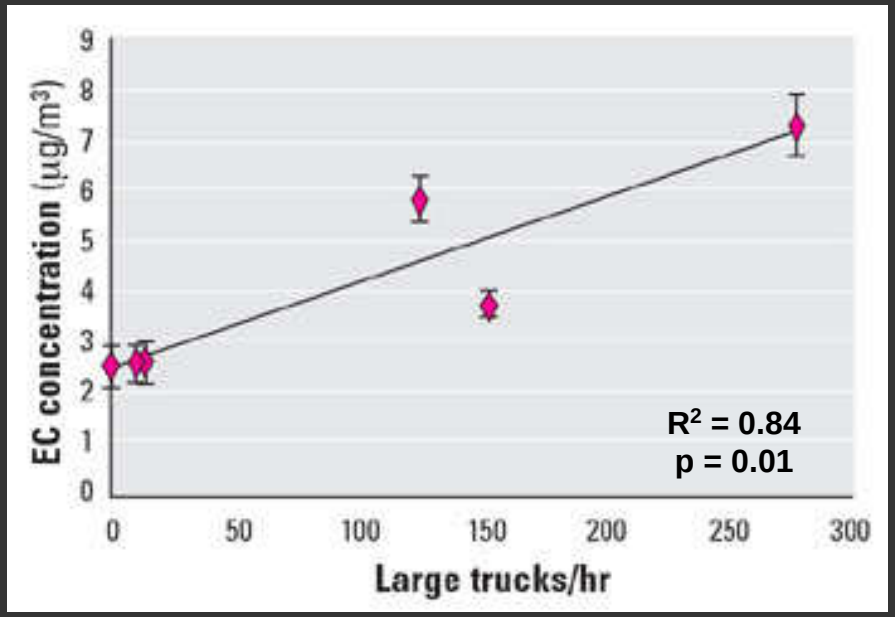
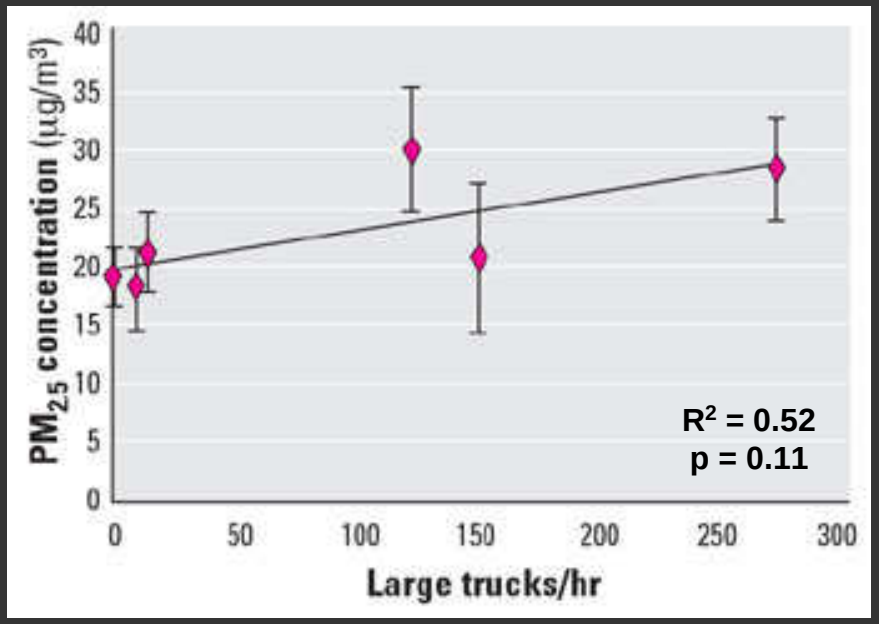
Comparing Acute Respiratory Effects of PM2.5, Black Carbon, and Ultrafine PM: Is there a Diesel Signal?

