April 28, 2014

MEMORANDUM

SUBJECT: Corrections to Estimates of Epidemiology-based Mortality and Morbidity Risks Presented in the *Health Risk and Exposure Assessment for Ozone, Second External Review Draft*

FROM: Erika Sasser, Acting Director /s/
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TO: Holly Stallworth
Designated Federal Officer
Clean Air Scientific Advisory Committee
EPA Science Advisory Board Staff Office

This memo documents the identification and correction of errors associated with the epidemiology-based risk estimates presented in the *Health Risk and Exposure Assessment for Ozone, Second External Review Draft* (2nd draft O_3 REA). The purpose of this memo is to (a) document those errors, (b) describe steps taken to correct the errors including quality assurance steps taken, (c) provide a set of revised risk estimates, and (d) discuss the extent to which the revised risk estimates differ from those originally presented in the 2nd draft O_3 REA, including any implications for interpretation of those risk estimates in the context of the 2nd draft O_3 Policy Assessment (2nd draft O_3 PA).

<u>Background</u>

On February 3, 2014, EPA released the *Health Risk and Exposure Assessment for Ozone Second External Review Draft* (2nd draft O_3 REA) which was completed as part of the current review of the National Ambient Air Quality Standards (NAAQS) for ozone. Subsequent to public release of that document, a member of the public requested all of the input data used in completing the epidemiology-based portion of that risk assessment. As described in Chapter 7 and its associated appendices in the 2nd draft O_3 REA, the epidemiology-based risk analysis was completed by EPA using the environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE), which combines GIS-based functionality with a computational framework capable of generating risk estimates using epidemiology-based effect estimates. EPA provided all of the input data used in the BenMAP-CE-based risk assessment to the requestor including composite monitor values, baseline incidence rates, demographic data, epidemiology-based effect estimates and GIS shapefiles outlining the urban study areas included in the risk assessment. The requestor used BenMAP-CE along with these input data provided by EPA to generate risk results comparable to those provided in the 2nd draft O_3 REA.

On March 20, 2014, EPA received an e-mail from the requestor alerting us to a discrepancy between their epidemiology-based risk estimates and the risk estimates presented in Chapter 7 of the 2nd draft O_3 REA. Specifically, they identified potential errors in each of the urban study area population totals used in the derivation of the EPA's risk estimates. All of the urban study area population totals used in EPA's calculations were greater than totals based on the sum of the counties comprising each urban study area with the exception of the New York urban area, for which the total calculated population was less than that expected based on county populations comprising this urban study area. These erroneous urban study area population totals used in EPA's epidemiology-based risk calculations were computed internally by BenMAP-CE based on the input urban study area shapefiles.

Identification of the reason for the erroneous population totals generated by BenMAP-CE

BenMAP-CE utilizes a GIS-based overlay function to estimate the population within a given study area based on underlying county-level demographic data. In EPA risk assessments, the selected urban study areas often encompass several counties. EPA identified that the overlay function in BenMAP-CE was erroneously including entire counties bordering the urban case study areas rather than simply including the counties (or portions of counties) falling within the defined urban study areas. This resulted in the over-estimates of the urban study area populations that were identified by the requestor. This error in the GIS-based overlay function in BenMAP-CE also led to errors in the baseline disease incidence rates derived for each study area because these rates would also include values from counties outside of a given urban study area. Given the goal of developing a revised set of risk estimates for the upcoming CASAC teleconference (to be held on May 28th), EPA determined it was most appropriate to use the previous version of BenMAP (BenMAP 4.0) to generate the corrected epidemiology-based risk estimates. This earlier version of BenMAP uses a different GIS module which does not have the error in the GIS-based overlay function identified in BenMAP-CE. Furthermore, it should be noted that national scale mortality risk estimates presented in Chapter 8 of the 2nd draft O_3 REA were generated using BenMAP 4.0 and did not use the same shapefiles that were used in generating risk estimates for Chapter 7. Thus, this population estimate error does not apply to any of the results presented in Chapter 8.

Development of the corrected risk estimates and associated quality assurance steps

A revised set of risk estimates were generated using BenMAP 4.0 for all health endpoints considered in Chapter 7 of the 2nd draft O3 REA. These data are provided as an attachment to this memo and follow the identical set of table numbering used in that Chapter for direct comparison. As part of ensuring the quality of the revised risk estimates, EPA completed a parallel set of ozone risk estimates outside of BenMAP using SAS software by incorporating county-level demographic and baseline disease incidence rates from the BenMAP 4.0 database along with the appropriate risk functions.[1] As an additional quality assurance step, EPA also compared the study area-level demographic counts used to develop the revised (BenMAP 4.0-based) risk estimates to produce hand calculations of the underlying county-level Census data associated with each urban study area. These two quality assurance steps verified that the revised risk estimates reflect the correct population and baseline disease incidence rate data for each urban study area. Further, in identifying the overlay function error in BenMAP-CE, EPA also discovered that the original GIS shapefile used for the New York urban study area was missing a county of interest, resulting in an underestimate of the population count for that study area. EPA also corrected that error in generating the revised set of epidemiology-based risk estimates for the New York urban study area documented in this memo.

Implications of the revised estimates on the role played by epidemiology-based risk in the review

The error related to the BenMAP-CE GIS-based overlay function as well as the shapefile error for the New York urban study area primarily affected population counts used in generating the risk estimates.[2] Estimates of total attributable deaths and total morbidity counts and estimates of changes in attributable deaths and morbidity counts are affected by population counts. Risks per 100,000 population and percent attributable risk estimates are largely unaffected.[3] Given that most of the observations included in the 2nd draft O_3 PA are based on epidemiology-based risk estimates that focus on population-standardized metrics and not total incidence metrics, this set of revised risk estimates does not substantially change any of the policy-related observations (related to these risk metrics) presented in the 2nd draft O_3 PA.

Description of revised risk results tables and figures included as attachments to this memo

Revised sets of all epidemiology-based risk estimates included in the 2nd draft O_3 REA were generated using BenMAP 4.0 (and the corrected New York City urban study area shapefile) including both core and sensitivity-analysis related estimates. Attached to this memo, we have included an updated set of the risk-related tables and figures included in the body of the 2nd draft O_3 REA (Attachment 1). In many, but not all, cases, the estimates of absolute numbers of deaths, hospital admissions, and symptoms and reductions in those absolute numbers were decreased compared to the original estimates. However, consistent with the observation above, revised Tables 7-8, 7-13, 7-14, and 7-15, in particular (which all reflect risks per 100,000 population or percent attributable risk estimates), are not substantially different from the original version of these tables. Likewise, Figures 7-4 through 7-8 are also largely unchanged from the original versions of these figures. In addition, we have included updated versions of the three figures from the 2nd draft O_3 PA (Attachment 2) that were affected by the altered population counts. Updated epidemiology-based risk estimates, as well as the updated set of the risk-related tables and figures, will be included in the final O_3 REA and PA.

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[1] The parallel set of risk estimates were generated using Base SAS software, Version 9.3 of the SAS System for Windows x64. Copyright ©2002-2010 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks or trademarks of SAS Institute Inc., Cary, NC, USA.

[2] While both shapefile errors will also have an effect on the aggregated baseline incidence rates for the urban area, the effect is small because baseline incidence rates are very similar amongst counties in a given urban area.

[3] In developing our revised risk estimates, EPA also refined our rounding convention used in calculating the total incidence per 100,000 population. This refinement had a negligible to modest impact on the risk results.

We appreciate the advice of the Panel and the opportunity to provide these corrected estimates for your review during the upcoming Panel teleconference on May 28th. Should you have any questions regarding this memorandum, please contact me (919-541-3889; email sasser.erika@epa.gov), Dr. Stephen Graham (919-541-4344; email graham.stephen@epa.gov), or Karen Wesson (919-541-3515; email wesson.karen@epa.gov).

Attachment 1: Revised 2nd Draft O_3 Health Risk and Exposure Assessment (REA) Epidemiology-based Risk and Sensitivity Analysis Tables and Figures

This attachment contains the revised epidemiology-based risk result tables and figures, using the same numbering and presented in the same order as appears in Chapter 7 of the second draft O_3 REA.

