California Studies of Fine Particulate Matter (PM2.5) and Mortality

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Overview

Three major studies reviewed:

1. American Cancer Society Cancer Prevention II studies (Jerrett et al. 2005; Krewski et al. 2009; Jerrett et al. in prep)

2. California Teachers Cohort (Ostro et al. 2009)

3. Adventists Study (Chen et al. 2005)

American Cancer Society Studies in California

- Long-term PM2.5 exposures in California-wide and Los Angeles analyses
- Based on the American Cancer Society Cohort
- Extensive control applied for 20 individual confounders (e.g., smoking) and 7 ecologic confounders (e.g., poverty in neighborhood)

INDIVIDUAL LEVEL COVARIATES:

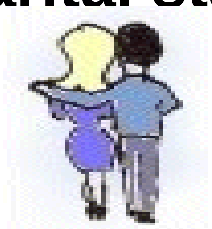
Tobacco smoke variables:

1. Indicator variable for current cigarette smoker
2. Indicator variable for pipe or cigar smoker,
3. Current smoker’s years smoked,
4. Current smoker’s years smoked squared,
5. Current smoker’s cigarettes per day,
6. Current smoker’s cigarettes per day squared,
7. Indicator variable for former cigarette smoker,
8. Former smoker’s years smoked,
9. Former smoker’s years smoked squared,
10. Former smoker’s cigarettes per day,
11. Former smoker’s cigarettes per day squared,
12. Indicator variables for starting smoking before or after age eighteen,
13. Number of hours per day exposed to passive cigarette smoke.

Education variables:

▲Indicator variables for high school completed and more than high school completed, versus high school not completed

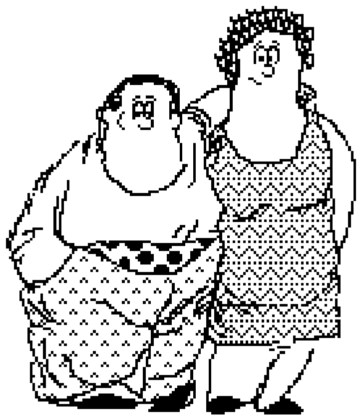
Marital status variables:



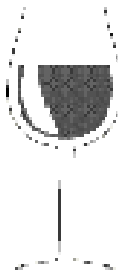
▲Indicator variables for “single” and “other” versus married

BMI:

▲BMI and BMI squared



Alcohol consumption:



▲Six variables including indicator variables for beer, liquor, and wine drinkers and non-responders versus non-drinkers

Occupational exposure:

▲A variable that indicated regular occupational exposure to asbestos, chemicals/acids/solvents, coal or stone dusts, coal tar/pitch/asphalt, diesel engine exhaust, or formaldehyde

▲9 additional indicator variables that reflected an occupational dirtiness index

Diet:

▲Quintile indicator variables for each of two diet indices that accounted for fat consumption and consumption of vegetables, citrus and high-fiber grains were derived based on information given in the enrollment questionnaire.

A land use regression model for predicting ambient fine particulate matter across Los Angeles, CA†

