Particulate Matter is Not Killing Californians

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Abstract

There is now overwhelming epidemiologic evidence that particulate matter (PM), both fine particulate matter (PM2.5) and course particulate matter (PM10), is not related to total mortality in California. I will examine all the long-term PM epidemiologic cohort studies in California, and discuss the ways the findings from these studies have be used and/or ignored. I will discuss the limitations of these studies: lack of access to key databases; the ecological fallacy; failure to consider other pollutants; failure to satisfy causality criteria; and failure to consider other competing health risks. Also, ethical issues underlying much of PM2.5 epidemiology will be discussed. I will make a strong case that PM2.5 is not killing Californians and that there is not a scientific or public health basis for the many of the existing and proposed regulations designed to reduce PM levels in California. Finally, I will make the case that PM health effects and regulations must be put into perspective with other factors that influence health in California, given the low age-adjusted total death rate in this state.

Key Words: epidemiology, particulate matter, mortality, causality, statistics, California

1. Background

1.1 Relationship of PM2.5 Epidemiology to EPA, CARB, and AQMD

This paper focuses on particulate matter (PM) epidemiology in California. PM consists of fine particulates (PM2.5), defined to have particle size <2.5 μm in diameter, and course particulates (PM10), defined to have a particle size <10 μm in diameter. PM2.5 is generated mainly by combustion processes, such as, forest fires, agricultural dust, industrial combustion, and diesel engines. PM2.5 epidemiology played a major role in the US Environmental Protection Agency (EPA) establishment of the 1997 National Ambient Air Quality Standard (NAAQS) for PM2.5 (http://www.epa.gov/air/criteria.html). EPA has recently proposed to lower the annual NAAQS for PM2.5 from the current level of 15 μg/m³ to 12-13 μg/m³

(http://www.epa.gov/pm/actions.html). The PM2.5 regulations established since 1997 have had multi-billion dollar economic impacts in the United States and California and have been highly contested (http://science.house.gov/press-release/harris-and-broun-question-administration%E2%80%99s-environmental-cost-benefit-analyses).

PM2.5 epidemiology has also been used by the California Air Resources Board (CARB) to establish the draconian Truck and Bus Regulation to reduce PM emissions from diesel vehicles in California (http://www.arb.ca.gov/msprog/onrdiesel/onrdiesel.htm). During the past five years, I have challenged the scientific and public health justifications for these regulations (http://www.arb.ca.gov/lists/gmbond2011/2-enstrom_letter_to_coal_cornez_re_suspend_carb_diesel_regs_121311.pdf).

PM2.5 epidemiology is also being used by the Southern California Air Quality Management District (AQMD) in the development of the 2012 Air Quality Management Plan (AQMP) (http://www.aqmd.gov/aqmp/2012aqmp/index.htm). The AQMP proposes aggressive and costly emission control measures in order to reduce existing PM and ozone levels in the South Coast Air Basin (SCAB). This air basin includes about 17 million residents in Orange County and the urban portions of Los Angeles, Riverside, and San Bernardino Counties. The primary goal of the AQMP is to bring the SCAB into compliance with the NAAQS for criteria pollutants, primarily, PM2.5 and ozone.

An elevated relative risk (RR > 1.00) in an epidemiologic cohort study, i.e., increase in total (all cause) mortality risk for a 10 μg/m³ increase in PM2.5 level, is interpreted by EPA, CARB, and AQMD as evidence that PM2.5 "causes" "premature deaths." Because EPA assigns a lifetime monetary value of about $7-9 million to each "premature death," the health benefits of preventing these deaths exceed the compliance costs of the regulations that are designed to reduce PM2.5 levels and PM2.5-related "premature deaths." Without PM2.5-related "premature deaths" the PM2.5 regulations are not justified on a cost-benefit basis.

During the past two decades there has been extensive criticism of PM2.5 epidemiology and its use for regulation of PM by EPA, CARB, and AQMD. Five major reasons for doubting a "causal" relationship between PM2.5 and "premature deaths" are: 1) the relative risk of death due to PM2.5 is small (RR ~ 1.10), varies by time and place, and shows no consistent dose-response relationship; 2) confounding variables, including other pollutants, often reduce the PM2.5 effect to zero (RR ~ 1.00); 3) the ecological fallacy applies to all PM2.5 epidemiology because PM2.5 measurements made at selected monitoring stations are imputed to individuals living near these stations; 4) the chemical composition of PM2.5 varies greatly across the US; and 5) the major PM2.5 epidemiologic findings that have been used to establish regulations are based on secret data maintained by the American Cancer Society and Harvard University (Krewski 2000), that is not accessible for independent reanalysis.