Patrick L. Kinney
Associate Professor
Columbia University

Associations between Truck Volume and $PM_{2.5}$ and Elemental Carbon





Source: Lena et al 2000, Environ Health Persp 110(10):1009-1015

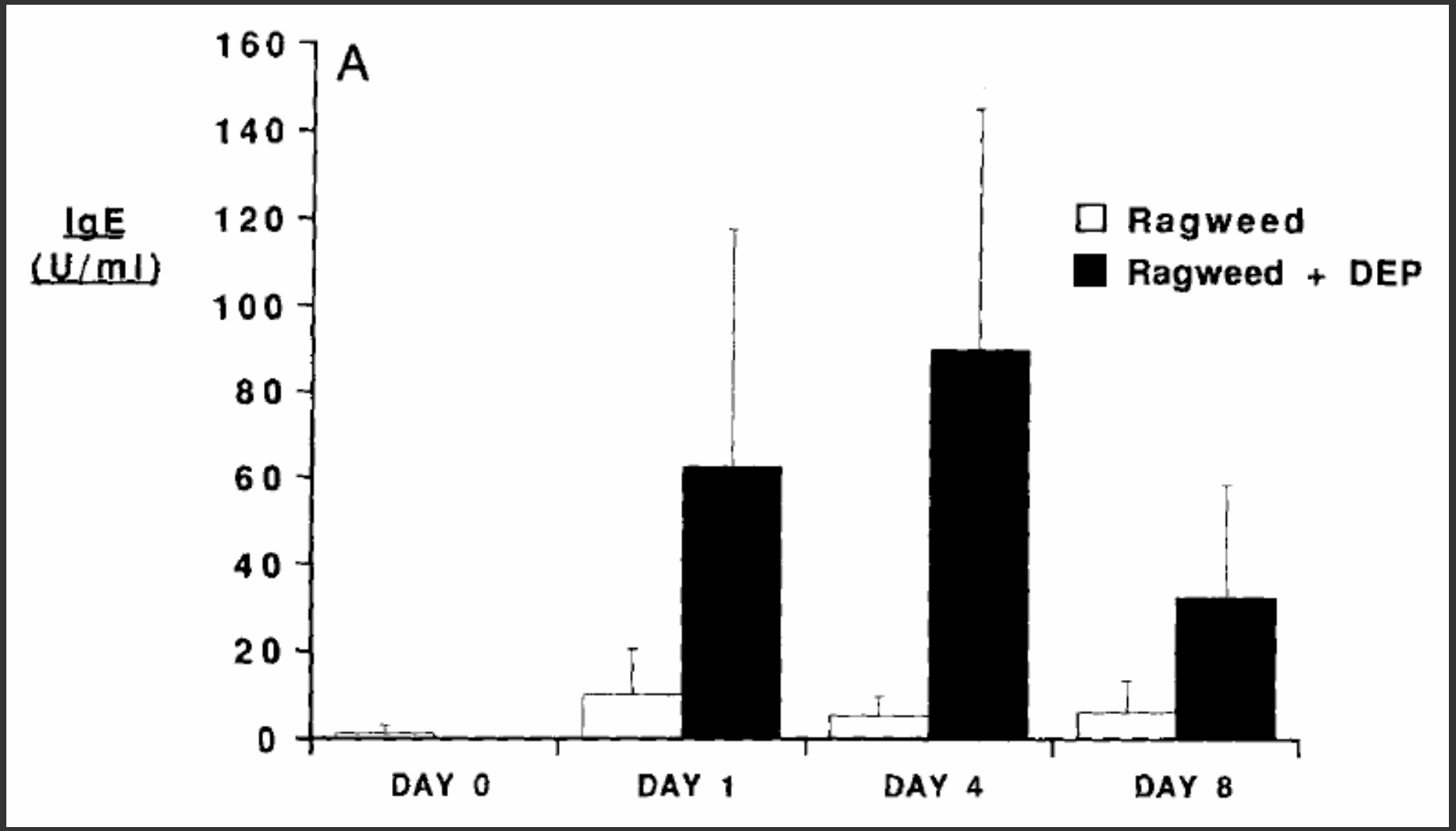
Studies Investigating Respiratory Effects of Diesel Exhaust Particles (DEP)

- Epidemiologic
  - Proximity of residence to major road associated with increased asthma prevalence, wheeze frequency (McConnell et al, 2006)
  - Higher truck counts associated with chronic respiratory symptoms, decreased lung function (Brunekreef et al, 1997)
  - Higher black carbon concentrations associated with higher asthma prevalence (Kim et al, 2004) and increases in airway inflammation in asthmatics (Jansen et al, 2005)

- Experimental exposure of humans
  - DEP exposure increases expression of IgE (Diaz-Sanchez, 1997) or pro-inflammatory cytokines (Salvi et al, 2000) in pulmonary cells collected from volunteers

Allergic response measured in nasal washings after challenge with ragweed allergen alone or ragweed plus diesel exhaust

