Application of GIS to Estimate Public Health Benefits of Whole House In-Duct Air Cleaning

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Background

- Ambient particulate air pollution has been associated with a variety of negative health outcomes

Spatial Analysis of Air Pollution and Mortality in Los Angeles

Michael Jerrett, Richard T. Burnett,† Renjun Ma,‡ C. Arden Pope III,§ Daniel Krewski,¶ K. Bruce Newbold,‖ George Thurston,** Yuanli Shi,¶ Norm Finkelstein,‖ Eugenia E. Calle,†† and Michael J. Thun††*

Association of Asthma Symptoms with Peak Particulate Air Pollution and Effect Modification by Anti-inflammatory Medication Use

Ralph J. Delfino,[1] Robert S. Zeiger,[2,3] James M. Seltzer,[2,4] Donald H. Street,[5] and Christine E. McLaren[1]

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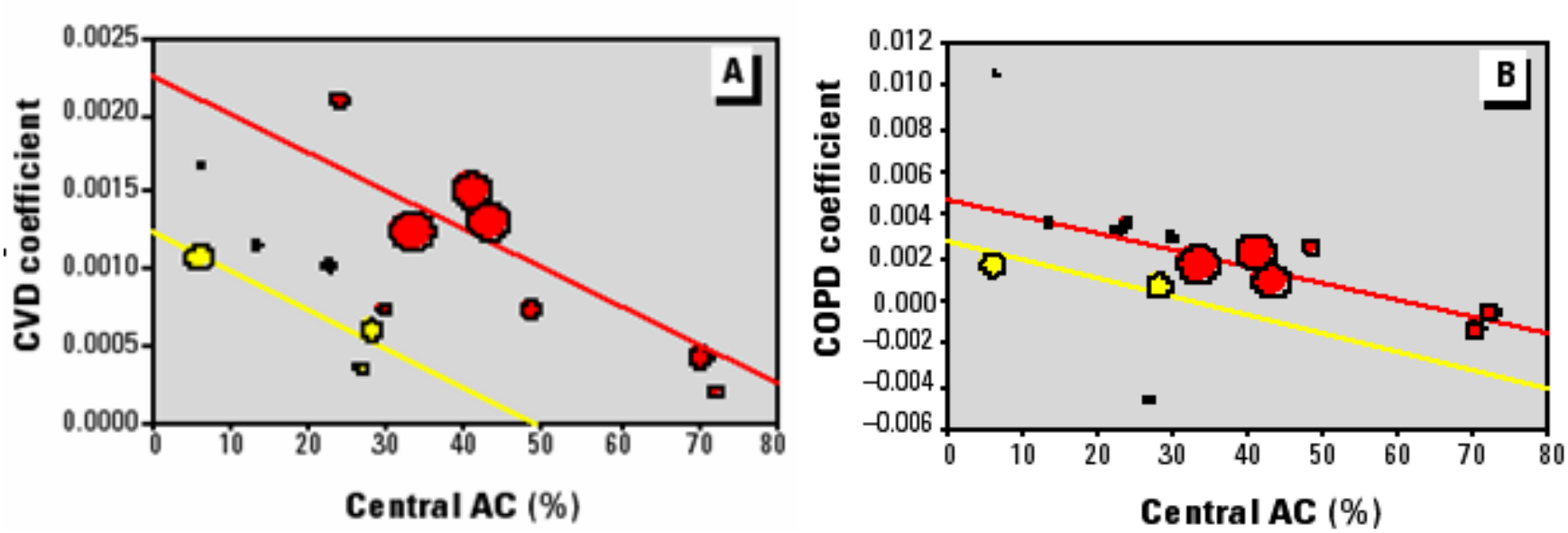
Long-Term Exposure to Air Pollution and Incidence of Cardiovascular Events in Women

Kristin A. Miller, M.S., David S. Siscovick, M.D., M.P.H., Lianne Sheppard, Ph.D., Kristen Shepherd, M.S., Jeffrey H. Sullivan, M.D., M.H.S., Garnet L. Anderson, Ph.D., and Joel D. Kaufman, M.D., M.P.H.

Background

- AC is an effect modifier for ambient PM-cardiovascular disease concentration response functions (Janssen et al. 2002, Franklin et al. 2007, Medina-Ramon et al. 2006)



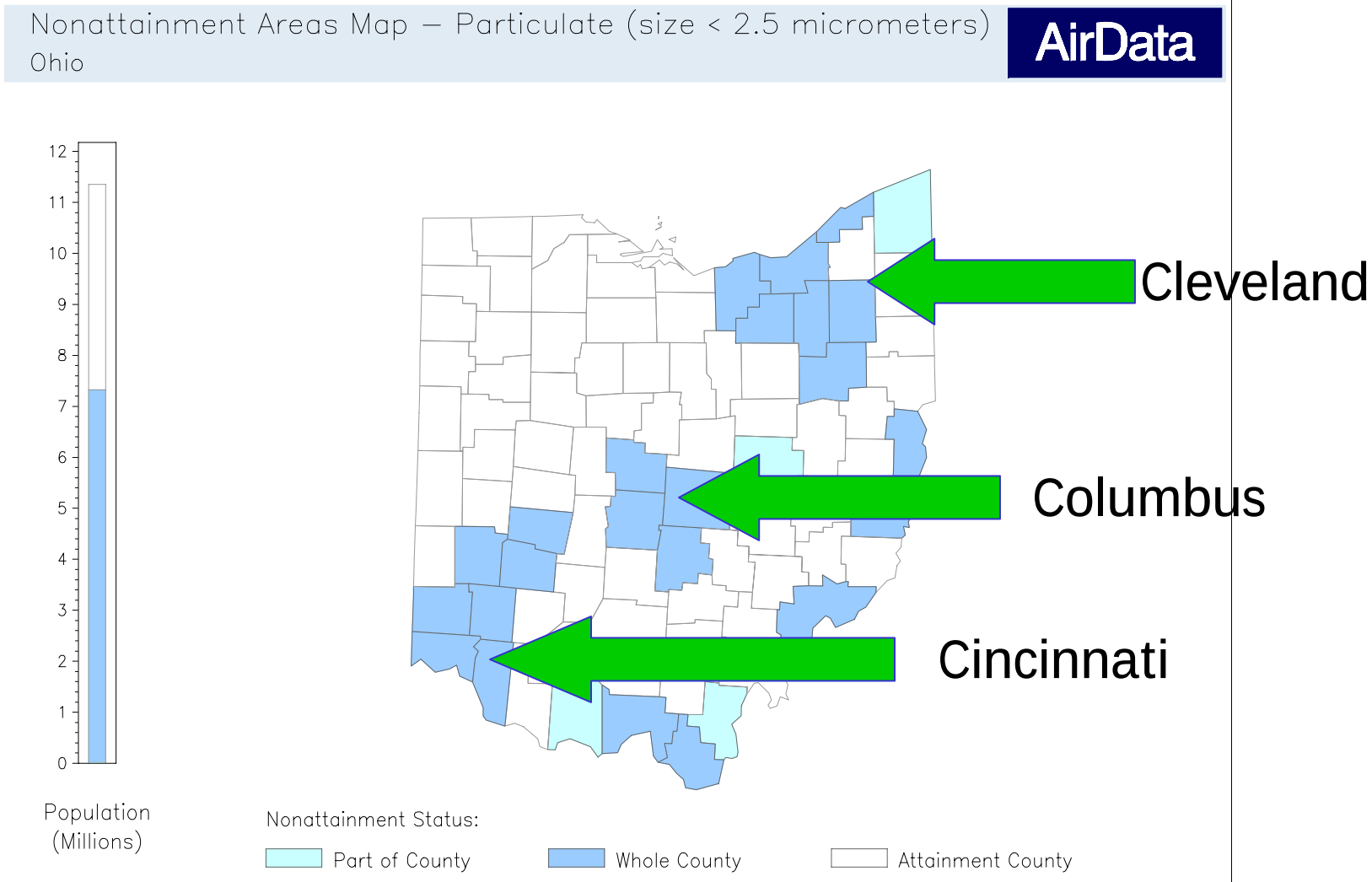
Source: Janssen N., Schwartz J, Zanobetti A, Suh H. 2002. Environmental Health Perspectives, 110(1):43-49.