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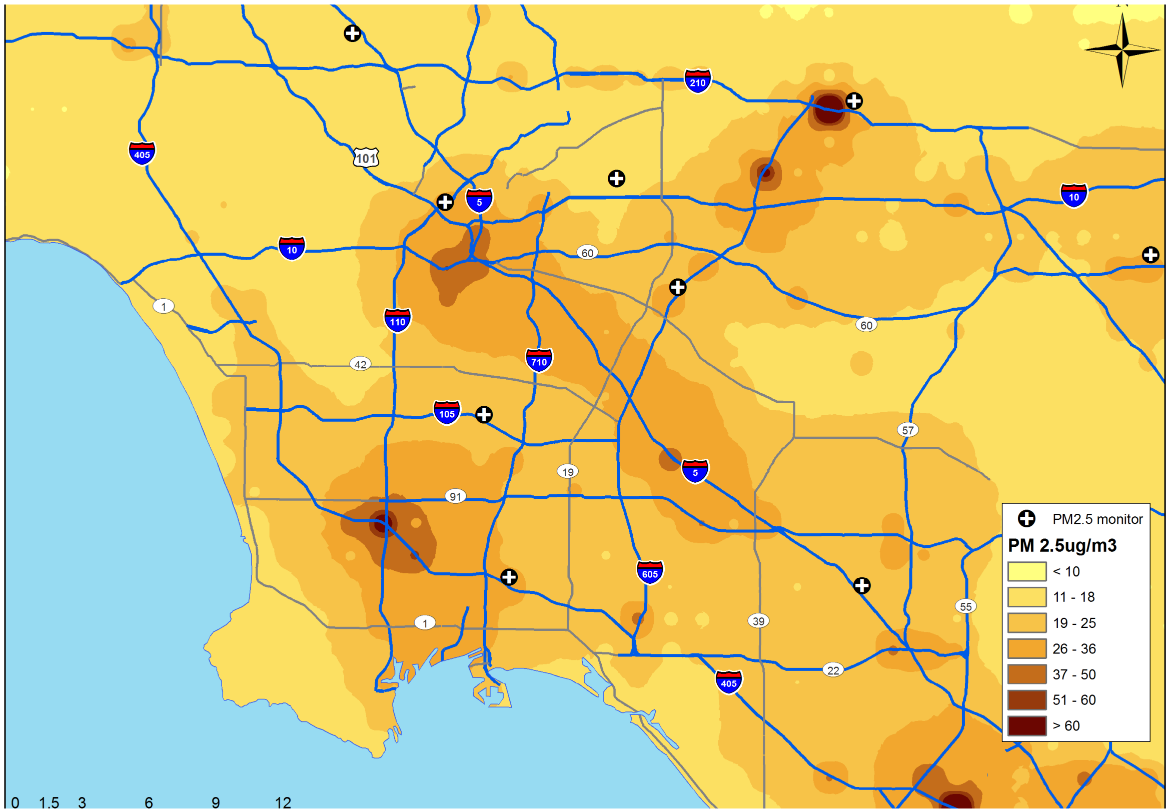


