered on and allowed to acquire signal lock on at least four satellites; 4) the internal clocks of the pDR and TR-52 were synchronized to the clock of the GPS Receiver; 5) the data-logging memory of each monitor was reset; 6) the monitoring equipment and pump were secured to an internal custom frame (Figure S1, right panel); 7) sampling hoses were connected and sampling equipment was placed in backpack; 8) monitors were activated (i.e., data-logging was initiated) and the sampling pump was turned on. The downtime for these procedures lasted approximately 3 hours each day (all within the school microenvironment, after the collection of uLTE4), so each child carried the backpack for approximately 21 of the 24 hours in a day.

At the end of each monitoring day, the backpack was collected from each child and sampling equipment was inspected, pump flow was re-calibrated, and then each monitor was de-activated. Subjects were then surveyed about behaviors (e.g. mode of transport during commute), and potential household exposure sources (cigarette smoke, cooking) from the previous 24 hours. Data from each monitor were then downloaded to a personal computer. Air sampling filters were removed, labeled, and then equilibrated at room temperature for 24 hours prior to gravimetric analysis. Data from the pDR, GPS receiver, and temperature monitor were collated into a database by matching the associated timestamps from each instrument, thereby integrating the data into a common array.

Data Post Processing

To include 10-sec personal PM$_{1.5}$ readings that were assigned zero values by the instrument (i.e., values lower than the instrument detection limit of 1 µg/m$^3$); an imputed value was substituted for the zero reading. This substitution was performed prior to (and necessary for) log-transformation of the data set. Imputed values were created first by stratifying the dataset by subject. Next, zero values for each subject were replaced with a heuristic value equal to one half of the smallest concentration recorded by the pDR (0.5 µg/m$^3$). Geometric means and geometric
standard deviations of the log-transformed stratified data subsets were then calculated. These distribution parameters were used to impute values for the original zero readings via a probability integral transform. The imputed, or modeled, values were then substituted for the original zero readings. These data were then log-transformed and aggregated up to the microenvironmental level. Multiple imputation procedures were performed and the outputs were evaluated for consistency; the average change in the mean values of the full dataset was less than 0.4%.

**Time-Activity Apportionment**

The microenvironmental apportionment methodology has been published (3), however, a brief description follows. Collected exposure data was post-processed using a temporal spatial algorithm that apportioned morning data into pre-determined location-activity categories (e.g., home, transit, school). Each 10-second data point was assigned a specific location-activity category (home, morning transit, school) using geographic proximity analyses supported by time-based rules and temperature measurement – the latter used to confirm when a subject passed from indoors to outdoors. The geographic proximity analysis determined if a recorded point lied within a predefined, two-dimensional area (i.e., a home boundary). The time-based rules further supported the proximity analysis by establishing expected times for the individual to be in the home or work/school area. For example, if the recorded position of a sample was within a certain radius of the work/school position (e.g., 50 m) during expected work/school hours then the exposure was assigned to the work/school category. Similarly, the home category was assigned if the recorded position of the sample was within the defined home area during expected home hours. If the recorded position of the sample was neither at home or work/school, the sample was considered in-transit.

**Models and interpretations of effect estimates**

Models for LTE\textsubscript{4} take the form

$$\ln(Y_{ij}) = \beta_0 + \beta_1 x_{ij} + \beta_2 \text{temp}_{ij} + \beta_3 \text{cold}_{ij} + b_i + \epsilon_{ij},$$

where $Y$ is LTE\textsubscript{4}, $x$ is the pollutant variable of interest, and $i$ and $j$ index subject and time, respectively. In the model, it is assumed that $\epsilon_{ij} \sim N(0, \sigma^2_\epsilon)$, independent of the random intercept $b_i \sim N(0, \sigma^2_b)$. Additionally, errors $\epsilon_{ij}$ are assumed to follow a spatial power structure (i.e., an AR(1) structure that accounts for intermittent responses) within subjects, and independent between subjects. Due to taking the natural log of LTE\textsubscript{4}, $e^{\beta_1}$ is the multiplicative increase in the mean of $Y$ for a 1-unit increase in $x$, while $100(e^{\beta_1} - 1)\%$ is the relative increase in the mean of $Y$ for a 1-unit increase in $x$.