1.2 Major Lectures on PM2.5 and Mortality in California by Enstrom

The above epidemiologic issues are too complex to fully address in this paper. Additional relevant information can be found in the following major lectures that I have given since 2010, often in conjunction with other experts on this subject:

February 26, 2010 CARB Symposium "Estimating Premature Deaths from Long-term Exposure to PM2.5, with Enstrom talk "Critique of CARB Diesel Science, 1998-2010" (http://www.arb.ca.gov/research/health/pm-mort/pm-mort-ws_02-26-10.htm) (http://www.arb.ca.gov/research/health/pm-mort/enstrom.pdf)

November 28, 2011 UCLA Institute of the Environment Enstrom Seminar "Does Fine Particulate Matter Kill Californians? An Epidemiologic and Regulatory Controversy" (http://www.environment.ucla.edu/calendar/showevent.asp?eventid=667) and (http://www.arb.ca.gov/lists/gmbond2011/3-ioes_seminar_does_particulate_matter_kill_californians_enstrom_112811.pdf)

April 24, 2012 Dose-Response 2012 Conference Enstrom Lecture "Pseudoscientific Aspects of Fine Particulate Matter Epidemiology, 1993-2012" (http://dose-response.org/conference/2012/pdf/Enstrom_Dose_Response_Fine_Particulate.pdf)

August 1, 2012 American Statistical Association Joint Statistical Meeting Session "Are Fine Particulates Killing Californians?" with title talk by Enstrom (http://www.amstat.org/meetings/jsm/2012/onlineprogram/ActivityDetails.cfm?SessionID=207510) and (http://www.scientificintegrityinstitute.org/ASA080112.pdf)

2. PM2.5 and Total Mortality in California

2.1 California-specific Epidemiologic Results Summarized

Table 1 summarizes ten separate analyses of five major California cohorts that have found no relationship between PM2.5 and total mortality. References to these analyses are cited in the table and listed at the end of this paper and additional details are provided at this link (http://www.scientificintegrityinstitute.org/Enstrom081512.pdf). Included in Table 1 is an analysis limited to the Los Angeles area (Jerrett 2005). Table 2 summarizes five separate analyses of three of the major California cohorts. These analyses have found no relationship between PM10 and total mortality. There are no statewide cohort analyses that show a positive relationship between PM (PM2.5 and PM10) and total mortality in California. Indeed, three of these analyses (Jerrett 2011, Lipsett 2011, Ostro 2011), funded by CARB and AQMD, found no relationship between any criteria pollutant and total mortality in California.

The first published evidence of no PM2.5 mortality risk in California is contained in the July 2000 Health Effects Institute (HEI) Reanalysis Report (Krewski 2000). Figure 21, a U.S. map of "Fine Particulates and Mortality Risk," indicates no excess mortality risk in California. Figure 5 provides further evidence of the geographic variation in PM2.5 mortality risk, with Fresno (city #3) ranking second lowest in risk among 49 cities and Los Angeles (city #39) ranking fifth lowest in risk (http://www.scientificintegrityinstitute.org/HEIFigure5093010.pdf). Figure 1 below reproduces Figure 21 and Figure 5 with a city number assigned to each data point. The null California PM2.5 mortality risk findings in Figure 21 were confirmed in the August 31, 2010 letter from Krewski to HEI (Krewski 2010).

2.2 Misrepresentation of PM2.5 and Mortality in California by CARB

My December 15, 2005 *Inhalation Toxicology* paper, "Fine Particulate Air Pollution and Total Mortality Among Elderly Californians, 1973–2002" (Enstrom 2005), found no relationship between PM2.5 and mortality in California during 1983-2002. This is the first, largest, and most detailed peer reviewed journal publication that focuses on the relationship between PM2.5 and total mortality in California. Enstrom 2005 appeared just after the November 2005 *Epidemiology* paper "Spatial Analysis of Air Pollution and Mortality in Los Angeles" (Jerrett 2005), which found an unusually large relative risk between PM2.5 and mortality in the Los Angeles basin during 1982-2000. The finding is in direct contrast to the low absolute PM2.5 mortality risk for Los Angeles found in Figure 21. These conflicting findings need to be resolved with further analysis.

