

Summary of PM2.5 Nonattainment Analysis

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```
## Loading required package: rpart
```

Basic Data Description (Section 2.2)

```
## [1] "Total number of locations = 825"
```

```
## [1] "Total number of fee-for-service Medicare beneficiaries = 3796166"
```

```
## [1] "Total number of managed care Medicare beneficiaries = 929861"
```

Nonattainment Description (Section 2.2)

```
## [1] "Number of nonattainment areas = 290"
```

```
## [1] "Number of n attainment areas = 535"
```

```
##      a_2012
## a      0      1
##      0 535      0
##      1  42 248
```

```
## [1] "Percentage of 2005 nonattainment areas that remained in nonattainment in 2012 = 0.86"
```

Covariate Description in Attainment and Nonattainment Areas (Table 1)

##	Mean	SD	Mean
## Ambient PM2.5 2002-2004 ($\mu\text{g}/\text{m}^3$)	11.59	1.88	14.48
## \% Ozone nonattainment 2005	30.65	46.15	92.41
## log(population)	11.43	1.59	12.59
## Completely Rural Area	0.08	0.27	0.01
## \% Urban	76.80	29.01	91.09
## \% Black	16.97	17.55	21.65
## \% Hispanic	4.38	5.87	6.48
## \% HS Grad.	31.17	6.75	30.52
## Median HH Inc. ($\backslash\backslash\backslash$)	37336.27	8877.77	42640.82
## \% Poor	14.44	5.90	13.62
## \% Female	51.50	1.46	51.74
## \% Occupied Housing	90.66	7.21	92.43
## 5-Year Migration Rate	0.49	0.08	0.47
## Median House Value ($\backslash\backslash\backslash$)	98270.45	38828.86	130134.92
## Smoking Rate	0.26	0.03	0.26
## Avg. Dew Point ($\backslash\backslash\backslash$)	46.33	7.96	44.66
## Avg. Temperature ($\backslash\backslash\backslash$)	56.13	8.54	53.99
## Avg. Rel. Humidity ($\backslash\backslash\backslash$)	72.31	1.84	71.91

## Total Medicare Benef. 2004\$~*\$\$~+\$	5230.32	5876.00	6812.31
## Avg. Medicare Age 2004 (years)\$~*\$\$~+\$	74.84	0.92	74.97
## \\% Female Medicare Benef. 2004\$~*\$\$~+\$	54.54	5.00	54.47
## \\% White Medicare Benef. 2004\$~*\$\$~+\$	87.71	13.89	88.09
## \\% Black Medicare Benef. 2004\$~*\$\$~+\$	7.21	11.29	6.95
## Mortality\$~*\$	49.48	9.41	50.61
## All CVD\$~*\$	94.87	16.25	94.23
## Respiratory\$~*\$	36.41	11.72	37.22
## COPD	13.76	6.48	14.52
## CV Stroke	18.61	7.85	19.04
## Heart Failure	22.43	8.72	21.80
## HRD	15.96	9.62	15.35
## Ischemic Heart Disease	27.95	9.15	27.67
## Peripheral Vascular Disease	7.50	4.60	7.84
## Respiratory Tract Infection	22.65	8.20	22.70
## Ambient PM2.5 2010-2012 (\$\\mu g/m^3\$)	9.38	1.65	11.13
## Mortality 2012	49.51	9.08	50.27
## COPD 2012	13.32	7.34	13.98
## CV Stroke 2012	18.54	7.56	18.77
## Heart Failure 2012	21.11	8.99	21.75
## HRD 2012	15.48	7.38	15.09
## Ischemic Heart Disease 2012	25.89	9.12	27.04
## Peripheral Vascular Disease 2012	6.80	4.74	7.40
## Respiratory Tract Infection 2012	21.90	8.84	22.11
## SD			
## Ambient PM2.5 2002-2004 (\$\\mu g/m^3\$)\$~*\$\$~+\$	1.39		
## \\% Ozone nonattainment 2005\$~*\$	26.52		
## log(population)\$~*\$\$~+\$	1.38		
## Completely Rural Area\$~*\$	0.08		
## \\% Urban\$~*\$\$~+\$	16.60		
## \\% Black\$~+\$	19.43		
## \\% Hispanic\$~+\$	8.20		
## \\% HS Grad.\$~*\$\$~+\$	7.26		
## Median HH Inc. (\\\$)\$~*\$	14281.80		
## \\% Poor\$~*\$\$~+\$	6.57		
## \\% Female	1.49		
## \\% Occupied Housing\$~*\$\$~+\$	3.19		
## 5-Year Migration Rate\$~*\$	0.07		
## Median House Value (\\\$)\$~*\$	77953.11		
## Smoking Rate\$~*\$	0.03		
## Avg. Dew Point (\$^\\circ\$F)\$~*\$	3.15		
## Avg. Temperature (\$^\\circ\$F)\$~*\$	3.57		
## Avg. Rel. Humidity (\\%)\$~*\$\$~+\$	1.62		
## Total Medicare Benef. 2004\$~*\$\$~+\$	7282.17		
## Avg. Medicare Age 2004 (years)\$~*\$\$~+\$	0.98		
## \\% Female Medicare Benef. 2004\$~*\$\$~+\$	4.01		
## \\% White Medicare Benef. 2004\$~*\$\$~+\$	13.41		
## \\% Black Medicare Benef. 2004\$~*\$\$~+\$	9.92		
## Mortality\$~*\$	9.18		
## All CVD\$~*\$	14.90		
## Respiratory\$~*\$	10.20		
## COPD	5.78		
## CV Stroke	6.39		
## Heart Failure	7.03		

