

# PM2.5 and Asthma: Hospitalizations and ER Visits in Three San Joaquin Valley Cities



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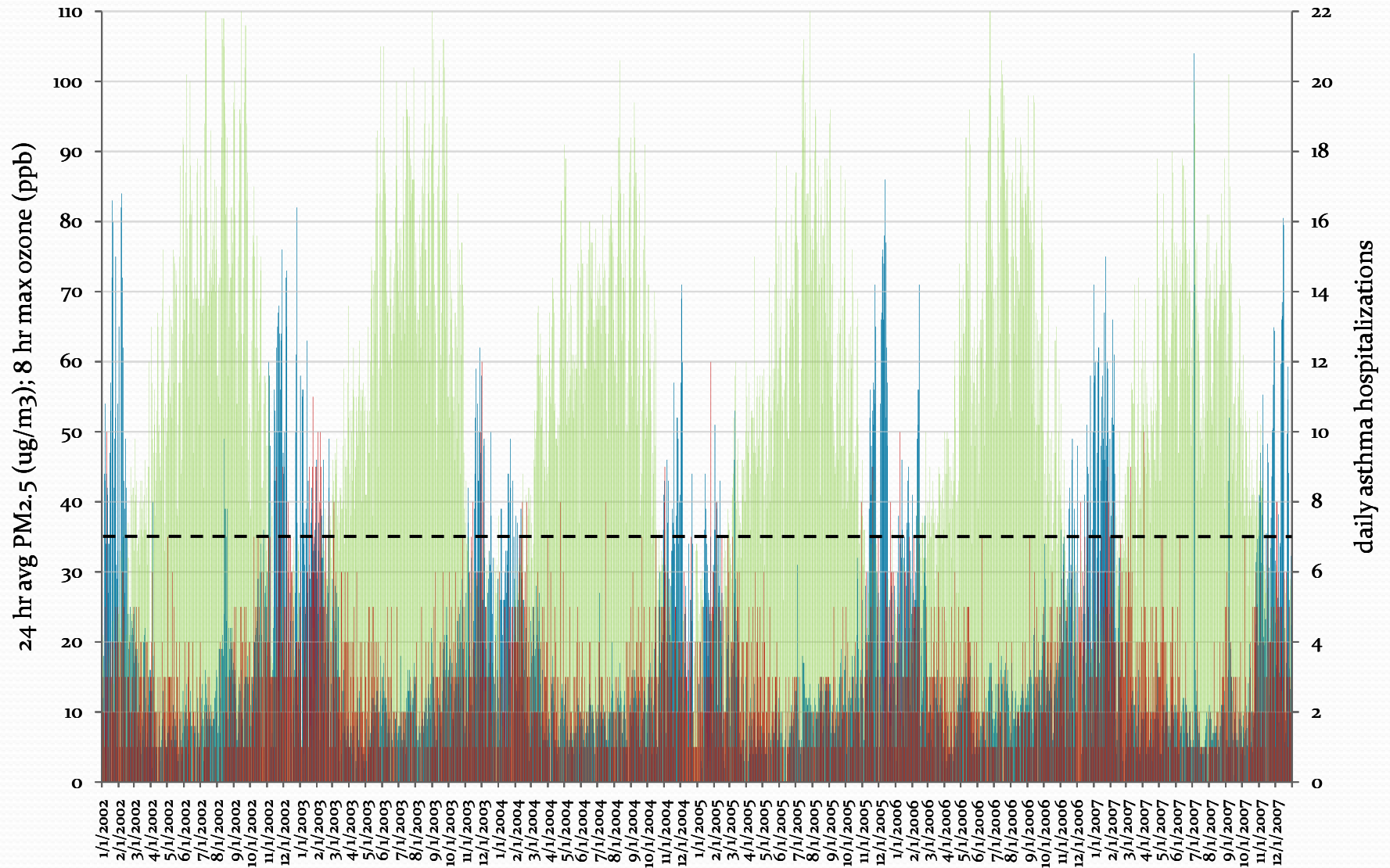
With financial support from the San Joaquin Valley Air Pollution Control District

# Study Objectives

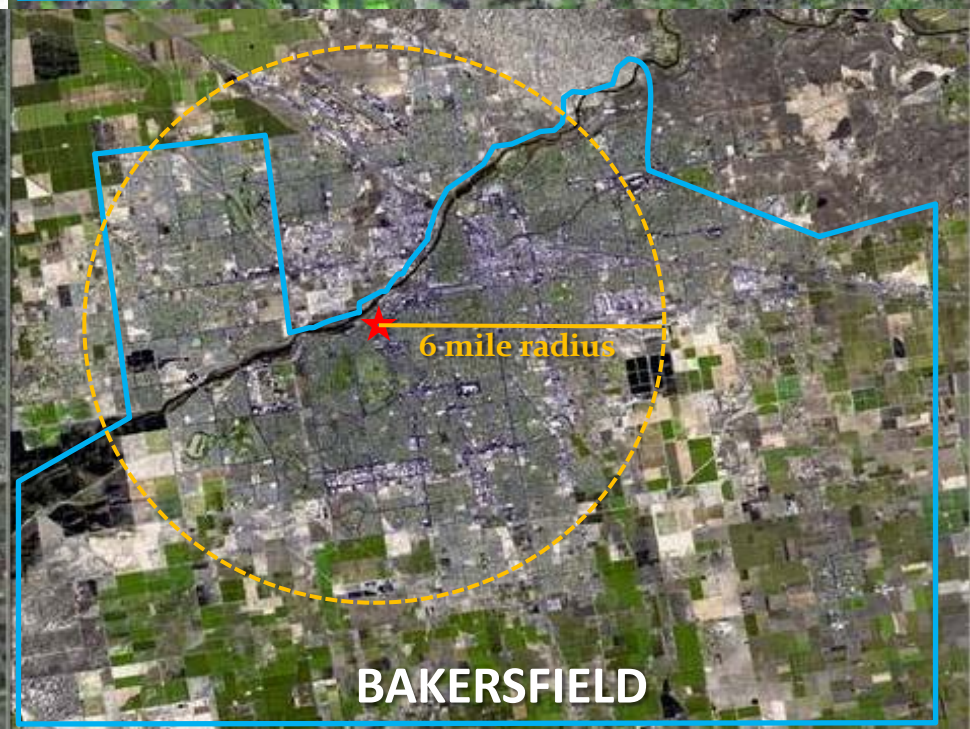
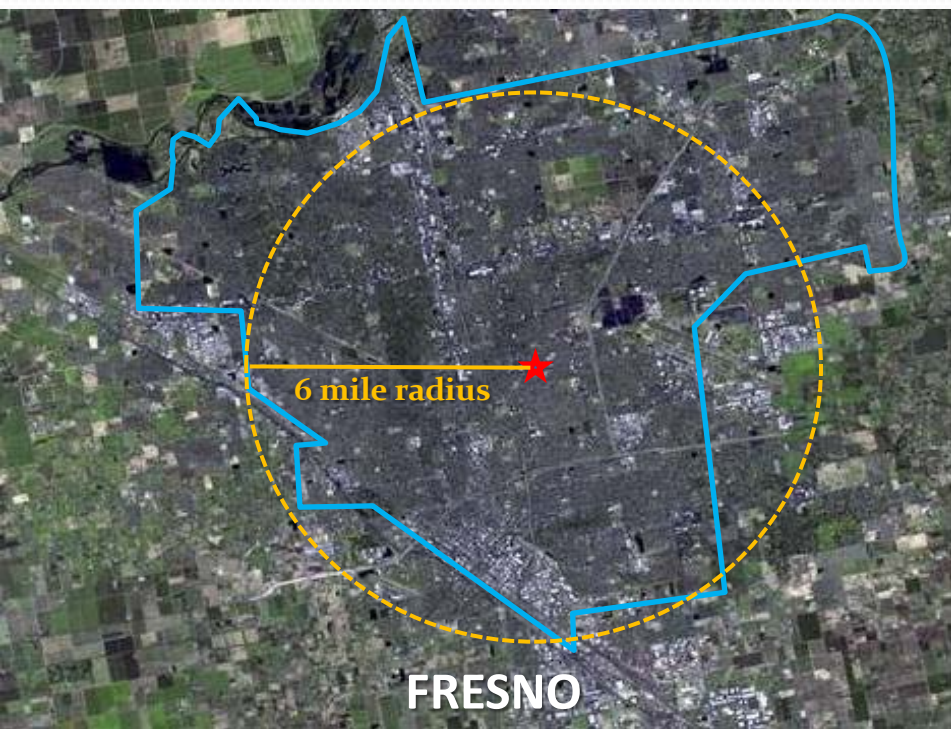
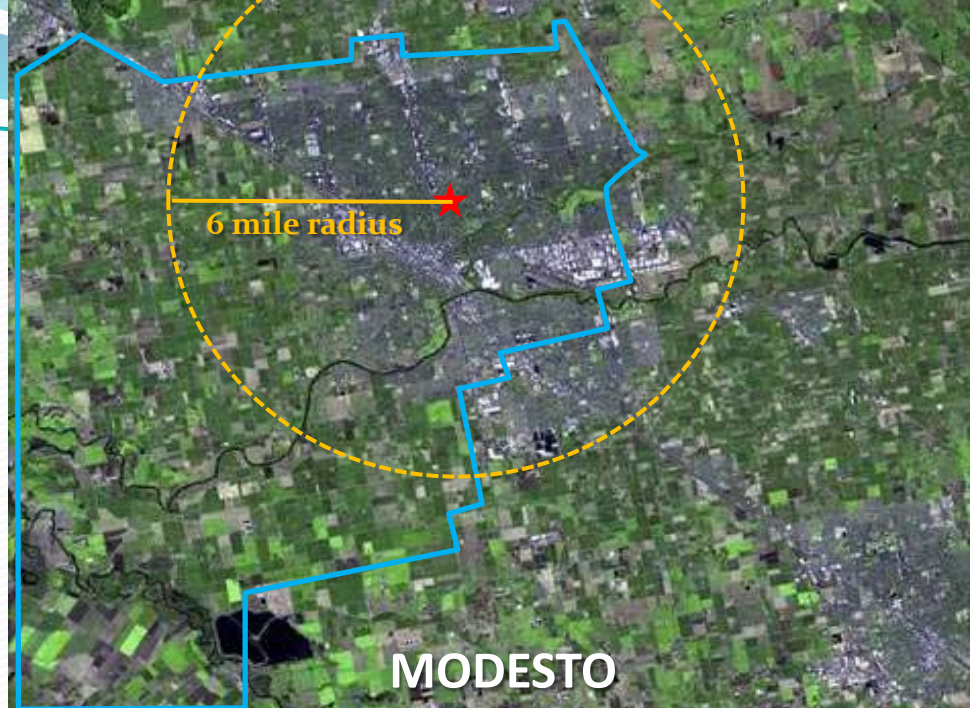
- Compare the effects of PM<sub>2.5</sub> at similar concentrations on asthma hospital and ER admissions in Modesto, Fresno and Bakersfield
- Determine the total impact of elevated PM<sub>2.5</sub> concentrations on asthma hospital and ER admissions in each city

