PARTICULATE AIR POLLUTION AND MORBIDITY IN THE CALIFORNIA CENTRAL VALLEY: A HIGH PARTICULATE POLLUTION REGION

ARB Presentation, 14 January 2003

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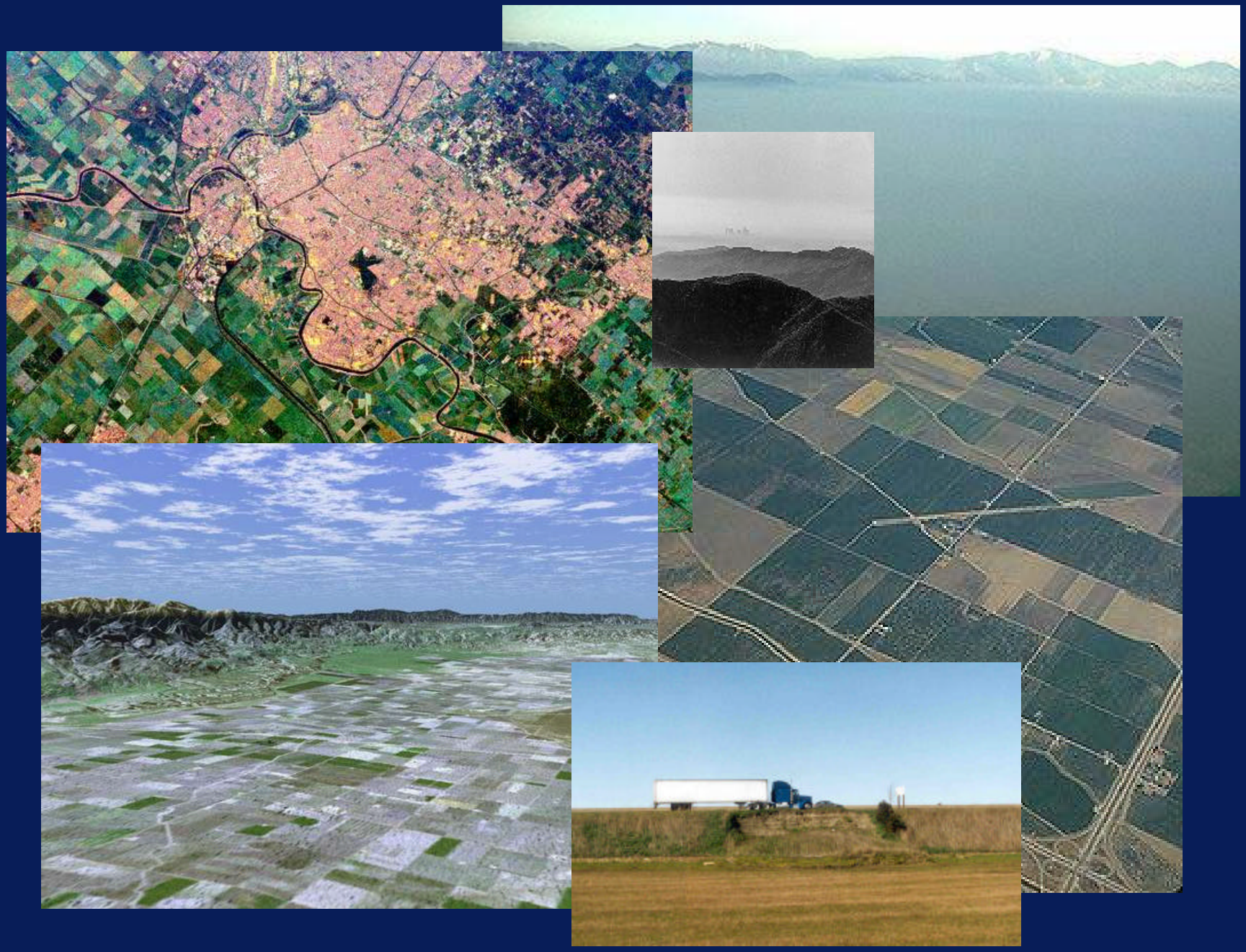
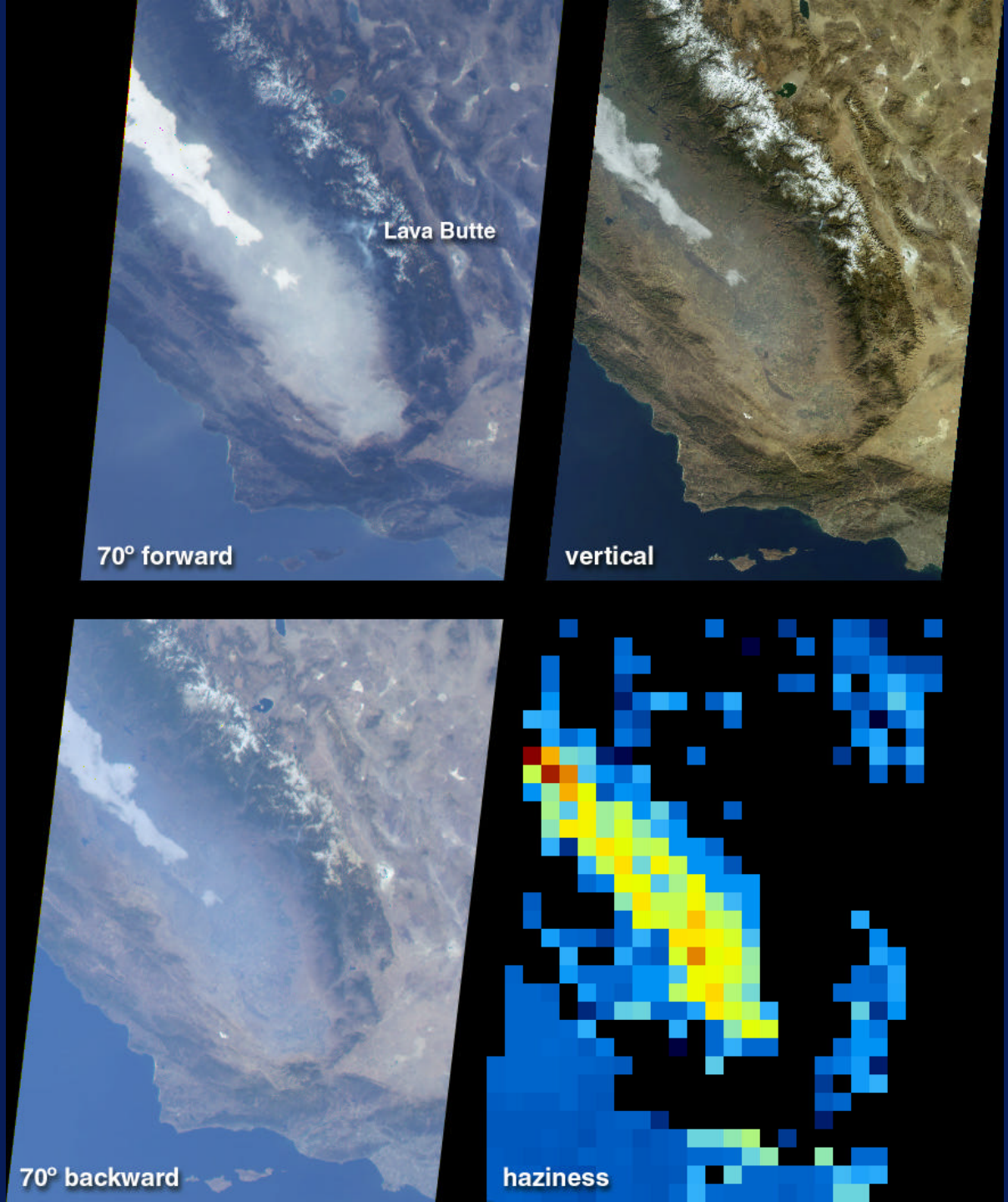


