Presentation to the California Air Resources Board Symposium on PM2.5 and Mortality

February 26, 2010

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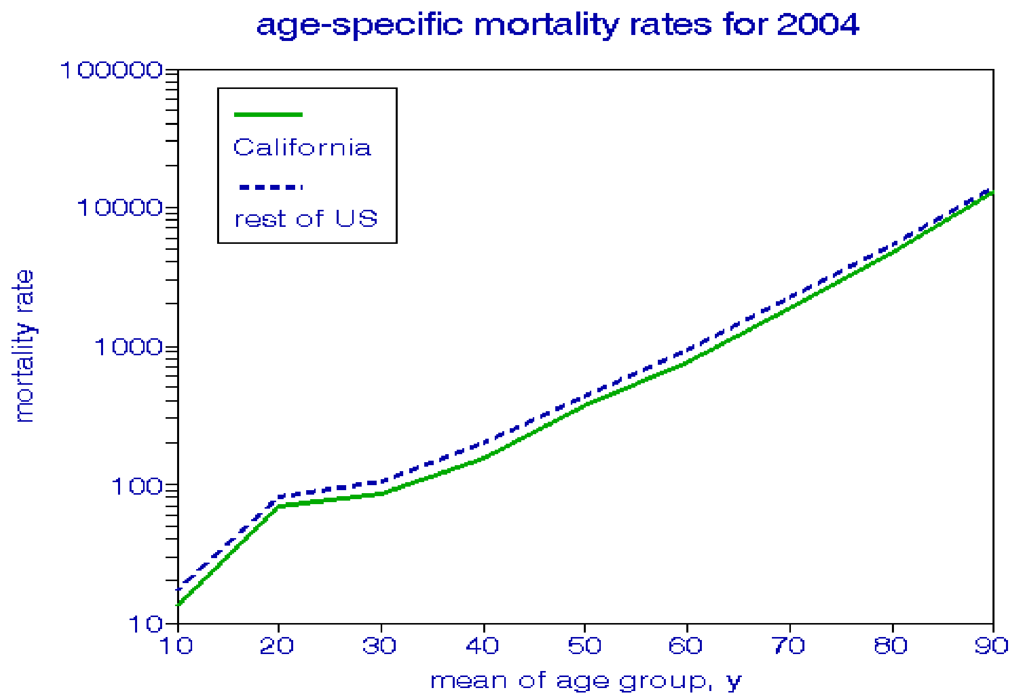
Some General Observations

California is basically a healthy state.



California mortality by age group is ~3% lower than in the rest of the U.S. Death rates converge for the very elderly.

•**PM2.5 (& PM10) are different from other criteria air pollutants.**

•PM (mass) is an *indicator* for a group of substances that are mainly related by the means of collection.

•PM**2.5** (mass) is thus not strictly a *pollutant*.

•There are no emission sources of PM**2.5** as measured; there are only sources of specific PM**2.5** *constituents* to be controlled.

•Studies of specific constituents are required to define control strategies that may actually benefit public health.

•Most toxicology studies employ specific chemicals or PM constituents, not PM mass

•Epidemiological studies based on PM mass are thus only useful to support regulations.

•Would you really want to trade ammonium nitrate for benzo(a)pyrene, Pb, Cd or Ni?

There have been 3 statewide studies of long-term PM2.5 - mortality effects.

•McDonnell et al. (2000) 943 deaths
PM**2.5** from visibility, 1973-77, mean = 32 Mean-min risk = 6.8%
(no effect on women)

•Enstrom (2005) 40,000 deaths
PM**2.5** from IP network, 1979-83, mean = 23 Mean-min risk = 4.9%
(no effect after 1982)

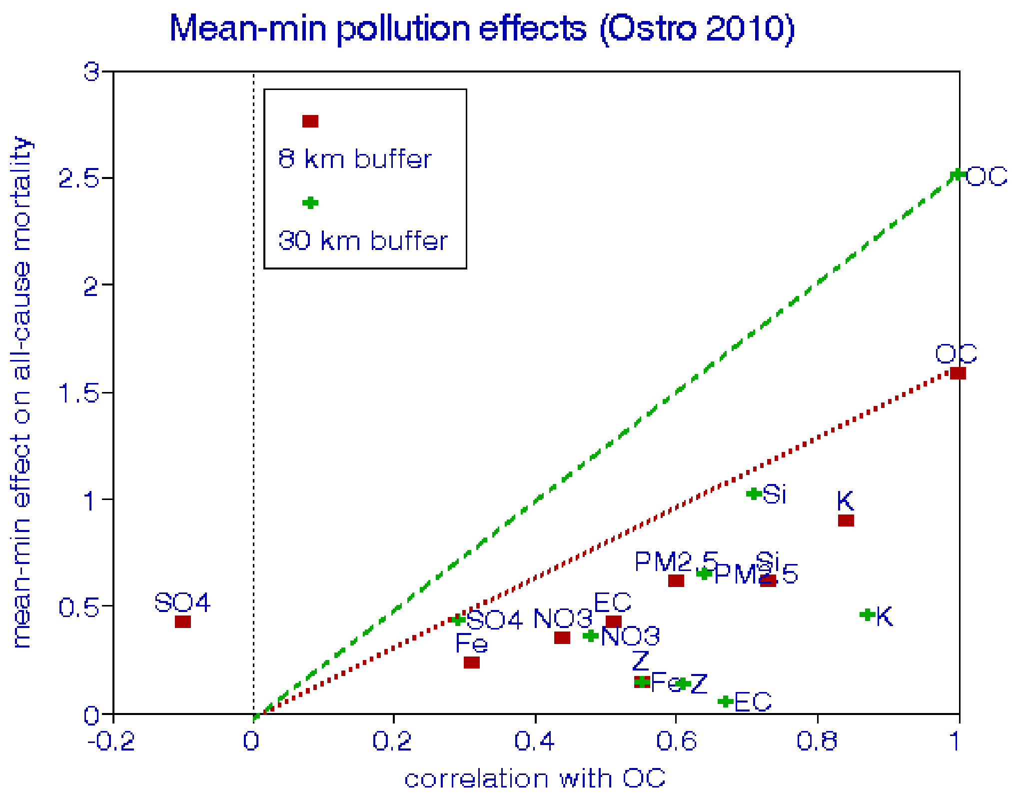
•Ostro et al. (2010) 2590 female deaths
STN data (10 counties), 2002-7, mean = 17 Mean-min PM**2.5** risk = 62%
(for 30 km buffer), dominated by organic carbon
(OC, mean – min risk = 160%)

(These risks are for all-cause mortality; it is not possible to target specific diseases by improving ambient air quality).