Table 7-7 Short-Term O_3-attributable All Cause Mortality Incidence (2007 and 2009) (Smith et al., 2009 C-R Functions) (O_3 season, CBSA-based study area, no threshold)

Study Area	Air Qualtiy Scenario			
	Absolute Incidence	Change in Incidence		
	75ppb	75-70	75-65	75-60
2007 Simulation Year				
Atlanta, GA	220	10	18	28
	(-310 - 740)	(-13 - 32)	(-24 - 60)	(-39 - 95)
Baltimore, MD	230	7	14	23
	(-130 - 570)	(-4 - 17)	(-8 - 35)	(-13 - 59)
Boston, MA	200	4	11	18
	(-290 - 670)	(-6 - 14)	(-16 - 39)	(-25 - 62)
Cleveland, OH	270	8	20	40
	(-25 - 550)	(-1 - 18)	(-2 - 41)	(-4 - 83)
Denver, CO	58	1	3	5
	(-190 - 300)	(-4 - 7)	(-10 - 15)	(-17 - 27)
Detroit, MI	520	18	33	54
	(26 - 990)	(1 - 35)	(2 - 64)	(3 - 110)
Houston, TX	580	4	9	20
	(110 - 1000)	(1 - 8)	(2 - 17)	(4 - 37)
Los Angeles, CA	750	26	52	96
	(-310 - 1800)	(-11 - 62)	(-22 - 130)	(-40 - 230)
New York, NY	3200	150	740	NA
	(1900 - 4500)	(92 - 220)	(440 - 1000)	NA
Philadelphia, PA	920	26	56	86
	(200 - 1600)	(6 - 46)	(12 - 100)	(19 - 150)
Sacramento, CA	160	3	6	10
	(-170 - 480)	(-3 - 9)	(-6 - 17)	(-11 - 31)
St. Louis, MO	350	15	31	49
	(-86 - 770)	(-4 - 33)	(-8 - 70)	(-12 - 110)
2009 Simulation Year				
Atlanta, GA	200	7	13	19
	(-280 - 670)	(-10 - 24)	(-18 - 45)	(-26 - 64)
Baltimore, MD	210	4	9	14
	(-110 - 520)	(-2 - 10)	(-5 - 23)	(-8 - 37)
Boston, MA	180	-1	3	8
	(-260 - 610)	(1 - -2)	(-4 - 10)	(-11 - 27)
Cleveland, OH	250	7	18	31
	(-23 - 510)	(-1 - 15)	(-2 - 37)	(-3 - 64)
Denver, CO	56	0	1	5
	(-180 - 290)	(-1 - 1)	(-4 - 7)	(-15 - 25)
Detroit, MI	460	-17	-5	12
	(23 - 880)	(-1 - -33)	(0 - -10)	(1 - 23)
Houston, TX	600	-1	3	12
	(110 - 1100)	(0 - -1)	(1 - 6)	(2 - 22)
Los Angeles, CA	770	25	53	98
	(-320 - 1800)	(-10 - 60)	(-22 - 130)	(-41 - 240)
New York, NY	3000	96	500	NA
	(1800 - 4200)	(57 - 130)	(300 - 700)	NA
Philadelphia, PA	820	14	33	51
	(180 - 1400)	(3 - 25)	(7 - 58)	(11 - 90)
Sacramento, CA	160	3	5	9
	(-170 - 490)	(-3 - 8)	(-6 - 17)	(-10 - 28)
St. Louis, MO	310	7	17	30
	(-77 - 690)	(-2 - 15)	(-4 - 37)	(-7 - 67)

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

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Table 7-8 Percent of Total All-Cause Mortality Attributable to O_3 and Percent Change in Ozone-Attributable Risk (2007 and 2009) (Smith et al., 2009 C-R functions) (O_3 season, CBSA-based study area, no threshold)

Study Area	Air Quality Scenario			
	% of Baseline Incidence	% Change in O_3-Attributable Risk		
	75ppb	75-70	75-65	75-60
2007 Simulation Year				
Atlanta, GA	1.1	4	8	13
Baltimore, MD	1.9	3	6	10
Boston, MA	1.2	2	5	9
Cleveland, OH	2.4	3	7	14
Denver, CO	0.8	2	5	9
Detroit, MI	3.0	3	6	10
Houston, TX	1.9	1	2	3
Los Angeles, CA	1.0	3	7	13
New York, NY	4.1	5	22	NA
Philadelphia, PA	3.2	3	6	9
Sacramento, CA	1.2	2	3	6
St. Louis, MO	2.5	4	9	14
2009 Simulation Year				
Atlanta, GA	1.0	3	7	9
Baltimore, MD	1.8	2	4	7
Boston, MA	1.1	-0.3	2	4
Cleveland, OH	2.3	3	7	12
Denver, CO	0.8	0.3	2	8
Detroit, MI	2.7	-4	-1	3
Houston, TX	1.9	-0.1	0.5	2
Los Angeles, CA	1.1	3	7	13
New York, NY	4.0	3	16	NA
Philadelphia, PA	3.0	2	4	6
Sacramento, CA	1.2	2	3	6
St. Louis, MO	2.3	2	5	9

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

Figure 7-2 Heat Maps for Short Term O_3-attributable Mortality (Just meeting existing standard and risk reductions from just meeting alternative standards) (2007) (Smith et al., 2009 C-R functions) (see Key at bottom of figure)

Current Standard (75)

Study area	Daily 8hr Max Ozone Level (ppb)																Total
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75	
Atlanta, GA	0	0	0	0	2	4	15	20	34	43	52	31	12	5	3	0	222
Baltimore, MD	0	0	0	0	1	6	11	22	43	37	36	38	23	6	5	2	228
Boston, MA	0	0	0	0	2	11	26	29	33	33	20	12	17	5	7	6	202
Cleveland, OH	0	0	0	1	3	9	25	41	55	50	27	25	19	8	6	0	268
Denver, CO	0	0	0	0	0	0	1	3	4	9	12	15	10	3	1	0	58
Detroit, MI	0	0	0	0	1	5	33	56	97	116	59	41	44	16	34	14	516
Houston, TX	0	0	0	0	14	42	107	124	126	81	42	42	2	0	0	0	580
Los Angeles, CA	0	0	0	0	0	0	0	10	204	268	233	27	8	3	0	0	753
New York, NY	0	0	0	0	24	113	341	625	851	545	418	268	45	0	0	0	3,230
Philadelphia, PA	0	0	0	2	0	25	46	115	157	175	155	122	75	31	7	7	916
Sacramento, CA	0	0	0	0	1	8	23	43	29	29	17	9	2	1	0	0	161
St. Louis, MO	0	0	0	1	2	6	15	52	53	61	60	38	24	23	10	3	348

Decrease 75 to 70

Study area	Daily 8hr Max Ozone Level (ppb)																Total	Change in risk	
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75		Inc.	Dec.
Atlanta, GA	0	0	0	0	0	0	0	0	1	2	3	2	1	0	0	0	10	0	10
Baltimore, MD	0	0	0	0	0	0	0	0	1	1	1	2	1	0	0	0	7	0	6
Boston, MA	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	0	4	0	3
Cleveland, OH	0	0	0	0	0	0	0	0	1	2	1	2	1	1	0	0	8	0	10
Denver, CO	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1
Detroit, MI	0	0	0	0	0	0	0	0	2	4	3	2	3	1	3	1	18	0	19
Houston, TX	0	0	0	0	-1	-1	-1	0	2	2	2	2	0	0	0	0	4	-3	8
Los Angeles, CA	0	0	0	0	0	0	0	0	4	10	10	1	0	0	0	0	26	0	25
New York, NY	0	0	0	0	-1	-2	0	14	31	37	41	29	6	0	0	0	154	-13	167
Philadelphia, PA	0	0	0	0	0	-1	0	0	2	5	6	6	4	2	0	1	26	-2	27
Sacramento, CA	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	3	0	4
St. Louis, MO	0	0	0	0	0	0	0	1	2	3	3	2	2	2	1	0	15	0	16