Background

- Effect of AC presumably reduces exposure to PM due to reduced air exchange
- Residential air cleaning systems are designed to reduce exposure to both PM generated indoors and outdoors

Objective: Evaluate the public health benefit of exposure reduction due to addition of a high efficiency filtration system for a large population using a GIS and indoor air quality model

Large Population

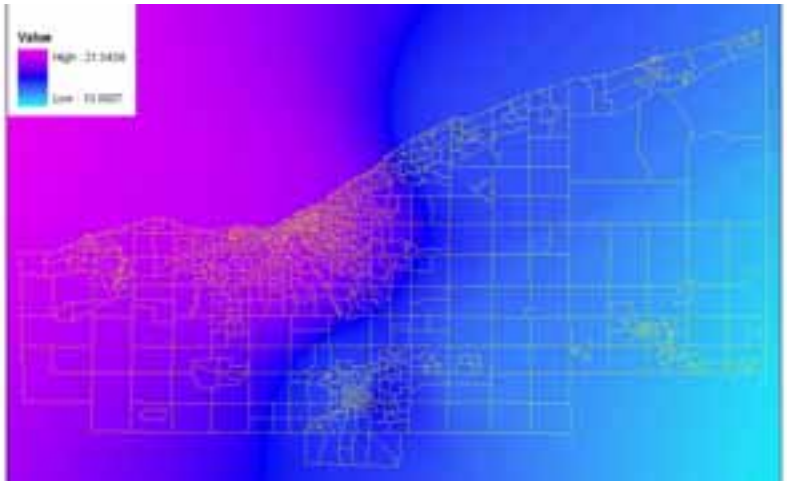


GIS

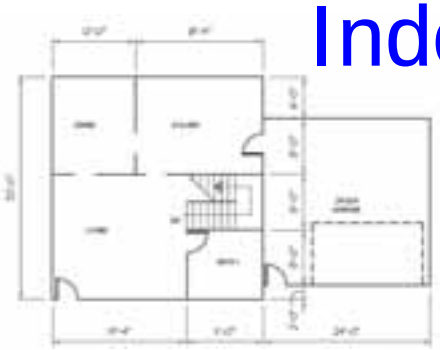
- Used to integrate spatial data:
  - Daily ambient $PM_{2.5}$
  - Daily weather conditions
  - County level housing stock
  - Census track population data
  - Indoor air quality modeling results