Conclusion: Estimates of long-term effects of PM**2.5** on California statewide mortality are inconsistent. Lack of statewide exposure data may be part of the problem.

More results from Ostro et al. (2010).

Risk estimates based on mean-min concentrations describe the benefits of controlling down to background levels.

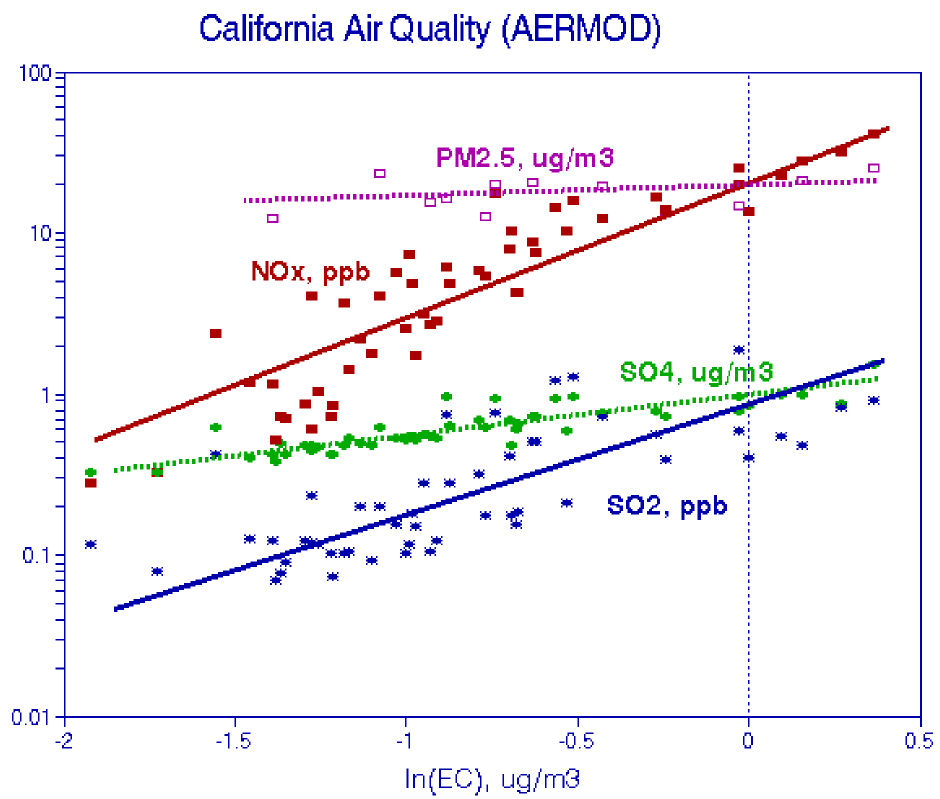


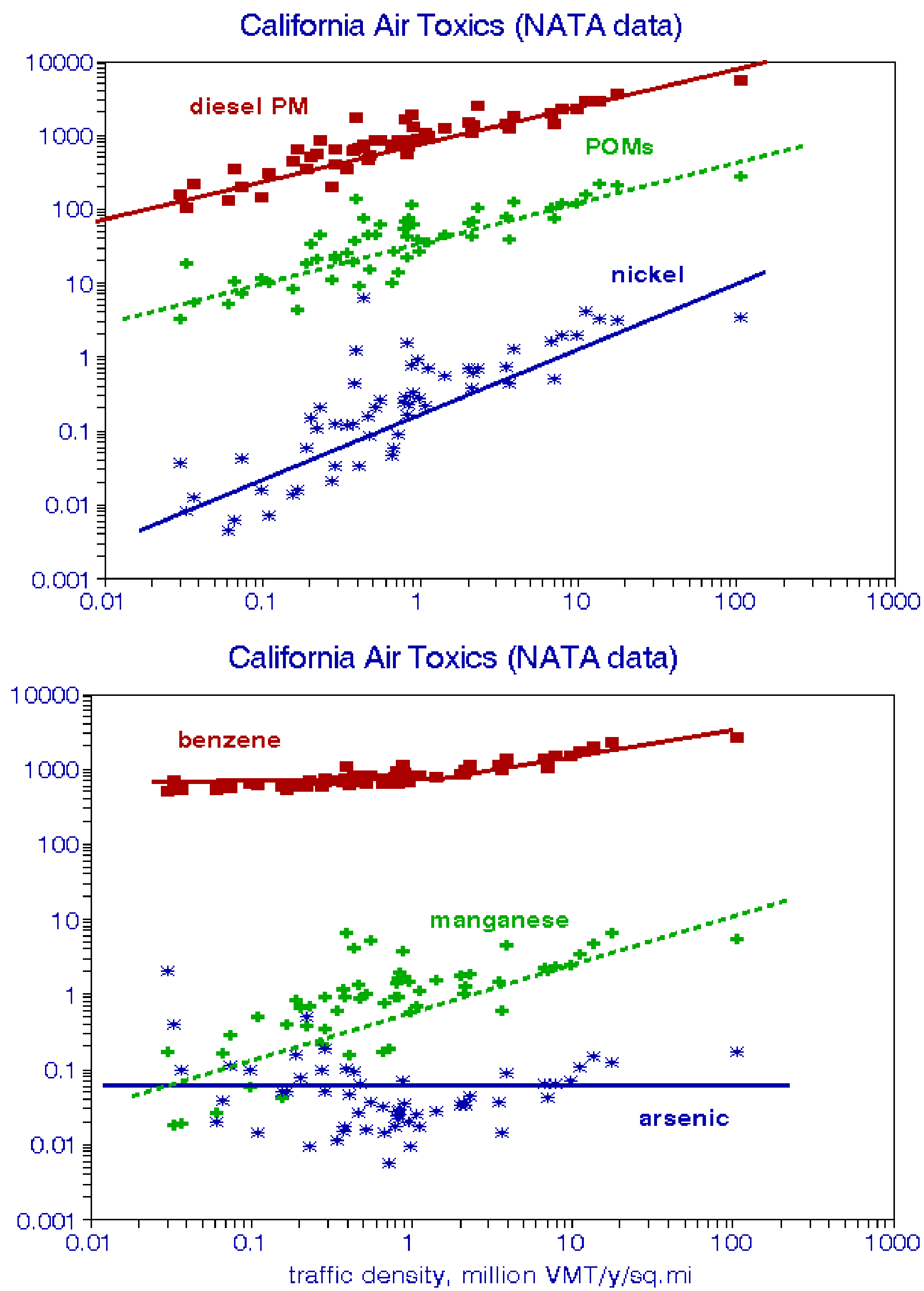
No other species has an effect larger than that expected from its correlation with organic carbon (OC), which is not unique to diesel; elemental carbon (EC) is more relevant, with smaller risks. Most of these risk estimates are an order of magnitude larger than those seen in other studies.