Latitude (degrees)
40
38
36
34


Lava Butte
70° forward
vertical
70° backward
haziness

Background

- **Studies have found PM associated with morbidity and mortality.**
- **Surprising few studies conducted in California**
- **Central Valley has high particulate air pollution levels**

Why this study?

- Additional daily monitoring data collected in Central Valley
- Considerable daily monitoring data available
- Kaiser Permanente able to rapidly access outcome data.
- Able to link to other health data
- Able to link exposure to residence

The Kaiser Permanente Medical Care Program of Northern California (KPMCP)

- Group practice prepaid HMO with 3.1 million members
- 15 hospitals, 23 outpatient clinics
- Physicians work only for KPMCP
- Uniform health care coverage
- Serves 30% of population in geographic region


California Division
North (by county)
MENDOCINO
LAKE
COLUSA
SUTTER
YUBA
NEV
PLACER
EL DORADO
ALPINE
AMADOR
SONOMA
NAPA
YOLO
SOLANO
SAC
SAN JOAQUIN
CALAVERAS
TUOLUMNE
MARIN
CONTRA COSTA
ALAMEDA
STANISLAS
MARIPOSA
SAN MATEO
SANTA CLARA
SANTA CRUZ
MERCED
MEDERA
MONTE-REY
SAN BENITO
FRESNO
Pacific
Ocean
Roseville
Sacramento
Rancho Cordova
Davis
Santa Rosa
Napa
Vacaville
Petaluma
South Sacramento
Fairfield
Novato
Vallejo
Martinez
San Rafael
Antioch
Stockton
Richmond
Walnut Creek
San Francisco
Oakland
Pleasanton
South San Francisco
Hayward
Modesto
Redwood City
Fremont
Mountain View
Milpitas
Santa Clara
San Jose/Santa Teresa
Gilroy
Fresno
Medical Center
Medical Office