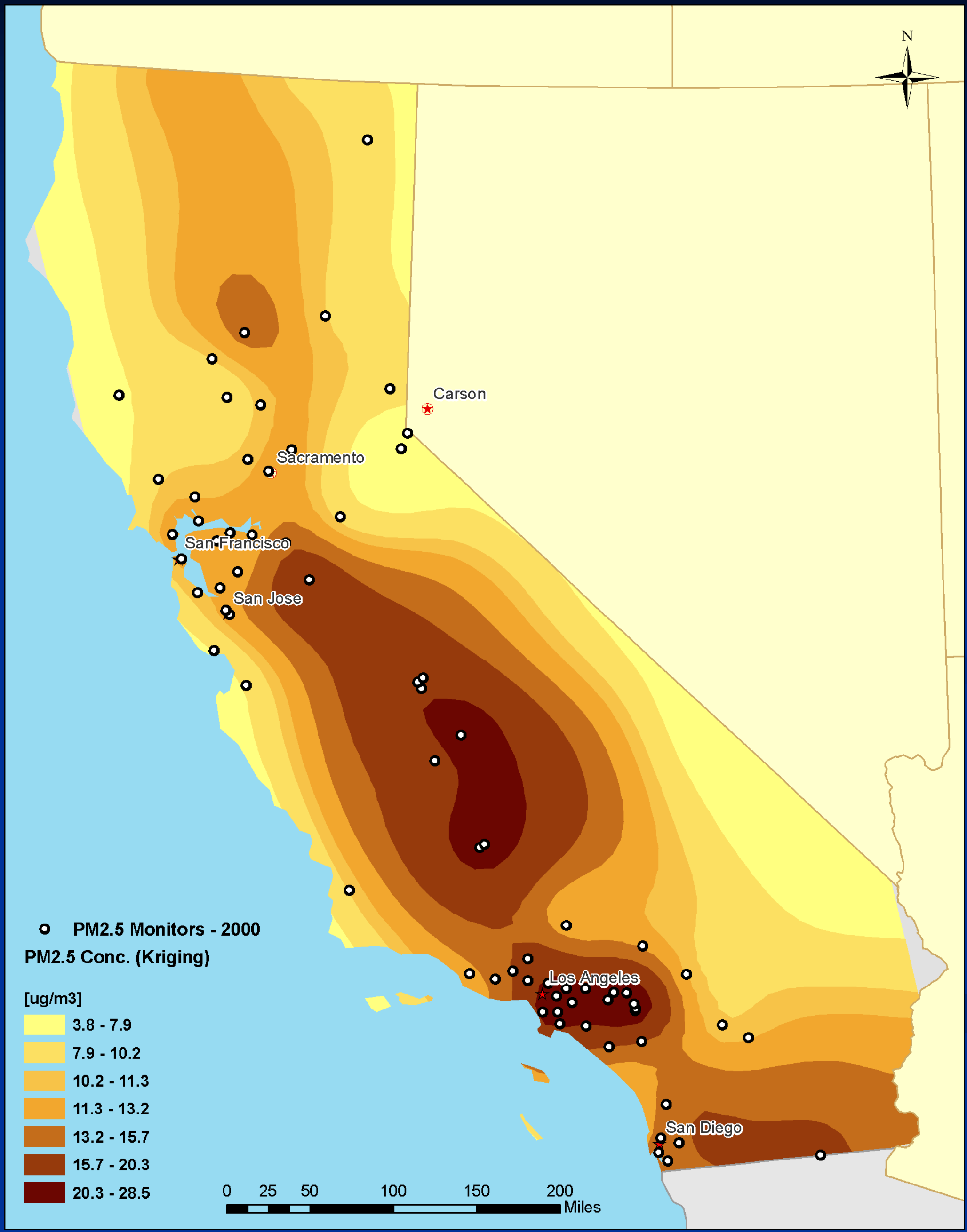
Table 2 Land use regression equation along with collinearity diagnostics