```
## HRD 5.45
## Ischemic Heart Disease 8.12
## Peripheral Vascular Disease 5.67
## Respiratory Tract Infection 6.62
## Ambient PM2.5 2010-2012 ( $\mu\text{g}/\text{m}^3$ ) 1.35
## Mortality 2012 7.98
## COPD 2012 5.20
## CV Stroke 2012 7.80
## Heart Failure 2012 6.77
## HRD 2012 5.34
## Ischemic Heart Disease 2012 8.10
## Peripheral Vascular Disease 2012 4.13
## Respiratory Tract Infection 2012 7.16
```

Propensity Score Analysis

```
## [1] "The propensity score model summary:"

##
## Call:
## glm(formula = inclformula, family = binomial(link = "logit"),
##      data = dat)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -2.43002  -0.22882  -0.02158   0.18269   2.76654
##
## Coefficients:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept)    2.250e+02  9.521e+01   2.363 0.018126 *
## PctUrban        2.095e-01  1.299e+00   0.161 0.871883
## PctHighSchool  -1.253e+01  4.186e+00  -2.993 0.002761 **
## MedianHHInc     1.276e-04  3.711e-05   3.439 0.000584 ***
## PctPoor         5.428e+00  4.908e+00   1.106 0.268763
## PctOccupied    -2.876e+00  4.645e+00  -0.619 0.535827
## PctMovedIn5    -1.037e+01  3.032e+00  -3.420 0.000625 ***
## MedianHValue    5.009e-06  5.958e-06   0.841 0.400514
## a_ozone         2.323e+00  4.114e-01   5.647 1.64e-08 ***
## smokerate2000   1.154e+01  6.164e+00   1.873 0.061126 .
## mean_age.2004   5.031e-01  1.733e-01   2.902 0.003705 **
## Female_rate.2004 -6.700e+00  3.255e+00  -2.058 0.039558 *
## White_rate.2004  2.405e+00  1.561e+00   1.540 0.123527
## Black_rate.2004  1.355e+00  1.942e+00   0.698 0.485394
## Tot_den_for_death_MA_FFS.2004 -2.778e-05  2.431e-05  -1.142 0.253252
## avgdewpt        2.464e-01  2.505e-01   0.984 0.325201
## avgtemp        -5.105e+00  1.663e+00  -3.070 0.002138 **
## avgrelhum       -3.741e+00  1.226e+00  -3.051 0.002282 **
## logpop         -3.126e-01  2.220e-01  -1.408 0.159117
## CompletelyRural -7.563e-01  1.116e+00  -0.677 0.498123
## pmbase          1.326e+00  1.476e+00   0.898 0.369305
## mortrate        1.064e-02  1.706e-02   0.624 0.532867
## CVDrate        -3.382e-03  9.108e-03  -0.371 0.710380
```