From: Diaz-Sanchez et al., Journal of Immunology, 1997



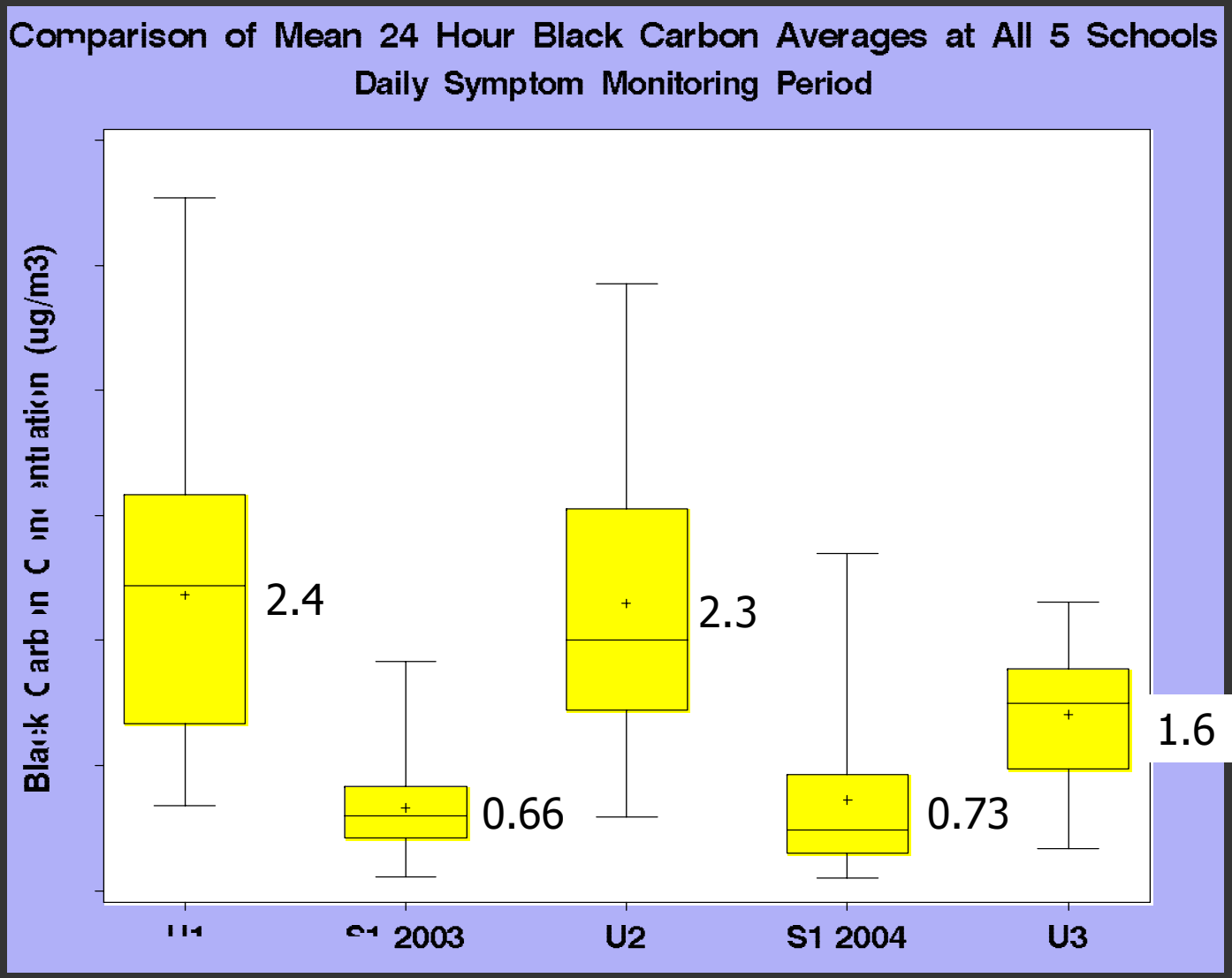
Motivation

- Epidemiologic evidence consistently supports associations between short-term increases in ambient fine PM ($PM_{2.5}$) and increases in respiratory symptoms, especially among asthmatics
- Traffic emissions are an important local source of fine particulate matter (PM) in NYC
- Black carbon appears to be a useful proxy for traffic-related PM
- UFP may be another useful measure of traffic impacts, but hasn't been studied extensively in epidemiologic studies