Decrease 75 to 65

Study area	Daily 8hr Max Ozone Level (ppb)																Total	Change in risk	
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75		Inc.	Dec.
Atlanta, GA	0	0	0	0	0	0	1	1	2	4	5	3	1	1	0	0	18	0	18
Baltimore, MD	0	0	0	0	0	0	0	0	2	2	3	4	2	1	1	0	14	0	15
Boston, MA	0	0	0	0	0	0	0	1	1	2	2	1	2	1	1	1	11	0	12
Cleveland, OH	0	0	0	0	0	0	0	1	4	4	3	3	3	1	1	0	20	-1	20
Denver, CO	0	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0	3	0	3
Detroit, MI	0	0	0	0	0	0	-1	0	3	7	5	4	5	2	5	2	33	-2	35
Houston, TX	0	0	0	0	-2	-2	-3	0	4	4	3	4	0	0	0	0	9	-8	16
Los Angeles, CA	0	0	0	0	0	0	0	0	8	20	21	2	1	0	0	0	52	0	52
New York, NY	0	0	0	0	-1	2	27	98	172	156	156	103	22	0	0	0	735	-7	742
Philadelphia, PA	0	0	0	0	0	-1	-1	0	5	11	13	14	9	4	1	1	56	-4	60
Sacramento, CA	0	0	0	0	0	0	-1	1	1	2	1	1	0	0	0	0	6	-1	6
St. Louis, MO	0	0	0	0	0	0	0	2	4	6	6	5	3	3	2	0	31	0	31

Decrease 75 to 60

Study area	Daily 8hr Max Ozone Level (ppb)																Total	Change in risk	
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75		Inc.	Dec.
Atlanta, GA	0	0	0	0	0	0	1	2	4	6	7	5	2	1	1	0	28	0	29
Baltimore, MD	0	0	0	0	0	0	0	0	3	4	5	6	4	1	1	0	23	0	25
Boston, MA	0	0	0	0	0	0	0	1	2	3	3	2	3	1	2	1	18	0	19
Cleveland, OH	0	0	0	0	0	0	0	3	7	9	6	6	5	2	2	0	40	-2	41
Denver, CO	0	0	0	0	0	0	0	0	0	0	1	2	2	1	0	0	5	0	6
Detroit, MI	0	0	0	0	0	0	-1	1	6	11	8	7	8	4	7	3	54	-2	57
Houston, TX	0	0	0	0	-2	-4	-4	1	7	8	6	7	1	0	0	0	20	-11	31
Los Angeles, CA	0	0	0	0	0	0	0	1	24	35	29	4	1	1	0	0	96	0	95
New York, NY	NA																		
Philadelphia, PA	0	0	0	0	0	-1	-1	1	8	17	19	20	13	6	1	2	86	-4	89
Sacramento, CA	0	0	0	0	0	-1	-1	2	3	3	2	1	0	0	0	0	10	-2	11
St. Louis, MO	0	0	0	0	0	0	0	4	6	9	10	7	5	5	2	1	49	0	49

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

Key: For *current standard (75)* which is an absolute risk metric expressed as incidence of mortality, color gradient ranges from blue (smallest O_3-related mortality count) to red (highest O_3-related mortality count). For *estimates of decreases in risk*, color gradient ranges from red (increase in risk – negative cell values) to blue (reduction in risk – positive cell values).

Figure 7-3 Heat Maps for Short Term O_3-attributable Mortality (Just meeting existing standard and risk reductions from just meeting alternative standards) (2009) (Smith et al., 2009 C-R functions) (see Key at bottom of figure)

Current Standard (75)

Study area	Daily 8hr Max Ozone Level (ppb)																Total
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75	
Atlanta, GA	0	0	1	2	7	13	15	28	41	37	24	25	8	1	0	0	201
Baltimore, MD	0	0	0	0	2	7	21	36	33	47	33	23	6	0	0	0	207
Boston, MA	0	0	0	0	7	14	26	33	29	31	27	4	2	3	5	2	183
Cleveland, OH	0	0	0	0	3	16	28	42	46	50	35	17	7	4	0	0	249
Denver, CO	0	0	0	0	0	1	2	3	6	12	15	13	4	1	0	0	56
Detroit, MI	0	0	1	7	5	21	36	53	89	116	30	40	36	0	17	5	456
Houston, TX	0	0	0	5	24	43	105	107	96	77	72	31	23	6	3	3	595
Los Angeles, CA	0	0	0	0	0	0	1	10	168	196	297	91	5	0	0	0	770
New York, NY	0	0	0	7	41	246	489	407	724	538	314	201	64	0	0	0	3,031
Philadelphia, PA	0	0	0	2	12	38	118	93	162	130	151	67	50	0	0	0	822
Sacramento, CA	0	0	0	0	1	10	28	30	32	24	18	14	3	0	0	0	162
St. Louis, MO	0	0	1	5	5	14	22	44	42	63	53	43	11	7	0	0	310

Decrease 75 to 70

Study area	Daily 8hr Max Ozone Level (ppb)																Total	Change in risk	
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75		Inc.	Dec.
Atlanta, GA	0	0	0	0	0	0	0	1	1	2	2	2	1	0	0	0	7	0	9
Baltimore, MD	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	4	0	4
Boston, MA	0	0	0	0	-1	0	-1	0	0	0	0	0	0	0	0	0	-1	-3	2
Cleveland, OH	0	0	0	0	0	0	0	1	1	2	2	1	0	0	0	0	7	0	7
Denver, CO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Detroit, MI	0	0	-1	-2	-1	-4	-4	-4	-4	-1	0	1	2	0	1	0	-17	-22	5
Houston, TX	0	0	0	-1	-2	-2	-3	-1	1	1	2	1	1	0	0	0	-1	-9	6
Los Angeles, CA	0	0	0	0	0	0	0	0	3	6	12	4	0	0	0	0	25	0	25
New York, NY	0	0	0	-1	-4	-16	-9	9	26	36	26	21	7	0	0	0	96	-44	139
Philadelphia, PA	0	0	0	0	-1	-2	-2	-1	3	4	6	3	3	0	0	0	14	-6	21
Sacramento, CA	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	0	3	0	4
St. Louis, MO	0	0	0	-1	0	-1	0	0	1	2	2	2	1	0	0	0	7	-2	9

Decrease 75 to 65

Study area	Daily 8hr Max Ozone Level (ppb)																Total	Change in risk	
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75		Inc.	Dec.
Atlanta, GA	0	0	0	0	-1	-1	0	1	3	4	3	3	1	0	0	0	13	-2	15
Baltimore, MD	0	0	0	0	0	0	0	0	1	3	2	2	1	0	0	0	9	-1	11
Boston, MA	0	0	0	0	-1	-1	-1	0	1	1	2	0	0	0	1	0	3	-4	6
Cleveland, OH	0	0	0	0	0	-1	0	2	3	5	4	3	1	1	0	0	18	-1	21
Denver, CO	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1
Detroit, MI	0	0	-1	-3	-1	-5	-4	-3	-2	3	1	4	4	0	2	1	-5	-21	16
Houston, TX	0	0	0	-1	-4	-4	-5	-1	2	3	5	3	3	1	1	0	3	-15	19
Los Angeles, CA	0	0	0	0	0	0	0	0	6	14	25	8	0	0	0	0	53	0	53
New York, NY	0	0	0	-1	-5	-19	18	60	122	138	93	72	24	0	0	0	500	-48	550
Philadelphia, PA	0	0	0	0	-2	-3	-3	-1	8	8	13	7	6	0	0	0	33	-11	44
Sacramento, CA	0	0	0	0	0	-1	0	1	2	2	1	1	0	0	0	0	5	-2	7
St. Louis, MO	0	0	0	-1	-1	-1	0	1	2	5	5	5	1	1	0	0	17	-4	22