```

## resprate                2.608e-03  1.378e-02   0.189 0.849904
## avgtemp:avgrelhum       6.423e-02  2.134e-02   3.010 0.002614 **
## avgtemp:pmbase         1.239e-02  2.724e-02   0.455 0.649281
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##    Null deviance: 1069.83  on 824  degrees of freedom
## Residual deviance:  339.49  on 799  degrees of freedom
## AIC: 391.49
##
## Number of Fisher Scoring iterations: 7

## [1] "Minimum estimated propensity score = 0"

## [1] "Maximum estimated propensity score = 1"

## [1] "Minimum propensity score among nonattainment areas = 0.022"

## [1] "Maximum propensity score among attainment areas = 0.948"

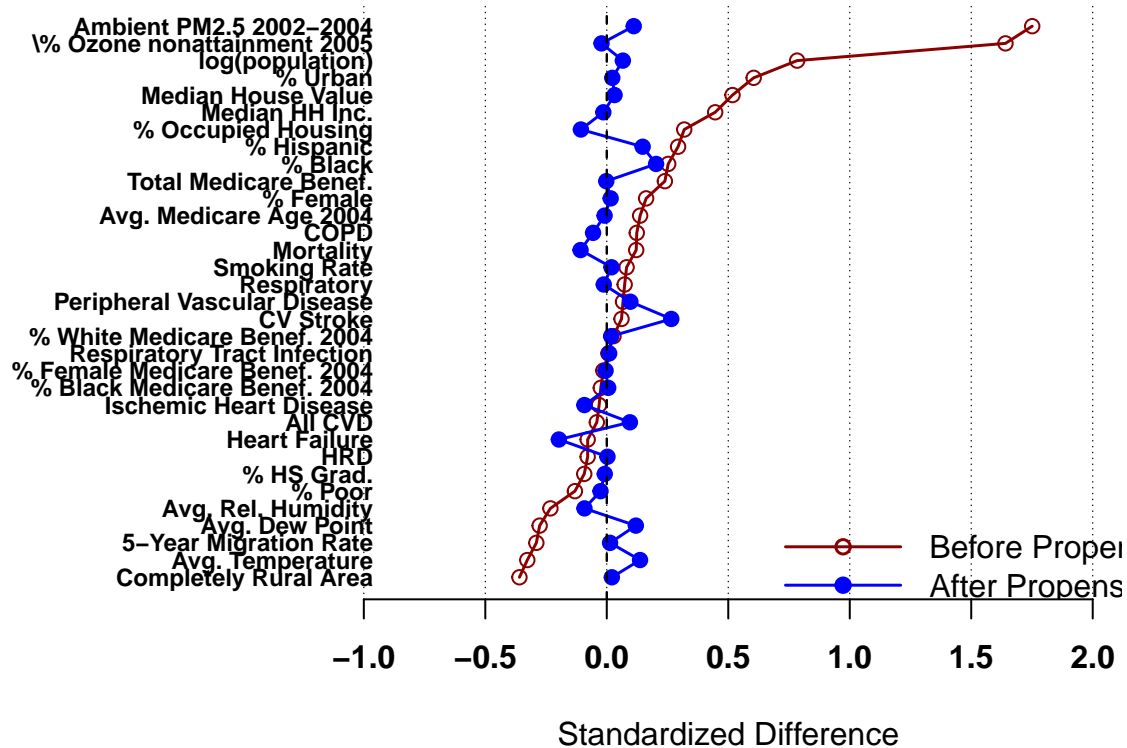
## [1] "Number of nonattainment areas pruned = 136"