Process

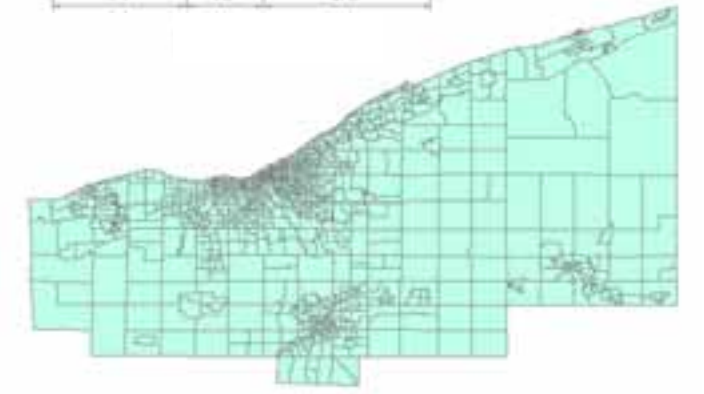
Ambient $PM_{2.5}$ levels



Indoor $PM_{2.5}$ levels



Exposed Population

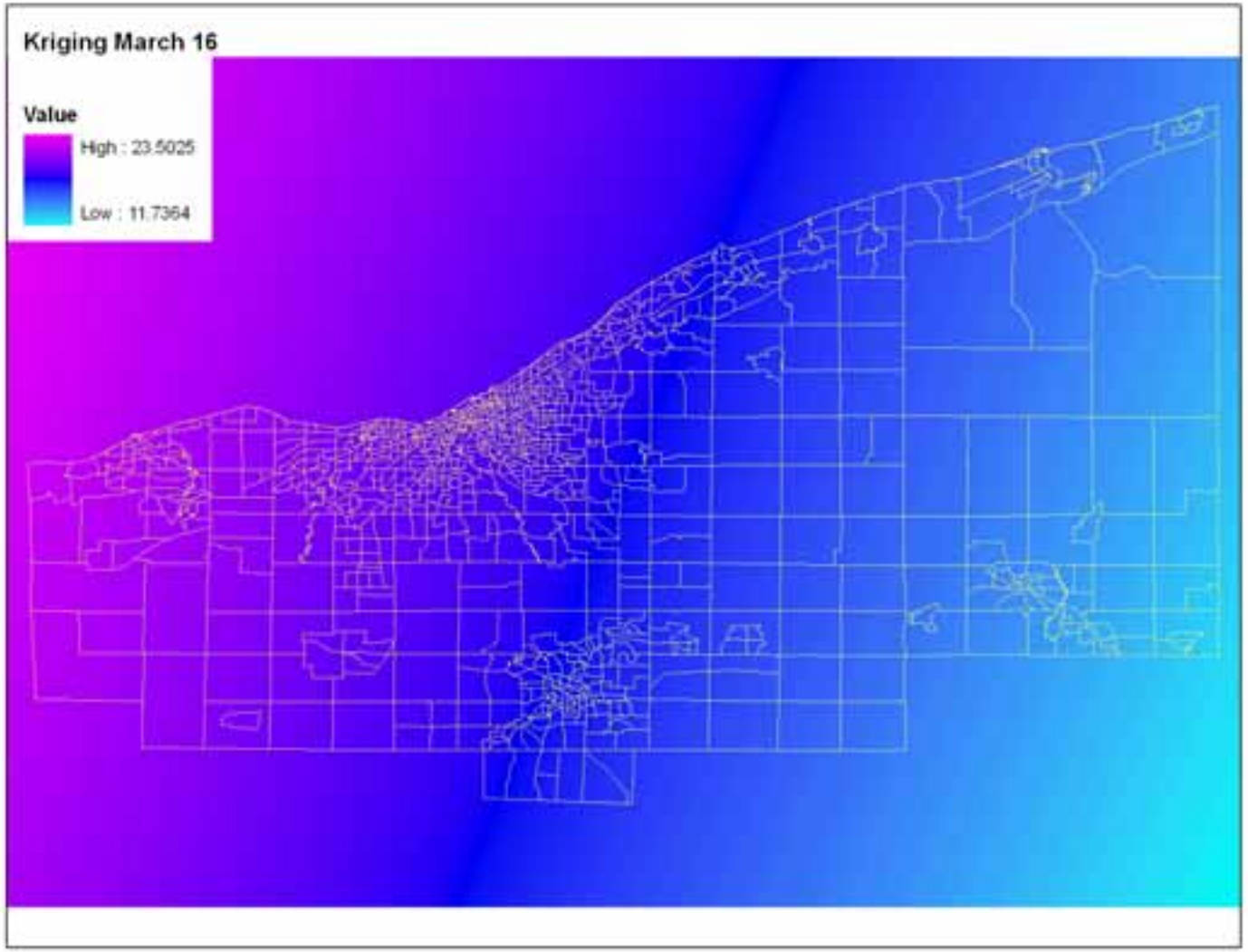


Health Effects

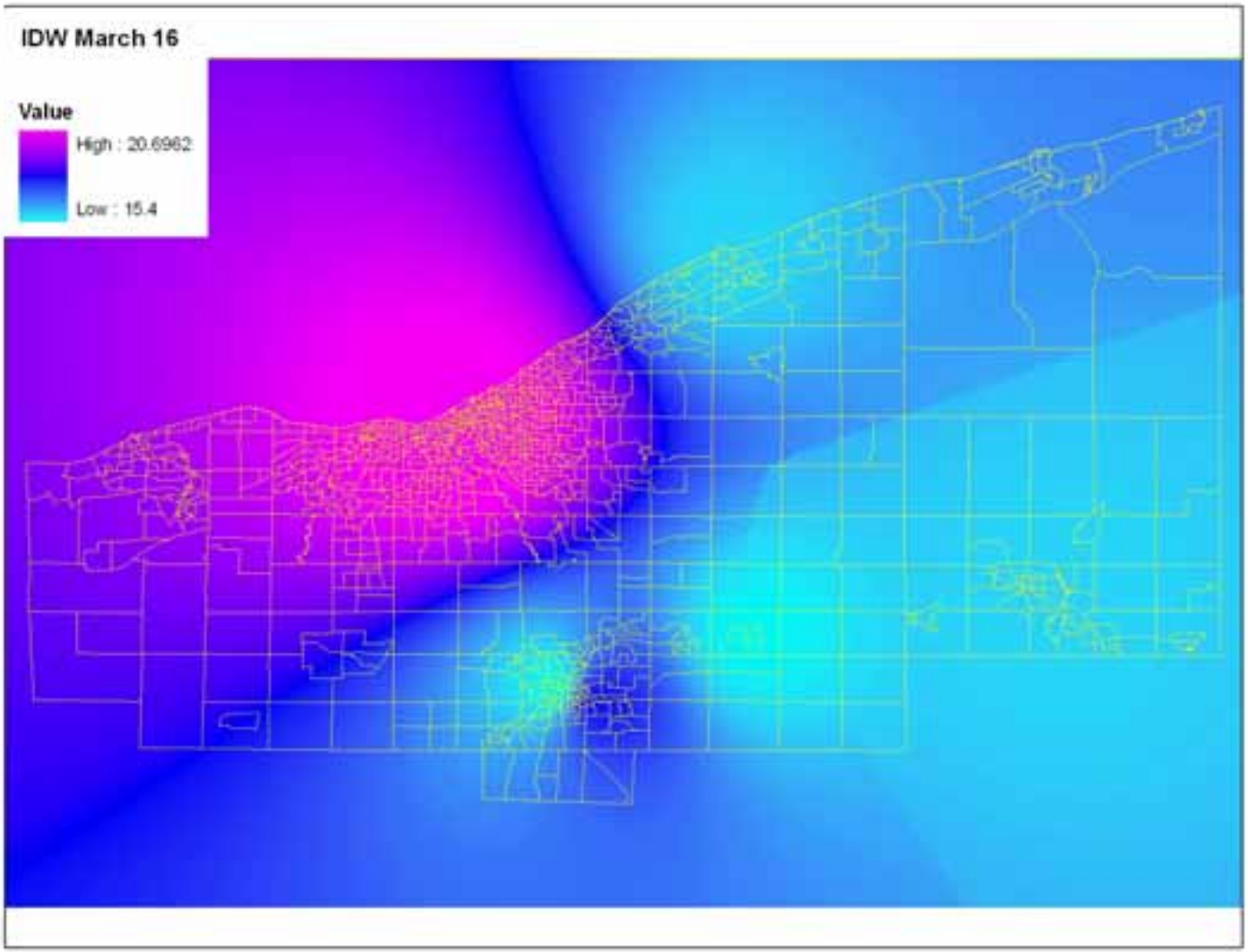
Ambient Particulate Data

- Used daily and hourly $PM_{2.5}$ data 34 monitors from EPA Air Quality System for 2005
- Missing data was estimated with an autoregressive model based on data from previous or next day
- Estimated daily $PM_{2.5}$ level for each census tract in ArcView with a combination of universal kriging and inverse distance weighting (Jerrett et al., 2005)
- Used tract level $PM_{2.5}$ to calculate a population weighted county average concentration