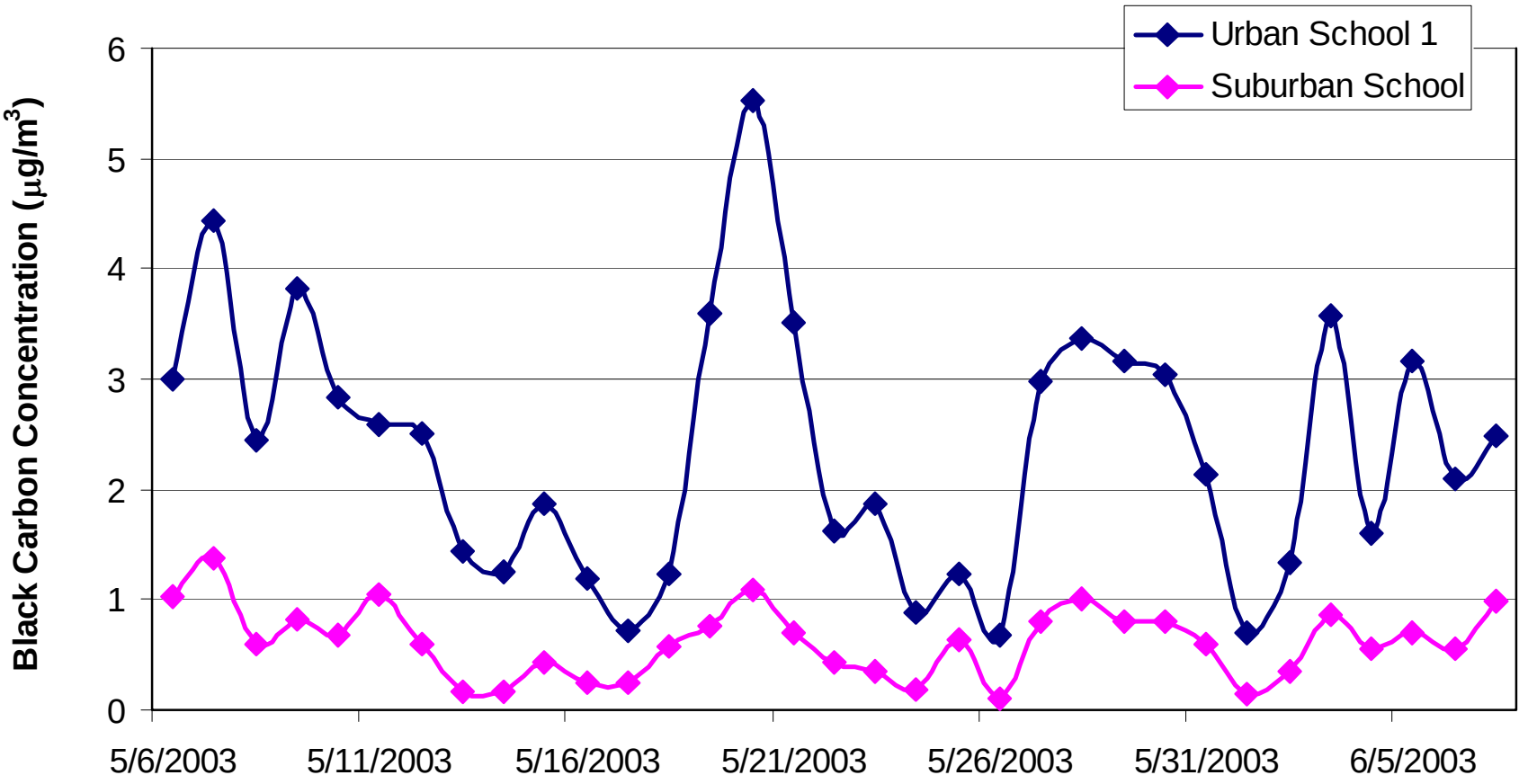
Objectives

- Assess correlations among $PM_{2.5}$, black carbon (BC), and UFP at a high school adjacent to a major highway in the Bronx
- Compare associations between these particle components and respiratory symptoms among adolescents attending the school

PM Components Study Nested Within Larger Study of Urban/Suburban High School Exposures and Health Effects



Daily Mean Black Carbon Concentrations Measured at Urban School 1 and the Suburban School
5/6/03-6/8/03



r = 0.83, p< 0.0001

STUDY LOCATION
High School in High-density Urban Area

- 34m east of major highway the Bronx, NY
- Annual Average of 8,300 Trucks/Buses Daily
- Annual Average of 64,000 Cars Daily

MEASUREMENT OF PM EXPOSURES

- Hourly PM2.5 monitored for 3 weeks using beta attenuation monitor
- Hourly black carbon monitored using aethalometers
- UFP monitored using scanning mobility particle sizer