Enstrom 2005 was submitted to CARB health effects scientist Linda Smith on January 9, 2006 (http://www.arb.ca.gov/planning/gmerp/dec1plan/gmerp_comments/enstrom.pdf). The March 23, 2006 CARB meeting PPT presentation "Stronger Relationship Between Particulate Matter (PM) and Premature Death" gave extensive details on Jerrett 2005 and cited several other positive national studies, including Krewski 2000, Pope 2002, and Laden 2006 (http://www.arb.ca.gov/research/health/healthup/march06.pdf). However, it made no mention of Enstrom 2005, which was published one month after Jerrett 2005 and one month before a major Harvard Six Cities Study analysis (Laden 2006) appeared online. On August 21, 2006 CARB scientists Richard Bode, Linda Smith, and Hien T. Tran conducted a "Public Workshop on Updating the Methodology for Estimating Premature Death Associated with PM2.5 Exposures" and gave a PPT presentation (http://www.arb.ca.gov/research/health/pm-mort/ws-slides.pdf). The PPT presentation for this Workshop specifically shows Jerrett 2005 and Laden 2006, but not Enstrom 2005, as "New studies emerged since 2002." These PPT presentations show a pattern of omission of null findings like Enstrom 2005.

Additional misrepresentation of PM2.5 mortality risk in California was contained in the Draft and Final versions of the 2008 CARB Staff Report by Hien T. Tran "Methodology for Estimating Premature Deaths Associated with Long-term Exposure to Fine Airborne Particulate Matter in California." The October 24, 2008 Final Report states that PM2.5 contributes to 18,000 annual premature deaths in California, with 3,500 of these deaths due to diesel PM. These estimates of premature deaths provided the primary public health justification for new on-road diesel vehicle regulations approved and implemented by CARB. However, the premature death claims in this report are now entirely contradicted by the null findings presented in Table 1. My December 10, 2008 CARB comments exposed major flaws in this report (http://www.arb.ca.gov/lists/truckbus08/897-carb_enstrom_comments_on_statewide_truck_regulations_121008.pdf). The CARB misrepresentations of PM2.5 mortality risk in California continue up to the present, as explained in my talks and submissions cited above.

2.3 Failure to Properly Review Particulate Matter Health Impacts by AQMD

As an essential part of its currently ongoing preparation of the 2012 AQMP, the AQMD is required to address the health effects of air pollution in the SCAB. Indeed, California Health and Safety Code (CHSC) Section 40471 (b) specifically states "On or before December 31, 2001, and every three years thereafter, as part of the preparation of the air quality management plan revisions, the south coast district board, in conjunction with a public health organization or agency, shall prepare a report on the health impacts of

particulate matter air pollution in the South Coast Air Basin. The south coast district board shall submit its report to the advisory council appointed pursuant to Section 40428 for review and comment. The advisory council shall undertake peer review concerning the report prior to its finalization and public release. The south coast district board shall hold public hearings concerning the report and the peer review, and shall append to the report any additional material or information that results from the peer review and public hearings." (http://www.leginfo.ca.gov/cgibin/displaycode?section=hsc&group=40001-41000&file=40460-40471).

However, based on available information, AQMD has never prepared a "report on the health impacts of particulate matter air pollution in the South Coast Air Basin" at the end of 2001, 2004, 2007, or 2010. The only "health impacts" reports are Appendix I "Health Effects" of the 2003 AQMP, 2007 AQMP, and Draft 2012 AQMP. However these reports do not specifically address PM health impacts in the SCAB. Indeed, the 2003 AQMP Appendix I states "The purpose of this appendix is to **p**rovide an overview of air pollution health effects, rather than to provide estimates of health risk from current ambient levels of pollutants in specific areas of the SCAB." (http://www.aqmd.gov/aqmp/docs/2003AQMP_AppI.pdf).

Failure to comply with CHSC Section 40471 (b) is a serious matter because the local health effects of PM provide the primary public health justification for the entire AQMP. As shown in Tables 1 and 2, there is now overwhelming epidemiologic evidence that there is NO relationship in California between PM and total mortality (also known as "premature deaths"). However, the 2003 AQMP Appendix I (https://aqmd.gov/aqmp/docs/2003AQMP_AppI.pdf, page I-14), 2007 AQMP Appendix I (https://aqmd.gov/aqmp/07aqmp/aqmp/Appendix_I.pdf, page I-14), 2012 Draft AQMP Appendix I (http://www.aqmd.gov/aqmp/2012aqmp/draft/Appendices/AppxI.pdf, page I-18), and 2012 Revised Draft AQMP Appendix I (http://www.aqmd.gov/aqmp/2012aqmp/RevisedDraft/AppI.pdf, page I-19) all make incorrect statements regarding the evidence in California and the SCAB.