The generalized linear model for albuterol use counts take the form
\[ \ln(\mu_{ij}) = \beta_0 + \beta_1 x_{ij} + \beta_2 \text{temp}_{ij} + \beta_3 \text{Friday}_{ij} \]

where \( \mu_{ij} \) is the mean albuterol use for subject \( i \) at time \( j \), \( \text{Friday} \) is an indicator for that day of the week. (On Monday through Thursday children received an albuterol pre-treat before exercising, but not on Fridays because they did not have a physical education class that day.)

The model was fit using generalized estimating equations, using an AR(1) working correlation structure to account for repeated measures. Due to the use of the natural log link, \( e^{\beta} \) will also have a multiplicative increase interpretation, although in this case the natural log is applied to the mean of outcome rather than the outcome itself.

Construction of increase and exposure event variables

Initially, exposure patterns within each sample-day (\( n=125 \)) were examined individually by 2 of the co-authors (MS and JV) to determine, qualitatively, whether a noticeable increase in PM exposure occurred within a given microenvironment. We then more formally constructed increase and exposure event variables to capture concentration spikes within microenvironments. The initial qualitative approach was very consistent with the more quantitative metrics (92% agreement with exposure events of at least 5\( \mu g/m^3 \) and 88% agreement with exposure events of at least 10\( \mu g/m^3 \)). Due to the better fits in health outcome models for 5\( \mu g/m^3 \), we chose to primarily focus on that cut-point in the manuscript.

References Cited:

1. Benton-Vitz K, Volckens J. Evaluation of the pdr-1200 real-time aerosol monitor. J Occup Environ Hyg 2008;5:353-359.
2. Casella G, Berger RL. Statistical inference. Duxbury Pacific Grove, CA; 2002.
3. Adams C, Riggs P, Volckens J. Development of a method for personal, spatiotemporal exposure assessment. J Environ Monit 2009;11:1331-1339.
### TABLE S1: DESCRIPTIVE STATISTICS FOR MEAN AND 1-MINUTE MAXIMUM PM$_{1.5}$ VARIABLES USED IN ANALYSIS.

| Microenvironment or time frame | Within-subject-sample variable | Mean  | Min  | 25th Quantile | Median | 75th Quantile | Max  |
|-------------------------------|--------------------------------|-------|------|---------------|--------|---------------|------|
| Home                          | Average                        | 4.2   | 0.2  | 1.8           | 4.4    | 11.5          | 103.5|
| Transit                       |                                | 3.7   | 0.1  | 1.8           | 4.7    | 8.5           | 56   |
| School                        |                                | 2.8   | 0.1  | 1.4           | 3.2    | 5.6           | 23.9 |
| 24-hr                         |                                | 4.3   | 0.2  | 2.6           | 4.3    | 8.3           | 29.8 |
| Home                          | 1-minute maximum               | 12.0  | 0.3  | 5.5           | 10.8   | 31.8          | 295.1|
| Transit                       |                                | 9.9   | 0.2  | 4.8           | 10.1   | 25.9          | 275.5|
| School                        |                                | 8.1   | 0.2  | 3.9           | 7.8    | 18.5          | 151.7|

Statistics were computed by first determining the mean or 1-minute averaged maximum of logged concentrations within subject samples, then determining composite statistics across subject samples, then exponentiating. Units are micrograms per cubic meter.
TABLE S2. ASSOCIATIONS BETWEEN HEALTH OUTCOMES (LTE\textsubscript{4} AND ALBUTEROL USAGE) AND MEAN PERSONAL EXPOSURE TO PM\textsubscript{1.5} AS MEASURED BY THE PERSONAL MONITOR.