RECRUITMENT OF STUDY SUBJECTS

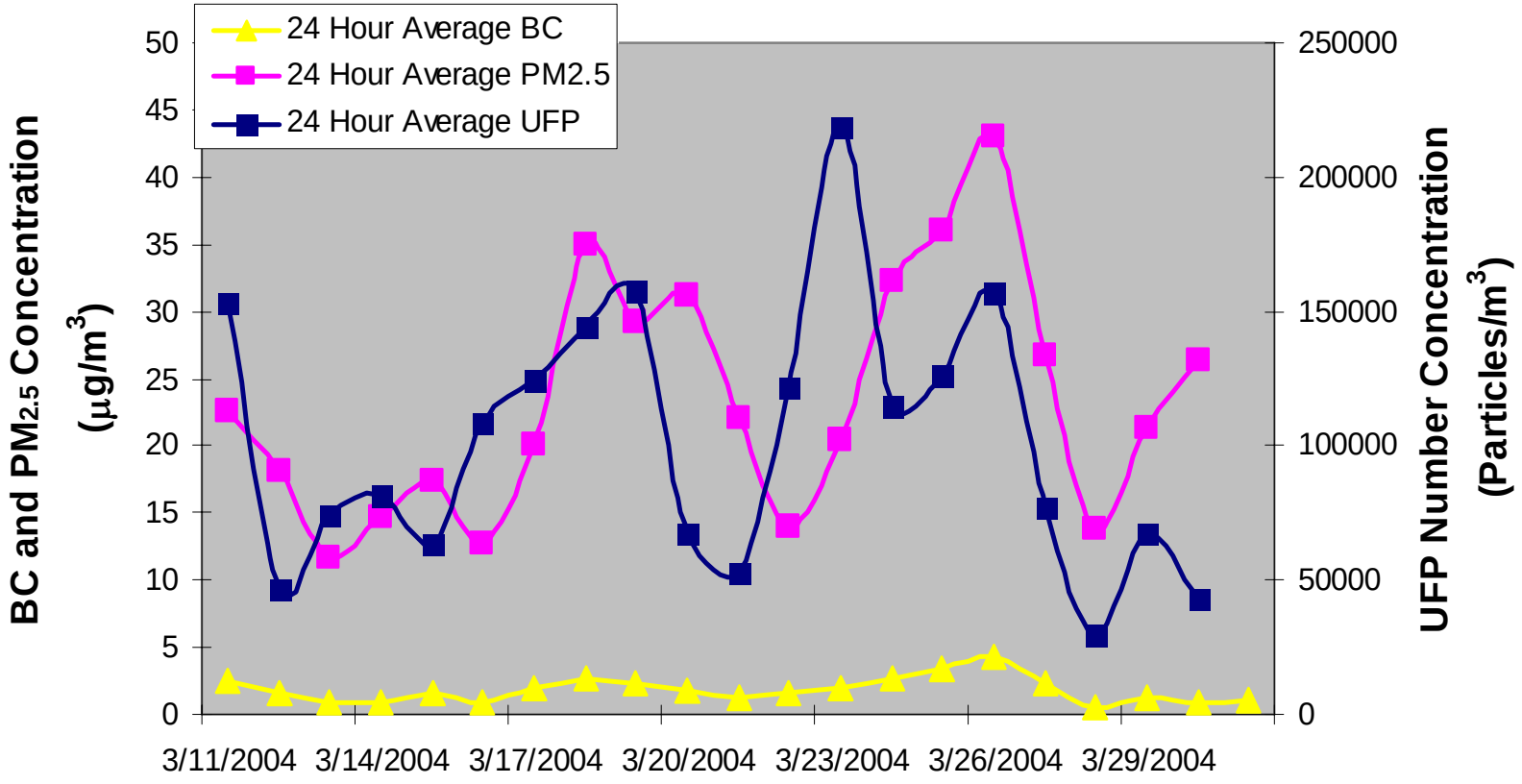
- Students recruited during classroom presentations
- Asthma prevalence and demographic data collected by questionnaire
- Consent forms distributed