All four Health Effects appendices have been authored by AQMD Health Effects Officer Jean Ospital (http://www.aqmd.gov/bios/ms_ospital_jean.html). These documents come to exactly the same conclusion regarding PM mortality risk: "Despite data gaps, the extensive body of epidemiological studies has both qualitative and quantitative consistency suggestive of causality. A considerable body of evidence from these studies suggests that ambient particulate matter, alone or in combination with other coexisting pollutants, is associated with significant increases in mortality and morbidity in a community. In summary, the scientific literature indicates that an increased risk of mortality and morbidity is associated with particulate matter at ambient levels. The evidence for particulate matter effects is mostly derived from population studies with supportive evidence from clinical and animal studies."

The null PM2.5 - mortality relationship in California has been known since 2000, but the specific null evidence is only partially presented in the Draft 2012 AQMP and was entirely omitted from the earlier AQMPs. For instance, each AQMP Appendix I cites Krewski 2000. However, only the nationwide PM2.5 mortality risk results in this report are cited, not the California-specific results in Figure 21. The 2007 AQMP Appendix review cites Jerrett 2005, Laden 2006, and the Pope 2006 review, which contains two references to Enstrom 2005, but Enstrom 2005 itself is not mentioned. Enstrom 2005 is mentioned briefly in the Draft 2012 Appendix I, but not assigned any major significance.

The overwhelmingly null evidence in Figures 1 and 2 is not fully or properly described in either the Draft or Revised Draft 2012 Appendix I. I pointed out major deficiencies in my April 21, 2011 CARB comments (http://www.arb.ca.gov/lists/sip2011/3-carb_enstrom_comments_on_sip_for_pm2.5_042711.pdf). Since August 2008 I have also had repeated direction communications with Ospital, including an April 4, 2012 email message requesting that null evidence be included in the 2012 AQMP Appendix I (http://www.scientificintegrityinstitute.org/Ospital040412.pdf).

The health impacts of PM in the SCAB are still not addressed in the September 7, 2012 Revised 2012 Draft AQMP Appendix I (http://www.aqmd.gov/aqmp/2012aqmp/RevisedDraft/AppI.pdf). Furthermore, this version makes an incorrect assessment of the California-specific evidence by uncritically relying on the June 2012 US EPA Regulatory Impact Analysis (RIA) (US EPA 2012). The RIA looked at California-specific studies regarding PM2.5 and mortality published in the scientific literature. Appendix I states "The EPA analysis concluded 'most of the cohort studies conducted in California report central effect estimates similar to the (nation-wide) all-cause mortality risk estimate we applied from Krewski et al. (2009) and Laden et al. (2006) albeit with wider confidence intervals. A couple cohort studies conducted in California indicate higher risks than the risk estimates we applied.' Thus in EPAs judgment the California related studies provided estimates of mortality consistent with or higher than those from the national studies."

However, there are clear errors in virtually every California-specific RR in EPA RIA Table 5.B-10. The McDonnell 2000 ratio, RR (males) =1.09 (0.98–1.24), should be RR (both sexes) ~ 1.00 (0.95–1.05), based on inclusion of an approximated RR for females. The partially adjusted Jerrett 2005 ratio, RR = 1.15 (1.03–1.29), should be the fully adjusted value, RR = 1.11 (0.99–1.25). The Enstrom 2005 ratio for 1973-1982, RR = 1.04 (1.01–1.07), should be the ratio for the entire follow-up period (1973-2002), RR = 1.01 (0.99–1.03). The Krewski 2009 ratio, RR = 1.42 (1.26–1.27), is obviously invalid and should be replaced by the Krewski 2010 ratio, RR = 0.968 (0.916–1.022), which is the ratio for all California subjects in Krewski 2009. The implausibly high Ostro 2010 ratio, RR = 1.84 (1.66–2.05), is invalid and has been replaced by the new Ostro 2011 ratio, RR = 1.06 (0.96–1.16). The corrected ratios are all consistent with RR = 1.00 and DO NOT support the EPA RIA claim that California-specific results are consistent with national results. Ospital uncritically accepted the EPA RIA and did not mention a single one of the EPA errors cited above.

The July 11, 2012 AQMP Advisory Council meeting did not result in proper peer review of Draft 2012 Appendix I. The three Advisory Council members with the most expertise on PM mortality studies and PM health effects epidemiology are John R. Froines, Ph.D., Samuel Soret, Ph.D., and Rob S. McConnell, M.D. They have not done peer review of Appendix I regarding "the health impacts of particulate matter air pollution in the South Coast Air Basin," as specified in CHSC Section 40471 (b). Also, there is evidence that they are not objective peer reviewers regarding PM health effects.