| Micro-environment | Lag    | % increase per IQR increase in pollutant (95% CI) |   |
|-------------------|--------|-------------------------------------------------|---|
|                   |        | Albuterol usage | LTE\textsubscript{4} |   |
| Home              | 0      | -0.8 (-12.1, 11.9) | 7.3 (-5.9, 22.4) |   |
|                   | 1      | 5.7 (-12.1, 27.1) | -8.4 (-22.7, 8.6) |   |
|                   | 2-day  | 3.3 (-9.4, 17.7) | 2.1 (-8.8, 14.2) |   |
| Transit           | 0      | 4.1 (-6.1, 15.5) | 10.7 (-0.4, 22.9) |   |
|                   | 1      | 12.0 (-2.0, 28.0) | 6.2 (-5.9, 19.8) |   |
|                   | 2-day  | 9.3 (-0.2, 19.8) | 9.3 (0.3, 19.2) |   |
| School            | 0      | 3.8 (-7.0, 15.7) | 5.3 (-6.7, 18.8) |   |
|                   | 1      | 4.7 (-10.7, 22.7) | 12.6 (-5.0, 33.6) |   |
|                   | 2-day  | 6.5 (-7.0, 22.0) | 9.6 (-2.1, 22.7) |   |

For 2-day moving average estimates, records were weighted by number of records used in the moving average (1 or 2). For Albuterol usage models, temperature and Friday indicator covariates were used; for LTE\textsubscript{4} models, temperature and cold indicator were used (the lag for cold was set as the same as the same for the air pollution variable). IQR for 0 and 1 day lags were 1.84, 1.39 and 1.54 for home, school and transit, respectively (for 2-day average they were 1.72, 1.36 and 1.47). 30 subjects were available for analysis; number of records used for model fits were: 114, 80 and 143 for 0, 1 and 2-day moving averages for albuterol usage, respectively, and 80, 58 and 111 for LTE\textsubscript{4}. For more detail, see the text.
Figure S2: Percent increase in uLTE₄ per IQR increase in mean personal exposure to PM₁.₅ by home, a.m. transit, and school microenvironments for same day (lag 0), one-day lag, and a 2-day moving average. Error bars represent 95% confidence intervals.
Figure S3: Percent increase in school-day albuterol usage per IQR increase in mean personal exposure to PM$_{1.5}$ by home, a.m. transit, and school microenvironments for same day (lag 0), one-day lag, and a 2-day moving average. Error bars represent 95% confidence intervals.
TABLE S3. COMPARISON OF AIC (FOR LTE₄) OR QICu (FOR ALBUTEROL USAGE) BETWEEN MODELS. THE BEST FIT (LOWEST AIC OR QICu) WITHIN OUTCOME, MICROENVIRONMENT AND LAG IS BOLDED. THE 5µg/m₃ EVENT INDICATOR PROVIDED THE BEST FIT MOST OFTEN AMONG METRICS.