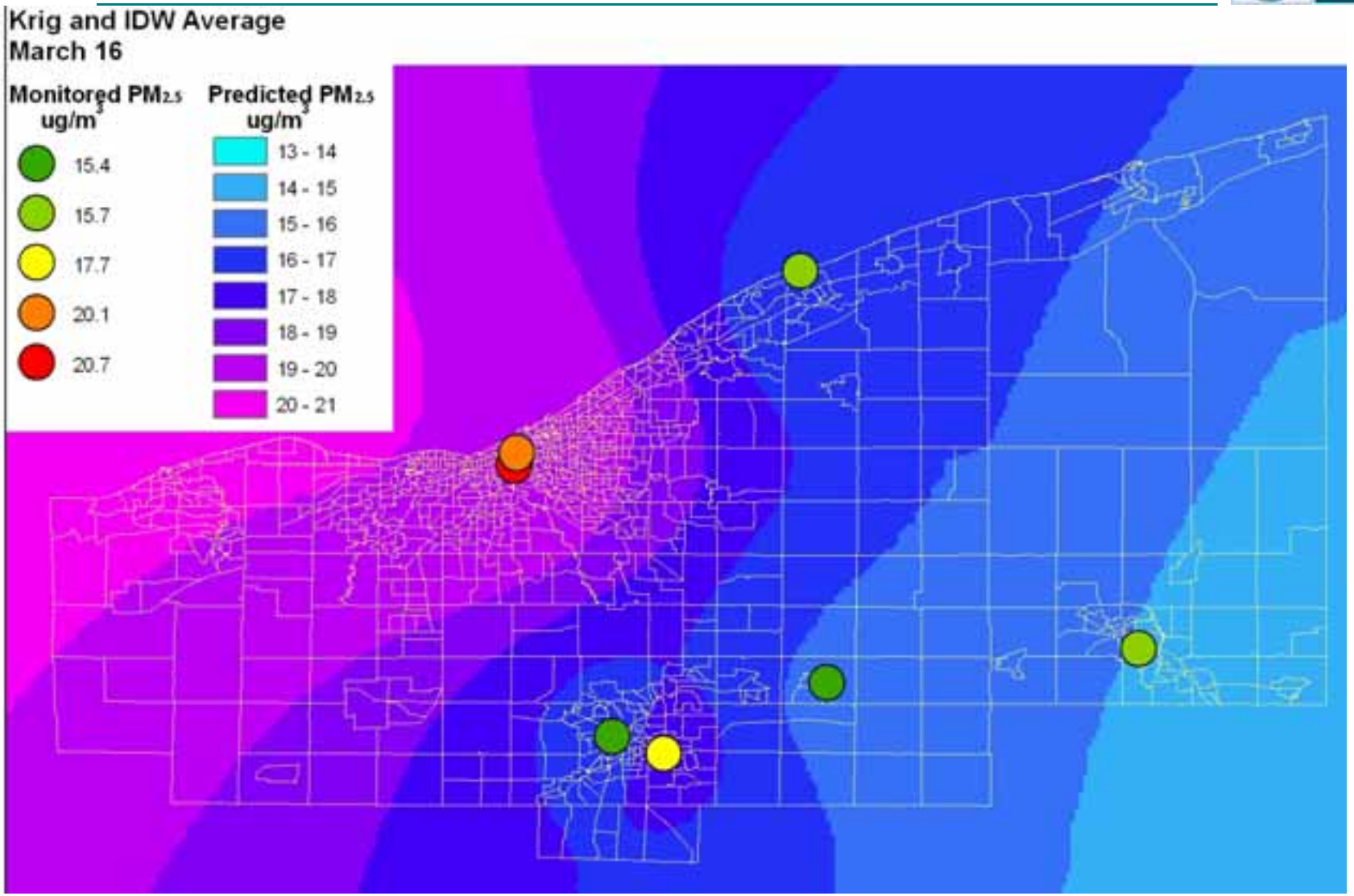
Ambient Particulate Data



Ambient Particulate Data



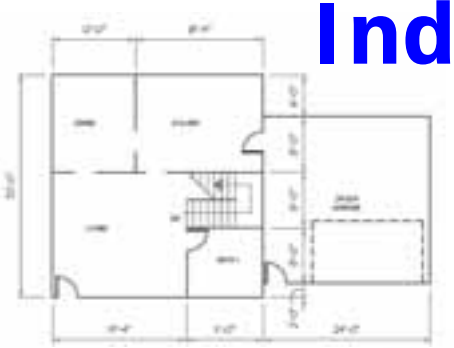
Ambient Particulate Data



Process

Outdoor $PM_{2.5}$ levels

Indoor $PM_{2.5}$ levels



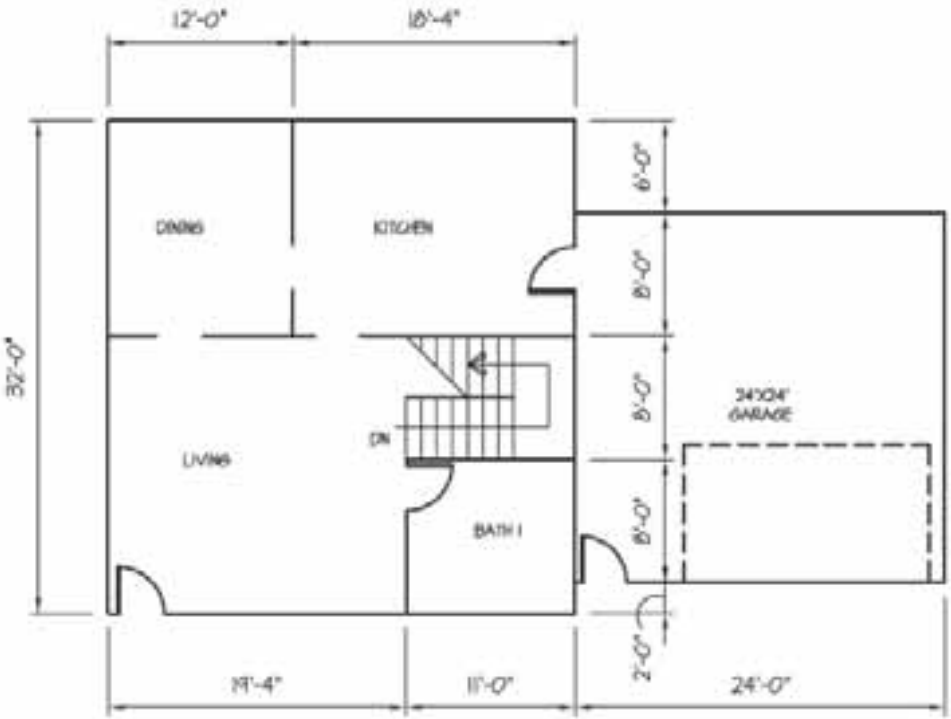
Exposed Population

Health Effects

Indoor Air

CONTAM 2.4
Multizone Airflow and Contaminant Transport Analysis Software

- Indoor $PM_{2.5}$ estimated using CONTAMW, a multi-zone indoor air quality and ventilation analysis program (NIST)
- Selected 7 housing templates to represent detached and attached homes built in different eras (Persily et al., 2006)

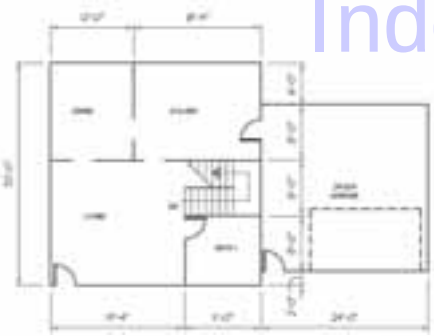


Model Inputs

- Outdoor $PM_{2.5}$ Levels from GIS
- Weather data for each city (NCDC)
- Window Schedule
  - Simulated by an algorithm specifying the window status (open/closed) by the hour (Johnson, 2003)
- Air handler run time schedule
  - EnergyPlus Energy Simulation Software (US DOE)
- Filtration Efficiency
  - EH&E testing comparing Conventional vs. Trane CleanEffects™