# Fresno County (2002-2007)

■ daily 8 hr max ozone    ■ daily PM<sub>2.5</sub> (24 hr avg)    ■ daily asthma hospitalizations



- Hospitalization and ER visits by patient's home zip code
- > 90% of study population live within 6 miles of PM2.5 monitor



# Populations Demographics

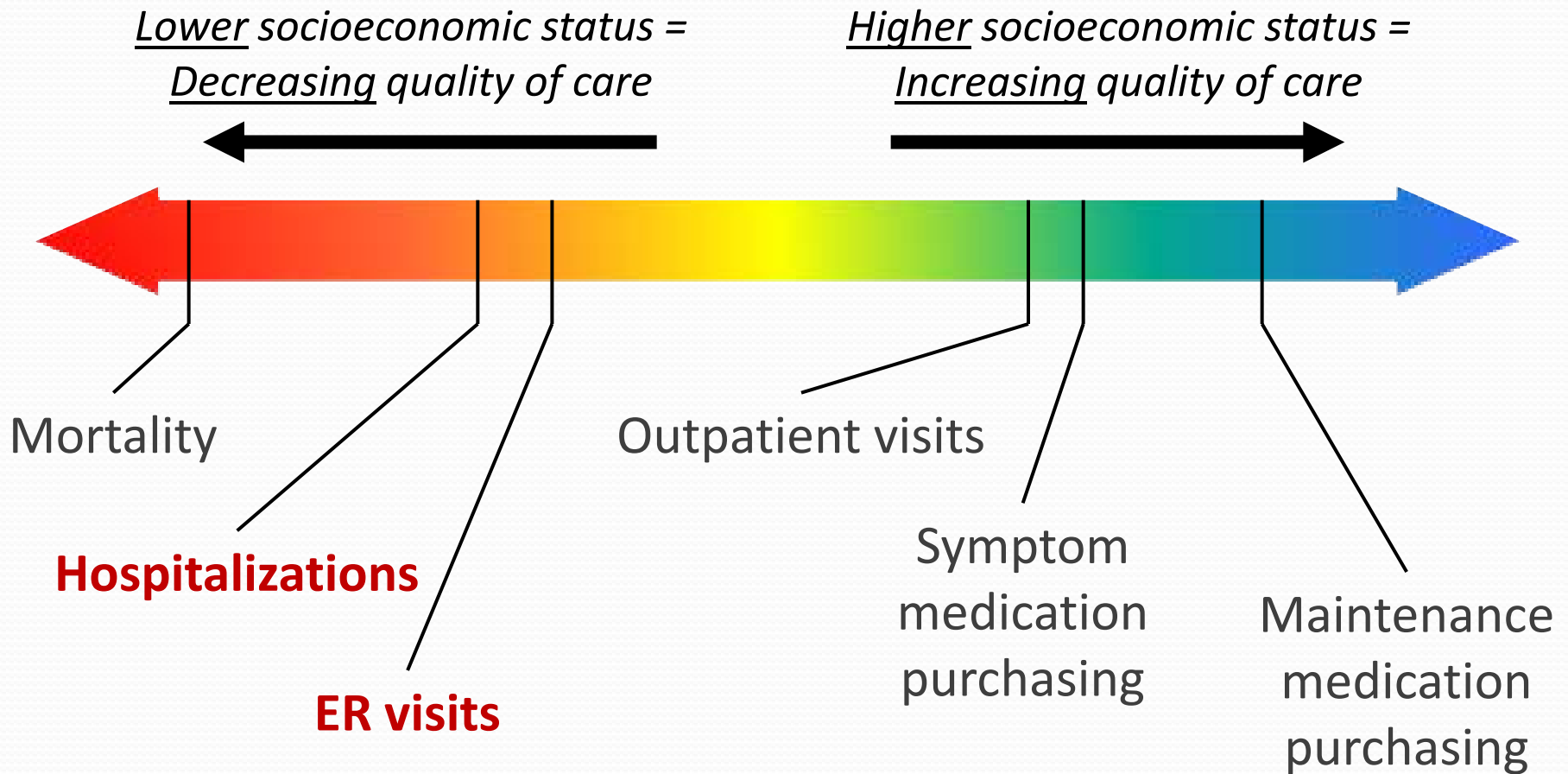
Aggregate of selected zip codes

|                    | population | medium<br>income | % children | % Hispanic |
|--------------------|------------|------------------|------------|------------|
| <b>MODESTO</b>     | 212,978    | \$40,865         | 44%        | 34%        |
| <b>FRESNO</b>      | 321,112    | <u>\$33,676</u>  | 40%        | 43%        |
| <b>BAKERSFIELD</b> | 323,066    | \$42,039         | 46%        | 39%        |