Decrease 75 to 60

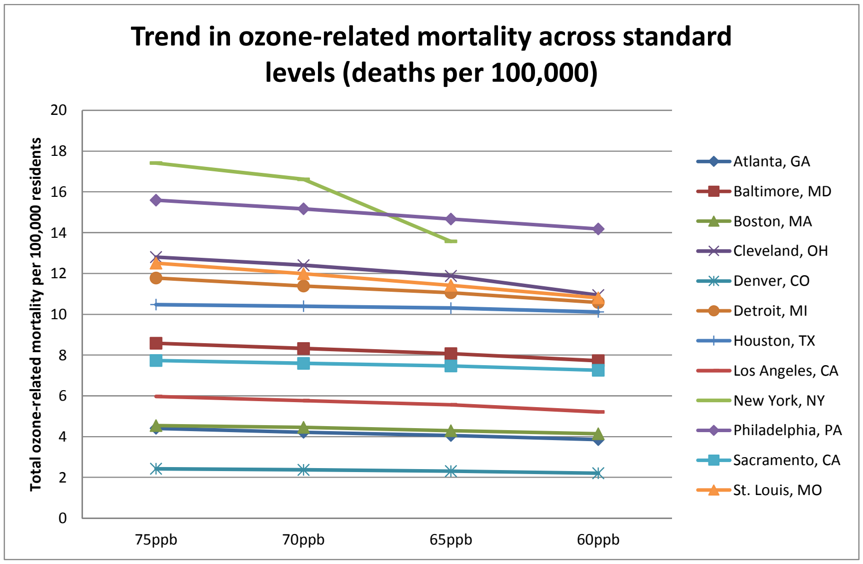
Study area	Daily 8hr Max Ozone Level (ppb)																Total	Change in risk	
	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75		Inc.	Dec.
Atlanta, GA	0	0	0	0	-1	-1	0	2	4	5	4	4	2	0	0	0	19	-2	21
Baltimore, MD	0	0	0	0	0	-1	0	1	2	5	4	3	1	0	0	0	14	-2	16
Boston, MA	0	0	0	0	-1	-1	-1	1	1	3	3	1	0	0	1	0	8	-4	11
Cleveland, OH	0	0	0	0	0	0	1	4	5	8	7	4	2	1	0	0	31	-1	33
Denver, CO	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	5	0	5
Detroit, MI	0	0	-1	-4	-2	-6	-4	-2	1	8	3	6	6	0	4	1	12	-22	32
Houston, TX	0	0	0	-2	-6	-6	-6	0	4	7	9	5	5	1	1	1	12	-22	35
Los Angeles, CA	0	0	0	0	0	0	0	1	19	26	37	13	1	0	0	0	98	0	97
New York, NY										NA									
Philadelphia, PA	0	0	0	-1	-2	-4	-3	0	12	12	19	10	8	0	0	0	51	-14	65
Sacramento, CA	0	0	0	0	0	-1	-1	1	3	3	2	2	0	0	0	0	9	-2	11
St. Louis, MO	0	0	-1	-2	-1	-1	0	3	4	8	8	7	2	1	0	0	30	-6	34

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

Key: For *current standard (75)* which is an absolute risk metric, color gradient ranges from blue (smallest O_3-related mortality count) to red (highest O_3-related mortality count). For *estimates of decreases in risk*, color gradient ranges from red (increase in risk – negative cell values) to blue (reduction in risk – positive cell values).

Figure 7-4 Plots of Short-Term O_3-attributable All-Cause Mortality for Meeting Existing standard and Alternative Standards (Smith et al., 2009) (Simulation year 2007 and 2009)

2007 Simulation year



2009 Simulation year

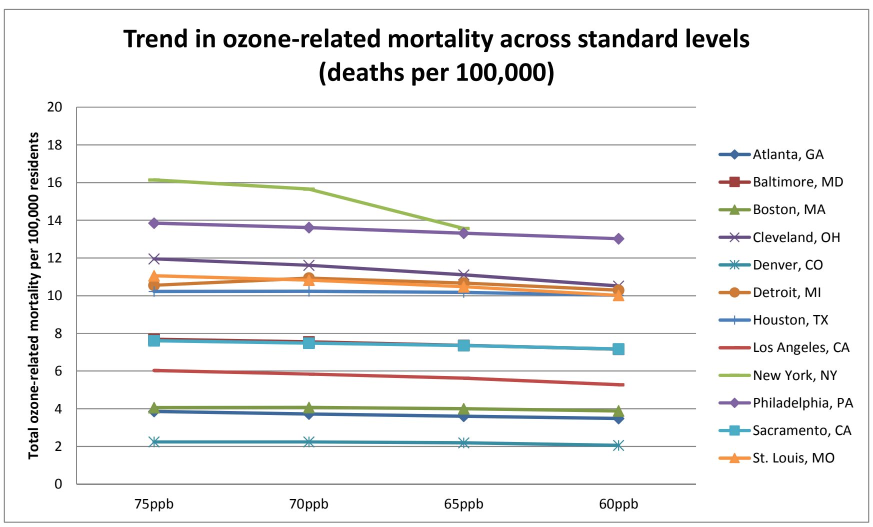


Table 7-9 Short-Term O_3-attributable Morbidity Incidence, Percent of Baseline and Reduction in Ozone-attributable Risk – Respiratory-Related Hospital Admissions (2007 and 2009)

Endpoint/Study Area/Descriptor	Air Quality Scenario							
	Absolute Incidence	Change in Incidence			Percent of Baseline	% Change in Ozone-Related Risk		
	75ppb	75-70	75-65	75-60	75ppb	75-70	75-65	75-60
2007 Simulation Year								
HA (respiratory); Detroit (Katsouyanni et al., 2009)								
1hr max, penalized splines	190	10	18	29	2.8	5	10	15
1hr max, natural splines	180	9.8	18	28	2.7	5	10	15
HA (respiratory); NYC (Silverman and Ito, 2010; Lin et al., 2008)								
HA Chronic Lung Disease (Lin)	140	7.9	34	NA	3.3	5	23	NA
HA Asthma (Silverman)	490	33	140		27.7	5	21	
HA Asthma, PM2.5 (Silverman)	360	23	98		20.2	5	22	
HA (respiratory); LA (Linn et al., 2000)								
1hr max penalized splines	480	11	23	36	2.4	2	5	7
HA (COPD less asthma); all 12 study areas (Medina-Ramon, et al., 2006)								
Atlanta, GA	55	3	5	8	2.5	5	9	15
Baltimore, MD	40	1	3	5	2.6	4	7	12
Boston, MA	58	1	3	6	2.2	2	6	9
Cleveland, OH	37	1	3	6	2.4	4	8	17
Denver, CO	18	1	1	2	2.9	3	6	11
Detroit, MI	71	2	4	7	2.5	3	6	10
Houston, TX	57	1	2	3	2.1	1	3	6
Los Angeles, CA	110	5	10	15	2.7	4	9	13
New York, NY	200	13	57	NA	2.2	6	28	NA
Philadelphia, PA	97	3	7	11	2.5	3	7	11
Sacramento, CA	15	1	1	2	2.5	3	7	11
St. Louis, MO	43	2	4	7	2.6	5	10	15
2009 Simulation Year								
HA (respiratory); Detroit (Katsouyanni et al., 2009)								
1hr max, penalized splines	170	2.8	10	20	2.5	2	6	11
1hr max, natural splines	160	2.7	9.8	19	2.4	2	6	11
HA (respiratory); NYC (Silverman and Ito, 2010; Lin et al., 2008)								
HA Chronic Lung Disease (Lin)	140	5.9	25	NA	3.2	4	17	NA
HA Asthma (Silverman)	470	28	110		27.3	4	17	
HA Asthma, PM2.5 (Silverman)	350	20	79		19.9	4	18	
HA (respiratory); LA (Linn et al., 2000)								
1hr max penalized splines	500	11	23	37	2.4	2	4	7
HA (COPD less asthma); all 12 study areas (Medina-Ramon, et al., 2006)								
Atlanta, GA	52	3	4	6	2.2	5	8	12
Baltimore, MD	37	1	2	3	2.3	2	5	8
Boston, MA	53	0	1	2	2.0	0	1	4
Cleveland, OH	36	1	3	5	2.2	3	8	14
Denver, CO	18	0	1	2	2.7	1	4	11
Detroit, MI	64	-3	-1	1	2.2	-4	-2	1
Houston, TX	63	0	1	3	2.2	1	2	5
Los Angeles, CA	120	5	10	16	2.7	4	8	13
New York, NY	190	8	40	NA	2.1	4	20	NA
Philadelphia, PA	88	2	4	6	2.3	2	4	7
Sacramento, CA	16	1	1	2	2.4	3	7	11
St. Louis, MO	41	2	3	5	2.4	3	8	12

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

Table 7-10 Short-Term O_3-attributable Morbidity Incidence, Percent of Baseline and Reduction in Ozone-attributable Risk – Emergency Room Visits (2007 and 2009)