KP Population Included

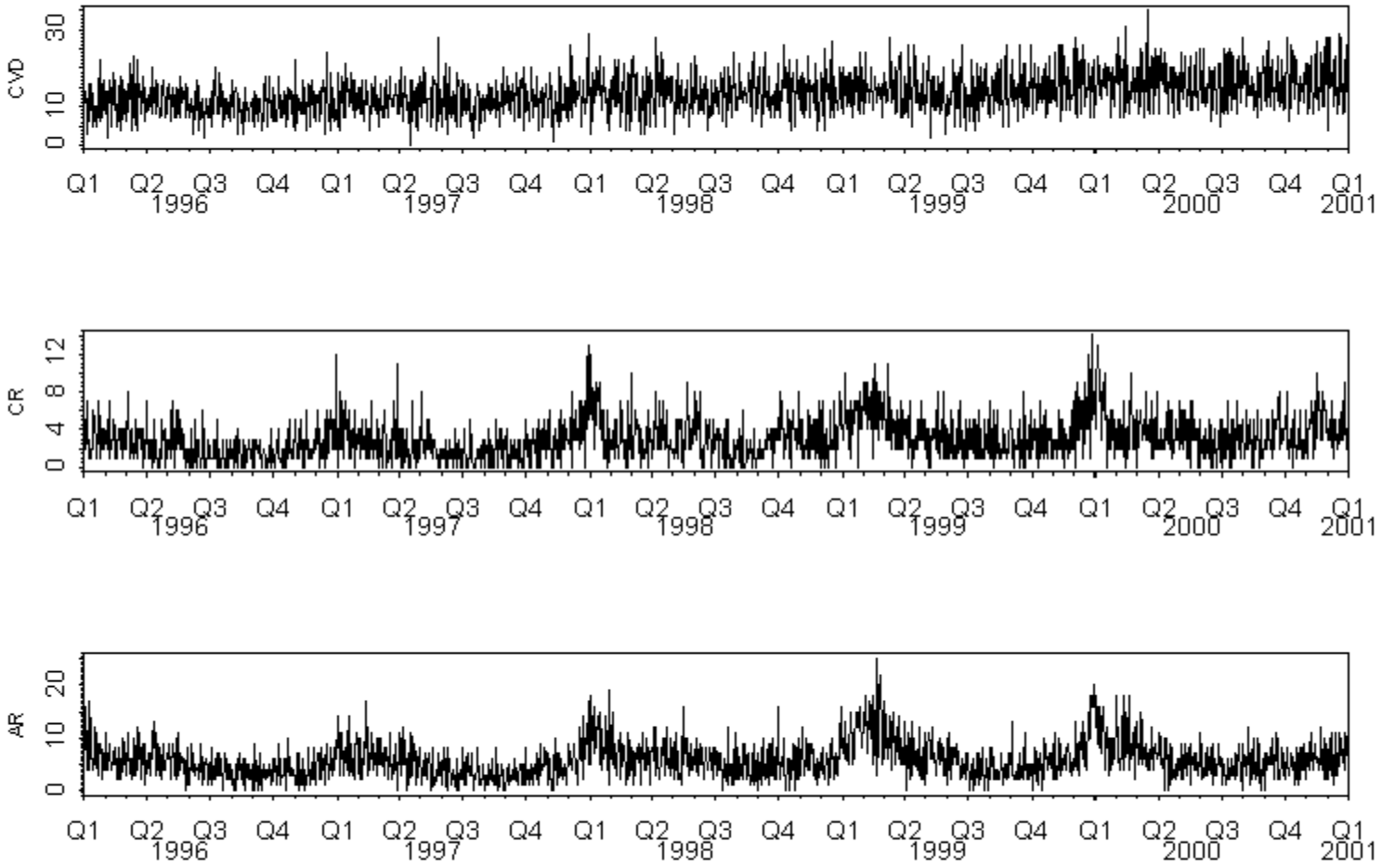
	1996	1997	1998	1999	2000	Total P-Y	Percent of total
Sacram.	**345,556**	**374,331**	**400,224**	**443,467**	**464,019**	**2,027,597**	**77.4**
Stockton	**35,418**	**40,145**	**45,620**	**51,897**	**59,603**	**232,683**	**8.9**
Modesto	**5,590**	**10,826**	**19,227**	**26,315**	**33,354**	**95,312**	**3.6**
Fresno	**45,637**	**51,658**	**53,329**	**55,419**	**56,384**	**262,427**	**10.0**
Total	**432,201**	**476,960**	**518,400**	**577,098**	**613,360**	**2,618,019**	**100.0**