UCLA Professor John R. Froines has engaged in inappropriate activism regarding PM science based on the information contained in the following documents:
1) June 30, 2009 letter and attachments from Norman R. Brown to UCLA officials (http://www.calcontrk.org/CARBdocs/Delta_UCLA_Letter_063009.pdf),
2) February 20, 2011 Bakersfield Californian column by Lois Henry

(http://www.bakersfieldcalifornian.com/columnists/lois-henry/x1902890284/Politics-air-rules-make-for-a-smelly-situation), and 3) April 15, 2012 Bakersfield Californian column by Lois Henry (http://www.bakersfieldcalifornian.com/health/x1322083219/The-ex-radical-who-heads-air-boards-key-panel).

Loma Linda University (LLU) Professor Samuel Soret has not responded to my August 23, 2012 and September 14, 2012 email messages regarding his peer review of the AQMP Appendix I (http://www.scientificintegrityinstitute.org/Soret091412.pdf). His July 11, 2012 email message to AQMD did not mention the highly relevant December 2010 paper that he co-authored and apparently submitted to *Epidemiology* "The Mortality & Long-Term Exposure to AP in Elderly CA Adventists" (Chen 2010). Also, he has not properly described the overwhelmingly null relationship between PM and total mortality in the 35-year LLU Adventist Health Study of Air Pollution (AHSMOG) project (http://www.llu.edu/public-health/health/ahsmog.page).

USC Professor Rob S. McConnell has not responded to my August 25, 2012 and September 17, 2012 email messages regarding his incomplete July 9, 2012 peer review of AQMP Appendix I, which did not discuss PM in the SCAB (http://www.scientificintegrityinstitute.org/McConnell091712.pdf).

I submitted comments to AQMD regarding AQMP Appendix I on August 30, 2012 (http://www.scientificintegrityinstitute.org/AQMP083012.pdf) and on September 20, 2012 (http://www.scientificintegrityinstitute.org/AQMP092012.pdf).
These comments emphasize the need for AQMD to comply with all provisions of CHSC Section 40471 (b) before finalizing the 2012 AQMP. It is particularly important that the AQMD Governing Board conduct a hearing on the health impacts of PM in the SCAB. This hearing will allow scientists with diverse views to directly present evidence to the Board Members. This hearing could have a profound impact on the emission control measures that are approved in the 2012 AQMP.

Conclusions

There is now overwhelming epidemiologic evidence that PM (PM2.5 and PM10) is not killing Californians. This evidence must be fully examined and recognized by EPA, CARB, and AQMD before there are any further regulations to reduce PM levels in California, particularly in the SCAB. In addition, there needs to be a full reassessment of the current PM regulations to be sure that they are based on the actual health effects evidence in California. AQMD should not be required to comply with NAAQS that are not appropriate for California or the SCAB. Instead, AQMD should request a waiver from compliance with the NAAQS using the special waiver status granted to California in Section 209 of the Clean Air Act (http://www.epa.gov/otaq/cafr.htm). Finally, PM health effects and regulations must be put into perspective with other factors that influence health in California. Keep in mind the findings in Figure 2, which show that, based on the 2009 age-adjusted total death rate by state, California had the third lowest rate. Furthermore, the SCAB had a total death rate that was lower than the rate for every state except Hawaii (http://www.scientificintegrityinstitute.org/NCHSRR070811.pdf).

Table 1. Epidemiologic Cohort Studies of PM2.5 and Total Mortality in California (http://www.scientificintegrityinstitute.org/Enstrom081512.pdf)
Relative risk of death from all causes (RR and 95% CI) associated with increase of 10 µg/m³ in PM2.5