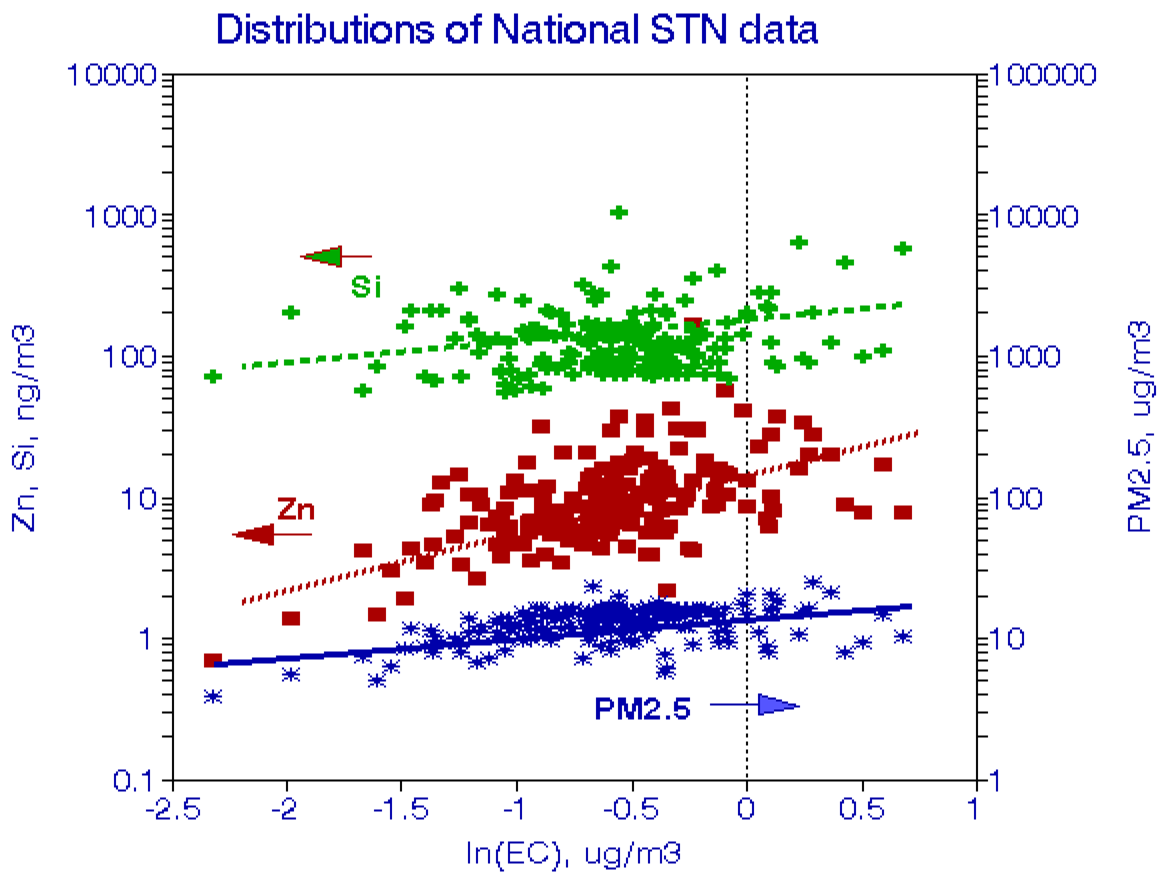
Modeled exposure estimates based on emissions and dispersion models can cover the whole state.

(Lipfert et al., 2009 – Veterans Cohort Study)

•Suitable for hazardous & criteria pollutants.
•Wider range of exposures (no lower detection limits)
•Sparsely distributed pollutants are more powerful and less sensitive to error.
•Traffic effects include many species, noise.




California Air Toxics (NATA data)
diesel PM
POMs
nickel
10000
1000
100
10
1
0.1
0.01
0.001
0.01
0.1
1
10
100
1000
California Air Toxics (NATA data)
benzene
manganese
arsenic
traffic density, million VMT/y/sq.mi



Distributions of National STN data
10000
1000
100
10
1
0.1
100000
10000
1000
100
10
1
Si
Zn
PM2.5
Zn, Si, ng/m3
PM2.5, ug/m3
-2.5
-2
-1.5
-1
-0.5
0
0.5
1
ln(EC), ug/m3

Bottom-Line Conclusions

- National studies may not apply to California, where pollutants and populations differ.

- There is little reliable evidence for current long-term effects on statewide California mortality from air pollution, including PM**2.5**.

- PM**2.5** may provide a convenient path for regulation, but is ill suited for epidemiology.

- California air quality relationships are highly collinear. Pristine areas are clean and polluted areas are dirty, by any of a number of measures, many of which relate to traffic.