Hospitalization Outcome Data

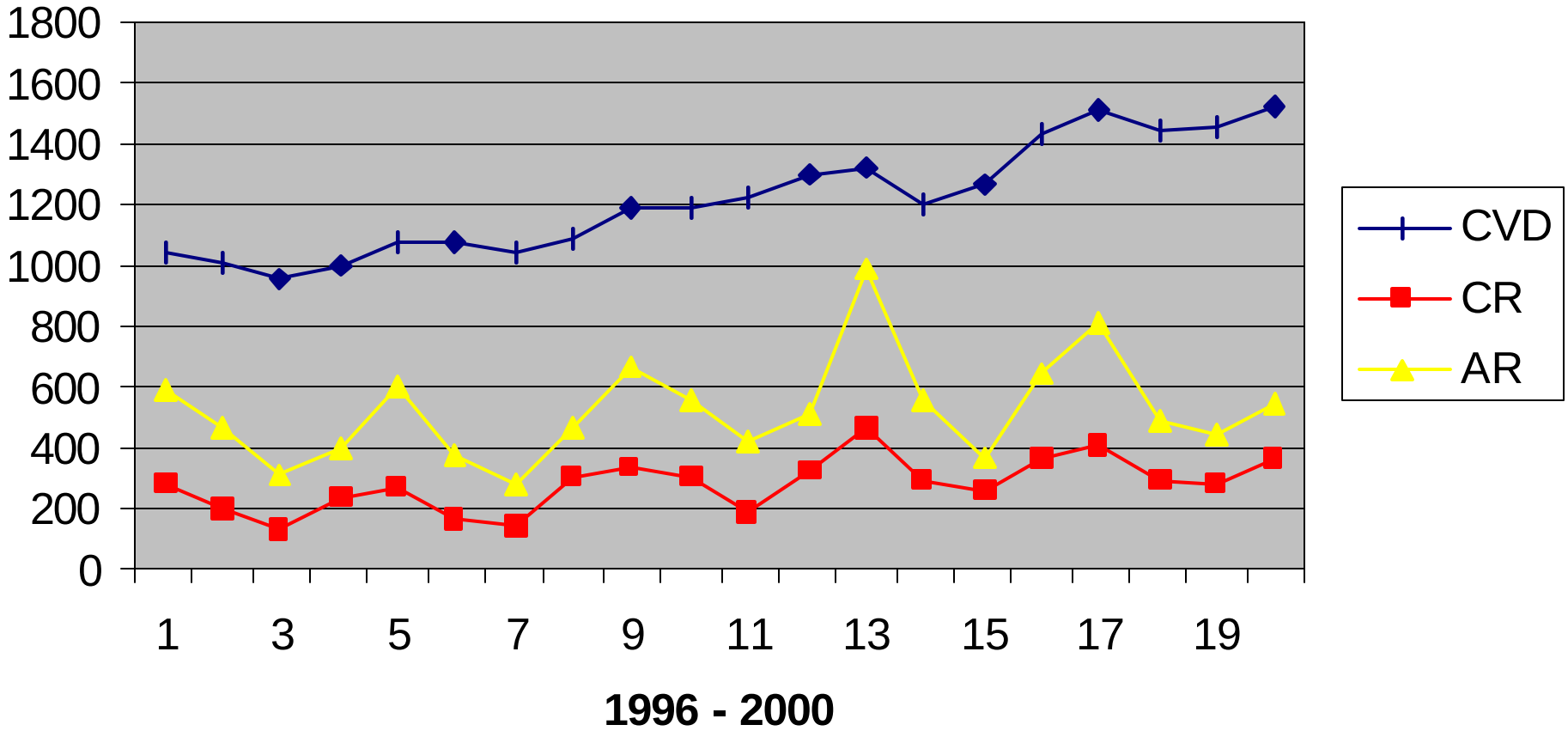
- **Hospitalizations of KP members within the geographic range covered by the enhanced monitoring program.**
- **Cardiovascular disease (ICD-9 410-417, 420-429, 440, 451-453).**
- **Acute Respiratory Disease (ICD-9 381, 382, 460-466, 480-487).**
- **Chronic Respiratory Disease (ICD-9 490-496).**

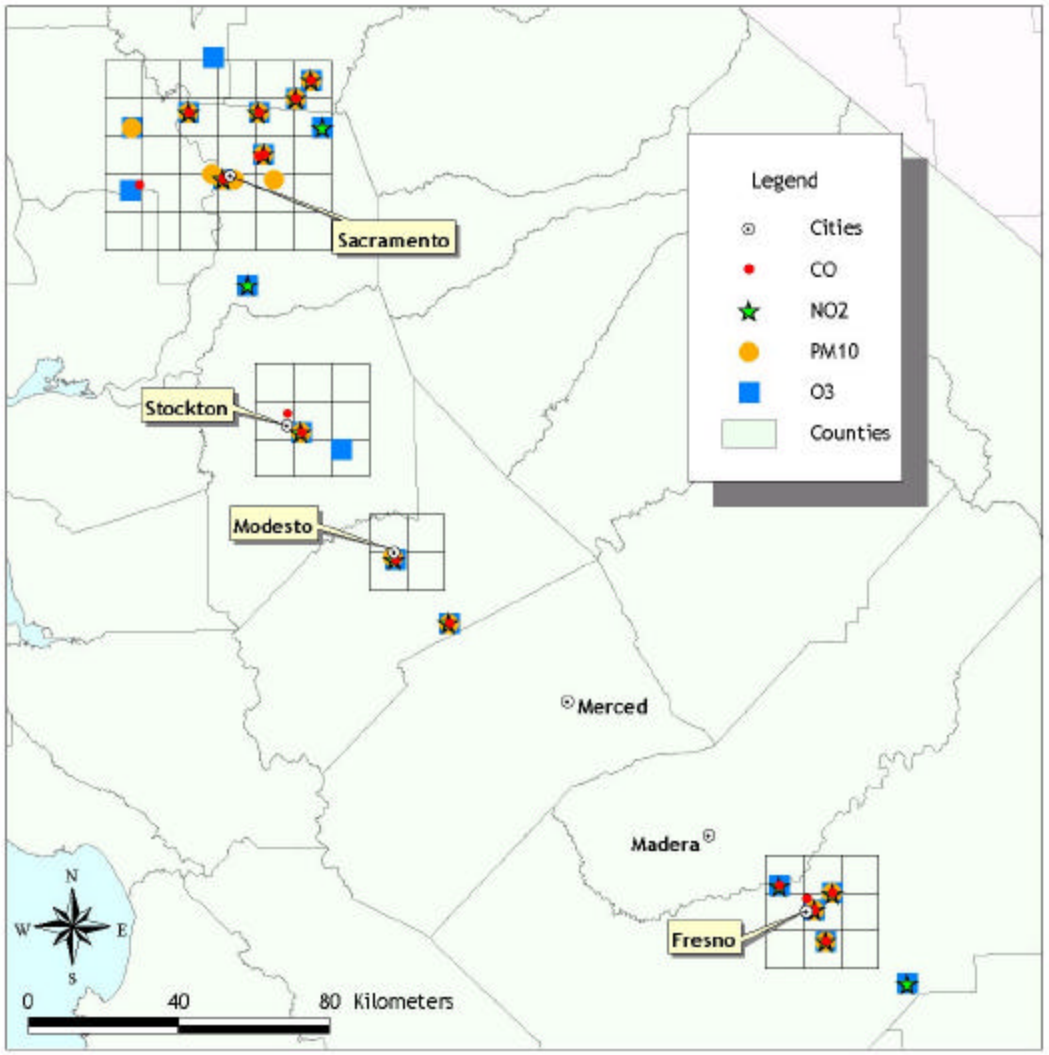
Emergency Room Outcome Data

- **ER admissions of KP members within the geographic range covered by the enhanced monitoring program.**
- **Used KP-specific system for recording outpatient admissions (OSCR).**
- **Cardiovascular disease**
- **Acute Respiratory Disease**
- **Chronic Respiratory Disease**