COLLECTION OF DAILY RESPIRATORY HEALTH DATA

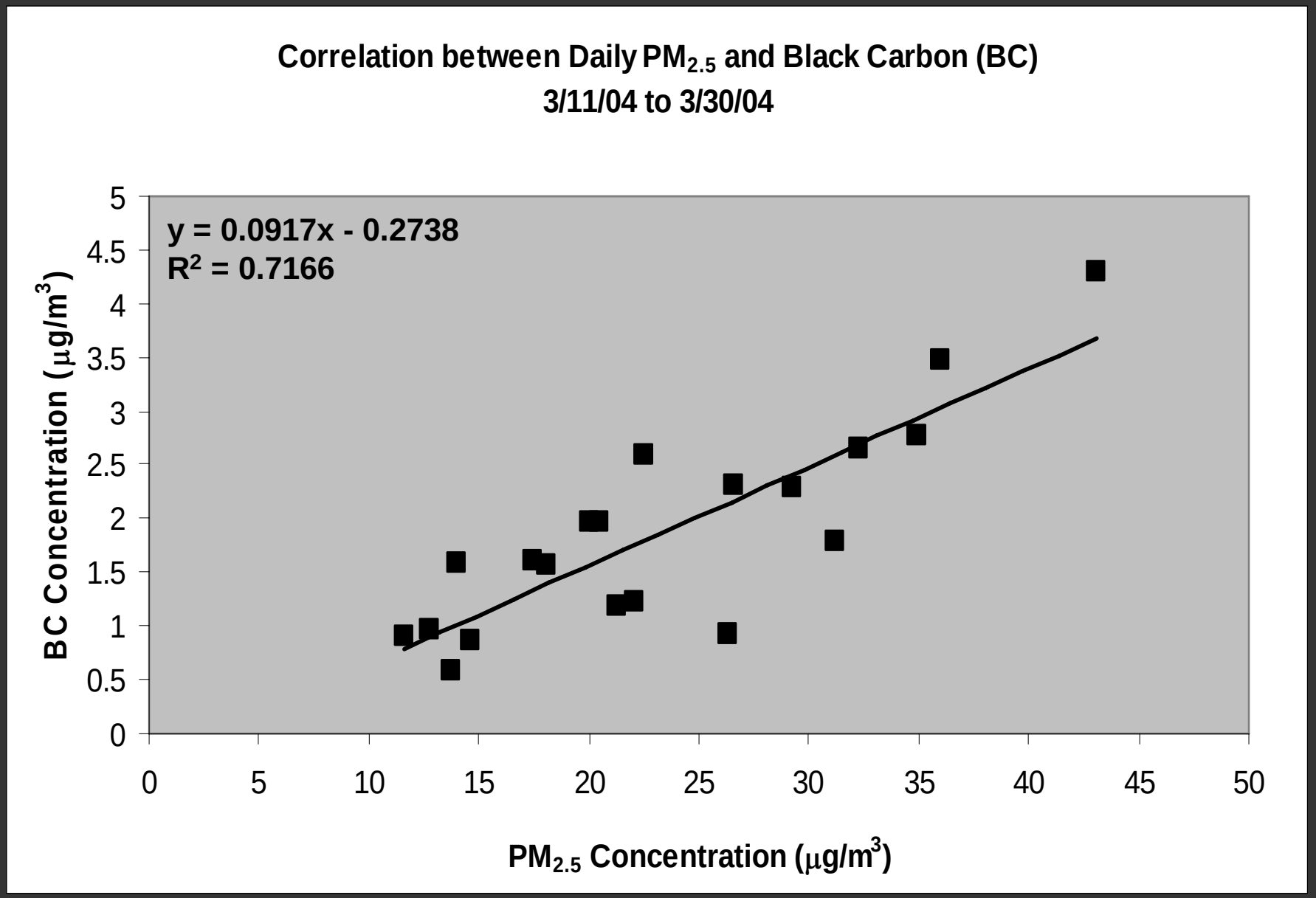
- Self-reported symptom and medication use in diaries for 4-5 weeks

Number of Students Completing Surveys		58
Number of Asthmatics (%)		14 (24%)
Age (mean±SD)		16±1
Sex (%)*	Male	11
	Female	89
Race (%)*	White, Non-Hispanic	0
	Black, Non-Hispanic	39
	Hispanic	55
	Other	5
Father's Education Level (%)*	<High School	17
	High School Graduate	43
	>=College Graduate	24
	Unknown	16
Smoker in Household (%)		30