\* While populations were selected to be equally representative of exposure classifications and demographic characteristics, Fresno represents a significantly lower income population

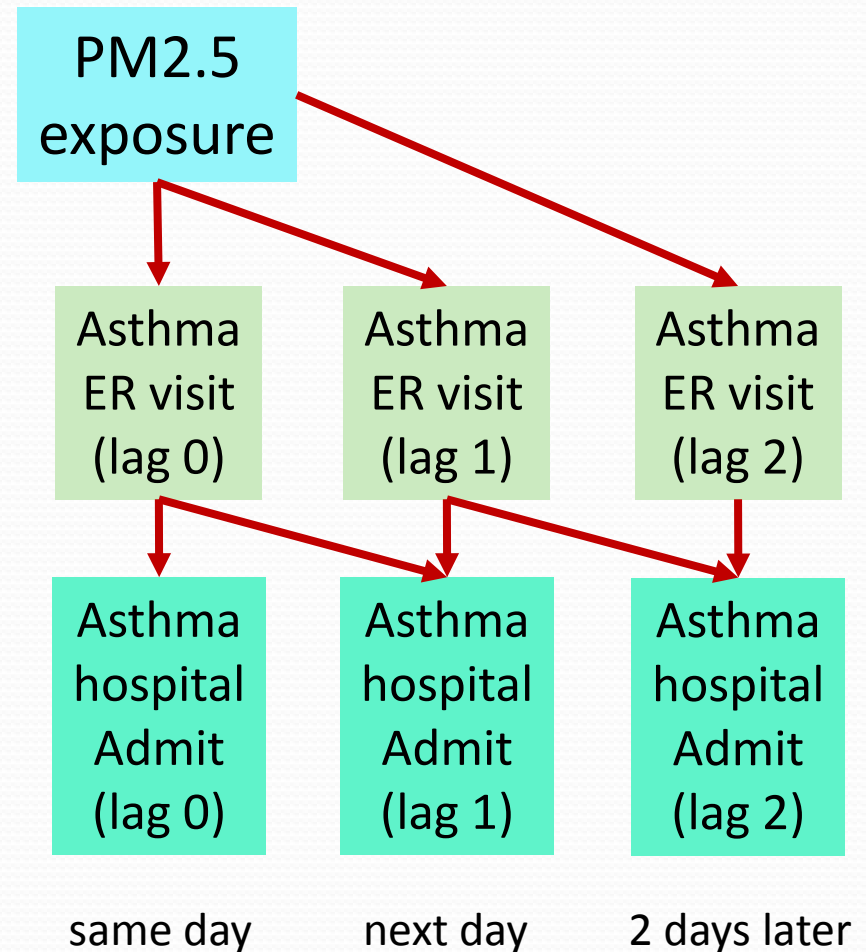
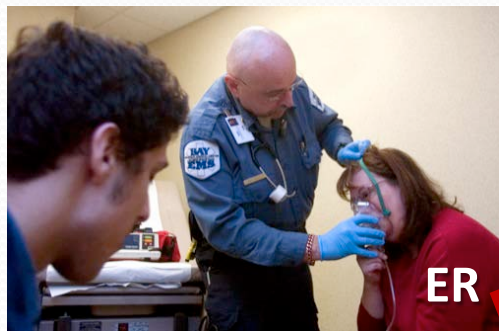
# Asthma Indicators & Income Disparities

Eric Roberts, EHTP/EHIB

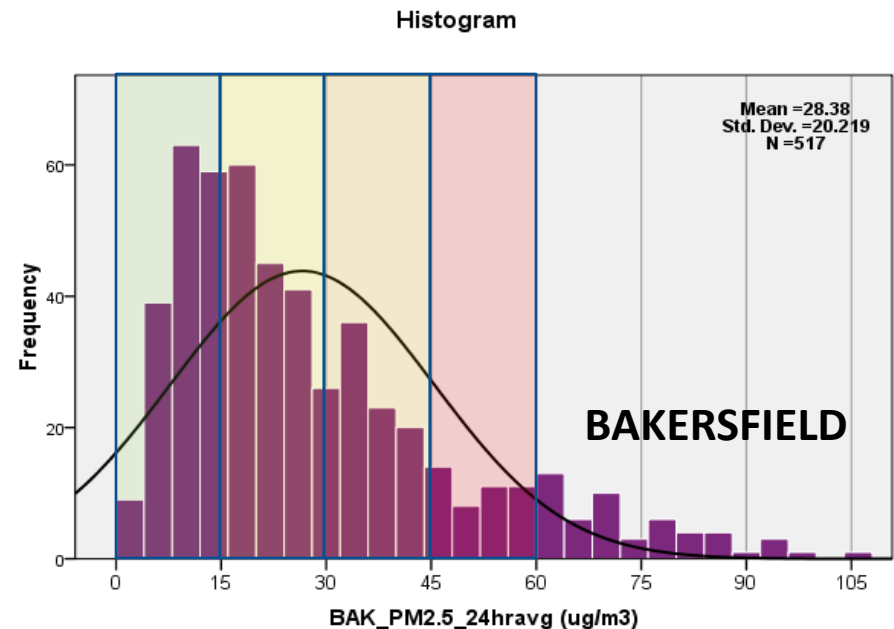
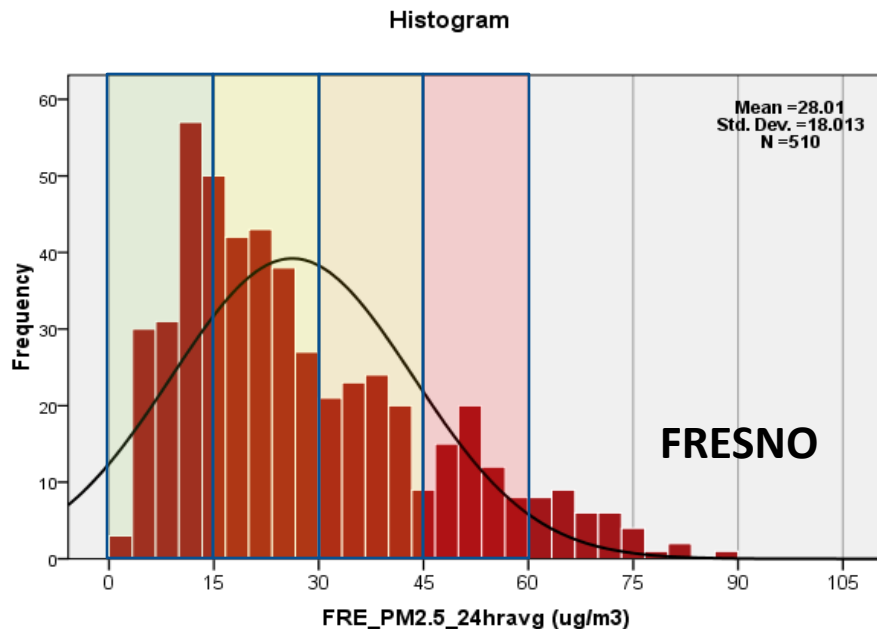
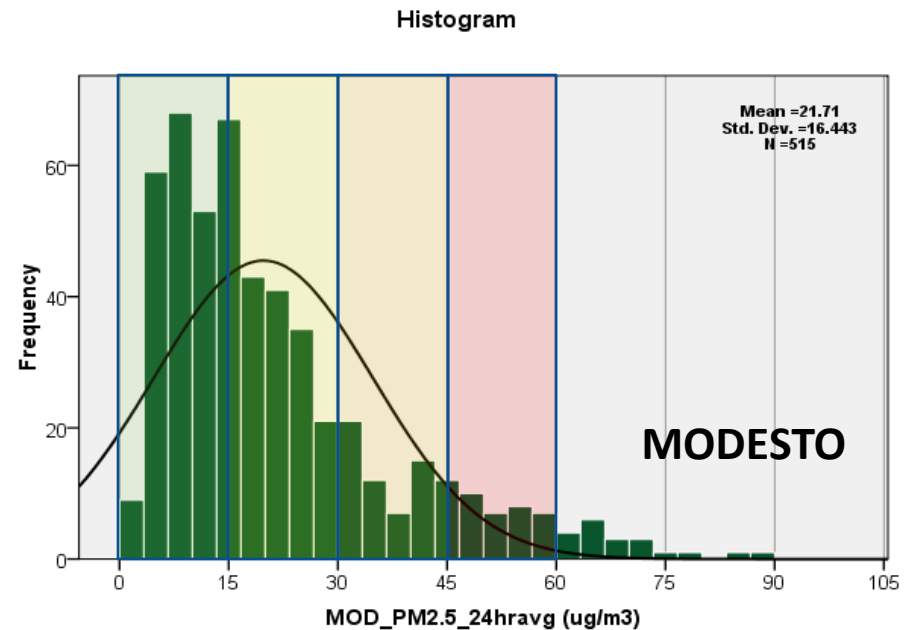