CVD
0 10 30
CR
0 4 8 12
AR
0 10 20
Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1 Q2 Q3 Q4 Q1
1996 1997 1998 1999 2000 2001

Hospital Admissions by Quarter, KP





San Joaquin Valley Air Quality Monitors and Grids

Rates of Hospitalizations Admissions

	Cardiovascular		Acute Respiratory		Chronic Respiratory	
Variable	N	Rate	N	Rate	N	Rate
Total	24359	9.30	10469	4.00	5586	2.13
Season						
Spring	6228	9.52	2813	4.30	1444	2.21
Summer	5819	8.89	1899	2.90	966	1.48
Fall	6034	9.22	2099	3.21	1299	1.98
Winter	6278	9.59	3658	5.59	1877	2.87
Center						
Sacramento	19126	9.43	8594	4.24	4370	2.16
Stockton	1905	8.19	706	3.03	525	2.26
Modesto	761	7.98	381	4.00	234	2.46
Fresno	2567	9.78	788	3.00	457	1.74
Age Group						
< 20	62	0.08	3965	5.17	747	0.97
20 - 49	2336	2.08	1011	0.90	885	0.79
50 +	21961	30.27	5493	7.57	3954	5.45

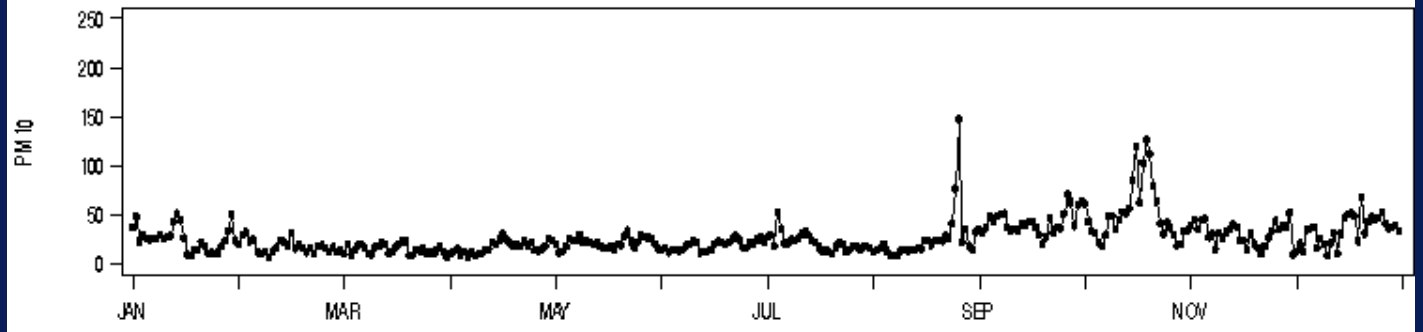
Rates of Emergency Room Admissions

	Cardiovascular		Acute Respiratory		Chronic Respiratory	
Variable	N	Rate	N	Rate	N	Rate
Total	19370	7.40	20749	7.93	20354	7.77
Season						
Spring	4956	7.57	5385	8.23	5890	9.00
Summer	4719	7.21	3328	5.08	3536	5.40
Fall	4888	7.47	4722	7.21	4606	7.04
Winter	4807	7.34	7314	11.17	6322	9.66
Center						
Sacramento	17604	8.68	18139	8.95	17383	8.57
Stockton	197	0.85	379	1.63	385	1.65
Modesto	127	1.33	201	2.11	216	2.27
Fresno	1442	5.49	2030	7.74	2370	9.03
Age Group						
< 20	128	0.17	7888	10.29	4503	5.87
20 - 49	2207	1.96	4764	4.23	6624	5.88
50 +	17035	23.48	8097	11.16	9227	12.72