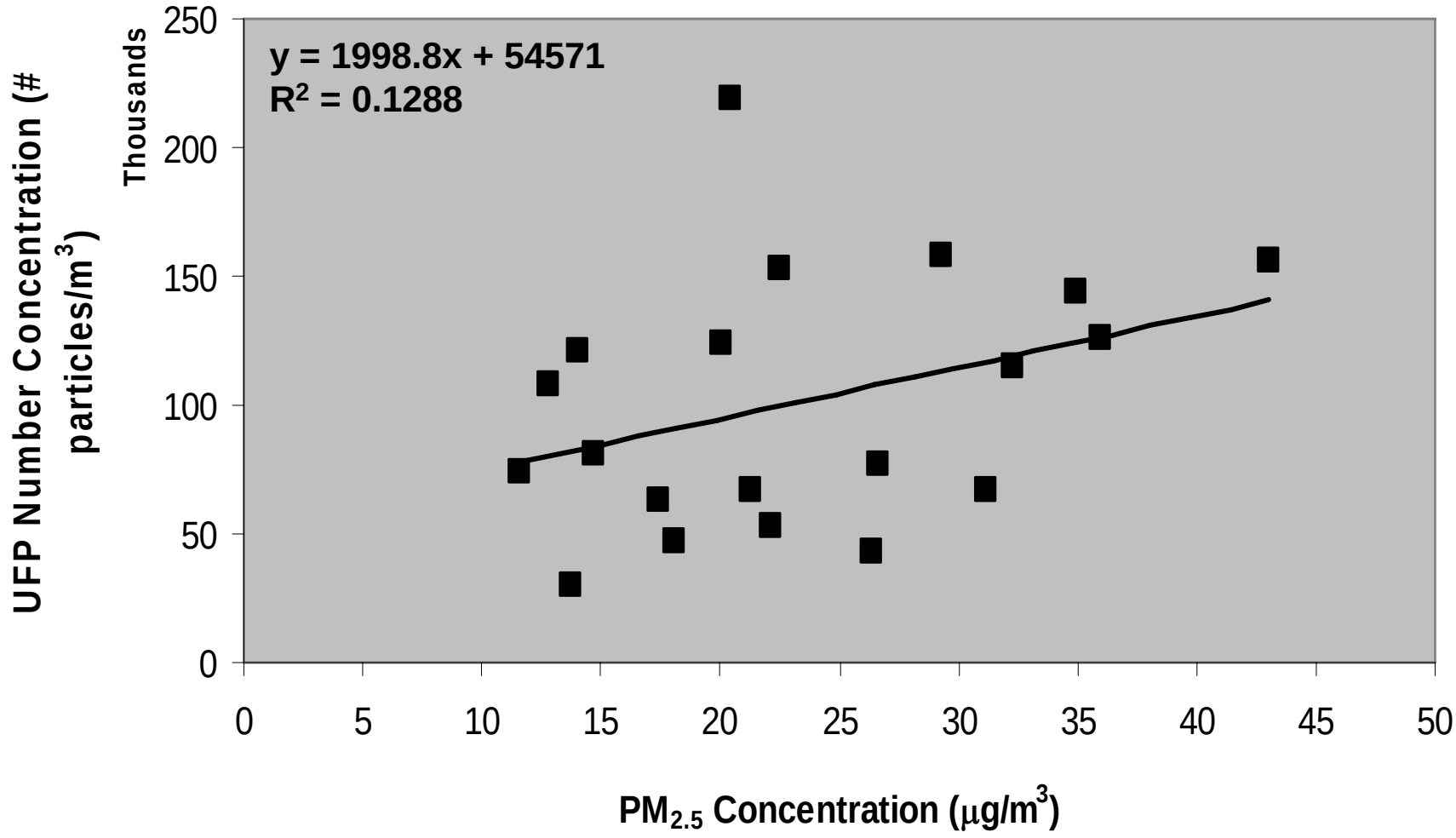
Comparing Daily Trends in $PM_{2.5}$, Black Carbon (BC), and Ultrafine Particles (UFP) at U2 Spring 2004