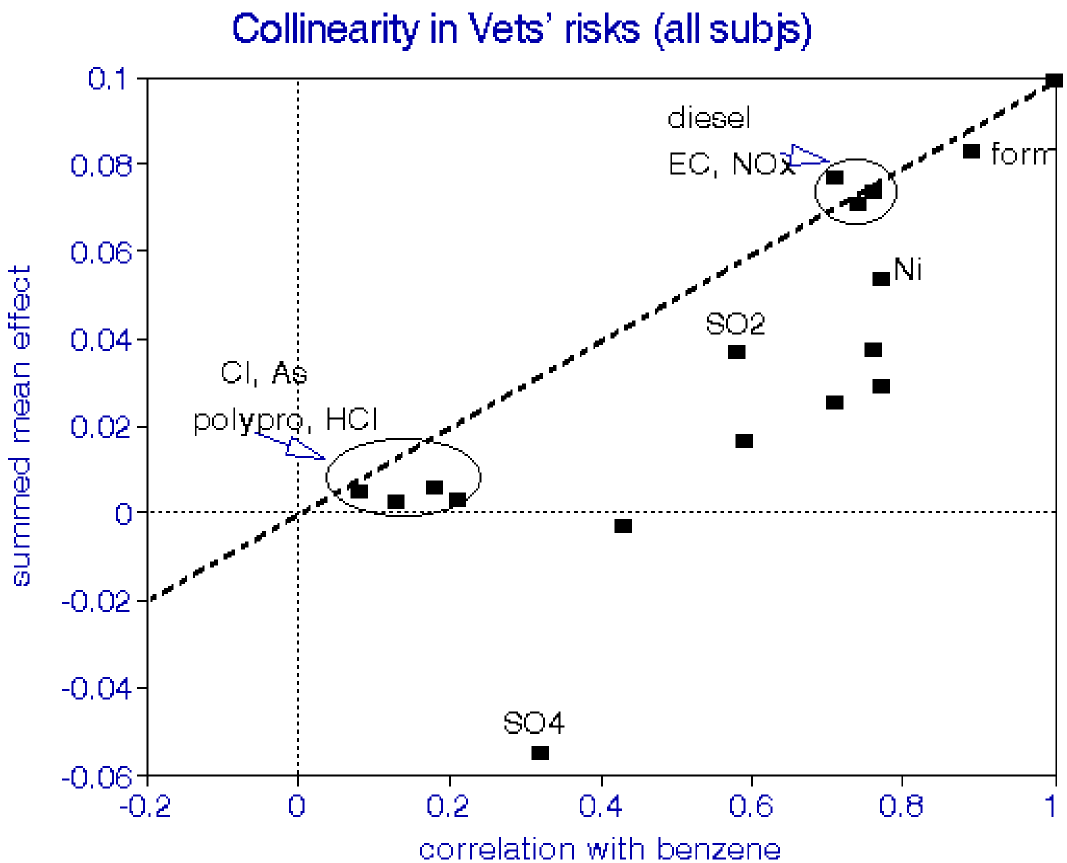
- Current epidemiology studies have not considered all pollutants and all locations and have been limited by the availability of regulatory air quality monitoring data.

- A new independent approach emphasizing all types of traffic effects will be required to make progress in protecting public health.

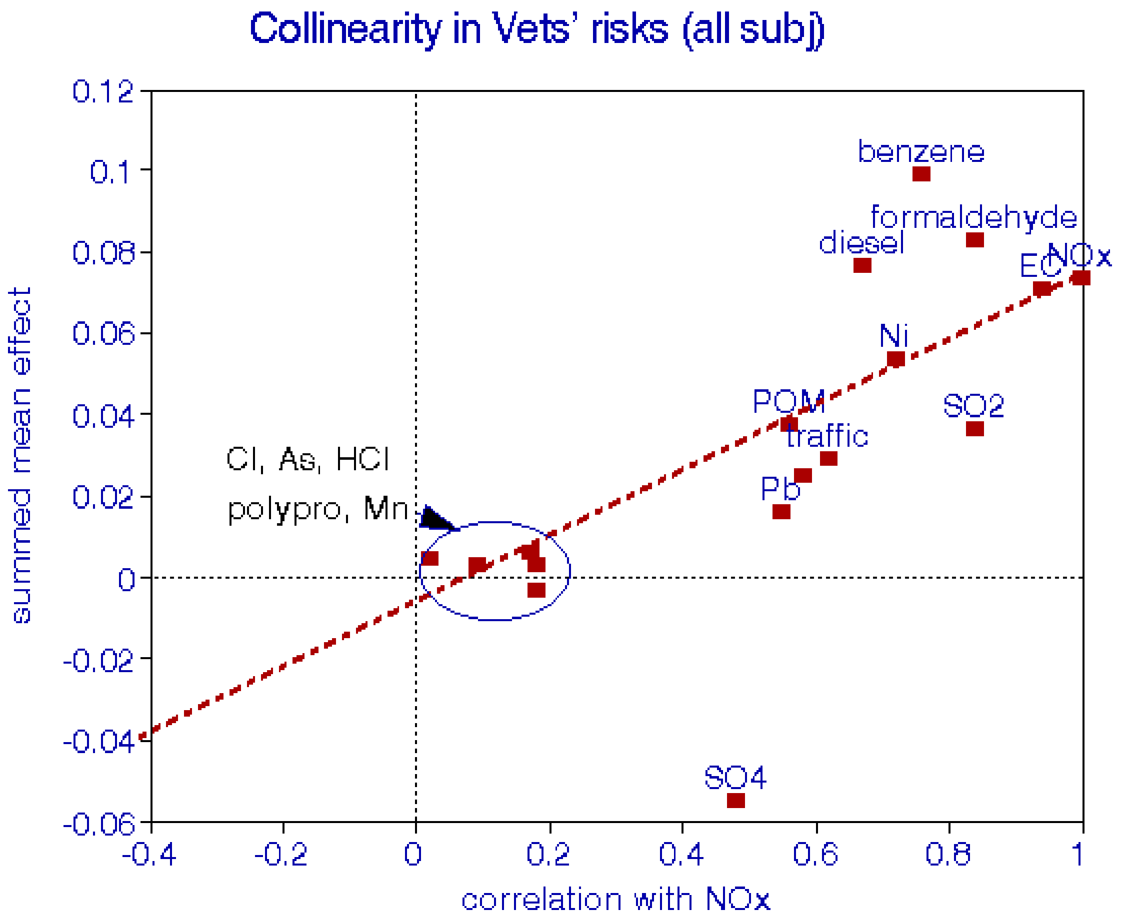
More on the Veterans Cohort Study, Based on Modeled Air Quality
(2009)

The Washington University – EPRI Veterans Cohort Study comprises about 70,000 male military veterans who were recruited ca. 1975, in conjunction with 32 VA hypertension clinics across the U.S. The cohort was 35% African-American, and 81% had smoked at some time. A series of peer-reviewed publications tested associations of survival (all causes of death) with various air pollution indicators. Recent analyses focused on vehicular traffic and associated air pollutants, for which county-level exposures were estimated by means of emissions data and atmospheric dispersion models. All counties in the contiguous U.S. were included, about 200 of which had at least 25 veteran subjects. Risks were adjusted for age, race, height, smoking, blood pressure, body mass, climate, and contextual socio-economic variables. Estimates were made for the entire follow-up period and for each of 4 subperiods.