Process

Outdoor $PM_{2.5}$ levels



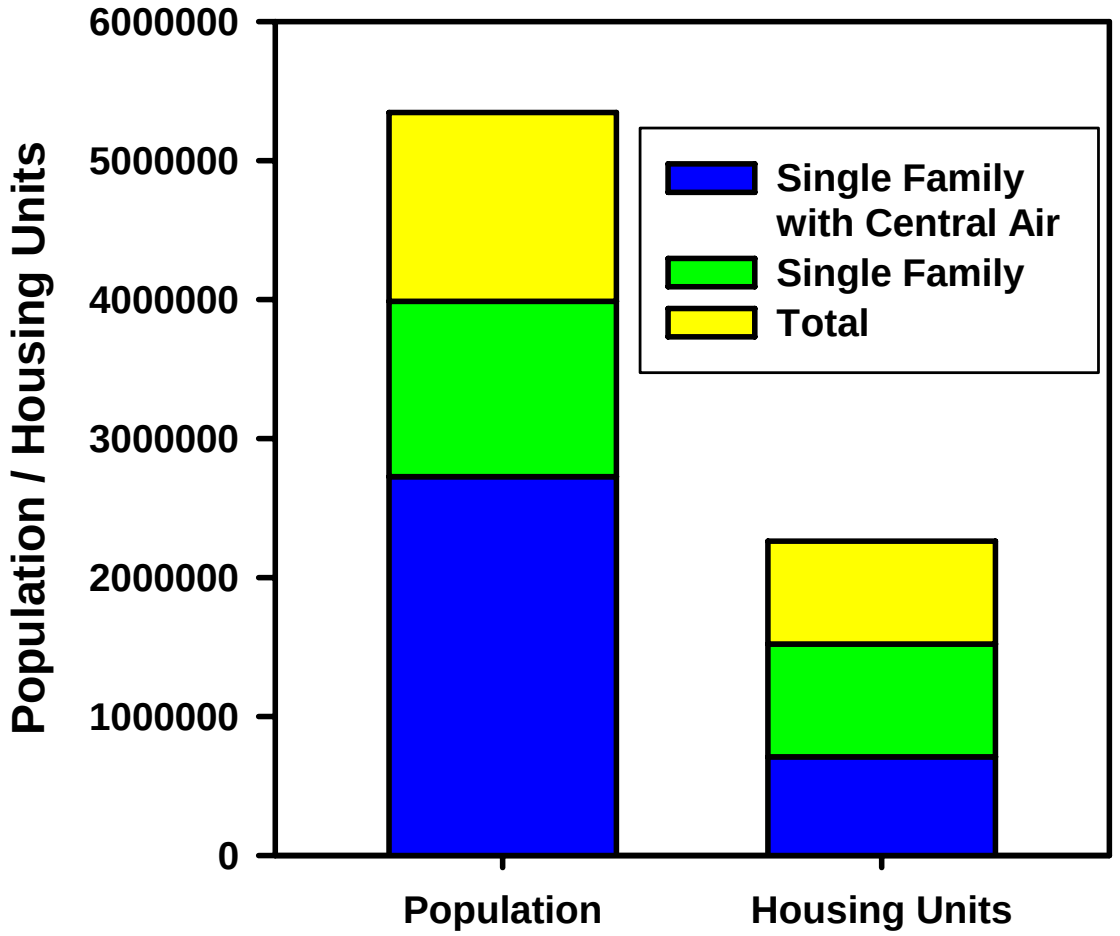
Indoor $PM_{2.5}$ levels

Exposed Population

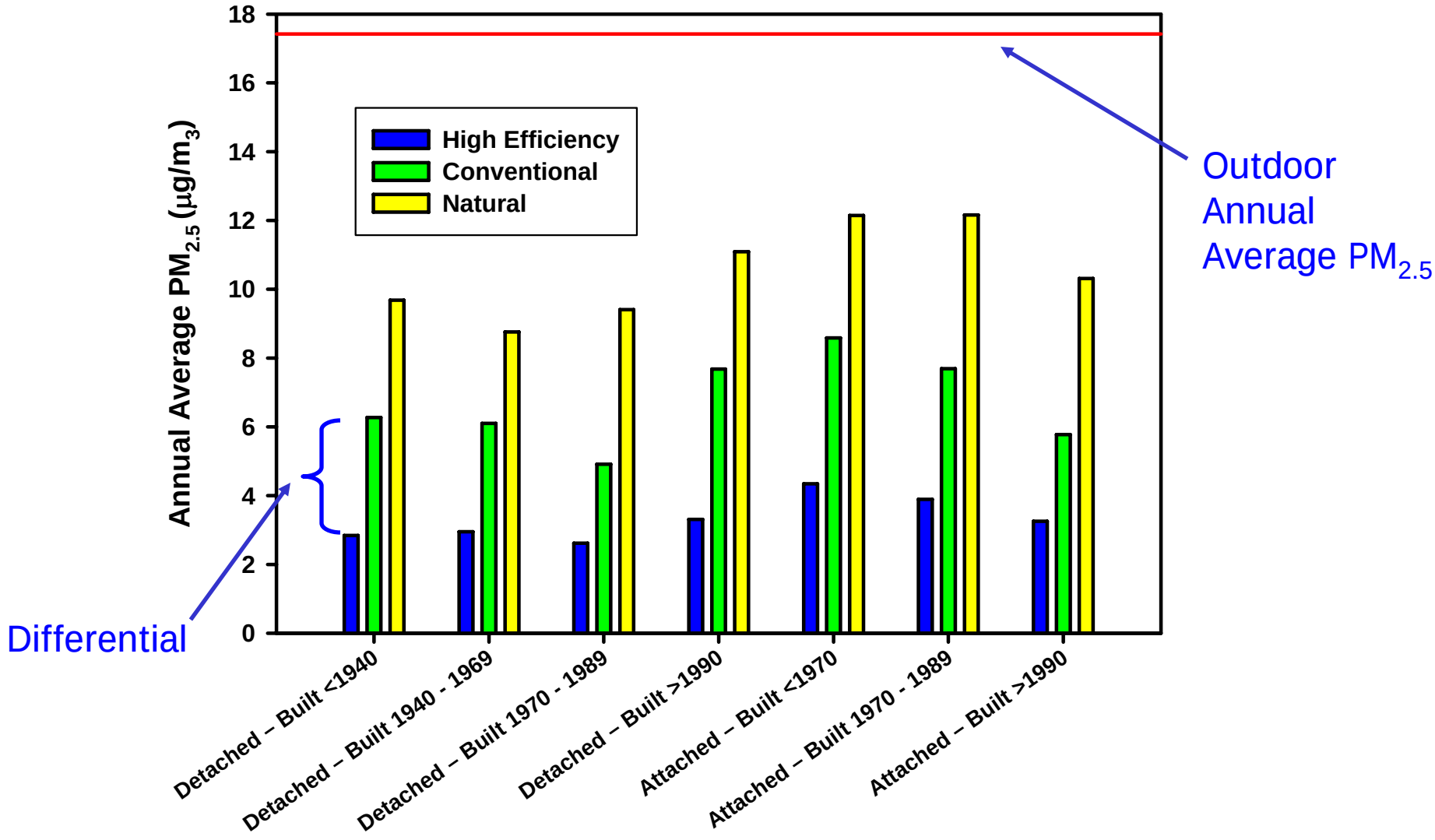
Health Effects

Exposed Population

- Estimate prevalence of single family homes (detached and attached) built in each era and have central air systems for each county (Year 2000 Census and American Housing Survey)