Variables	Buffer/m	Beta	*T*-value	Std. error	*P*-value	VIF[a]
Constant		2.28621	22.81	0.1002109	0.000	
Mean traffic (m)	300	0.00001	2.99	0.0000034	0.007	1.09
Industrial area (Ha)	5000	0.00032	3.33	0.0000958	0.004	1.05
Government area (Ha)	5000	0.00072	3.35	0.0002139	0.003	1.04

[a] Average VIF is 1.06.

Kriged PM2.5 exposures based on 72 monitoring for 2000 annual average

Exposures show broad regional pattern, higher in South and Central Valley



Exposure Assignment

- For LA study assigned PM2.5 exposure to zip code of residence for 22,905 subjects
- For statewide study assigned PM2.5 exposure to home address of 77,767 subjects
- Followed up for death from 1982-2000

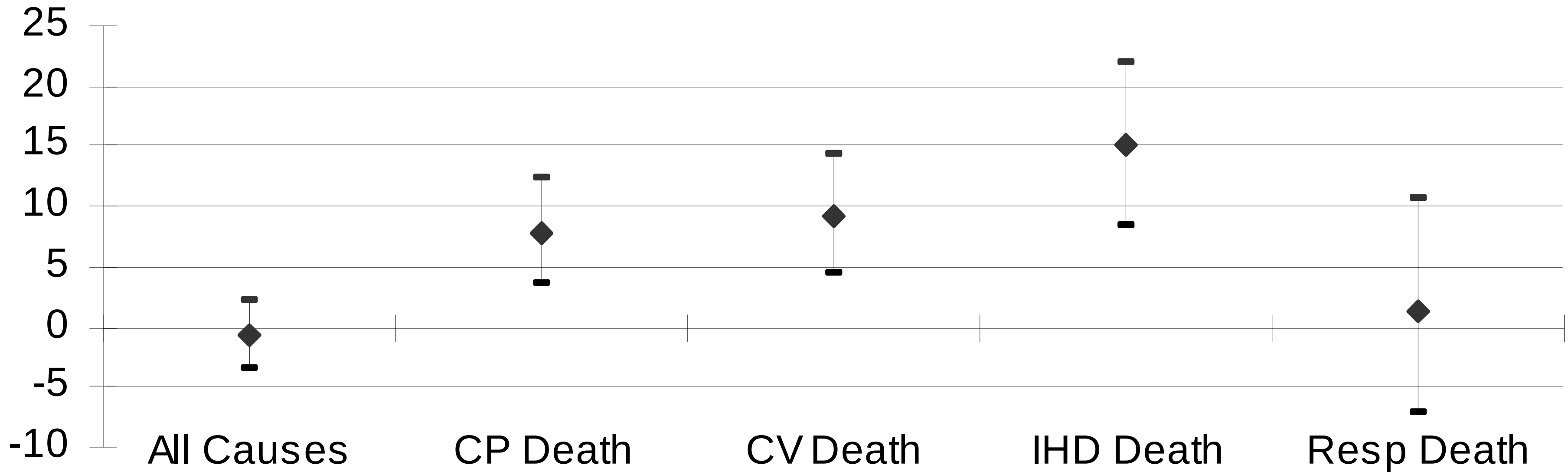
Modeling Approach

- Cox survival model with allowance for clustering at the zip code area
- Sensitivity analyses conducted with clusters at different geographic scales and a geographic latitude term included to control for south-north trend
- Also tested other particle metrics (sulfate and PM10) and ozone in statewide analysis

Results for LA Analysis 10 ug/m3 Exposure Increment

Follow up 1982-2000 Cox Model Covariates	All Cause	IHD ICD9: 410-414
Total subjects: N=22,905	5,856	1,462
PM2.5 (LUR28pred) only	1.197 (1.082,1.325)	1.415 (1.154,1.735)
44 Individual Covariates	1.143 (1.033,1.266)	1.331 (1.084,1.634)
+ Air Conditioning	1.142 (1.031,1.265)	1.333 (1.085,1.638)
+ Percent of Black	1.145 (1.033,1.269)	1.347 (1.096,1.656)
+ Percent of White	1.151 (1.036,1.278)	1.362 (1.103,1.682)
+ Percent of Hispanic	1.132 (1.016,1.261)	1.322 (1.065,1.641)
+ Percent of Unemployed	1.127 (1.015,1.252)	1.328 (1.075,1.641)
+ Mean Income	1.146 (1.035,1.268)	1.332 (1.086,1.635)
+ Total population	1.141 (1.030,1.264)	1.322 (1.076,1.624)
+ Income inequality	1.110 (0.999,1.234)	1.254 (1.014,1.552)
+ Percent of GRD12	1.144 (1.033,1.266)	1.334 (1.087,1.637)
+ All social factors	1.142 (1.026,1.272)	1.322 (1.064,1.642)
+ AC, Income, GRD12,SF	1.115 (1.003,1.239)	1.263 (1.020,1.563)
+ Parsimonious con. Covs.	1.126 (1.014,1.251)	1.264 (1.022,1.563)
Copollutant control		
44 Covs .+ O3 (EPDC)	1.191 (1.069,1.327)	1.455 (1.171,1.810)
44 Covs. + O3 (Average)	1.176 (1.057,1.307)	1.431 (1.155,1.772)
44 Cvos. + FreeWays	1.170 (1.054,1.299)	1.393 (1.127,1.721)

Percent Excess Mortality Associated with PM2.5 Exposure Increment for Statewide Estimate (Interquartile Range ~ 8.5 ug/m3)