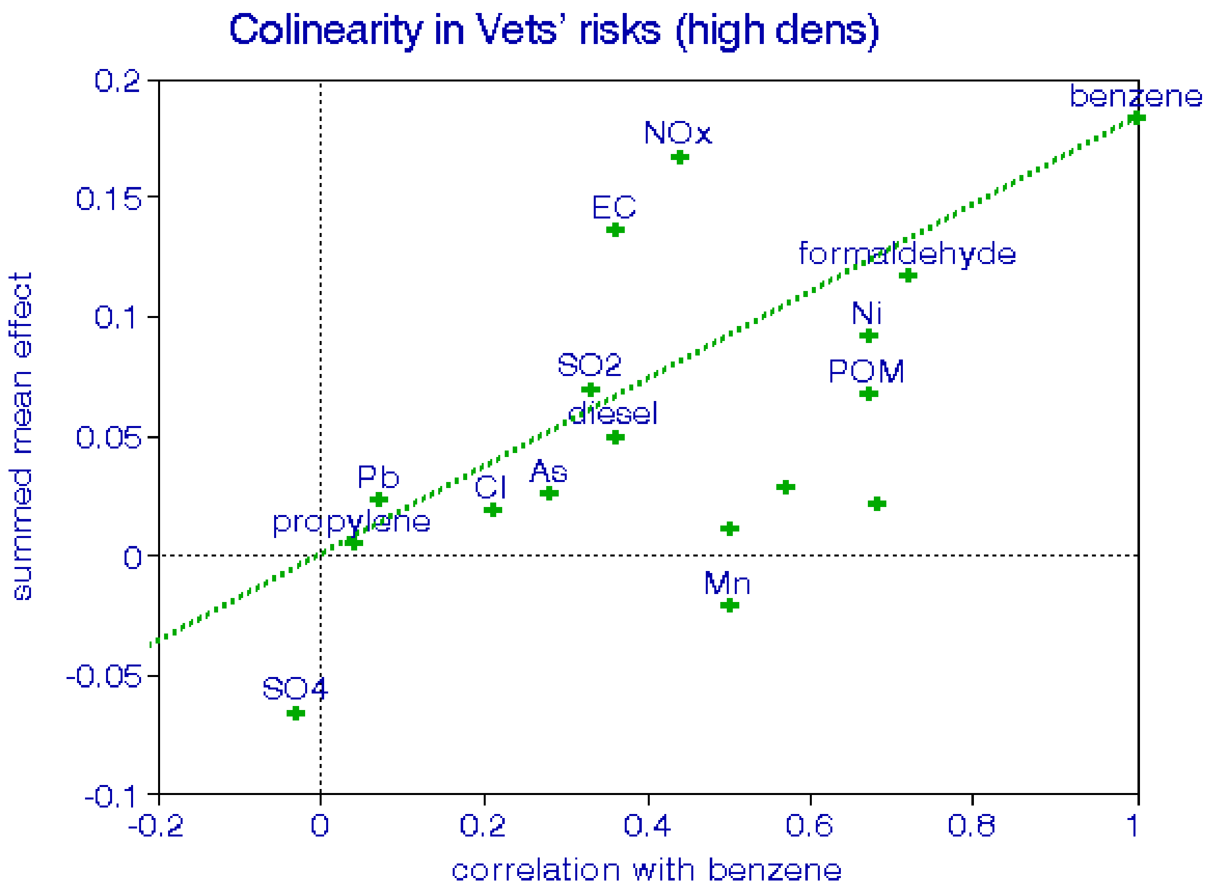
No pollutant appears to pose risks greater than would be expected from its correlation with benzene (all subjects).



Benzene, formaldehyde, and diesel PM appear to pose risks independent from NOx (all subjects).

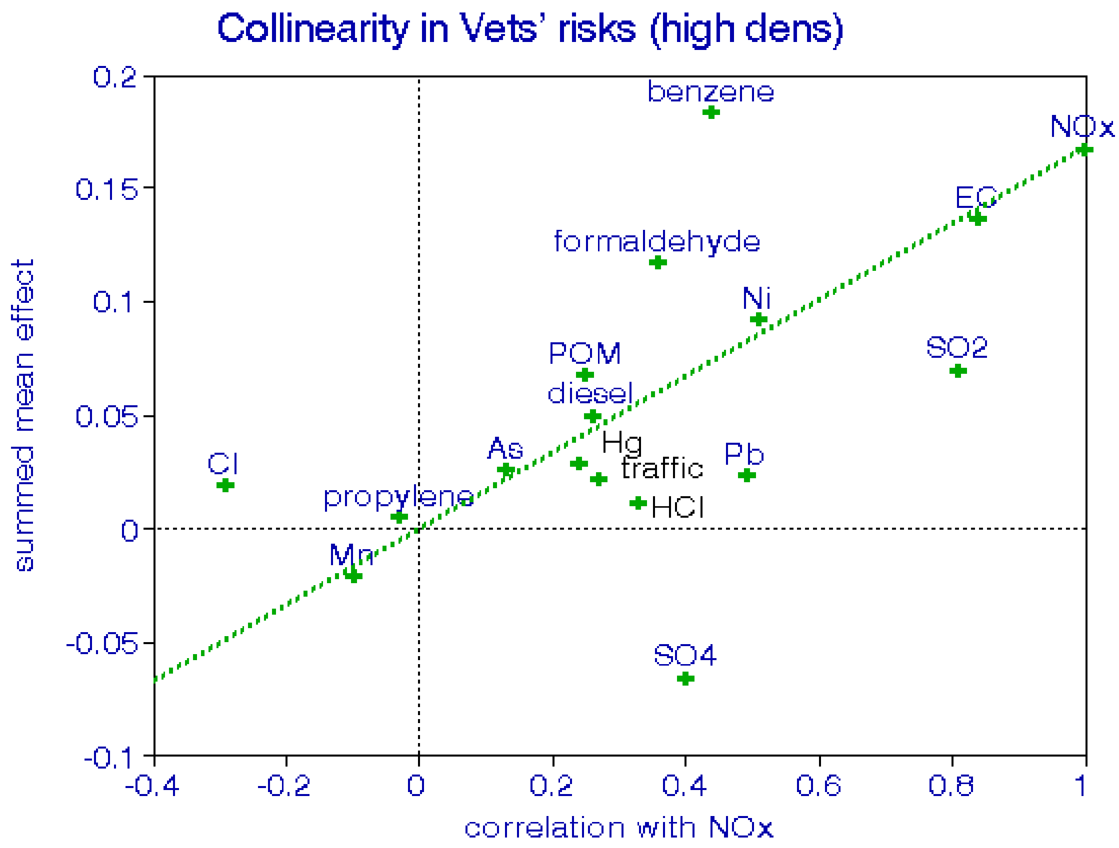


In counties with high traffic density, risks are about double, and EC and NOx appear to pose risks independent from benzene.