# Exposure – Exacerbation

Timeline of PM2.5 exposure and asthma exacerbation



- Frequency and distribution of PM2.5 concentrations (Oct-Mar, 2002-2007)
- Compare 15 ug PM2.5 ranges:
  - **low** (0-15 ug/m3)
  - **moderate** (15-30 ug/m3)
  - **high** (30-45 ug/m3)
  - **very high** (45-60 ug/m3)



# Poisson General Linear Regression Model

pGLRM

Control for potential **confounding variables**

- Temperature, Humidity
- CO, NO<sub>2</sub>
- Day of the week, Holidays

**Not Included in Model:**

Viral infections

cold, flu, RSV

Bioaerosols

grass and tree pollens

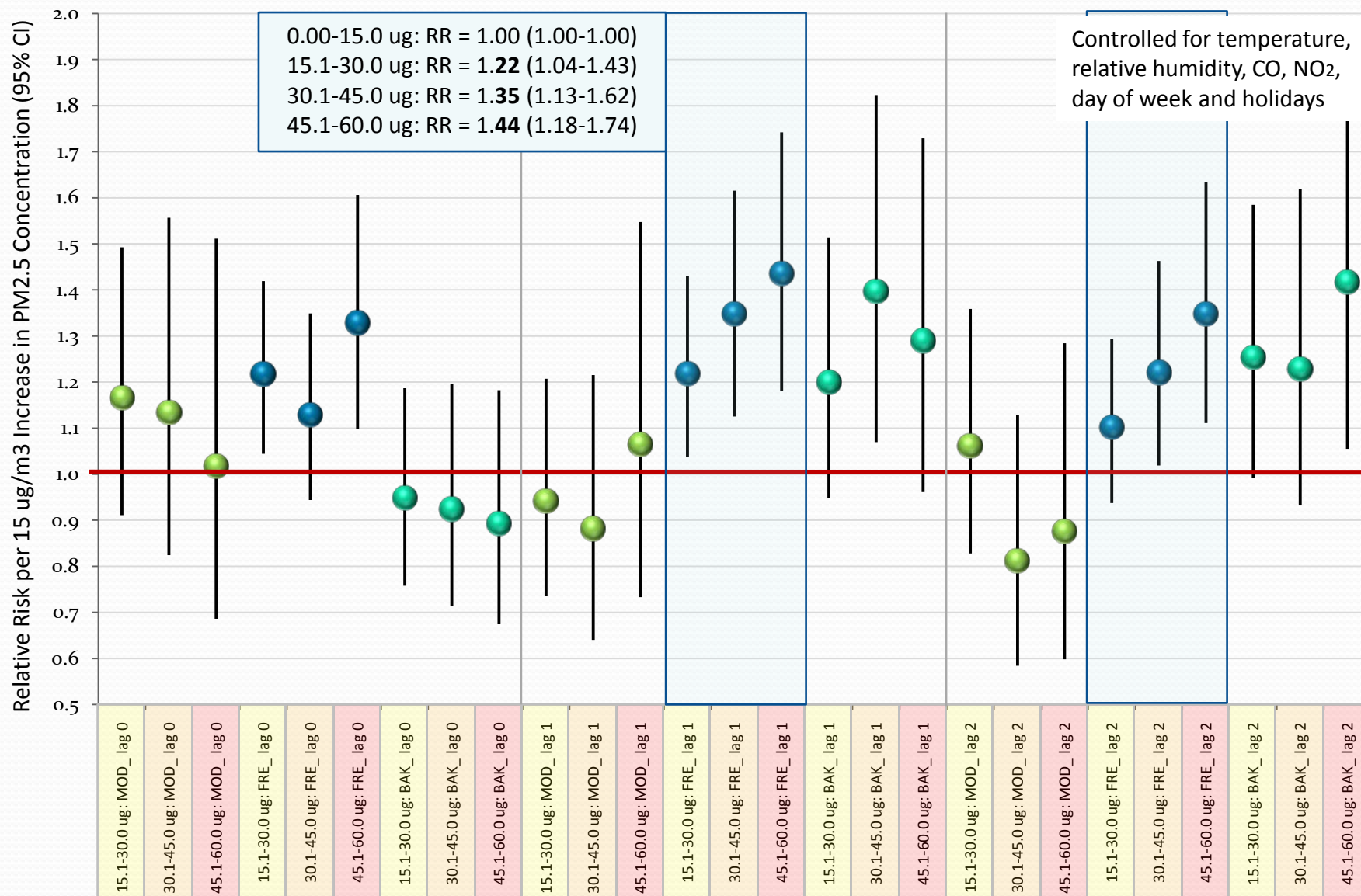
mold and fungal spores

bacterial endotoxin

**Relative Risk (RR)** per increase in PM<sub>2.5</sub> range

- RR = % change in hospitalizations compared to baseline hospitalization rate (lowest PM<sub>2.5</sub> range)
  - RR of 1.50 = 50% increase in hospitalizations
    - Significance: lower 95% confidence interval > 1.00
    - Dose response: ↑ PM<sub>2.5</sub> range = ↑ RR