Krewski 2000 & 2010	CA CPS II Cohort (N=40,408 [18,000 M + 22,408 F]; 4 MSAs; 1979-1983 PM2.5; 44 covariates)	RR = 0.872 (0.805-0.944)	1982-1989
McDonnell 2000	CA AHSMOG Cohort (N~3,800 [1,347 M + 2,422 F]; SC&SD&SF AB; M RR=1.09(0.98-1.21) & F RR~0.98(0.92-1.03))	RR ~ 1.00 (0.95 – 1.05)	1977-1992
Jerrett 2005	CPS II Cohort in Los Angeles Basin (N=22,905; 267 zip code areas; 1999-2000 PM2.5; 44 cov + max confounders)	RR = 1.11 (0.99 - 1.25)	1982-2000
Enstrom 2005	CA CPS I Cohort (N=35,783 [15,573 M + 20,210 F]; 11 counties; 1979-1983 PM2.5; 25 county internal comparison)	RR = 1.039 (1.010-1.069) RR = 0.997 (0.978-1.016)	1973-1982 1983-2002
Enstrom 2006	CA CPS I Cohort (N=35,783 [15,573 M + 20,210 F]; 11 counties; 1979-1983 & 1999-2001 PM2.5)	RR = 1.061 (1.017-1.106) RR = 0.995 (0.968-1.024)	1973-1982 1983-2002
Zeger 2008	MCAPS Cohort "West" (3.1 M [1.5 M M + 1.6 M F]; Medicare enrollees in CA+OR+WA (CA=73%); 2000-2005 PM2.5)	RR = 0.989 (0.970-1.008)	2000-2005
Jerrett 2010	CA CPS II Cohort (N=77,767 [34,367 M + 43,400 F]; 54 counties; 2000 PM2.5; KRG ZIP; 20 ind cov+7 eco var; Slide 12)	RR ~ 0.994 (0.965-1.025)	1982-2000
Krewski 2010	CA CPS II Cohort (N=40,408; 4 MSAs; 1979-1983 PM2.5; 44 cov) (N=50,930; 7 MSAs; 1999-2000 PM2.5; 44 cov)	RR = 0.960 (0.920-1.002) RR = 0.968 (0.916-1.022)	1982-2000 1982-2000
Jerrett 2011	CA CPS II Cohort (N=73,609 [32,509 M + 41,100 F]; 54 counties; 2000 PM2.5; KRG ZIP Model; 20 ind cov+7 eco var; Table 28)	RR = 0.994 (0.965-1.024)	1982-2000
Jerrett 2011	CA CPS II Cohort (N=73,609 [32,509 M + 41,100 F]; 54 counties; 2000 PM2.5; Nine Model Ave; 20 ic+7 ev; Fig 22 & Tab 27-32)	RR = 1.002 (0.992-1.012)	1982-2000
Lipsett 2011	CA Teachers Cohort (N=73,489 [73,489 F]; 2000-2005 PM2.5)	RR = 1.01 (0.95 – 1.09)	2000-2005
Ostro 2011	CA Teachers Cohort (N=43,220 [43,220 F]; 2002-2007 PM2.5) replaced Ostro 2010 Incorrect 2010 Result:	RR = 1.06 (0.96 – 1.16) RR = 1.84 (1.66 – 2.05)	2002-2007 2002-2007

Table 2. Epidemiologic Cohort Studies of PM10 and Total Mortality in California

Relative risk of death from all causes (RR and 95% CI) associated with increase of 10 µg/m³ in PM10

Abbey 1999 (N=6,338 [2,278 M + 4,060 F]; PM10 monitors in SC & SD & SF Air Basins) [N=610M+965F, all natural causes ICD9=001-799]	CA AHSMOG Cohort	M	RR = 1.04	(0.99 – 1.10)	1977-1992
		F	RR = 0.98	(0.93 – 1.02)	1977-1992
		BS	RR = 1.00	(0.97 – 1.04)	1977-1992
McDonnell 2000 (N~3,800 [1,347 M + 2,422 F]; PM10 monitors in SC & SD & SF Air Basins) [all natural causes ICD9=001-799]	CA AHSMOG Cohort	M	RR = 1.05	(0.98 – 1.12)	1977-1992
		F	RR ~ 0.98	(0.92 – 1.03)	1977-1992
		BS	RR ~ 1.01	(0.96 – 1.05)	1977-1992
Chen 2010 (N=4,830 [1,750 M + 3,080 F]; PM10 monitors in SC & SD & SF Air Basins) [all natural causes ICD9=001-799]	CA AHSMOG Cohort		RR = 1.01	(0.98 – 1.04)	1977-2006
Jerrett 2011 (N=76,135 [33,625 M + 42,510 F]; 54 counties; 1988-2002 PM10; KRG Zip Model; 20 ind cov+7 eco var; Table 37)	CA CPS II Cohort		RR = 1.001	(0.987-1.017)	1982-2000
Lipsett 2011 (N=73,489 [73,489 F]; 2000-2005 PM10)	CA Teachers Cohort		RR = 1.01	(0.95 – 1.09)	2000-2005