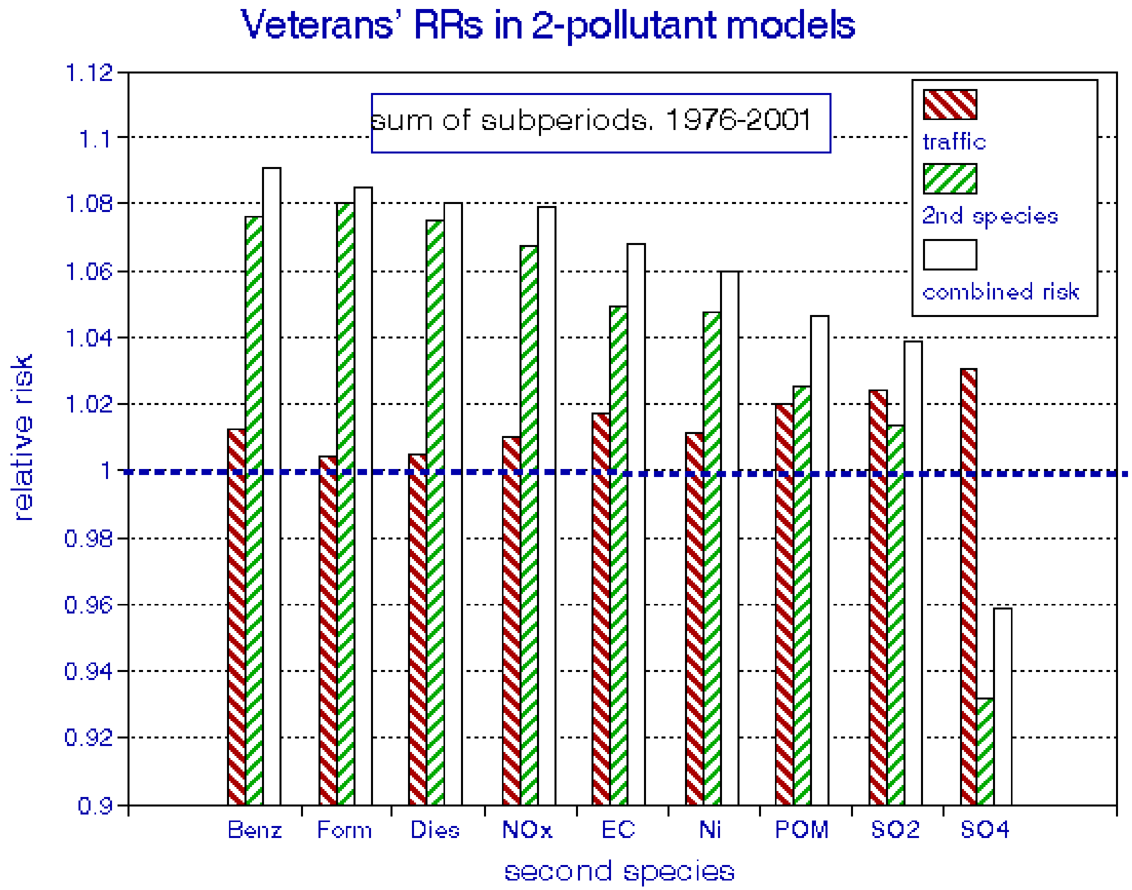


In high-density counties, benzene and formaldehyde, but not EC or diesel PM, appear to pose risks independent from NOx.

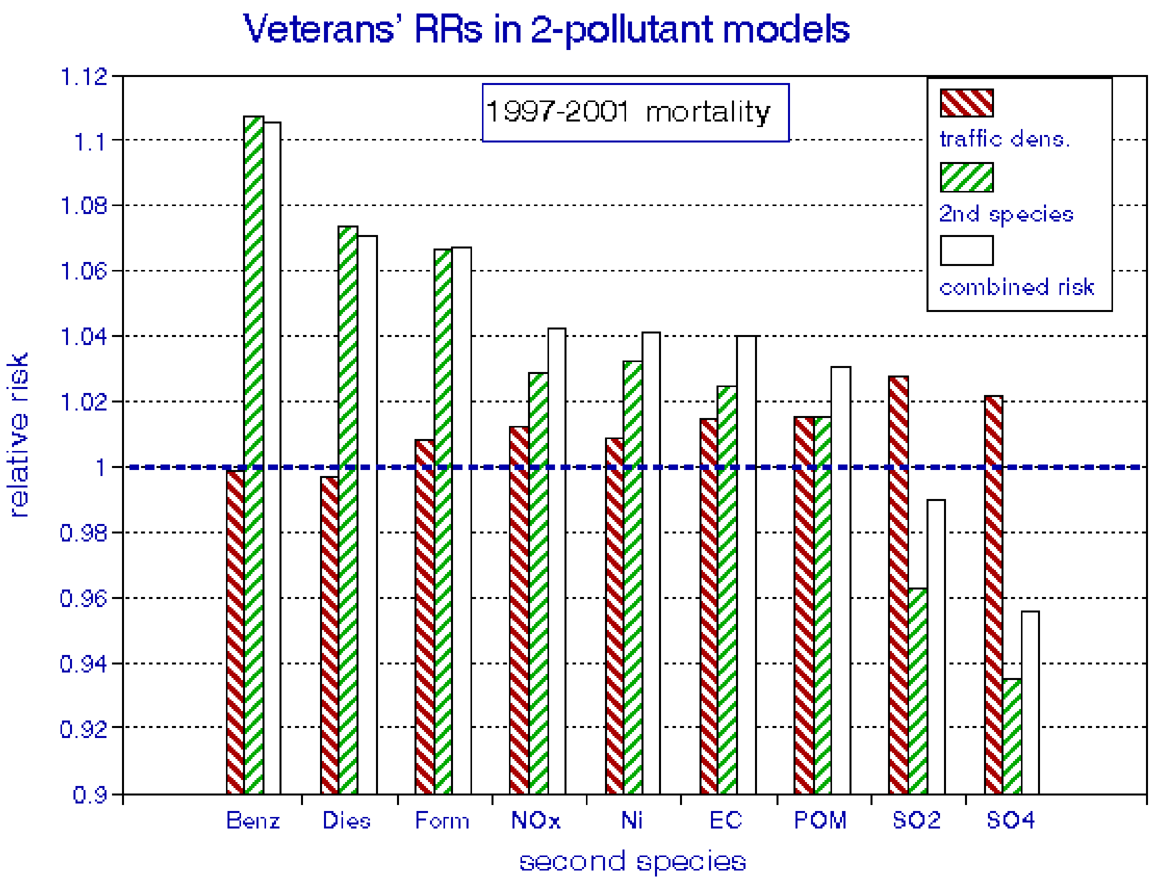
Risk differences between high-density and all counties suggest thresholds.