## Risk of Asthma Hospitalization (all ages) Associated with PM2.5 Levels in Modesto, Fresno and Bakersfield (2002-2007)

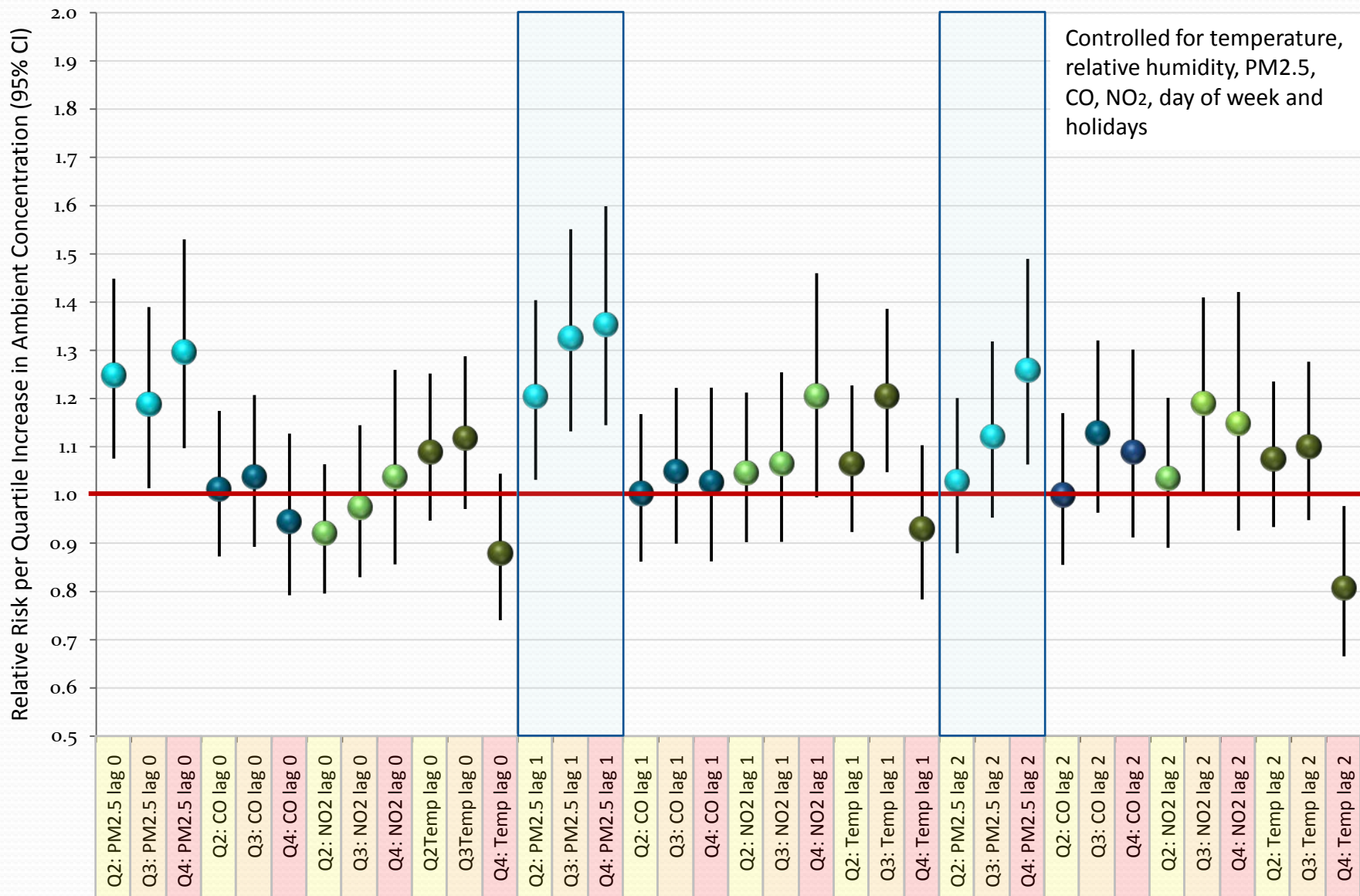


## Correlations between PM2.5 and co-variates (Fresno)

| Pearson Correlations    | PM2.5 (avg) | NO2 (max) | CO (max) | Temperature (max) | Relative Humidity (avg) |
|-------------------------|-------------|-----------|----------|-------------------|-------------------------|
| PM2.5 (avg)             | 1           | .376**    | .574**   | -.112**           | -.014                   |
| Sig. (2-tailed)         |             | .000      | .000     | .000              | .658                    |
| NO2 (max)               |             | 1         | .514**   | .465**            | -.091**                 |
| Sig. (2-tailed)         |             |           | .000     | .000              | .003                    |
| CO (max)                |             |           | 1        | -.005             | -.029                   |
| Sig. (2-tailed)         |             |           |          | .884              | .344                    |
| Temperature (max)       |             |           |          | 1                 | -.282**                 |
| Sig. (2-tailed)         |             |           |          |                   | .000                    |
| Relative Humidity (avg) |             |           |          |                   | 1                       |
| Sig. (2-tailed)         |             |           |          |                   |                         |

- **Collinearity**: pGLRM analysis, while controlling for other factors, cannot exclude the possible effects of a co-variate if it is correlated with the independent variable (e.g. PM2.5 and CO)

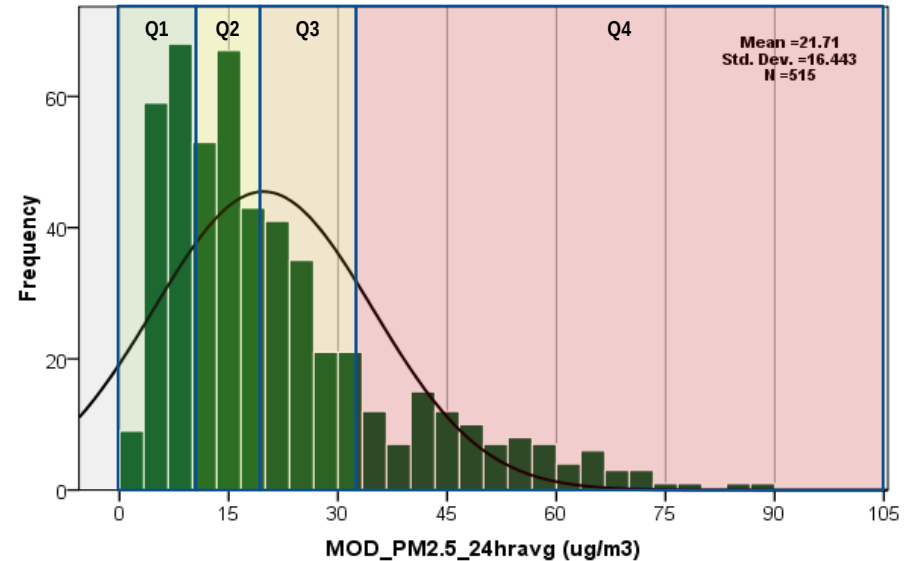
# Risk of Asthma Hospitalization (all ages) Associated with Ambient Pollution Levels in Fresno (2002-2007)



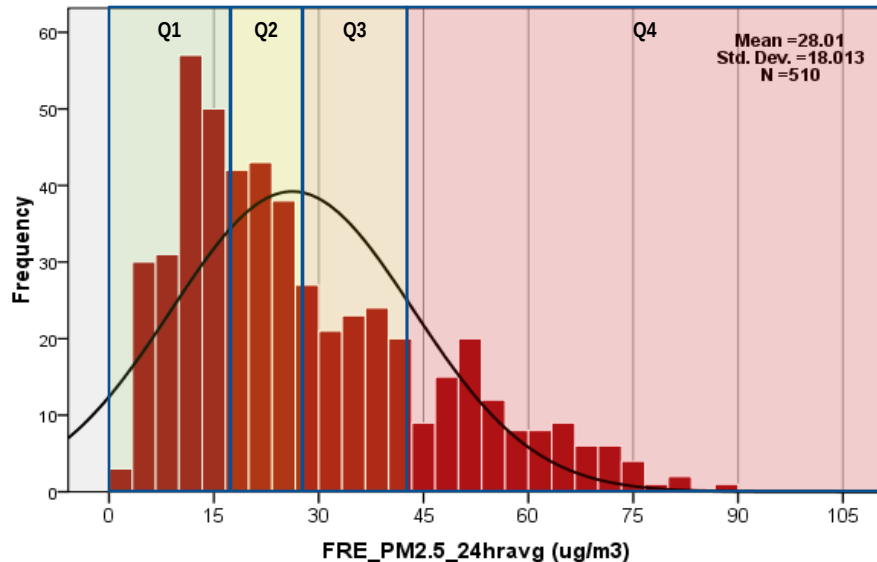
- Total impact of PM2.5 on asthma hospitalizations in each city: PM2.5 exposure quartiles

| Quartiles of PM2.5 | Q1     | Q2        | Q3        | Q4     |
|--------------------|--------|-----------|-----------|--------|
| <b>Modesto</b>     | < 10.7 | 10.7-18.8 | 18.8-32.5 | > 32.5 |
| <b>Fresno</b>      | < 17.0 | 17.0-27.5 | 27.6-42.5 | > 42.5 |
| <b>Bakersfield</b> | < 16.0 | 16.0-26.4 | 26.5-41.4 | > 41.4 |