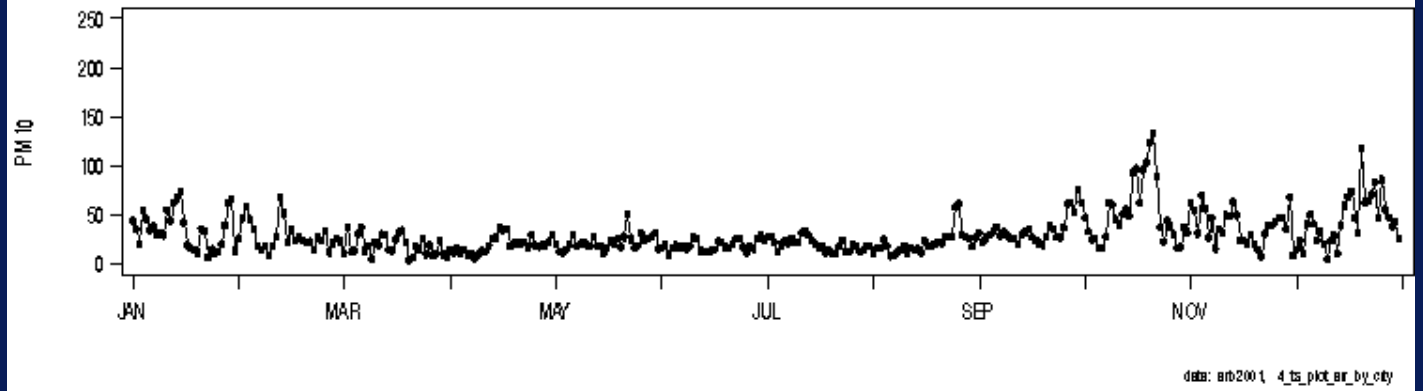
Exposure Data

- Criteria gaseous pollutants from ambient air quality monitors – primary data from the ARB
- Analytic dataset prepared by STI
- Meteorological data from NWS and local airports.

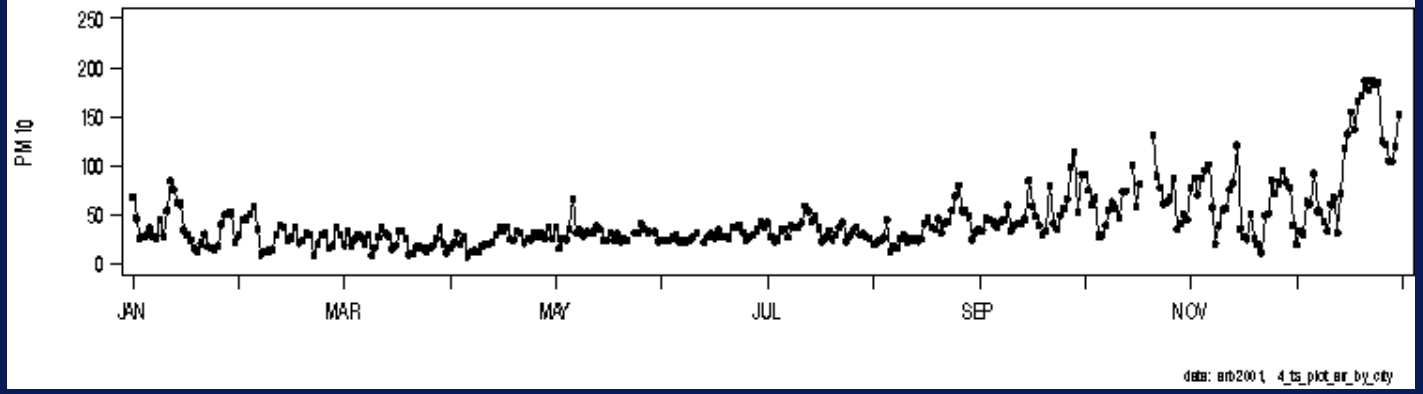
PM10 24hr for Sacramento, ARB Project, 1999



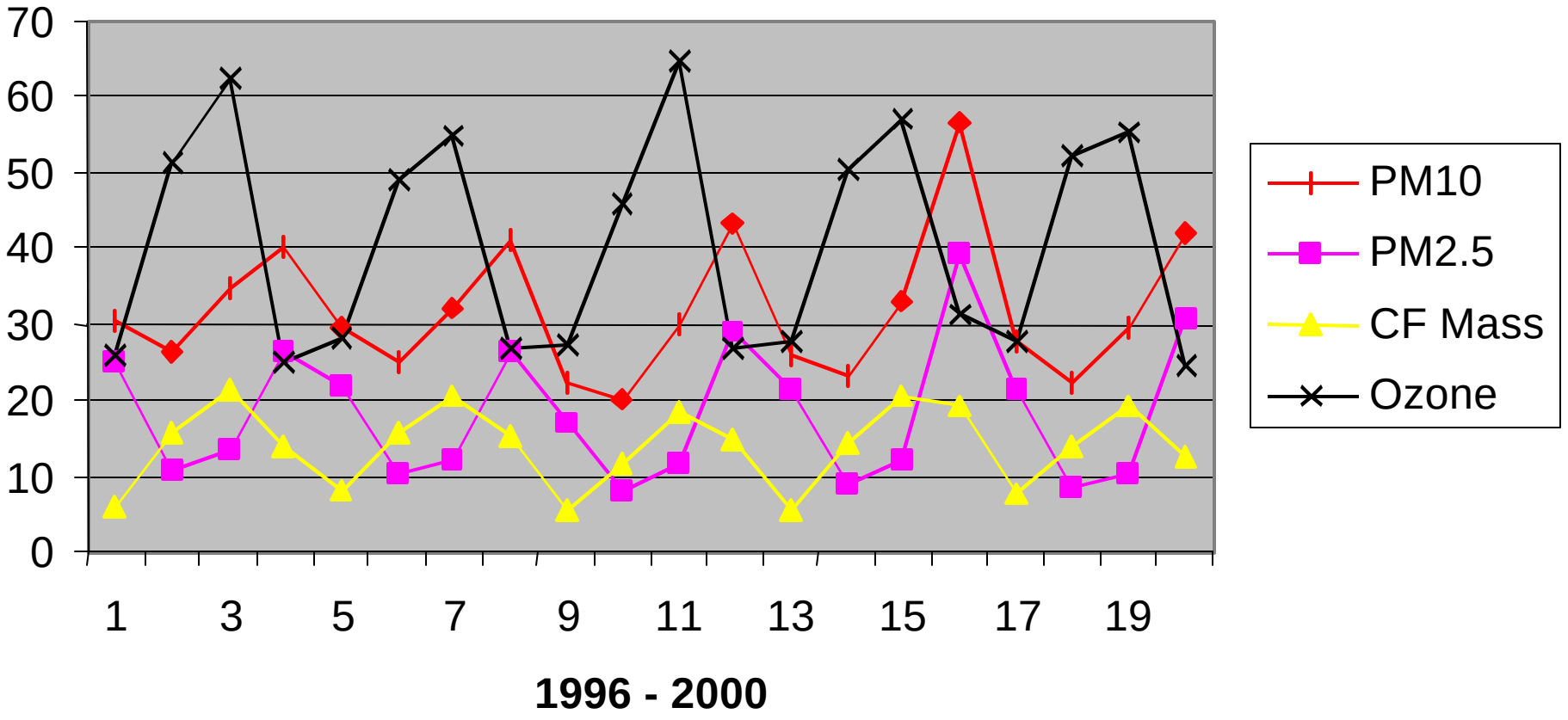
PM10 24hr for Stockton, ARB Project, 1999