| Outcome | Micro-environment | Metric* | Lag 0 (n=80, LTE4; n=114, alb.) | Lag 1 (n=58, LTE4; n=80, alb.) | 2-day MA (n=111, LTE4; n=143, alb.) |
|---------|-------------------|---------|---------------------------------|---------------------------------|-------------------------------------|
|         |                   | Mean    | 136.2                           | 107.6                           | 168.1                              |
|         |                   | 1-min max| 136.4                           | 108.4                           | 168.2                              |
|         |                   | 5µg/m³ event | 133.7                     | **106.4** (best fit)       | 166.2                              |
|         |                   | 10µg/m³ event | **132.8** (best fit) | 106.8                           | **165.2** (best fit)               |
|         |                   | Increase amount | 135.0                     | 108.2                           | 166.5                              |
| Home    | LTE4 Transit      | Mean    | 133.8                           | 108.3                           | 164.4                              |
|         |                   | 1-min max| 136.5                           | 108.5                           | 168.0                              |
|         |                   | 5µg/m³ event | **131.0** (best fit) | **104.8** (best fit)       | **164.0** (best fit)               |
|         |                   | 10µg/m³ event | 134.2                     | 106.5                           | 166.2                              |
|         |                   | Increase amount | 135.4                     | 108.1                           | 167.5                              |
| School  |                   | Mean    | 136.2                           | **106.3** (best fit)       | **165.2** (best fit)               |
|         |                   | 1-min max| 133.4                           | 107.9                           | 165.4                              |
|         |                   | 5µg/m³ event | 134.2                     | 107.0                           | **165.2** (best fit)               |
|         |                   | 10µg/m³ event | **132.7** (best fit) | 106.9                           | 165.3                              |
|         |                   | Increase amount | 134.7                     | 109.0                           | 167.6                              |
| Home    | Albuterol usage   | Mean    | 737.4                           | 401.3                           | 826.8                              |
|         |                   | 1-min max| 734.2                           | 398.2                           | 821.3                              |
|         |                   | 5µg/m³ event | **734.1** (best fit) | 404.3                           | 822.9                              |
|         |                   | 10µg/m³ event | 741.2                     | **396.7** (best fit)       | 814.8                              |
|         |                   | Increase amount | 731.2                     | 396.9                           | **813.4** (best fit)               |
| Transit |                   | Mean    | 728.15                          | 396.0                           | 812.9                              |
|         |                   | 1-min max| 728.5                           | 396.9                           | **811.2** (best fit)               |
|         |                   | 5µg/m³ event | **727.55** (best fit) | **394.6** (best fit)       | 814.0                              |
|         |                   | 10µg/m³ event | 733.7                     | 396.3                           | 813.3                              |
|         |                   | Increase amount | 728.8                     | 400.8                           | 817.1                              |
| School  |                   | Mean    | **739.0** (best fit)           | 398.7                           | 822.7                              |
|         |                   | 1-min max| 752.5                           | **398.5** (best fit)       | 826.9                              |
|         |                   | 5µg/m³ event | 752.1                     | 399.8                           | **815.6** (best fit)               |
|         |                   | 10µg/m³ event | 742.6                     | **398.5** (best fit)       | 817.4                              |
|         |                   | Increase amount | 751.2                     | 399.3                           | 828.5                              |

*Continuous variables (Mean, 1-min max, Increase amount) all analyzed on the log scale.
Figure S4 (beginning on the following page): Profiles of 1-minute averaged PM\textsubscript{1.5} across 3 microenvironments: home (to left of vertical dashed bars), transit (in between bars) and school (to right of bars) by subject and date. PM\textsubscript{1.5} exposure data were computed by averaging logged concentrations by minute, then exponentiating.
Subject 4615, Sampledate 17554

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 4615, Sampledate 17555

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am  7am  8am  9am
Subject 4615, Sampledate 17556

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 4615, Sampledate 17611

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 4724, Sampledate 17563

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 4724, Sampledate 17624

Time of day

6am  7am  8am  9am

PM$_{1.5}$ (µg/m$^3$)
Subject 5001, Sampledate 17540

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 5001, Sampledate 17541

PM$_{1.5}$ (µg/m$^3$) vs Time of day

6am 7am 8am 9am
Subject 5001, Sampledate 17542

Time of day

6am 7am 8am 9am

PM$_{1.5}$ ($\mu$g/m$^3$)
Subject 5001, Sampledate 17597

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 5001, Sample date 17598

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am  7am  8am  9am
Subject 5605, Sample Date 17560

PM$_{1.5}$ (µg/m$^3$) vs Time of day

- 6am
- 7am
- 8am
- 9am

The graph shows a spike in PM$_{1.5}$ readings around 7am, which is a significant increase compared to other times of the day.
Subject 5605, Sampledate 17561

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 5605, Sampledate 17562

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 5605, Sampledate 17623

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am  7am  8am  9am
Subject 5605, Sampledate 17624