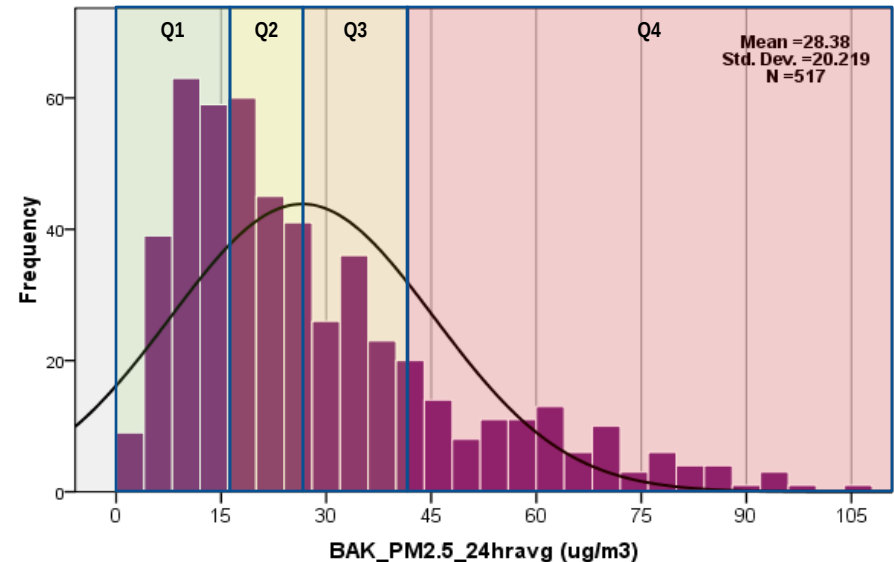
Histogram



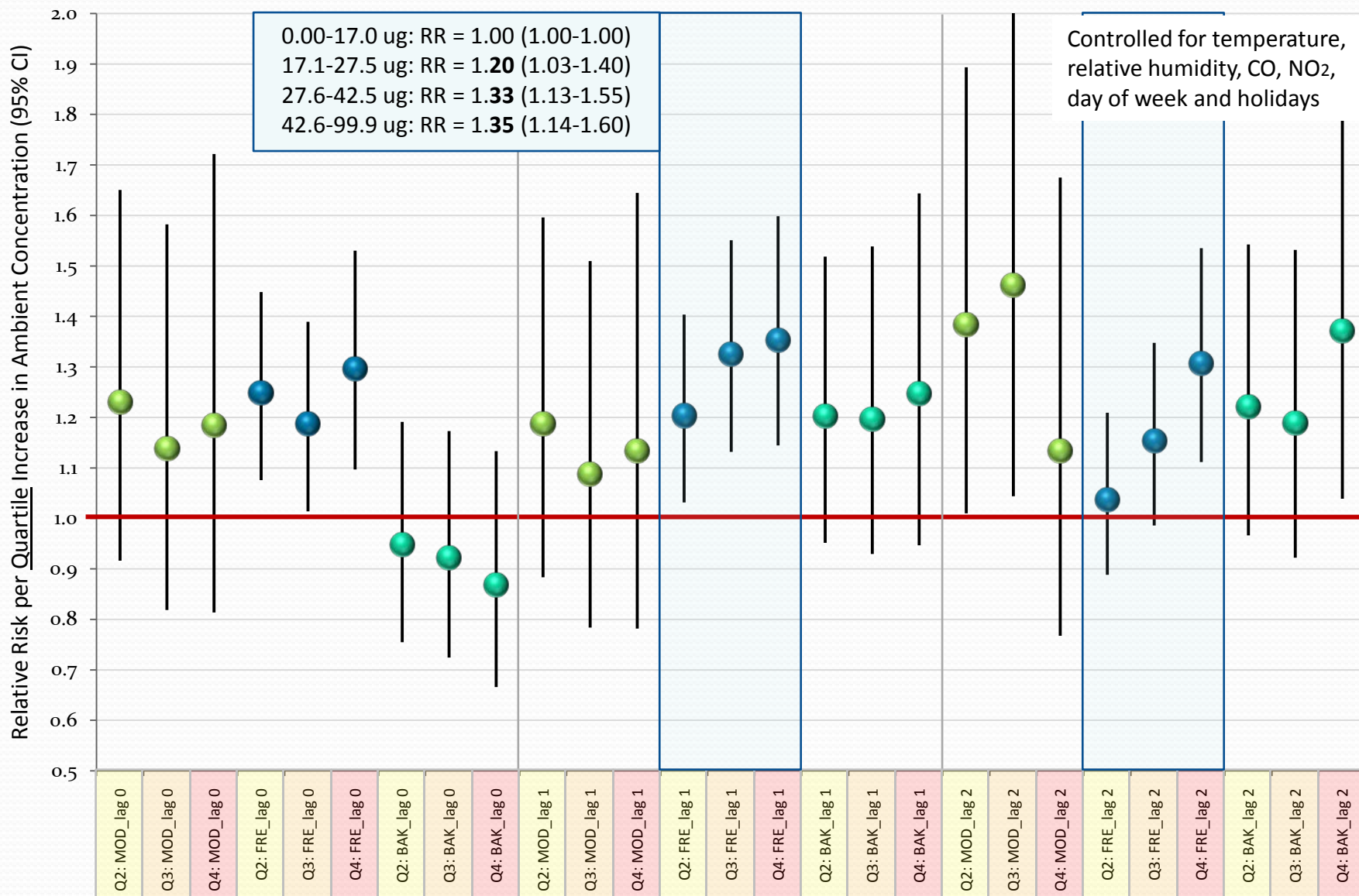
Histogram



Histogram



## Risk of Asthma Hospitalization (All Ages) Associated with PM2.5 Levels in Modesto, Fresno and Bakersfield (2002-2007)

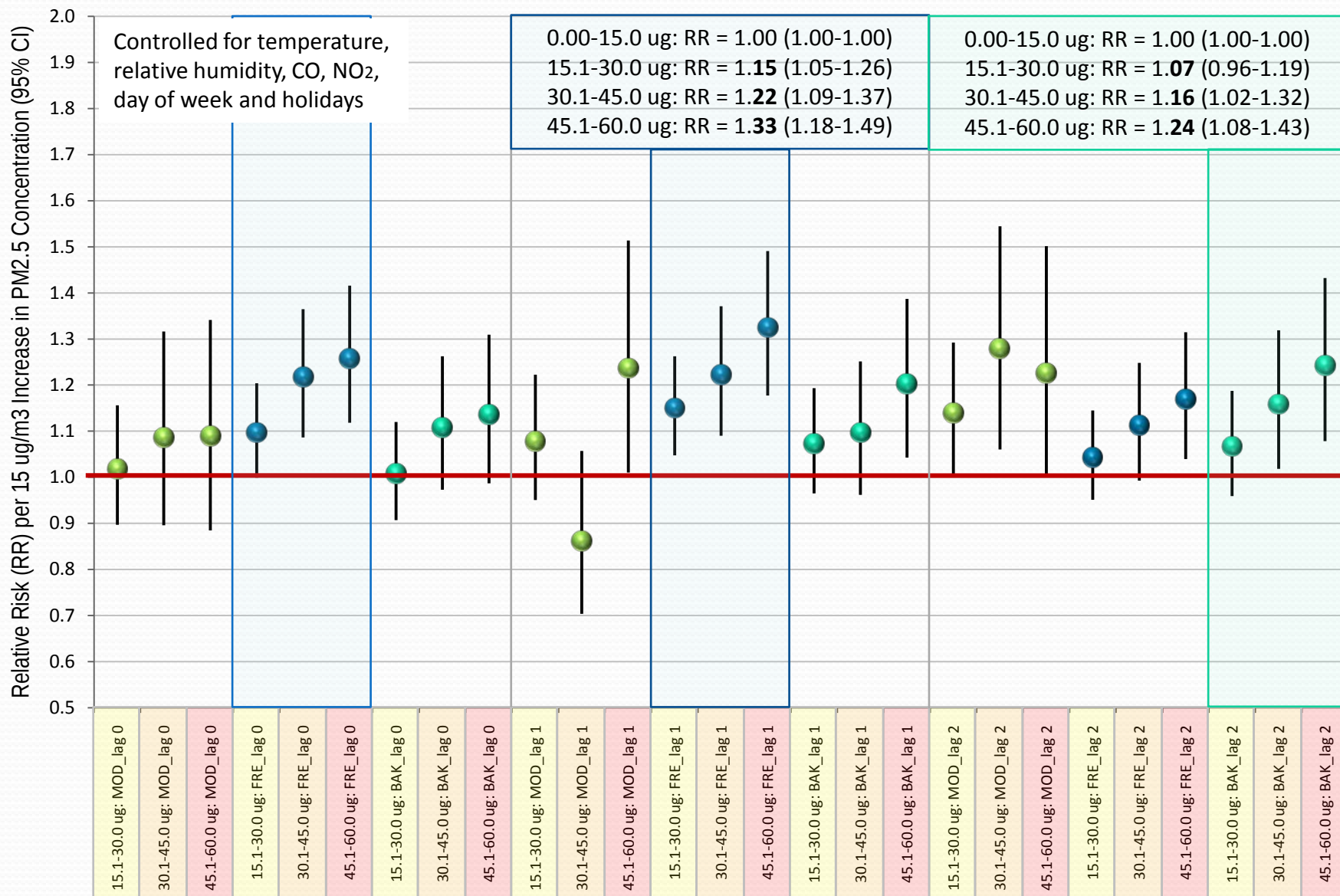


# Estimate of PM2.5-related Hospital Costs

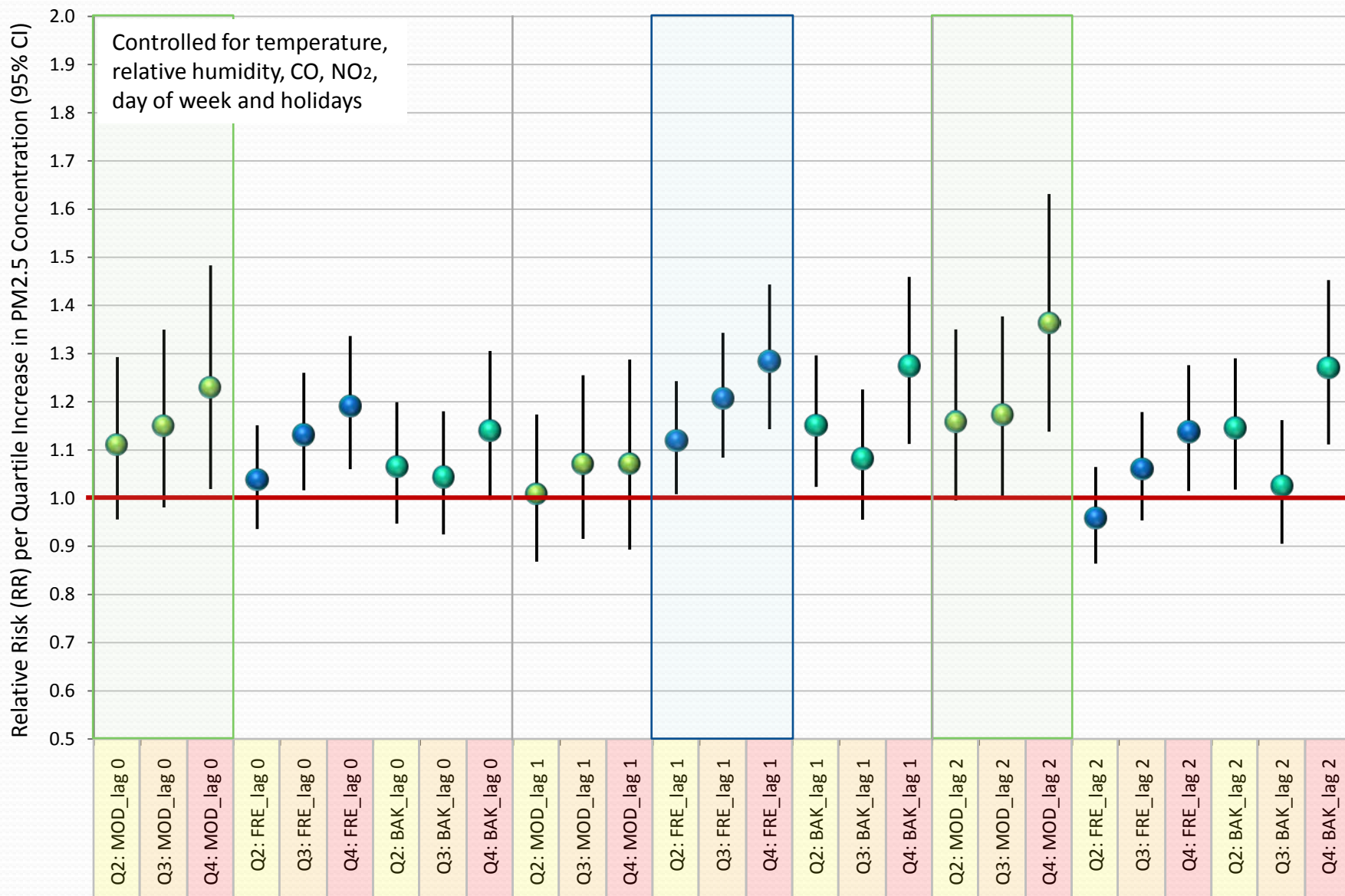
Fresno/Clovis metropolitan area

| <u>Fresno/Clovis Population:</u><br>Average 2005-2007 = 537,000<br><u>Average Asthma Hospitalizations:</u><br>18 per 10,000 people per year | annual increase in<br>asthma hospital<br>admissions associated<br>with elevated PM2.5 | additional cost associated with<br>annual PM2.5-related asthma<br>hospital admissions |
|---------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| PM2.5 <b>Q1</b> ( < 17 ug/m3)                                                                                                               |                                                                                       |                                                                                       |
| PM2.5 <b>Q2</b> (17-27 ug/m3)                                                                                                               | <b>19</b> (3-37)                                                                      | <b>\$236,784</b> (\$36,638-\$470,327)                                                 |
| PM2.5 <b>Q3</b> (28-42 ug/m3)                                                                                                               | <b>30</b> (12-51)                                                                     | <b>\$378,319</b> (\$153,308-\$641,797)                                                |
| PM2.5 <b>Q4</b> ( > 42 ug/m3)                                                                                                               | <b>33</b> (13-55)                                                                     | <b>\$410,595</b> (\$168,135-\$697,214)                                                |
| PM2.5 <b>Q2-Q4</b> ( > 17 ug/m3)                                                                                                            | <b>81</b> (28-144)                                                                    | <b>\$1,025,698</b> (\$358,080-\$1,809,338)                                            |
| Annual Avg Asthma Hospitalizations                                                                                                          | 967                                                                                   | \$12,190,169 (8.4%)                                                                   |
| Avg Oct-Mar Asthma Hospitalizations                                                                                                         | 622                                                                                   | \$7,841,554 (13.1%)                                                                   |