Figure 1. Figures 21 and 5 from HEI Reanalysis Report (Krewski 2000)

Figure 21 Spatial Overlay of PM2.5 Level and Mortality Risk by City (page 197)

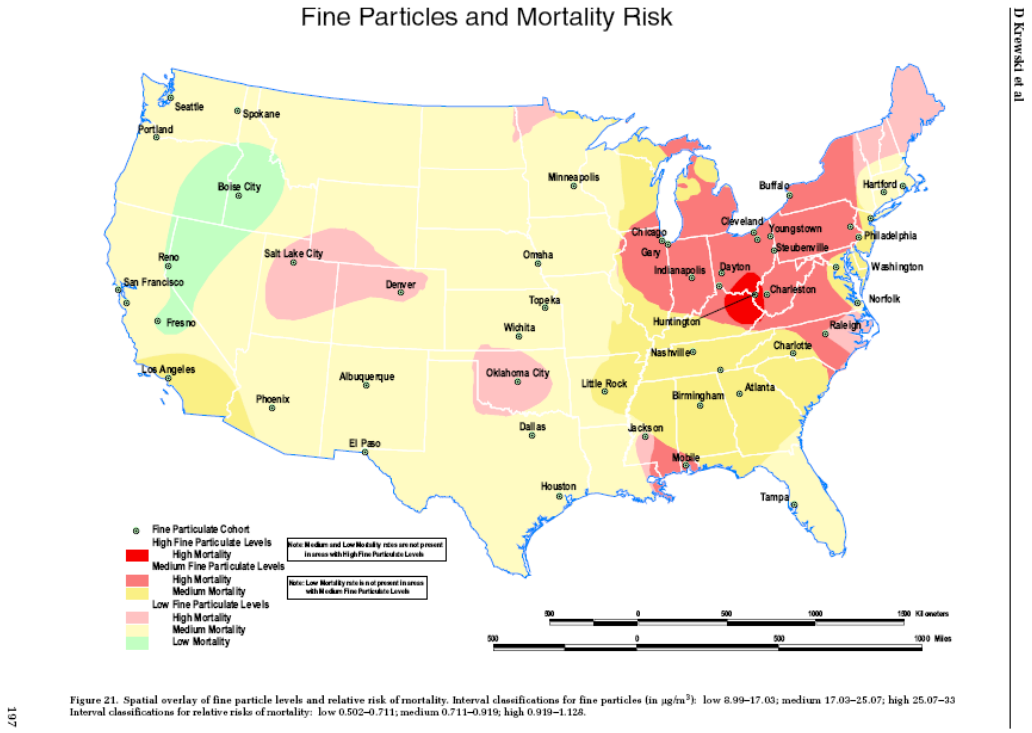

Figure 21. Spatial overlay of fine particle levels and relative risk of mortality. Interval classifications for fine particles (in $\mu g/m^3$): low 8.99–17.03; medium 17.03–25.07; high 25.07–33 Interval classifications for relative risks of mortality: low 0.502–0.711; medium 0.711–0.919; high 0.919–1.128.

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Figure 5 (Upper Right) Relative Risk for PM2.5 and Total Mortality by City (page 161)