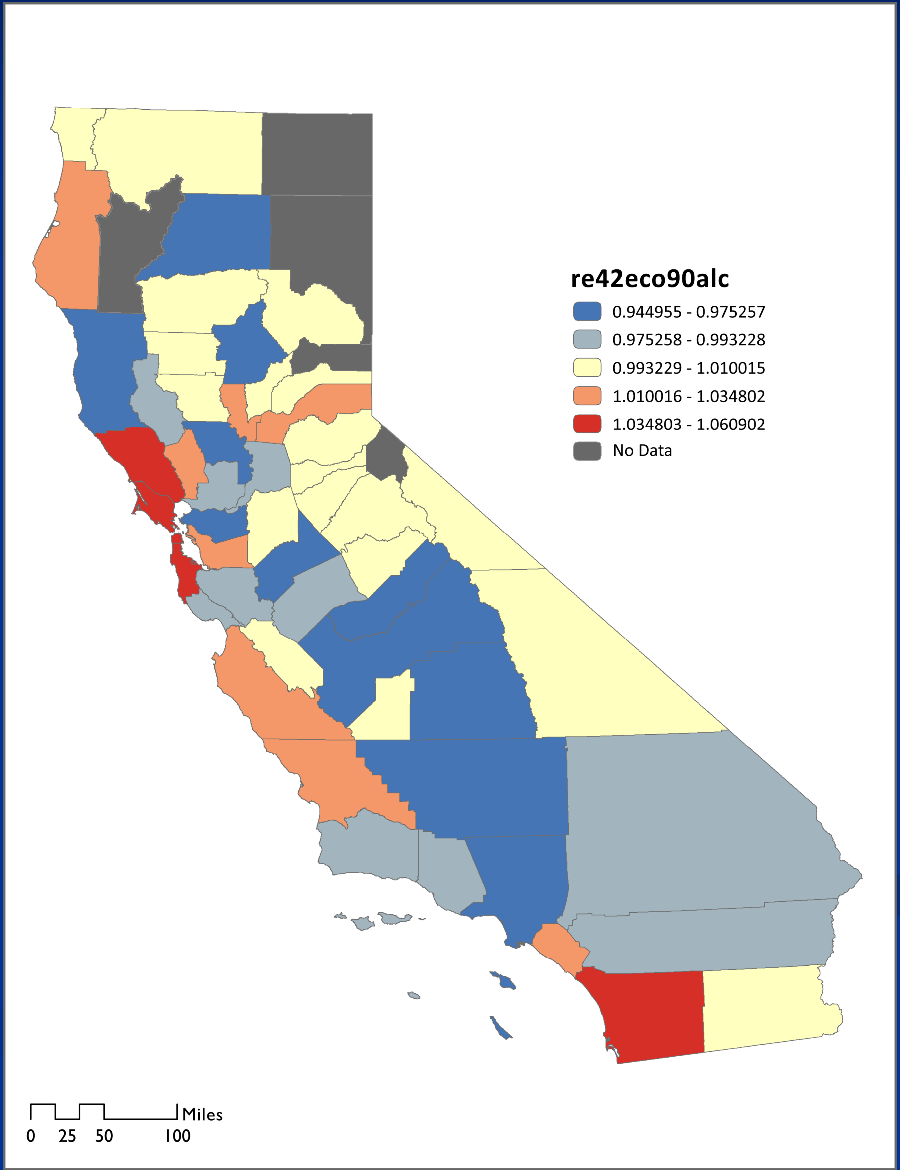


Results Continued

- Results for PM2.5 not confounded by latitude, county clustering or by ozone as a co-pollutant
- All cause without cancer: RR = 1.04 (95% CI: 1.00, 1.08)
- Why null results for PM2.5 on all causes?

All Cancer Death Negative

- Null PM2.5 effects on all cause mortality resulted from strong negative association with cancer risk
- Statistical models geared toward predicting for cardiopulmonary death
- Unexpected low cancer mortality residuals in LA and Central Valley where PM2.5 is high



California Teachers Study Cohort: Background (Ostro et al. 2009)

- Statewide cohort (133,479) of female members of State Teachers Retirement System, established to examine breast cancer risk factors
- Annual re-contact since inception in 1995
- Four waves of questionnaires (1995, 1997, 2000, 2005)
- Outcome follow-up via linkage to hospitalization and mortality databases

California Teachers Study Cohort: Advantages

- Monthly residential history
- Low active smoking prevalence (5% at baseline)
- Aging cohort (average age 54 at inception) with many at risk for cardiovascular disease
- Little likelihood of significant occupational exposures or major SES differences