## Risk of Asthma ER Visit (all ages) Associated with PM2.5 in Modesto, Fresno and Bakersfield (Oct-Mar, 2005-2007)



## Risk of Asthma ER Visit (all ages) Associated with PM2.5 in Modesto, Fresno and Bakersfield (Oct-Mar, 2005-2007)



# Estimated PM2.5-related Asthma ER Costs

Fresno/Clovis metropolitan area

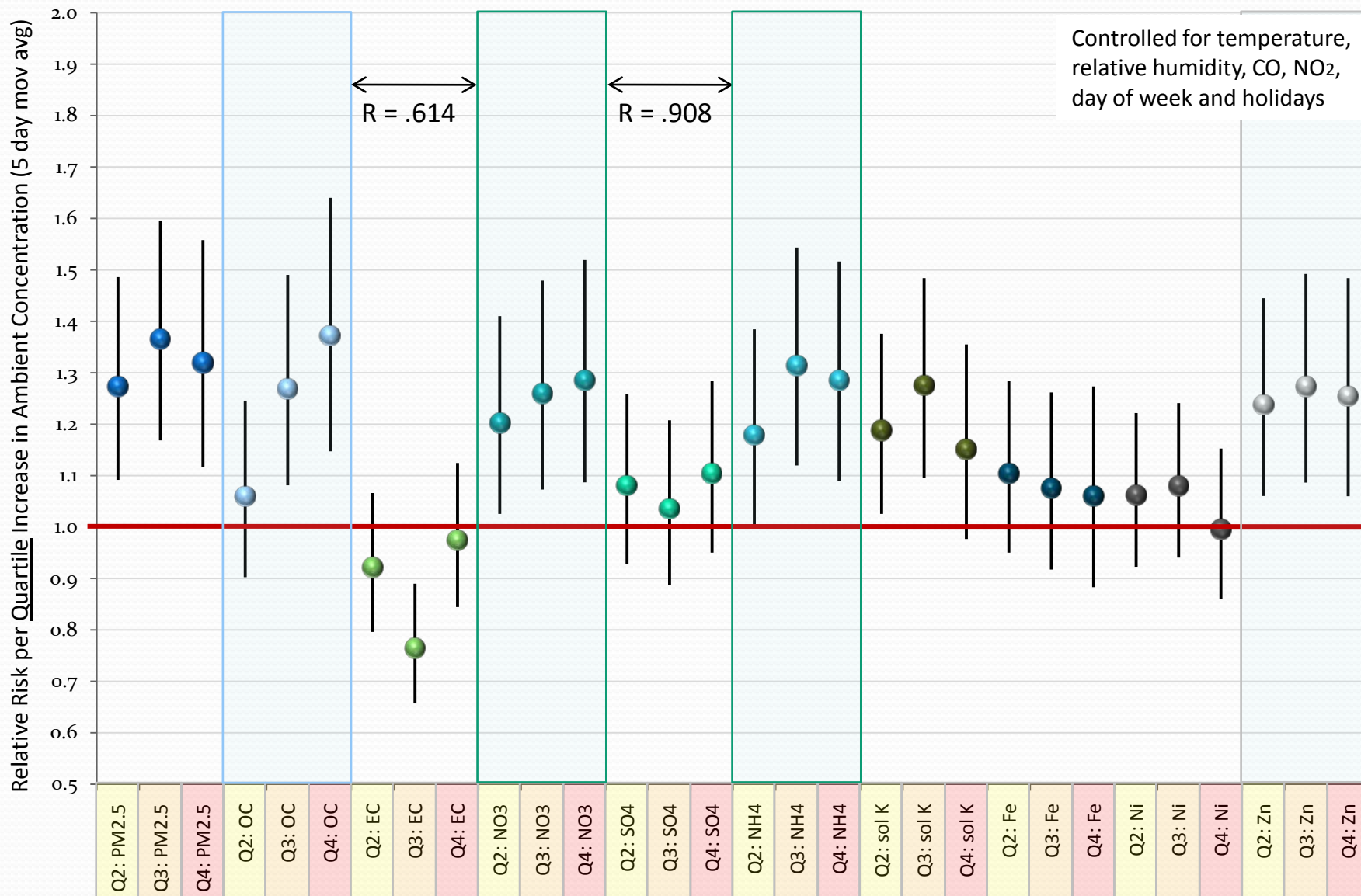
| <u>Fresno/Clovis Population:</u><br>Average 2005-2007 = 537,000<br><br><u>Average Asthma ER Visits:</u><br>per 10,000 people per year | annual increase in<br>asthma ER visits<br>associated with<br>elevated PM2.5 | additional cost associated with<br>annual PM2.5-related asthma ER<br>visits |
|---------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------|-----------------------------------------------------------------------------|
| PM2.5 <b>Q1</b> ( < 17 ug/m3)                                                                                                         |                                                                             |                                                                             |
| PM2.5 <b>Q2</b> (17-27 ug/m3)                                                                                                         | <b>53</b> (4-108)                                                           | <b>\$85,140</b> (\$5,644-\$173,423)                                         |
| PM2.5 <b>Q3</b> (28-42 ug/m3)                                                                                                         | <b>92</b> (38-153)                                                          | <b>\$147,756</b> (\$60,092-\$245,351)                                       |
| PM2.5 <b>Q4</b> ( > 42 ug/m3)                                                                                                         | <b>127</b> (64-198)                                                         | <b>\$203,252</b> (\$102,247-\$316,760)                                      |
| PM2.5 <b>Q2-Q4</b> ( > 17 ug/m3)                                                                                                      | <b>273</b> (105-460)                                                        | <b>\$436,148</b> (\$167,983-\$735,533)                                      |
| Annual Avg Asthma ER Visits<br>Avg Oct-Mar Asthma ER Visits                                                                           | 3550<br>2074                                                                | \$5,680,000 (7.7%)<br>\$3,318,400 (13.1%)                                   |

# PM2.5 Chemical Composition

Which species are associated with health effects?

- Organic carbon (OC)
- Elemental carbon (EC)
- Nitrate (NO<sub>3</sub>)
- Sulfate (SO<sub>4</sub>)
- Ammonium (NH<sub>4</sub>)
- Potassium (K)
- Copper (Cu)
- Iron (Fe)
- Nickel (Ni)
- Vanadium (V)
- Zinc (Zn)

# Risk of Asthma Hospitalization (all ages) Associated with PM2.5 Components (5 day moving average exposure) in Fresno (2002-2007)



# Wrap-up

- PM2.5 is strongly associated with asthma ER visits in Fresno, and possibly in Modesto and Bakersfield (depending on exposure metric)
- PM2.5 accounts for approximately 8% of all asthma hospitalizations in Fresno, but no significant associations were found in Modesto or Bakersfield
- Secondary aerosols, like OC and NO<sub>3</sub>, as well as transition metals, like zinc, may be important components of PM2.5 associated with respiratory health effects

# Acknowledgements

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