		Air Quality Scenario						
	Absolute Incidence	Change in Incidence			Percent of Baseline	% Change in Ozone-Related Risk		
Endpoint/Study Area/Descriptor	75ppb	75-70	75-65	75-60	75ppb	75-70	75-65	75-60
2007 Simulation Year								
ER Visits (repiratory); Atlanta (Strickland et al., 2007)								
Distributed lag 0-7 days	6,600	350	650	1,000	19.6	4	8	13
Average day lag 0-2	3,900	200	370	580	11.6	5	8	13
ER-visits (respiratory); Atlanta (Tolbert et al., 2007, Darrow et al., 2011)								
Tolbert	7,000	310	580	920	5.8	4	8	12
Tolbert-CO	6,300	280	510	810	5.1	4	8	12
Tolbert-NO2	5,700	250	460	730	4.6	4	8	12
Tolbert-PM10	4,400	200	360	570	3.6	4	8	12
Tolbert-PM10, NO2	4,300	190	350	550	3.5	4	8	12
Darrow	3,800	170	310	490	3.1	4	8	12
ER-visits (asthma); NYC (Ito et al, 2007)								
single pollutant model	11,000	620	2,700	NA	19.9	5	22	NA
PM2.5	8,300	480	2,100		15.5	5	22	
NO2	6,800	390	1,700		12.8	5	23	
CO	11,000	660	2,900		21.0	5	22	
SO2	8,500	490	2,200		16.1	5	22	
2009 Simulation Year								
ER Visits (repiratory); Atlanta (Strickland et al., 2007)								
Distributed lag 0-7 days	5,900	270	490	700	17.2	4	7	10
Average day lag 0-2	3,500	150	280	400	10.1	4	7	10
ER-visits (respiratory); Atlanta (Tolbert et al., 2007, Darrow et al., 2011)								
Tolbert (single pollutant	6,400	230	440	620	5.1	3	6	9
Tolbert-CO	5,700	200	390	550	4.5	3	6	9
Tolbert-NO2	5,200	180	350	500	4.1	3	6	9
Tolbert-PM10	4,100	140	270	390	3.2	3	6	9
Tolbert-PM10, NO2	3,900	140	260	380	3.1	3	6	9
Darrow (single pollutant	3,500	120	230	330	2.8	3	6	9
ER-visits (asthma); NYC (Ito et al, 2007)								
single pollutant model	10,000	470	2,100	NA	19.3	4	17	NA
PM2.5	8,100	360	1,600		15.1	4	17	
NO2	6,700	290	1,300		12.4	4	18	
CO	11,000	500	2,200		20.4	4	17	
SO2	8,300	370	1,700		15.5	4	17	

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

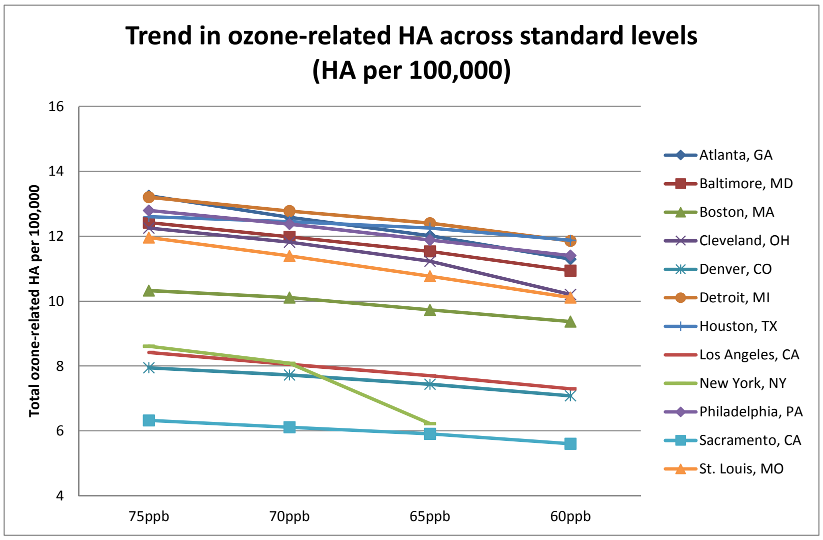
Table 7-11 Short-Term O_3-attributable Morbidity Incidence, Percent of Baseline and Reduction in Ozone-attributable Risk – Asthma Exacerbations (2007 and 2009)

Endpoint/Study Area/Descriptor	Air Quality Scenario							
	Absolute Incidence	Change in Incidence			Percent of Baseline	% Change in Ozone-Related Risk		
	75ppb	75-70	75-65	75-60	75ppb	75-70	75-65	75-60
2007 Simulation Year								
Asthma exacerbation (wheeze); Boston (Gent et al., 2003, 2004)								
Chest Tightness (1hr max)	40,000	1,200	3,300	5,100	28.9	2	5	9
Chest Tightness (8hr max)	30,000	680	1,900	3,000	21.2	2	5	8
Chest Tightness (1hr max, PM2.5)[a]	41,000	1,200	3,300	5,100	29.1	2	5	9
Chest Tightness (1hr max, PM2.5)[b]	38,000	1,100	3,000	4,700	26.9	2	5	9
Shortness of Breath (1hr max)	29,000	800	2,200	3,400	16.3	2	6	10
Shortness of Breath (8hr max)	35,000	780	2,100	3,400	19.6	2	5	8
Wheeze (PM2.5)	76,000	2,200	6,000	9,300	23.3	2	6	9
2009 Simulation Year								
Asthma exacerbation (wheeze); Boston (Gent et al., 2003, 2004)								
Chest Tightness (1hr max)	38,000	290	1,400	2,800	27.0	0.4	2	5
Chest Tightness (8hr max)	28,000	-110	470	1,300	19.8	-0.4	1	3
Chest Tightness (1hr max, PM2.5)[a]	38,000	300	1,400	2,900	27.2	0.4	2	5
Chest Tightness (1hr max, PM2.5)[b]	35,000	270	1,300	2,600	25.1	0.4	3	5
Shortness of Breath (1hr max)	27,000	190	930	1,900	15.1	1	3	6
Shortness of Breath (8hr max)	32,000	-120	540	1,500	18.3	-0.4	1	4
Wheeze (PM2.5)	71,000	530	2,600	5,200	21.7	0.5	3	6

a-privous day, b-same day

Figure 7-5 Plots of Short-Term O_3-attributable Respiratory HA for Meeting Existing standard and Alternative Standards (Medina-Ramon, et al., 2006) (Simulation year 2007 and 2009)

2007 Simulation year



2009 Simulation year

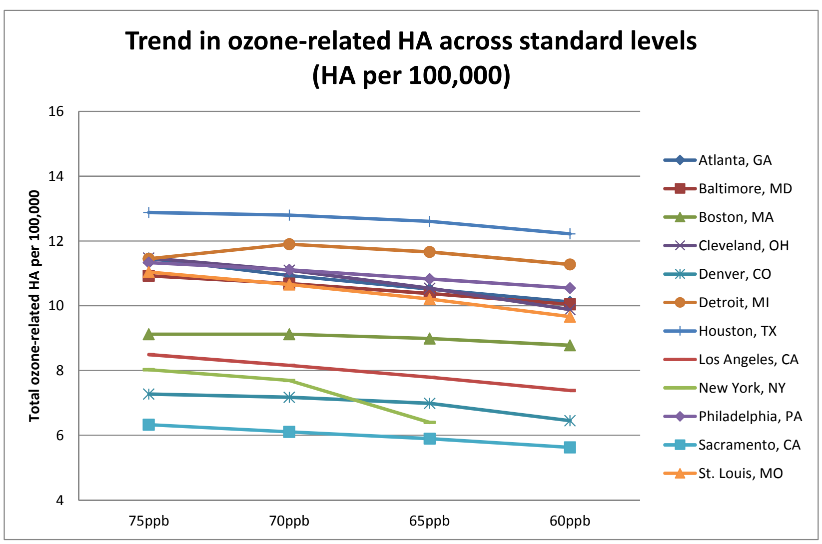


Table 7-12 Long-Term O_3-attributable Respiratory Mortality Incidence (2007 and 2009) (Jerrett et al., 2009 C-R Functions) (CBSA-based study area, no threshold)