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 5902, Sampledate 17547

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 5902, Sampledate 17602

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 5902, Sample date 17604

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 5902, Sampledate 17605

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 6288, Sample date 17575

PM$_{1.5}$ (µg/m$^3$) vs. Time of day

Time of day

6am 7am 8am 9am
Subject 6288, Sampledate 17577

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 6288, Sampledate 17638

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 6288, Sampledate 17640

PM$_{1.5}$ (µg/m$^3$) vs Time of day

6am 7am 8am 9am
Subject 6486, Sampledate 17547

Time of day

PM$_{1.5}$ (µg/m$^3$)
Subject 6486, Sampledate 17548

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 6486, Sampledate 17602

PM$_{1.5}$ ($\mu g/m^3$)

Time of day

6am  7am  8am  9am
Subject 6486, Sample date 17604

Time of day

PM$_{1.5}$ ($\mu$g/m$^3$)

6am  7am  8am  9am

0  20  40  60  80  100
Subject 7055, Sampledate 17560

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 7055, Sampledate 17561

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 7352, Sampledate 17555

Time of day

PM$_{1.5}$ (µg/m$^3$)
Subject 7352, Sampledate 17609

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am 7am 8am 9am
Subject 7352, Sampledate 17612

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am 7am 8am 9am

0 20 40 60 80 100
Subject 7857, Sampledate 17598

PM$_{1.5}$ (µg/m$^3$) vs Time of day

- 6am
- 7am
- 8am
- 9am
Subject 8003, Sampledate 17567

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 8003, Sampledate 17568

PM$_{1.5}$ (µg/m$^3$)

Time of day
Subject 8003, Sampledate 17569

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am, 7am, 8am, 9am
Subject 8003, Sampledate 17570

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am 7am 8am 9am
Subject 8003, Sample date 17630

Time of day

PM$_{1.5}$ ($\mu$g/m$^3$)

6am 7am 8am 9am
Subject 8003, Sampledate 17633

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 8102, Sampledate 17507

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 8319, Sampledate 17569

PM$_{1.5}$ ($\mu$g/m$^3$)

Time of day

6am  7am  8am  9am
Subject 8319, Sampledate 17570

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 8319, Sampledate 17630

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am 7am 8am 9am
Subject 8319, Sample date 17631

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am    7am    8am    9am

0

50

100
Subject 8319, Sampledate 17633

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 8409, Sampledate 17556

PM$_{1.5}$ (µg/m$^3$) vs Time of day

6am - 7am - 8am - 9am
Subject 8409, Sampledate 17609

PM$_{1.5}$ (µg/m$^3$) vs Time of day

Time of day:
- 6am
- 7am
- 8am
- 9am
Subject 8418, Sampledate 17548

PM$_{1.5}$ ($\mu$g/m$^3$)

Time of day

6am  7am  8am  9am
Subject 8418, Sampledate 17603

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 8418, Sampledate 17605

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am 7am 8am 9am
Subject 8498, Sampledate 17603

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 8508, Sampledate 17513

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 8508, Sampledate 17583

PM$_{1.5}$ (µg/m$^3$)

Time of day

$\mu$g/m$^3$
Subject 8508, Sampledate 17584

PM$_{1.5}$ ($\mu$g/m$^3$)

Time of day

6am  7am  8am  9am
Subject 8706, Sampledate 17583

Time of day

6am 7am 8am 9am
Subject 8715, Sample date 17562

Time of day

PM$_{1.5}$ ($\mu$g/m$^3$)

6am  7am  8am  9am

0  20  40  60

100
Subject 8715, Sampledate 17623

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 8715, Sample date 17624

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 8715, Sampledate 17626

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 8904, Sampledate 17574

PM$_{1.5}$ (µg/m$^3$) vs Time of day

0 20 40 60 80 100

6am 7am 8am 9am

Time of day
Subject 8904, Sampledate 17576

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 8904, Sampledate 17577

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 8904, Sampledate 17640

PM$_{1.5}$ (µg/m$^3$) vs Time of day

6am 7am 8am 9am
Subject 8913, Sampledate 17574

PM$_{1.5}$ (µg/m$^3$) vs Time of day

| Time of day | PM$_{1.5}$ Values |
|-------------|-------------------|
| 6am         | Low               |
| 7am         | High              |
| 8am         | Low               |
| 9am         | Moderate          |
Subject 8913, Sampledate 17575