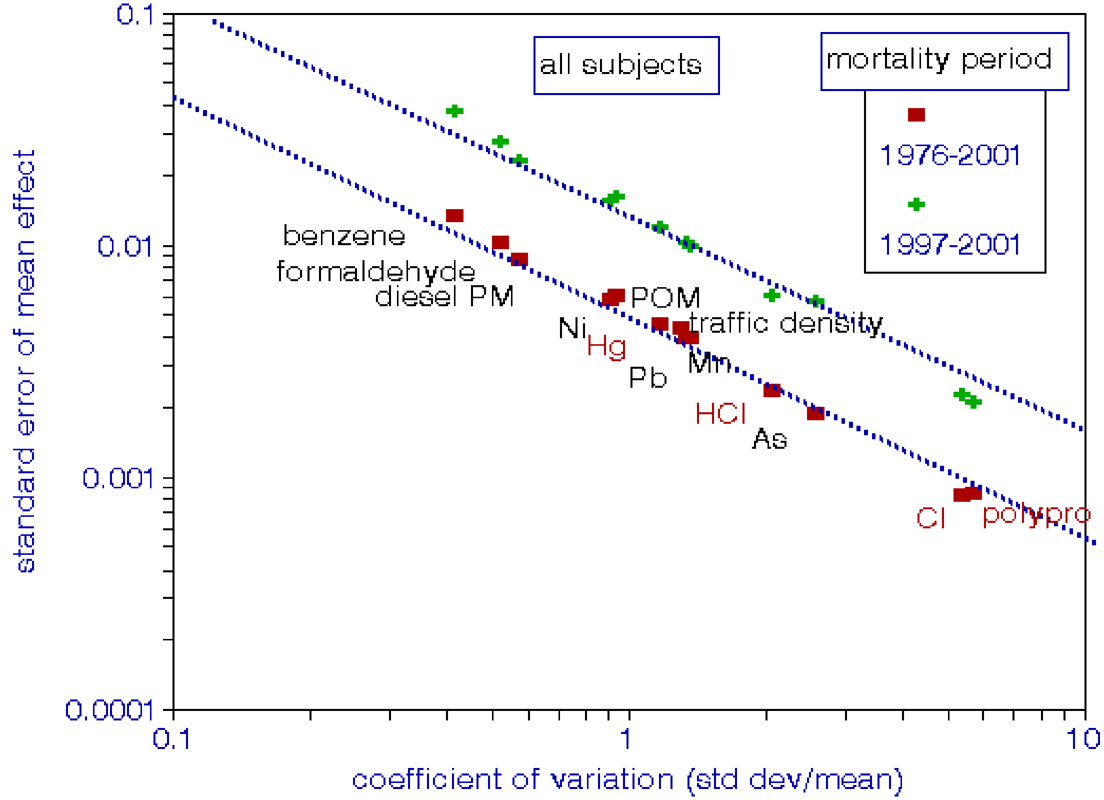
Two-pollutant models with traffic density show that traffic-related pollutants dominate (all subjects).



Except for benzene, mortality risks are lower in the most recent period.

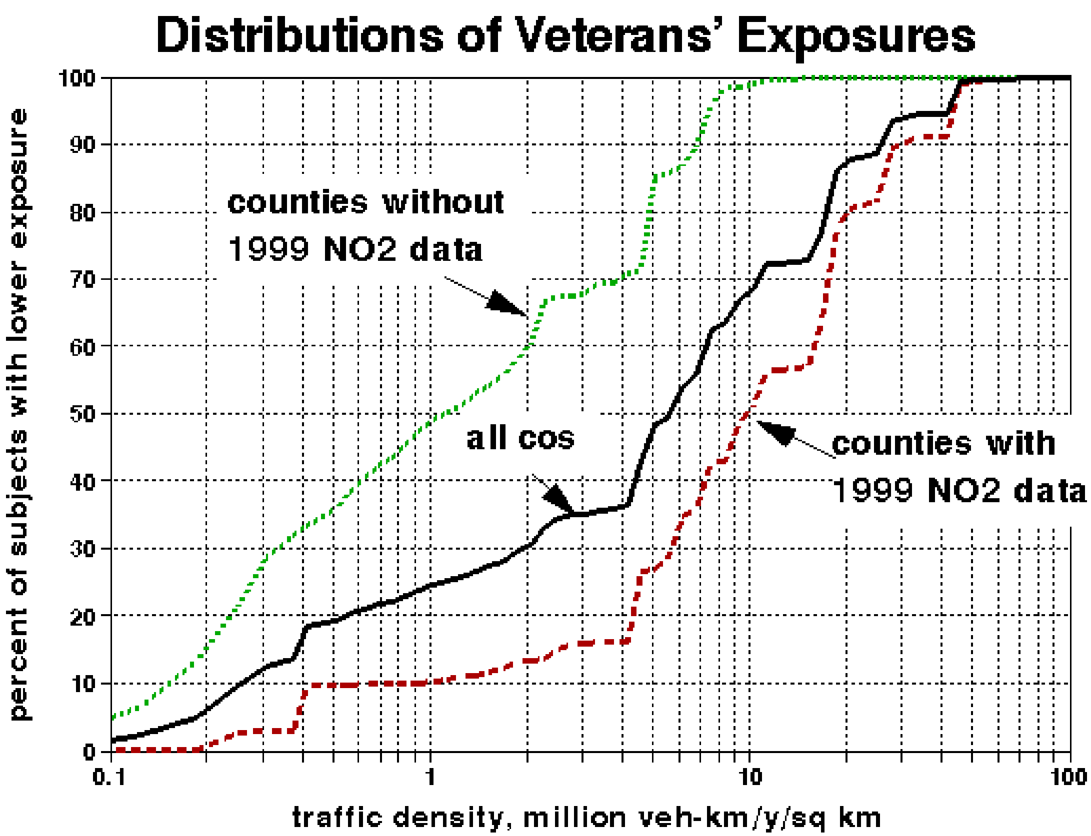


Standard errors of effect estimates are inversely proportional to the coefficient of variation (s dev/mean). Statistical significance per se is thus not a valid indicators of a pollutant's importance to public health.