Study Area	Air Qualtiy Scenario			
	Absolute Incidence	Change in Incidence		
	75ppb	75-70	75-65	75-60
2007 Simulation Year				
Atlanta, GA	590	35	64	100
	(370 - 920)	(22 - 59)	(39 - 110)	(61 - 160)
Baltimore, MD	390	17	35	57
	(250 - 610)	(11 - 29)	(21 - 57)	(35 - 93)
Boston, MA	640	20	53	82
	(410 - 1000)	(12 - 33)	(33 - 88)	(51 - 140)
Cleveland, OH	330	16	35	64
	(210 - 510)	(10 - 27)	(21 - 58)	(39 - 100)
Denver, CO	330	13	26	43
	(210 - 500)	(8 - 21)	(16 - 44)	(27 - 71)
Detroit, MI	600	28	50	78
	(380 - 940)	(17 - 46)	(30 - 82)	(48 - 130)
Houston, TX	460	8.0	16	27
	(290 - 720)	(5 - 13)	(10 - 26)	(16 - 44)
Los Angeles, CA	1,500	82	160	240
	(990 - 2400)	(50 - 140)	(97 - 260)	(150 - 400)
New York, NY	2,100	140	550	NA
	(1300 - 3300)	(86 - 230)	(340 - 900)	
Philadelphia, PA	930	42	87	130
	(590 - 1400)	(25 - 69)	(54 - 140)	(79 - 210)
Sacramento, CA	300	14	26	44
	(190 - 470)	(8 - 22)	(16 - 43)	(27 - 73)
St. Louis, MO	480	27	56	84
	(310 - 750)	(330 - 800)	(34 - 92)	(52 - 140)
2009 Simulation Year				
Atlanta, GA	550	32	59	82
	(350 - 860)	(20 - 53)	(36 - 98)	(51 - 140)
Baltimore, MD	360	12	27	41
	(230 - 560)	(7 - 20)	(16 - 44)	(25 - 68)
Boston, MA	580	3.7	23	47
	(370 - 920)	(2 - 6)	(14 - 38)	(29 - 77)
Cleveland, OH	300	14	32	50
	(190 - 470)	(9 - 24)	(20 - 53)	(31 - 82)
Denver, CO	320	5.8	18	45
	(200 - 490)	(4 - 10)	(11 - 30)	(28 - 75)
Detroit, MI	540	-6.7	14	38
	(340 - 850)	(-4 - -11)	(8 - 23)	(24 - 64)
Houston, TX	490	11	24	40
	(310 - 770)	(7 - 18)	(15 - 40)	(24 - 66)
Los Angeles, CA	1,600	77	160	250
	(1000 - 2400)	(47 - 130)	(98 - 260)	(150 - 400)
New York, NY	2,000	120	420	NA
	(1300 - 3200)	(73 - 200)	(260 - 690)	
Philadelphia, PA	850	31	66	97
	(540 - 1300)	(19 - 52)	(41 - 110)	(60 - 160)
Sacramento, CA	310	14	28	44
	(190 - 480)	(9 - 24)	(17 - 46)	(27 - 73)
St. Louis, MO	440	19	41	66
	(280 - 690)	(290 - 700)	(25 - 67)	(41 - 110)

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

Table 7-13 Long-Term O_3-attributable Respiratory Mortality Percent of Baseline Incidence and Percent Reduction in O_3-attributable Risk (simulation years 2007 and 2009) (Jerrett et al., 2009 C-R Functions) (CBSA-based study area, no threshold)

Study Area	Air Quality Scenario			
	% of Baseline Incidence	% Change in O_3-Attributable Risk		
	75ppb	75-70	75-65	75-60
2007 Simulation Year				
Atlanta, GA	18.6	5	9	15
Baltimore, MD	18.8	4	8	12
Boston, MA	17.2	3	7	11
Cleveland, OH	17.7	4	9	17
Denver, CO	20.8	3	7	11
Detroit, MI	18.4	4	7	11
Houston, TX	16.3	1	3	5
Los Angeles, CA	20.4	4	9	13
New York, NY	16.9	6	24	NA
Philadelphia, PA	18.4	4	8	12
Sacramento, CA	17.8	4	7	13
St. Louis, MO	18.8	5	10	15
2009 Simulation Year				
Atlanta, GA	17.0	5	9	13
Baltimore, MD	17.4	3	6	10
Boston, MA	16.0	1	3	7
Cleveland, OH	16.8	4	9	15
Denver, CO	20.0	1	5	12
Detroit, MI	17.0	-1	2	6
Houston, TX	16.9	2	4	7
Los Angeles, CA	20.7	4	8	13
New York, NY	16.7	5	18	NA
Philadelphia, PA	17.2	3	7	10
Sacramento, CA	18.0	4	8	12
St. Louis, MO	17.7	4	8	13

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

Figure 7-6 Plots of Long-Term O3-attributable Respiratory Mortality for Meeting Existing standard and Alternative Standards (Jerrett et al., 2009) (Simulation year 2007 and 2009)

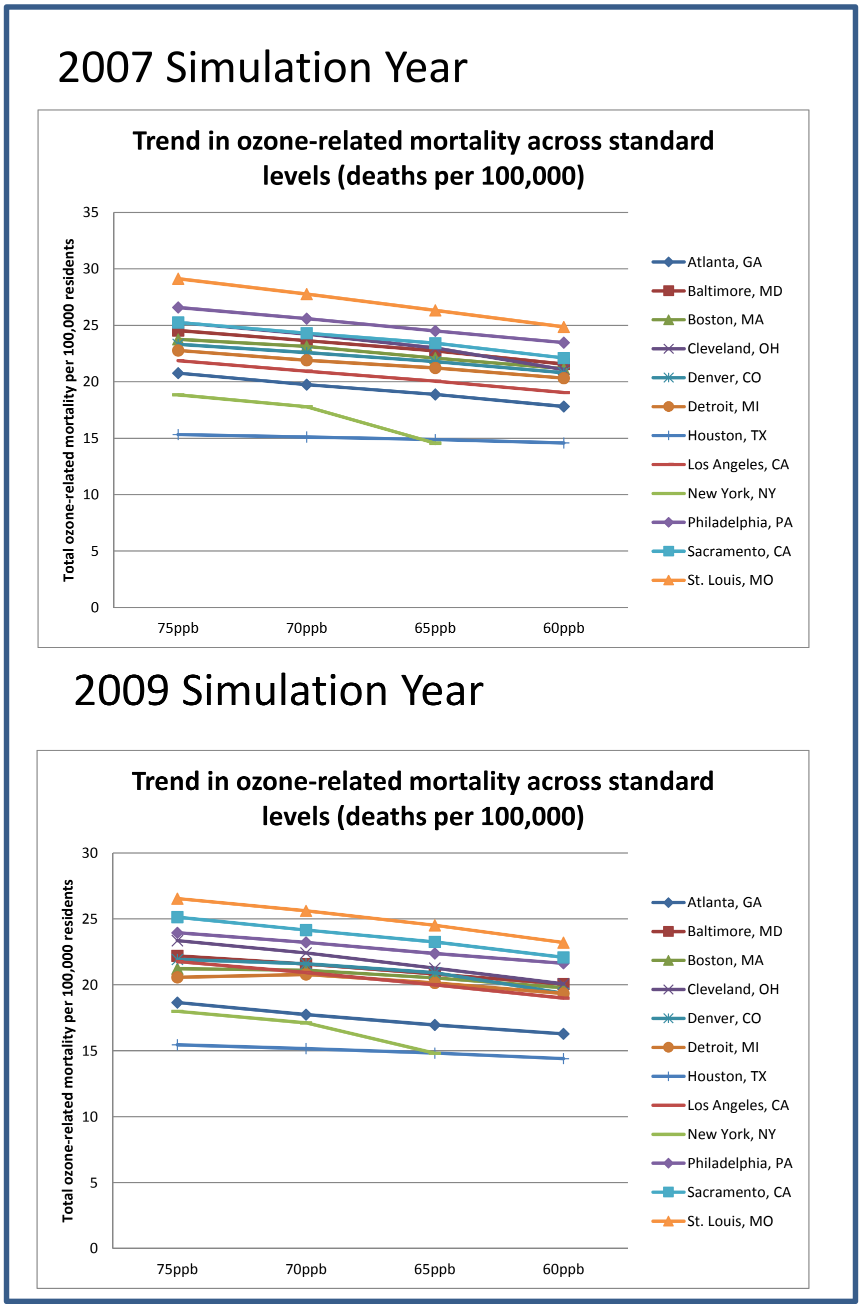


Figure 7-7 Sensitivity Analysis: Short-Term O3-attributable Mortality (air quality-related factors including study area size and method used to simulate attainment of existing and alternative standard levels) (2009) SA1-smaller (Smith-based) study area, SA2-alternative method for simulating standards.