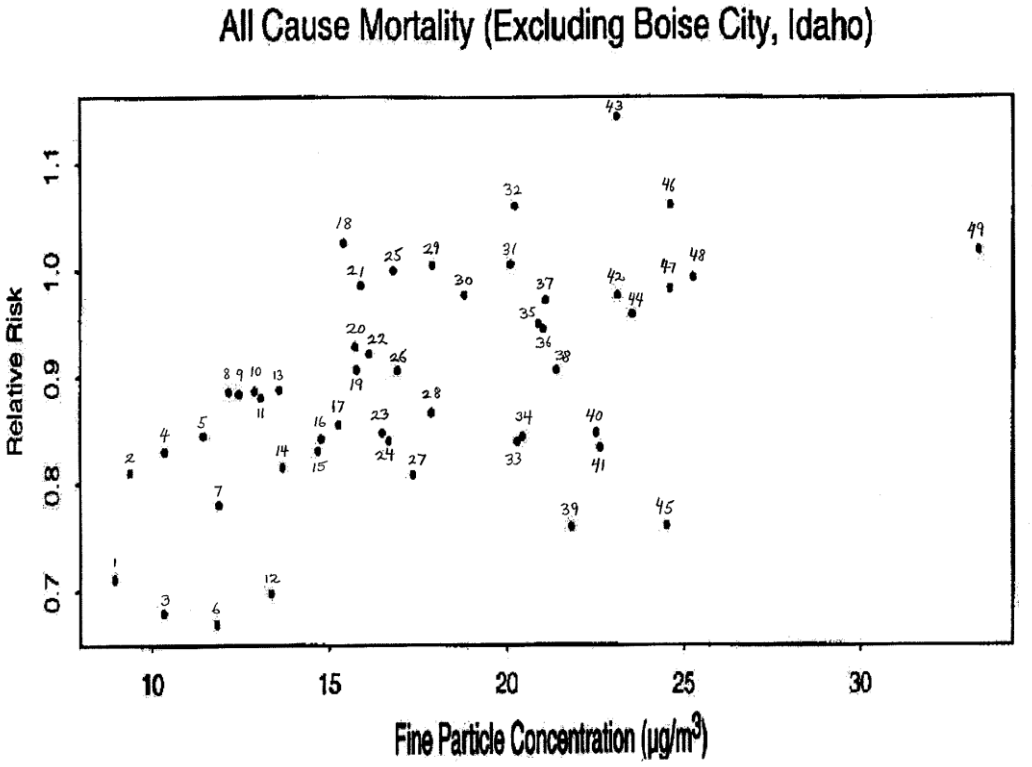
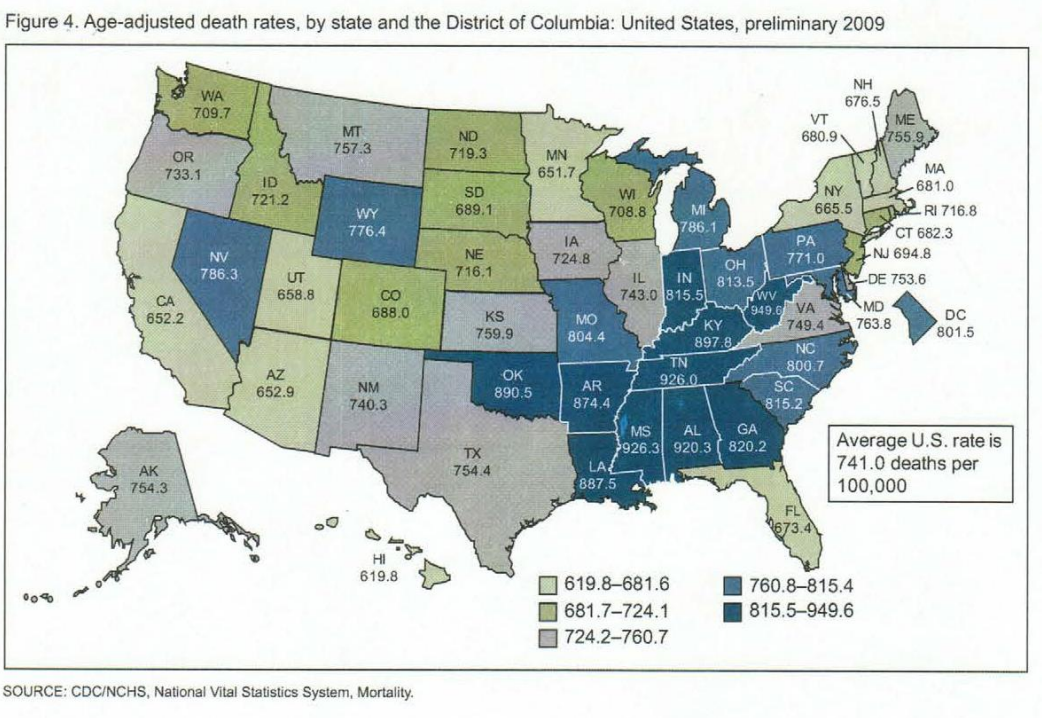


Figure 2. 2009 Age-Adjusted Total Death Rates by State for the United States
NCHS Data Brief Number 64, July 2011 "Death in the United States, 2009"
(http://www.cdc.gov/nchs/data/databriefs/db64.pdf)
(http://www.scientificintegrityinstitute.org/NCHSDR070811.pdf)



Ratio of 2009 Age-Adjusted Total Death Rates (Deaths/100,000)

California / U.S.	652.2 / 741.1 = 0.880 = 88.0%
'South Coast Air Basin' (4 Counties) / U.S.	650.8 / 741.1 = 0.878 = 87.8%
Los Angeles County / U.S.	637.3 / 741.1 = 0.860 = 86.0%
Orange County / U.S.	570.9 / 741.1 = 0.770 = 77.0%

References

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