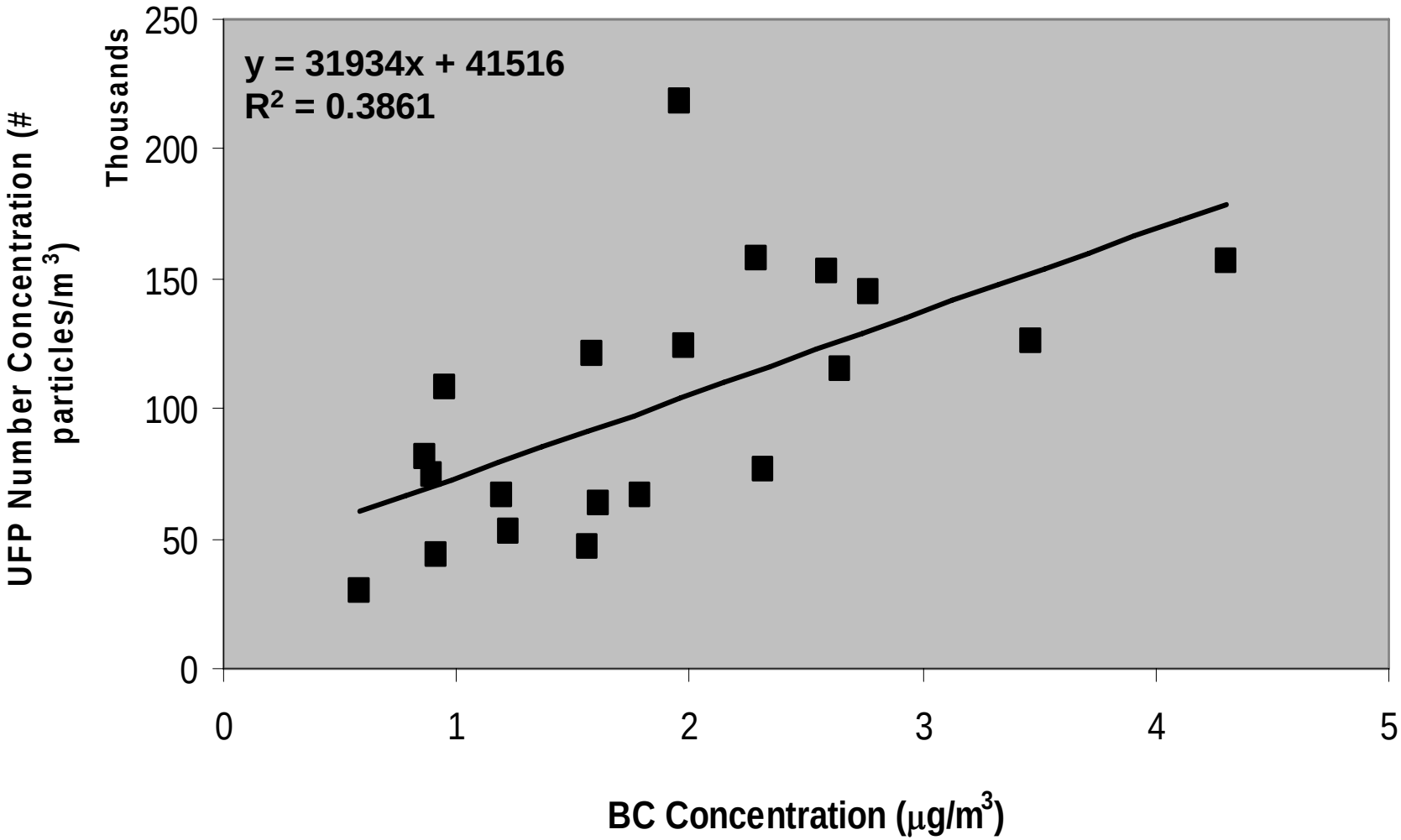
- Mean (SD) PM2.5 mass concentration = 23.4 (8.8) µg/m^3. Range = 11.6 – 43.0 µg/m^3.
- Mean (SD) BC mass conc = 2.2 (1.1) µg/m^3. Range = 0.6 – 4.9 µg/m^3.
- Mean (SD) UFP number conc = 101,000 (49,000) particles/m^3. Range = 30,000 – 220,000 particles/m^3.


Correlation between Daily PM2.5 and Black Carbon (BC)
3/11/04 to 3/30/04
y = 0.0917x - 0.2738
R2 = 0.7166
BC Concentration (μg/m3)
PM2.5 Concentration (μg/m3)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
5
10
15
20
25
30
35
40
45
50

Correlation between $PM_{2.5}$ and Ultrafine Particles (UFP)
3/11/04 to 3/30/04



Correlation between Daily Black Carbon (BC) and Ultrafine Particles (UFP)
3/11/04 to 3/30/04



Rate Ratios for Increased Respiratory Symptoms

	$PM_{2.5}$	BC	UFP
Wheeze	1.01 (0.99, 1.03)	1.05 (0.93, 1.19)	1.01 (0.97, 1.05)
Cough	0.99 (0.97, 1.00)	0.98 (0.91, 1.06)	0.98 (0.96, 1.01)
Chest Tightness	1.00 (0.97, 1.02)	1.04 (0.92, 1.18)	0.99 (0.95, 1.02)
Shortness of Breath	1.01 (0.99. 1.02)	**1.11 (1.01, 1.21)**	0.99 (0.97, 1.01)
Medication Use	1.00 (0.98, 1.02)	1.04 (0.90, 1.19)	1.01 (0.98, 1.05)

Summary of Results

- In repeated measures analyses, BC showed a greater tendency towards positive associations with wheeze, shortness of breath, chest tightness, and medication use relative to $PM_{2.5}$ and UFP number
- Only the BC association with shortness of breath was statistically significant

Conclusions

- These preliminary results provide insight into elucidating the active component of ambient PM and point to the importance of monitoring traffic-related particles in cities
- Sample size may have limited study power Future studies should increase the number of asthmatics since the effects of traffic-related particles may be more apparent in individuals prone to bronchial hyper-responsiveness
- Also note: Recer et al., poster showing associations between max daily EC and increased emergency room visits for asthma in the Bronx