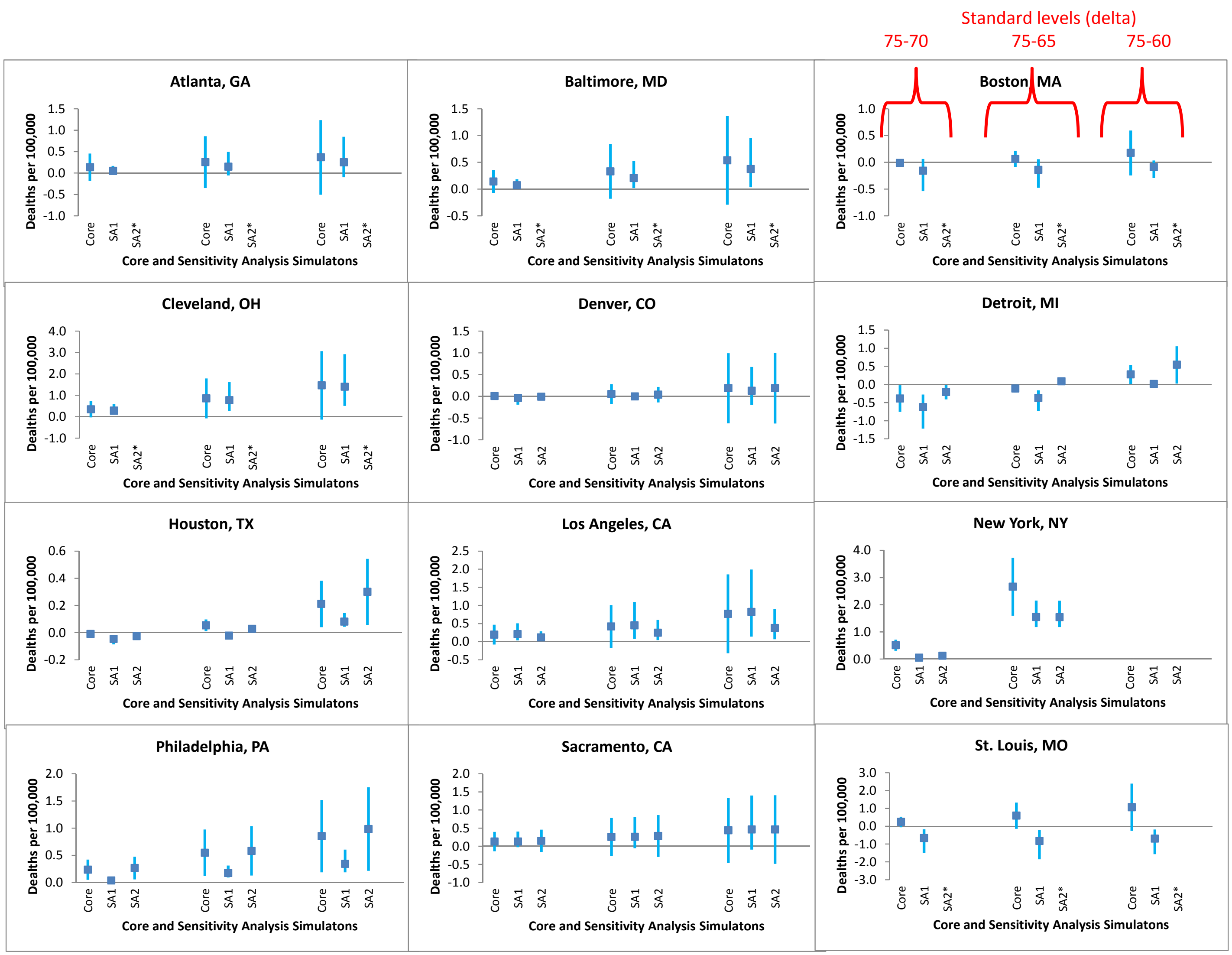


Figure 7-8 Sensitivity Analysis: Short-Term O_3-attributable Mortality (C-R function specification) (2009) SA1-regional Bayes-based adjustment; SA2-copollutant model (PM_{10}); SA

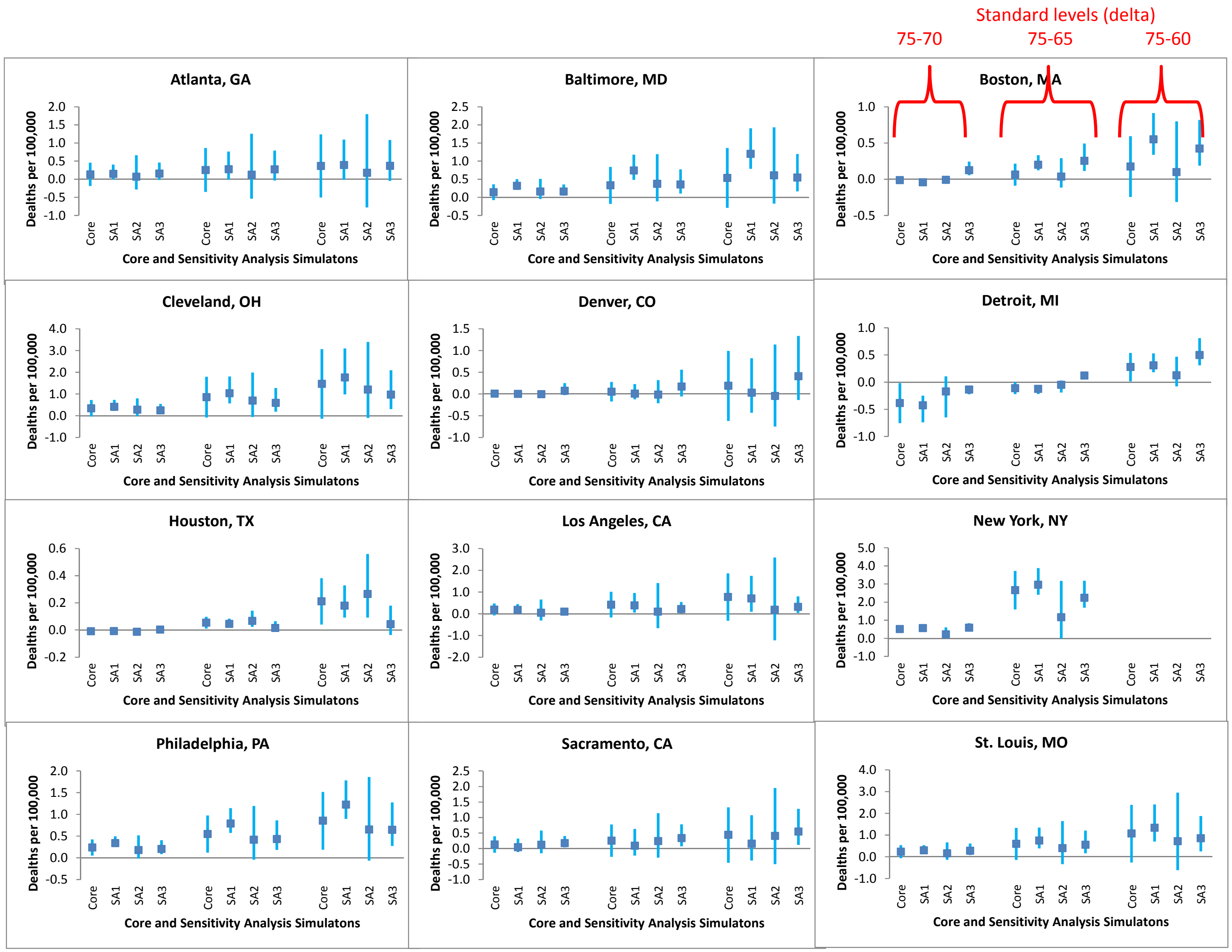


Table 7-14 Sensitivity Analysis for Long-Term O_3-attributable Respiratory Mortality – Alternative C-R Function Specification (regional effect estimates) ***% of baseline all-cause mortality and change in O_3-attribuable risk*** **(2009)** (Smith et al., 2009, O_3 season))