Methods – Outcomes

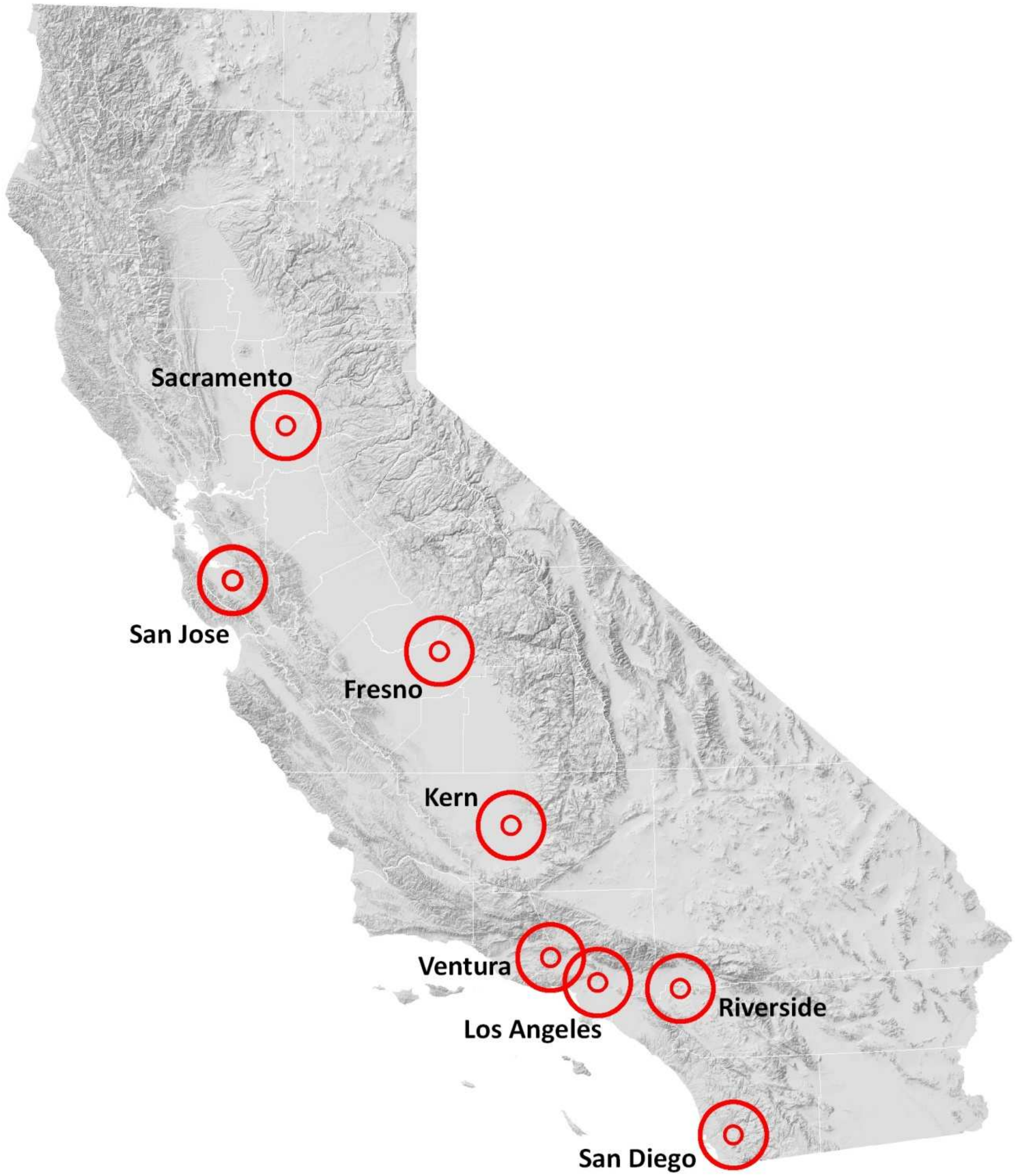
- All-cause (non-traumatic) mortality
- Cardiopulmonary mortality
- Ischemic heart disease mortality
- Pulmonary mortality

Methods – Exposures I

- PM2.5 and species data from the Speciation Trends Network (STN), 24-hr averages collected every 3rd or 6th day
- 8 counties with data from June 1, 2002 to July 31, 2007: Fresno, Kern, Los Angeles, Riverside, Santa Clara, San Diego, Sacramento and Ventura.
- Based on prior evidence of associations from time-series studies (Mar et al. 2000; Ostro et al. 2007) and from other epidemiological or toxicological studies, we examined:
  - PM2.5 mass
  - EC, OC, sulfates, nitrates, Fe, K, Si and Zn.