PM10 24hr for Fresno, ARB Project, 1999



Ambient Air Pollution Levels by Quarter, KP



Correlations

	PM_{10}	$PM_{2.5}$	CF mass	O3	CO	NO2	Temp	RH
PM_{10}	1.00	0.80	0.62	0.01	0.66	0.66	-0.05	-0.04
$PM_{2.5}$		1.00	0.03	-0.35	0.76	0.53	-0.43	0.33
CF Mass			1.00	0.48	0.10	0.41	0.49	-0.51
Ozone 8hr				1.00	-0.38	0.07	0.83	-0.76
CO 8hr					1.00	0.62	-0.45	0.32
NO_2 1hr						1.00	-0.06	-0.02
Temp							1.00	-0.74
Rel. Hum.								1.00

STATISTICAL ANALYSIS

- **Initial analyses included visual inspection of the data, time series & correlations**
- **Generalized additive models used with various approaches to control confounding**
- **Smoothes for temperature, relative humidity, and time fit first using AIC criteria.**
- **Offset term put into models for population size.**

STATISTICAL ANALYSIS con't

- **Results presented here are based on the following model:**

	CV	AR	CR
date (df)	15	60	67
temp. (df)	4	1	1
rel. humidity	1	1	4
day_week			
season			
city			
pollutant(s)			

STATISTICAL ANALYSIS con’t

- **Lag analyses (0 to 5 days prior to event)**
- **Moving averages**
- **Rerun with more stringent convergence parameters per recent report.**

Cardiovascular Hospitalizations. Percent change in rate of admission per 10 unit increase in pollutant level for four-day moving average.
Kaiser Permanente Central Valley Study, 1996-2000.

Pollutant	b (x 1000)	STD (x 1000)	Percent change	95% CI	
				Lower	Upper
PM_{10}	-0.051	0.502	-0.051	-1.030	0.938
$PM_{2.5}$	1.176	0.622	1.183	-0.042	2.423
CF Mass	-2.947	1.053	-2.904	-4.888	-0.879
Ozone 8hr	-0.722	0.782	-0.720	-2.229	0.813
CO 8hr	46.467	15.578	59.149	17.273	115.978
NO_2 1hr	1.845	0.715	1.862	0.445	3.300
NO_3 (PM_{10})	2.956	3.501	3.000	-3.831	10.315
SO_4 (PM_{10})	-16.446	20.948	-15.165	-43.732	27.907
TC (PM_{10})	1.166	2.335	1.173	-3.352	5.910

Acute Respiratory Hospitalizations. Percent change in rate of admission per 10 unit increase in pollutant level for four-day moving average.
Kaiser Permanente Central Valley Study, 1996-2000.

Pollutant	b (x 1000)	STD (x 1000)	Percent change	95% CI	
				Lower	Upper
PM_{10}	2.290	0.761	0.761	0.803	3.853
$PM_{2.5}$	4.031	0.908	0.908	2.278	5.983
CF Mass	-0.380	1.735	1.735	-3.710	3.066
Ozone 8hr	-2.820	1.257	1.257	-5.147	-0.355
CO 8hr	84.793	23.412	23.412	47.559	269.433
NO_2 1hr	4.051	1.201	1.201	1.712	6.613
NO_3 (PM_{10})	12.127	5.116	5.116	2.122	24.800
SO_4 (PM_{10})	39.135	30.464	30.464	-18.596	168.705
TC (PM_{10})	9.944	3.514	3.514	3.103	18.332

Chronic Respiratory Hospitalizations. Percent change in rate of admission per 10 unit increase in pollutant level for four-day moving average.
Kaiser Permanente Central Valley Study, 1996-2000.