Time of day

PM$_{1.5}$ (µg/m$^3$)
Subject 8913, Sampledate 17639

PM$_{1.5}$ (µg/m$^3$) vs Time of day

- 6am
- 7am
- 8am
- 9am
PM$_{1.5}$ (µg/m$^3$)

Time of day

Subject 8913, Sampledate 17640
Subject 9290, Sampledate 17567

PM$_{1.5}$ (µg/m$^3$) vs Time of day

- PM$_{1.5}$ levels remain relatively stable from 6am to 7am.
- There is a significant increase in PM$_{1.5}$ levels starting around 7am, peaking sharply after 8am.
- Levels remain high until 9am.
Subject 9290, Sampledate 17569

PM$_{1.5}$ (µg/m$^3$)

Time of day
Subject 9290, Sample date 17630

PM$_{1.5}$ ($\mu$g/m$^3$)

Time of day

6am 7am 8am 9am
Subject 9290, Sampledate 17631

PM$_{1.5}$ (µg/m$^3$) vs Time of day

- 6am to 7am: Increase in PM$_{1.5}$
- 7am to 8am: Peak concentration
- 8am to 9am: Drop in PM$_{1.5}$
Subject 9290, Sampledate 17632

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 9290, Sampledate 17633

Time of day

PM$_{1.5}$ (µg/m$^3$)
Subject 9379, Sampledate 17540

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 9379, Sample date 17597

Time of day

PM$_{1.5}$ (µg/m$^3$)
Subject 9379, Sampledate 17598

Time of day

PM$_{1.5}$ (µg/m$^3$)
Subject 9478, Sampledate 17588

PM\(_{1.5}\) (\(\mu g/m^3\))

Time of day

- 6am
- 7am
- 8am
- 9am
Subject 9478, Sample date 17589

PM$_{1.5}$ (µg/m$^3$) vs Time of day

- 6am
- 7am
- 8am
- 9am
Subject 9597, Sample Date 17574

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
PM$_{1.5}$ (µg/m$^3$)
Subject 9597, Sampledate 17576

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 9675, Sampledate 17590

PM$_{1.5}$ (µg/m$^3$)

Time of day
Subject 9774, Sampledate 17506

PM$_{1.5}$ (µg/m$^3$)

Time of day

- 6am
- 7am
- 8am
- 9am
Subject 9774, Sample date 17590

PM$_{1.5}$ (µg/m$^3$) vs Time of day

- PM$_{1.5}$ levels are plotted against time of day.
- The graph shows a spike in PM$_{1.5}$ levels between 7am and 8am, with a peak around 7am.
- There are minor fluctuations before and after this peak.
- The y-axis represents PM$_{1.5}$ levels in µg/m$^3$.

Time of day:
- 6am
- 7am
- 8am
- 9am

The spike in PM$_{1.5}$ levels around 7am could indicate a time when pollution levels are unusually high, possibly due to traffic or industrial activities.
Subject 9873, Sampledate 17554

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 9873, Sampledate 17556

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am  7am  8am  9am
Subject 9873, Sample date 17609

Time of day

PM$_{1.5}$ (µg/m$^3$)

6am 7am 8am 9am
Subject 9873, Sample date 17611

PM$_{1.5}$ (µg/m$^3$)

Time of day
Subject 9873, Sampledate 17612

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
PM$_{1.5}$ (µg/m$^3$)

Time of day

6am  7am  8am  9am
Subject 9993, Sampledate 17569

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 9993, Sampledate 17630

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am

0 20 40 60 80 100
Subject 9993, Sampledate 17631

PM$_{1.5}$ (µg/m$^3$)

Time of day

6am 7am 8am 9am
Subject 9993, Sampledate 17632

Time of day

PM$_{1.5}$ (µg/m$^3$)
PM$_{1.5}$ (µg/m$^3$)

Time of day

Subject 9993, Sampledate 17633

- 6am
- 7am
- 8am
- 9am