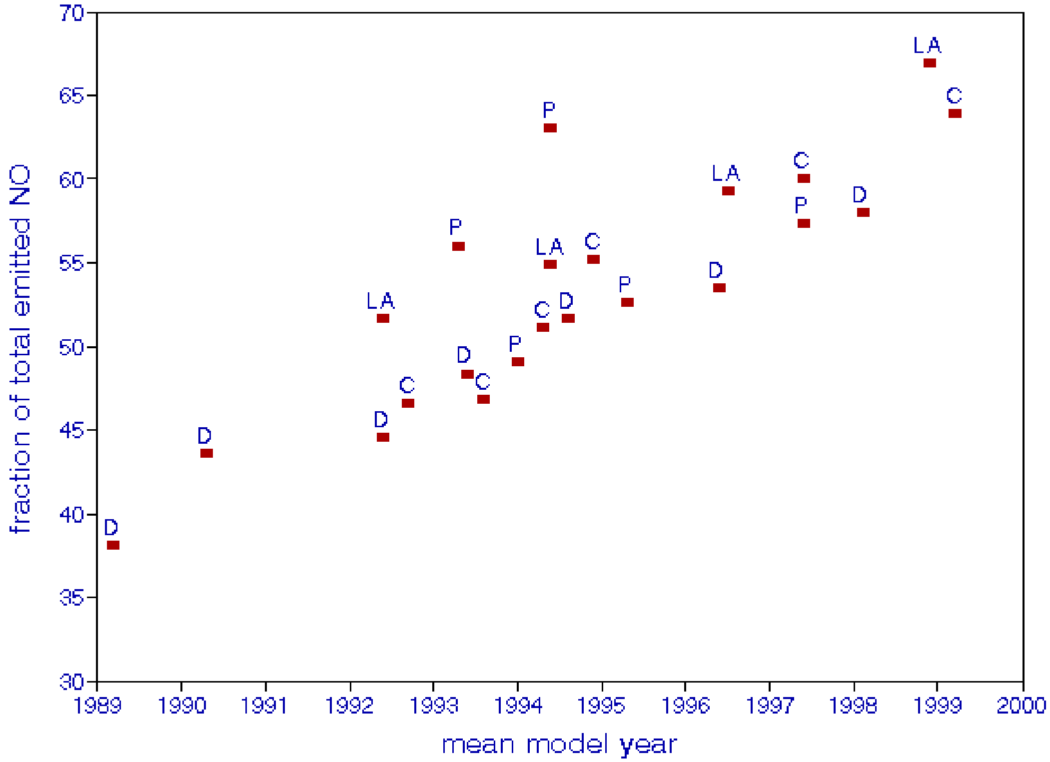


Air Quality Monitoring Data

The basic purpose of regulatory air quality monitoring is to insure compliance with ambient standards. This objective emphasizes "dirty" areas and does not provide the uniform coverage desired for long-term epidemiological studies. Counties with NO_2 monitors have 10 times the traffic density (and related pollutants) of those without monitors.



Percentages of total sampled fleet emissions of nitric oxide (NO) contributed by the highest emitting 10% of vehicles by vehicle model year, for four U.S. cities (C=Chicago, D=Denver, LA=Los Angeles, P=Phoenix).



As overall fleet emissions decreased over time, the relative contributions of “high emitters” has increased dramatically in all four cities. Data for 2008 is reported to show that half of the fleet’s total pollution burden is emitted by only 3% of the vehicles. Controlling or removing these high emitters may be more cost-effective than mandating new control devices.

Correlations among Traffic-Related Air Toxics for 3032 US Counties

	benz.	buta.	dies.PM	POMs
benzene	1.00	0.86	0.77	0.72
butadiene	0.86	1.00	0.58	0.76
diesel PM	0.77	0.58	1.00	0.61
POMs	0.72	0.76	0.61	1.00
formaldehyde	0.81	0.69	0.76	0.62
nickel	0.41	0.34	0.38	0.32
traffic density	0.62	0.49	0.70	0.52
EC	0.72	0.55	0.82	0.57
SO_2	0.52	0.37	0.71	0.41
average	*0.68*	*0.58*	*0.67*	*0.57*

	formal.	nickel	traffic dens.	EC
benzene	0.81	0.41	0.62	0.72
butadiene	0.69	0.34	0.49	0.55
diesel PM	0.76	0.38	0.70	0.82
POMs	0.62	0.32	0.52	0.57
formaldehyde	1.00	0.33	0.68	0.71
nickel	0.33	1.00	0.30	0.33
traffic density	0.68	0.30	1.00	0.56
EC	0.71	0.33	0.56	1.00
SO_2	0.52	0.29	0.42	0.79
average	*0.64*	*0.34*	*0.54*	*0.63*

red = R > 0.7; blue = R > 0.5

Summary of Nationwide Correlations

Benzene, diesel PM, and formaldehyde are the most highly intercorrelated pollutants, for which it is most difficult to identify independent health effects. SO_2 is highly correlated with diesel PM and EC, suggesting contributions from traffic sources. Traffic density is less highly inter-correlated, probably because this exposure measure does not account for meteorology. These relationships are also seen in the Veterans Cohort Study. We have no comparable information on noise impacts or on dust from roads, tires, or brakes, none of which may be ruled out.

CA county population-weighted average air quality levels are similar to national averages. Traffic density is lower.

Pollutant		CA mean	US (Vets)
$PM_{2.5}$	($\mu g/m^3$)*	19.09	14.34
OC	($\mu g/m^3$)*	7.03	4.42
SO_4^{2-}	($\mu g/m^3$)#	0.91	3.87
EC	($\mu g/m^3$)#	0.93	0.82
SO_2	(ppb)#	0.65	4.28
NO_x	(ppb)#	21.2	19.5

* measured in 13 counties (STN) # computed by AERMOD

Selected Air Toxics (from NATA, ng/m³)		
diesel PM	2196	1810
formaldehyde	1532	1155
benzene	1480	1520
POMs	144	96
Pb	5.48	5.70
Mn	3.76	3.10
Ni	2.04	2.09
Hg	1.90	0.57
Cd	0.105	n/a
As	0.094	0.152

Traffic dens (10^6 VMT/y/mi^2)	9.9	12.2
Major counties	LA = 14	NYC=182