Study Area	Air Quality Scenario			
	% of Baseline Incidence	% Change in O_3-Attributable Risk		
	75ppb	75-70	75-65	75-60
Core analysis (2009)				
Atlanta, GA	17.0	5	9	13
Baltimore, MD	17.4	3	6	10
Boston, MA	16.0	1	3	7
Cleveland, OH	16.8	4	9	15
Denver, CO	20.0	1	5	12
Detroit, MI	17.0	-1	2	6
Houston, TX	16.9	2	4	7
Los Angeles, CA	20.7	4	8	13
New York, NY	16.7	5	18	NA
Philadelphia, PA	17.2	3	7	10
Sacramento, CA	18.0	4	8	12
St. Louis, MO	17.7	4	8	13
Sensitivity analysis (regional effect estimates) (2009)				
Atlanta, GA	41.3	4	8	11
Baltimore, MD	-6.9	4	9	13
Boston, MA	-6.1	1	5	9
Cleveland, OH	0.0	0	0	0
Denver, CO	27.5	1	4	11
Detroit, MI	0.0	0	0	0
Houston, TX	41.2	2	3	6
Los Angeles, CA	4.6	3	7	11
New York, NY	-6.5	7	23	NA
Philadelphia, PA	-6.7	4	9	13
Sacramento, CA	24.9	4	7	11
St. Louis, MO	0.0	0	0	0

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

Table 7-15 Sensitivity Analysis for Long-Term O_3-attributable Respiratory Mortality – Alternative C-R Function Specification (national O_3-only effect estimates) *% of baseline all-cause mortality and change in O_3-attribuable risk* (2009) (Smith et al., 2009, O_3 season))

Study Area	Air Quality Scenario			
	% of Baseline Incidence	% Change in O_3-Attributable Risk		
	75ppb	75-70	75-65	75-60
Core analysis (2009)				
Atlanta, GA	17.0	5	9	13
Baltimore, MD	17.4	3	6	10
Boston, MA	16.0	1	3	7
Cleveland, OH	16.8	4	9	15
Denver, CO	20.0	1	5	12
Detroit, MI	17.0	-1	2	6
Houston, TX	16.9	2	4	7
Los Angeles, CA	20.7	4	8	13
New York, NY	16.7	5	18	NA
Philadelphia, PA	17.2	3	7	10
Sacramento, CA	18.0	4	8	12
St. Louis, MO	17.7	4	8	13
Sensitivity analysis (ozone-only effect estimates) (2009)				
Atlanta, GA	11.9	5	10	14
Baltimore, MD	12.2	3	7	10
Boston, MA	11.2	1	3	7
Cleveland, OH	11.8	4	10	15
Denver, CO	14.1	2	5	12
Detroit, MI	11.9	-1	2	6
Houston, TX	11.9	2	4	7
Los Angeles, CA	14.6	4	9	14
New York, NY	11.7	5	19	NA
Philadelphia, PA	12.1	3	7	10
Sacramento, CA	12.6	4	8	13
St. Louis, MO	12.4	4	8	13

NA: for NYC, the model-based adjustment methodology was unable to adjust O_3 distributions such that they would meet the lower alternative standard level of 60 ppb.

Attachment 2: Revised 2nd Draft O_3 Policy Assessment (PA) Epidemiology-based Risk Figures

This attachment contains the revised epidemiology-based risk result figures presented in Chapters 3 and 7 of the second draft O_3 PA.

Figure 3-16. Estimates of O_3-Associated Deaths Attributable to Full Distributions of 8-Hour Area-Wide O_3 Concentrations and to Area-Wide Concentrations at or above 20, 40, or 60 ppb for Air Quality Just Meeting Current Standard - Deaths Summed Across Urban Case Study Areas

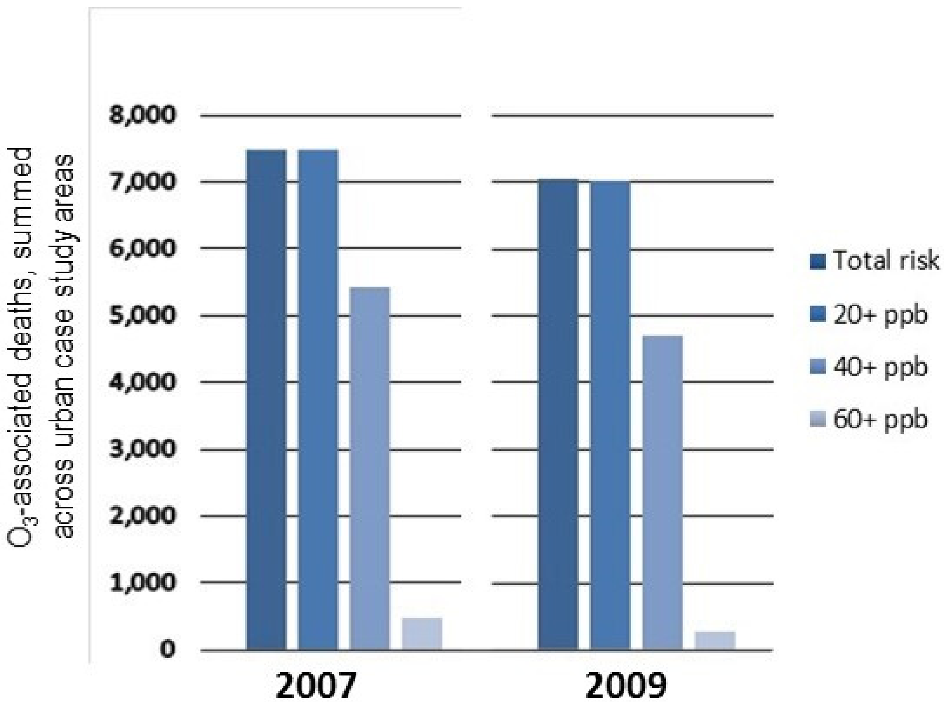


Figure 4-10. Estimates of O_3-Associated Deaths Attributable to Full Distributions of 8-Hour Area-Wide O_3 Concentrations and to Area-Wide Concentrations at or above 20, 40, or 60 ppb for Air Quality Just Meeting Current and Alternative Standards - Deaths Summed Across Urban Case Study Areas

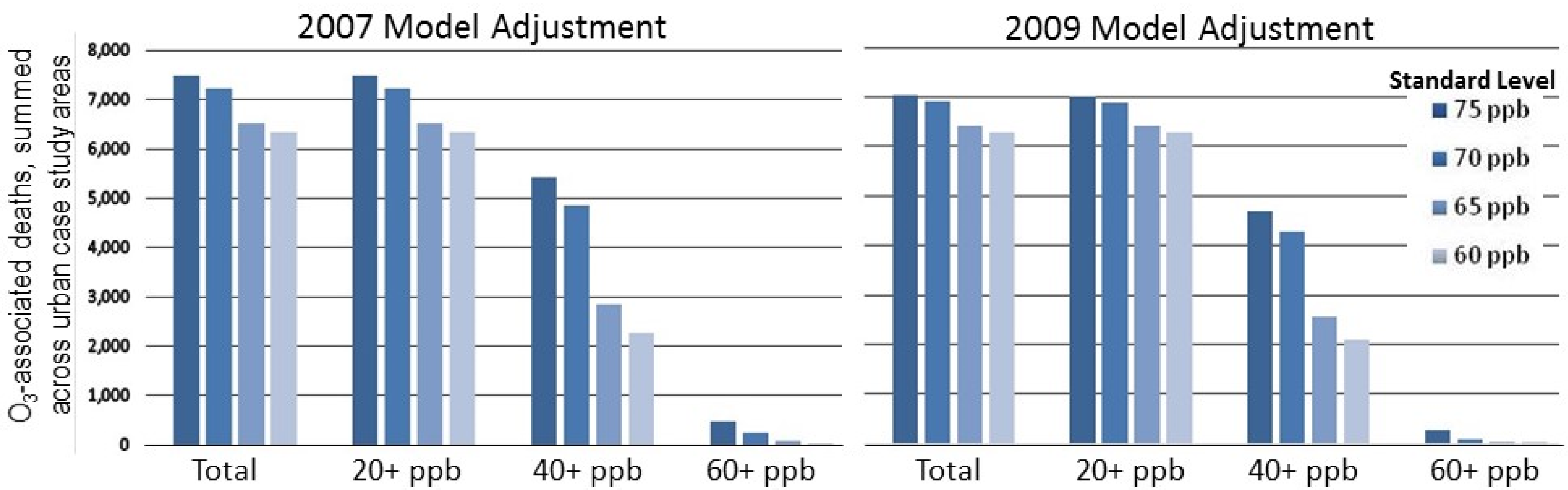


Figure 4-13. Estimates of O_3-Associated Deaths Attributable to Full Distributions of 8-Hour Area-Wide O_3 Concentrations and to Concentrations at or above 20, 40, or 60 ppb - Deaths Summed Across Urban Case Study Areas and Expressed Relative to 75 ppb