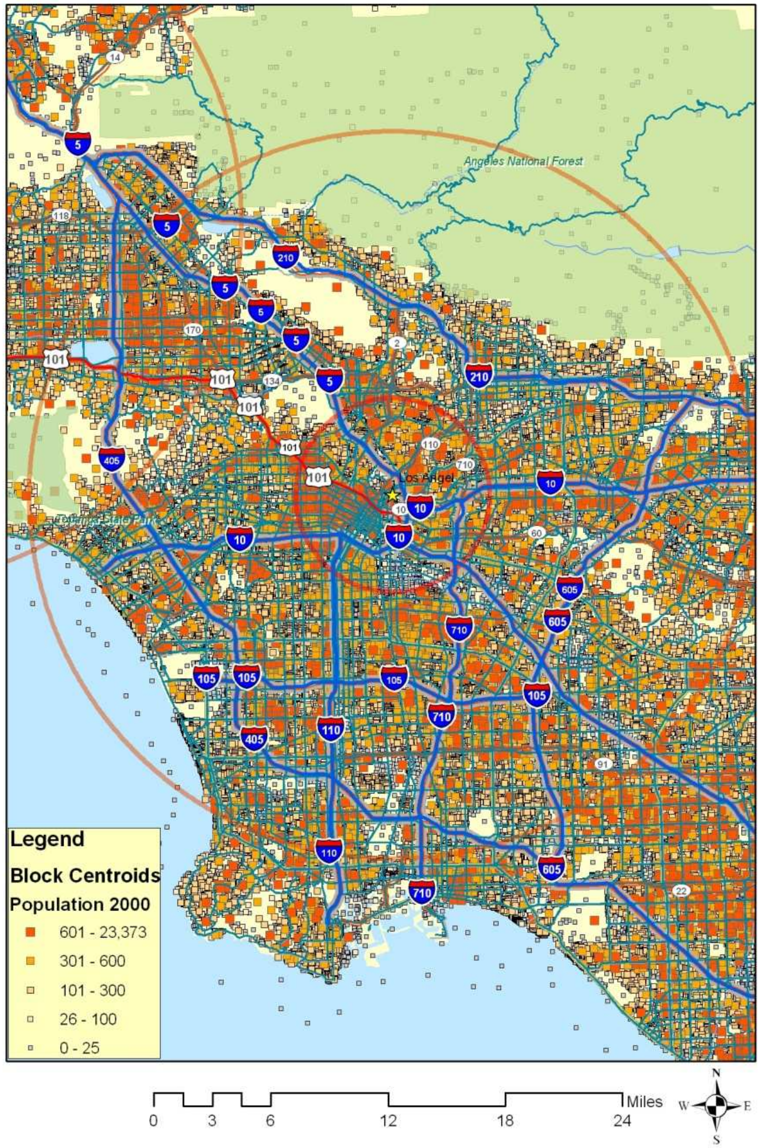
Methods – Exposures II

- Monthly residential addresses from study enrollment were geo-coded.
- Long-term exposure = sum of all person-months of pollution data divided by the total months of data
- Two different exposure assessments:
  - Subjects with residences within 8 km of a monitor
  - Subjects with residences within 30 km of a monitor



Sacramento
San Jose
Fresno
Kern
Ventura
Los Angeles
Riverside
San Diego

Los Angeles County



Methods – Statistical Analysis

- Cox Proportional Hazards regression with 16 individual-level covariates (a total of 47 terms) and 6 ecological covariates.
- Stratified by age and race
- Adjusted for:
  - BMI, alcohol use, diet, physical activity
  - Smoking status, pack-years, second-hand smoke exposure at home
  - Marital status, family medical history, medication use
  - Menopausal status and HRT use

Adventist Study (Chen et al. 2005)

- 6,338 non-smoking, non-Hispanic white Seventh Day Adventist residents of California who were enrolled in 1977 study (non-smoking)
- Included if they lived 10 years or longer within 5 miles of their residence at time of enrolment
- Most from San Francisco, South Coast and San Diego with 13% random statewide sample