Hamilton County



Process

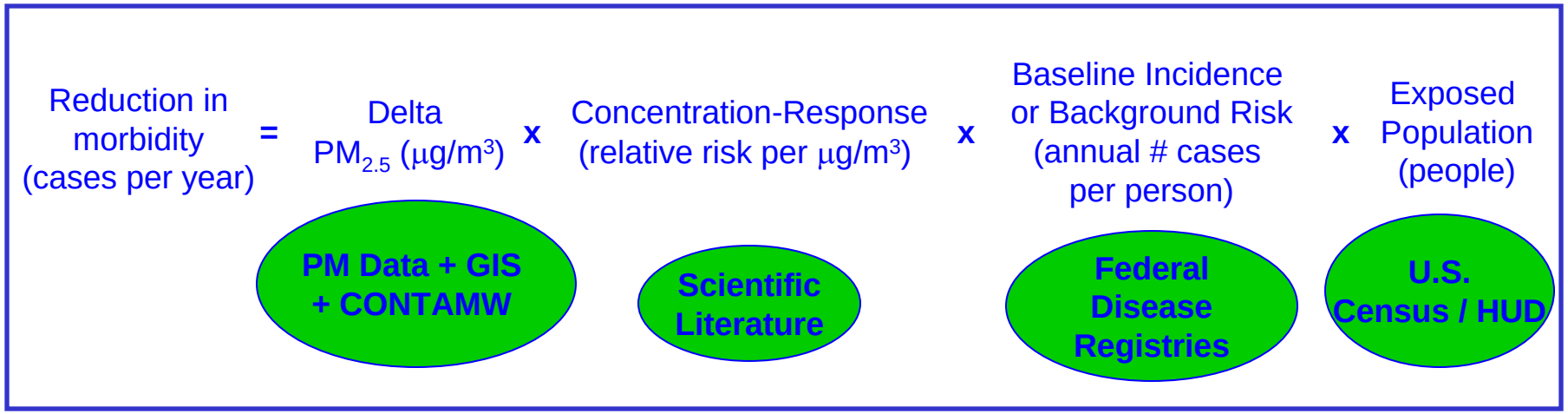
Outdoor $PM_{2.5}$ levels

Indoor $PM_{2.5}$ levels

Exposed Population

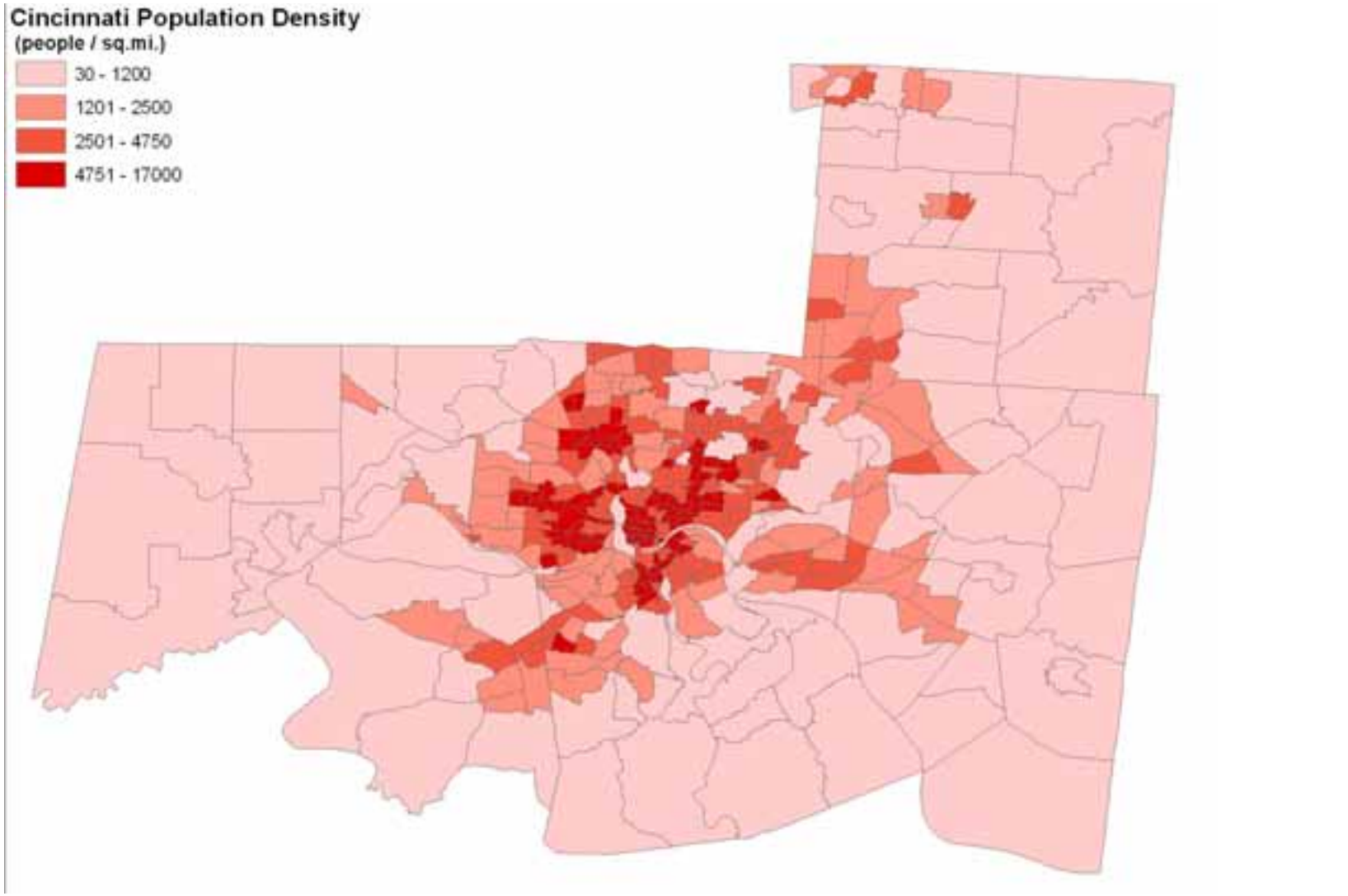
Health Effects

Public Health Impact

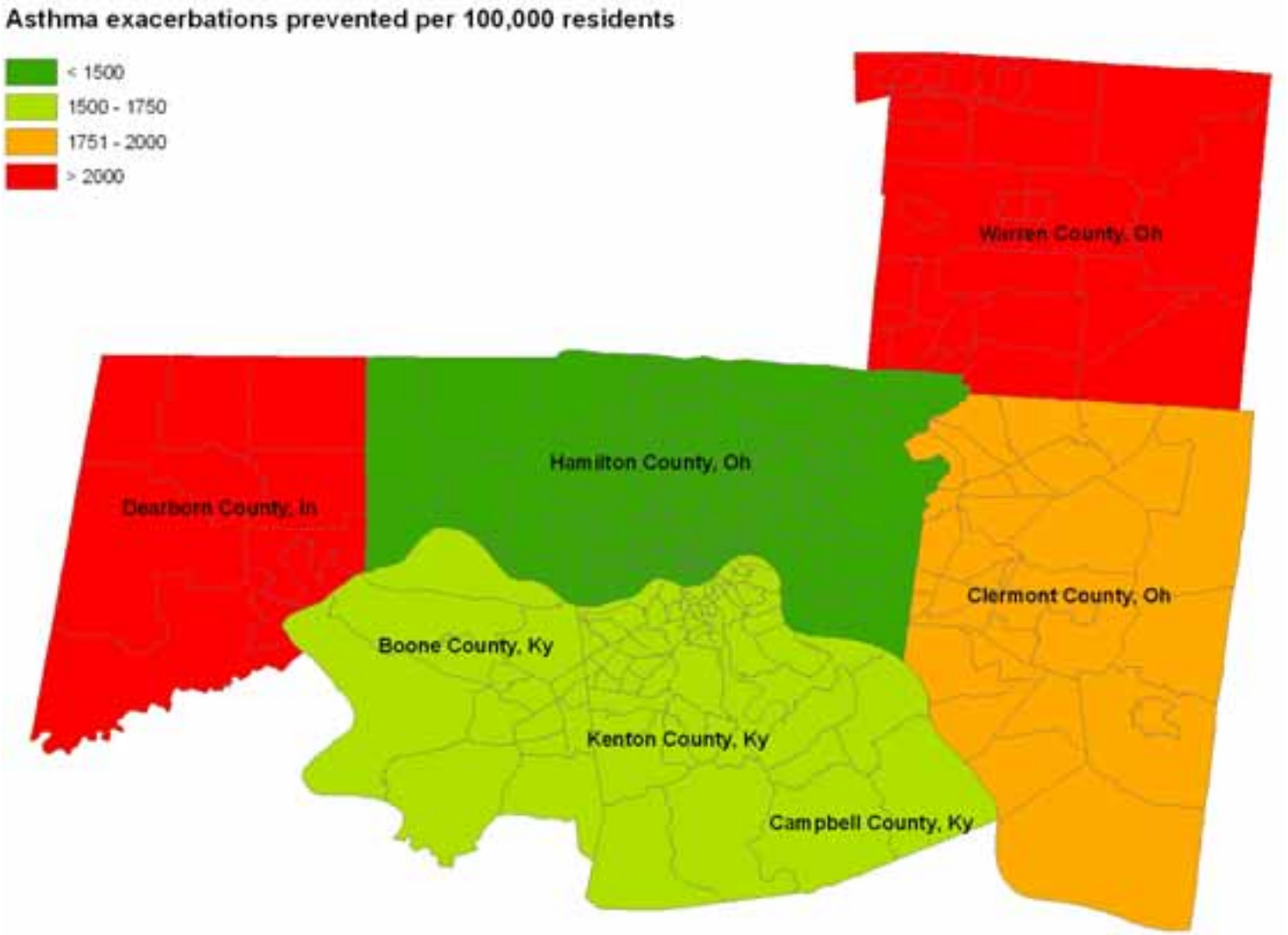


- Standard approach for air pollution cost-benefit analyses
  - EPA. The Benefits and Costs of the Clean Air Act: 1990 to 2010 (1999)
  - Levy and Spengler. J Air Waste Manag Assoc 52: 5-18 (2002)

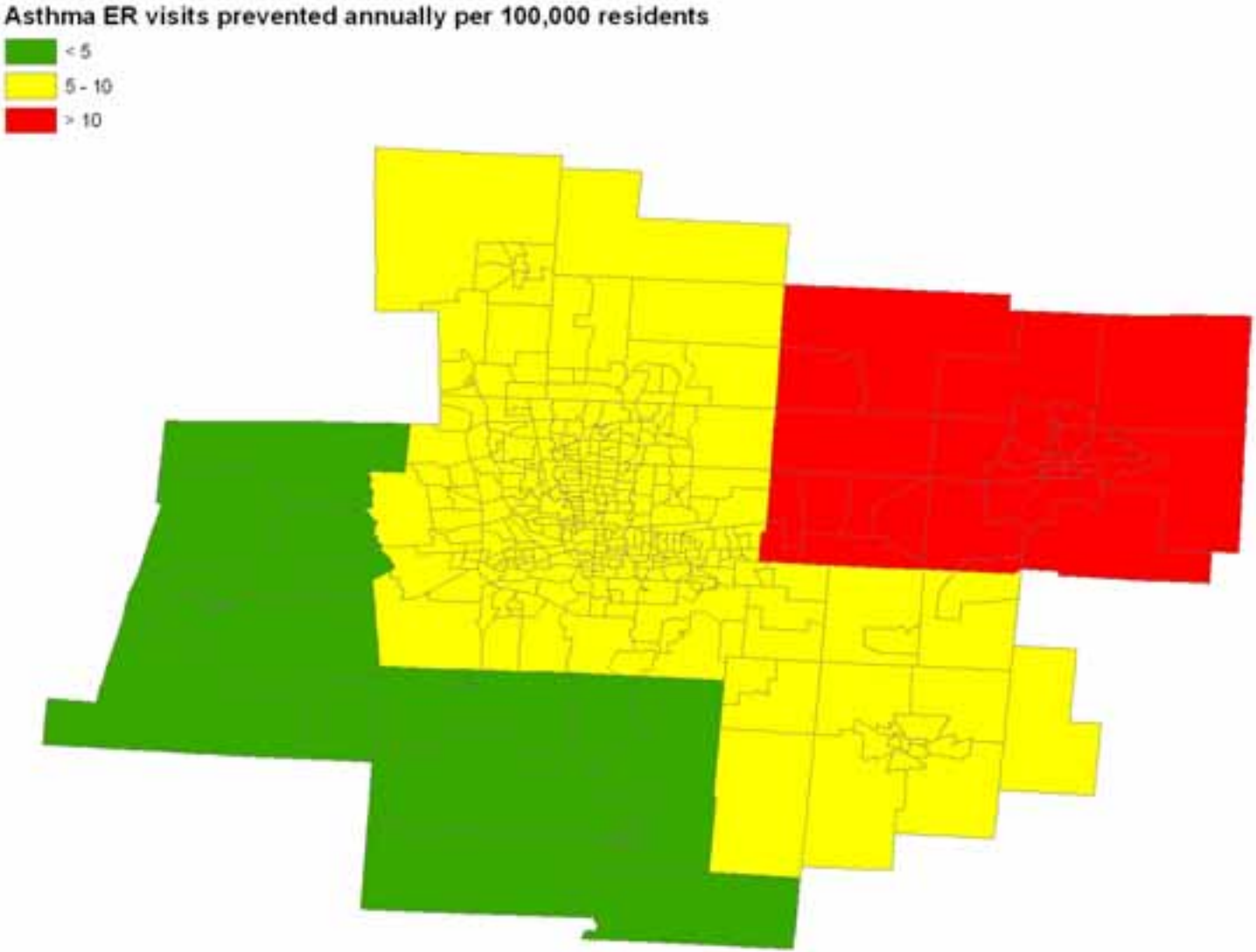
Cincinnati


Cincinnati Population Density
(people / sq.mi.)
30 - 1200
1201 - 2500
2501 - 4750
4751 - 17000

Cincinnati


Asthma exacerbations prevented per 100,000 residents
< 1500
1500 - 1750
1751 - 2000
> 2000
Warren County, Oh
Hamilton County, Oh
Dearborn County, In
Clermont County, Oh
Boone County, Ky
Kenton County, Ky
Campbell County, Ky

Columbus


Asthma ER visits prevented annually per 100,000 residents
< 5
5 - 10
> 10

Health Effects Prevented

City	Respiratory Hospital Admissions	Cardiovascular Hospital Admissions	Emergency room visits for Asthma	Asthma Exacerbations
Cincinnati	**41**	**27**	**98**	**25,000**
Columbus	**44**	**25**	**110**	**27,000**
Cleveland	**54**	**44**	**140**	**33,000**

Next Steps

- Evaluate/refine exposure methodology
- Evaluate impact from roadway exposures
- Analyze impact of market penetration
- Conduct cost/benefit analysis