Pollutant	b (x 1000)	STD (x 1000)	Percent change	95% CI	
				Lower	Upper
PM_{10}	5.374	0.921	5.521	3.633	7.443
$PM_{2.5}$	7.240	1.112	7.509	5.190	9.879
CF Mass	3.622	2.157	3.689	-0.604	8.167
Ozone 8hr	-6.280	1.672	-6.087	-9.116	-2.958
CO 8hr	149.618	29.504	346.459	150.404	696.015
NO_2 1hr	5.111	1.557	5.244	2.081	8.505
NO_3 (PM_{10})	31.897	6.032	37.571	22.232	54.836
SO_4 (PM_{10})	185.418	37.381	538.645	206.950	1228.777
TC (PM_{10})	27.595	4.152	31.779	21.479	42.952

Hospitalization Results by Season and Age

- Cardiovascular
  - No significant interactions. Slight elevations for PM metrics in Spring & Summer
  - Age affects limited to over 50 years of age.
- Acute Respiratory
  - No significant interactions. Significant elevations for PM10, PM2.5, CO, NO2 & PM components in Winter.
  - Most pollutants associated in 50+ age category.
- Chronic Respiratory
  - No significant interactions. Significant elevations for PM10, PM2.5, CF mass,CO, NO2 & PM components in Winter.
  - Most pollutants associated with 20-49 & 50+ groups.

Cardiovascular Emergency Room Admissions. Percent change in rate of admission per 10 unit increase in pollutant level for four-day moving average.
Kaiser Permanente Central Valley Study, 1996-2000.

Pollutant	b (x 1000)	STD (x 1000)	Percent change	95% CI	
				Lower	Upper
PM_{10}	0.089	0.637	0.089	-1.153	1.347
$PM_{2.5}$	1.512	0.777	1.524	-0.011	3.083
CF Mass	-3.189	1.328	-3.138	-5.627	-0.584
Ozone 8hr	-2.689	0.910	-2.654	-4.375	-0.901
CO 8hr	23.798	19.231	26.869	-12.972	84.948
NO_2 1hr	-0.237	0.876	-0.237	-1.935	1.490
NO_3 (PM_{10})	5.822	5.219	5.995	-4.311	17.411
SO_4 (PM_{10})	42.440	30.248	52.867	-15.504	176.562
TC (PM_{10})	4.120	2.933	4.206	-1.616	10.371

Acute Respiratory Emergency Room Admissions. Percent change in rate of admission per 10 unit increase in pollutant level for four-day moving average.
Kaiser Permanente Central Valley Study, 1996-2000.

Pollutant	b (x 1000)	STD (x 1000)	Percent change	95% CI	
				Lower	Upper
PM_{10}	3.392	3.392	3.450	2.354	4.558
$PM_{2.5}$	5.057	5.057	5.187	3.885	6.507
CF Mass	0.324	0.324	0.324	-2.195	2.908
Ozone 8hr	-2.035	-2.035	-2.015	-3.828	-0.168
CO 8hr	95.043	95.043	158.682	82.522	266.623
NO_2 1hr	6.173	6.173	6.368	4.467	8.303
NO_3 (PM_{10})	17.665	17.665	19.321	10.855	28.434
SO_4 (PM_{10})	131.312	131.312	271.776	132.677	494.032
TC (PM_{10})	15.641	15.641	16.931	11.563	22.558

Chronic Respiratory Emergency Room Admissions. Percent change in rate of admission per 10 unit increase in pollutant level for four-day moving average. Kaiser Permanente Central Valley Study, 1996-2000.

Pollutant	b (x 1000)	STD (x 1000)	Percent change	95% CI	
				Lower	Upper
PM_{10}	3.708	0.557	3.778	2.650	4.917
$PM_{2.5}$	6.268	0.658	6.469	5.104	7.851
CF Mass	-0.431	1.332	-0.430	-2.996	2.204
Ozone 8hr	-1.502	0.992	-1.491	-3.389	0.444
CO 8hr	133.519	18.680	280.071	163.549	448.112
NO_2 1hr	7.113	0.932	7.373	5.429	9.352
NO_3 (PM_{10})	9.099	3.838	9.526	1.589	18.083
SO_4 (PM_{10})	41.156	25.147	50.917	-7.811	147.055
TC (PM_{10})	18.393	2.424	20.193	14.617	26.040

ER Admission Results by Season and Age

- Cardiovascular
  - No significant interactions. Slight elevations for PM metrics in Spring & Summer
  - Age affects limited to over 50 years of age.
- Acute Respiratory
  - No significant interactions. Significant elevations for PM10, PM2.5, CO, NO2 & PM components in Winter.
- Chronic Respiratory
  - No significant interactions. Significant elevations for PM10, PM2.5, CO, NO2 & PM components in Winter.

Prior Work

- PM found associated in numerous other studies.
  - Studies in California (and elsewhere) have found $PM_{10-2.5}$ associated with CV & respiratory outcomes.
- Inverse relationship with ozone found in other studies. Likely due to unmeasured factors; outdoor activity level, or air conditioning during periods of high ozone
- CO linked in many other studies to CV & respiratory outcomes.

Conclusions

- Consistent adverse health effects were observed between PM_{10} and $PM_{2.5}$ hospitalizations and emergency room visits for acute and chronic respiratory conditions.
- To a lesser extent CO and NO_2 were associated with increases in admissions for all outcomes in our study.
- In contrast, no convincing evidence of an association with any outcome and CF mass.

Ongoing Analyses

- Specific disease conditions
  - COPD
    - Discharge dx only
  - Asthma
    - Discharge dx only

Possible Future Studies

- **Susceptibility**
  - **Past/current medical history – a comorbidity score.**
  - **SES**
- **Additional PM chemical composition data can be analyzed.**
- **Mortality**

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ARB Presentation, 14 January 2003

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