Exposures

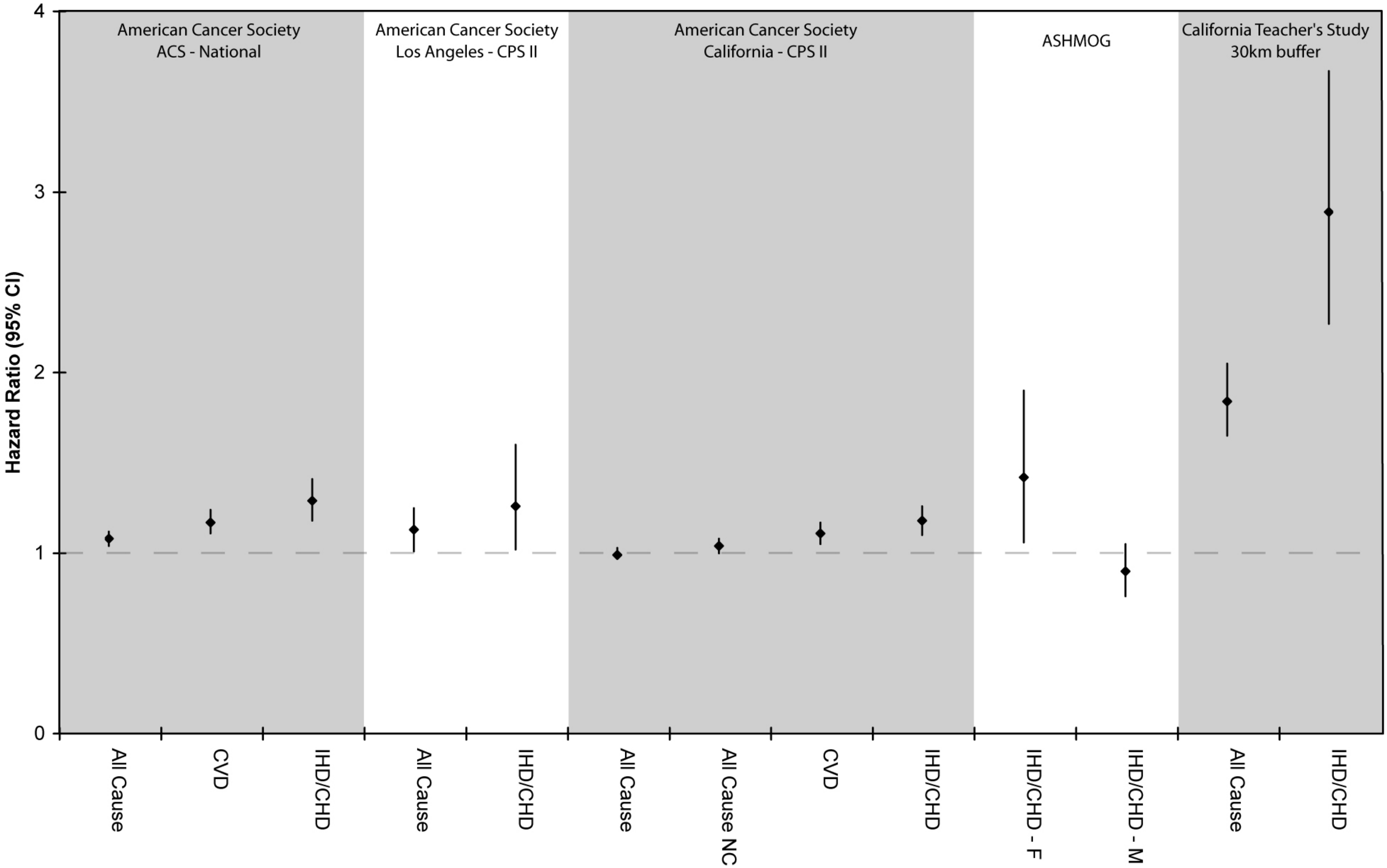
- PM2.5 imputed for 11 airsheds from visibility data at 9 airports from 1973-1998
- Chen et al. (2005) included 3,239 subjects with 22 years of follow up (to 1998)
- Vital status for coronary heart disease death ascertained by death certificate and verified by social contacts through churches

Results

- Significantly elevated associations in females, but not for males

- Over 10 ug/m3 exposure increment, hazard ratio is
- F: 1.42 (1.06, 1.90)
- M: 0.90 (0.76, 1.05)

Summary of California cohort studies associated with long-term particulate matter exposure based 10 ug/m3 increment



Conclusions

- California-specific studies all show associations between mortality and PM2.5
- Some heterogeneity in the effect sizes, the groups affected, and the causes of death associated with PM2.5
- Overall California studies are consistent with broader body of research indicating associations between PM2.5 and mortality

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