## [1] "Number of attainment areas pruned = 316"

##      1  2  3  4
## 0 85 77 47 10
## 1  9 16 46 83
##   94 93 93 93

## [1] TRUE

```



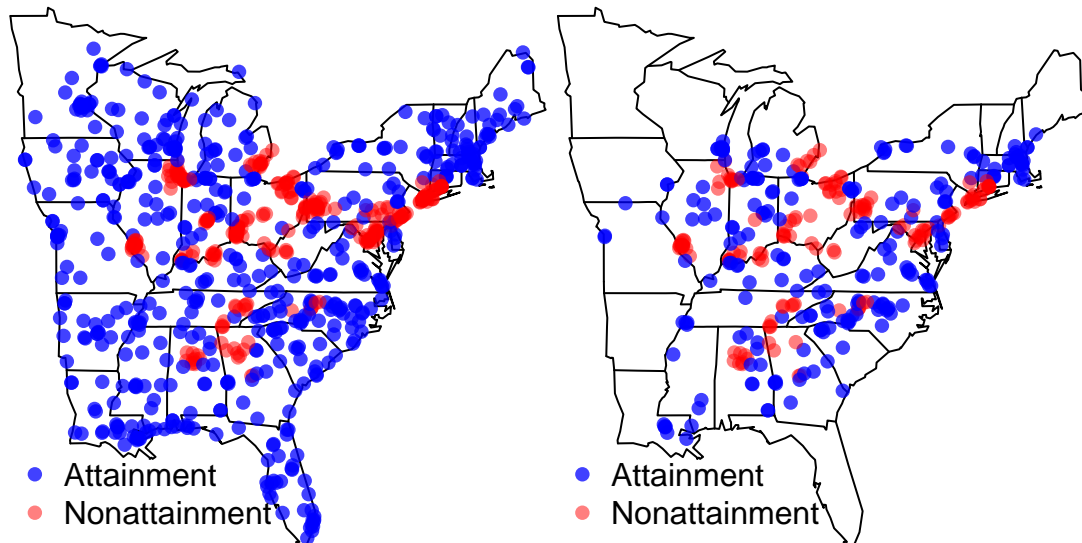
##	a	b	c	d	includevar	
## Ambient PM2.5 2002-2004	0.00	0.00	0	0.00	0.1600	0
## \\% Ozone nonattainment 2005	0.00	0.00	0	0.00	0.1725	0
## log(population)	0.00	0.00	0	0.00	0.2725	1
## % Urban	0.00	0.00	0	0.00	0.1325	0
## Median House Value	0.00	0.00	0	0.00	0.1675	0
## Median HH Inc.	0.00	0.00	0	0.00	0.0650	0
## % Occupied Housing	0.00	0.00	0	0.00	0.2400	0
## % Hispanic	0.57	0.00	0	0.00	0.2550	1
## % Black	0.00	0.00	0	0.72	0.2925	1
## Total Medicare Benef.	0.00	0.00	0	0.00	0.1825	0
## % Female	0.00	0.00	0	0.00	0.2475	0
## Avg. Medicare Age 2004	0.00	0.00	0	0.00	0.1750	0
## COPD	0.00	0.00	0	0.00	0.2100	0
## Mortality	0.00	0.00	0	0.00	0.1825	0
## Smoking Rate	0.00	0.00	0	0.00	0.2650	1
## Respiratory	0.00	0.00	0	0.00	0.0575	0
## Peripheral Vascular Disease	0.00	0.76	0	0.00	0.3300	1
## CV Stroke	0.00	0.56	0	0.00	0.2875	1
## % White Medicare Benef. 2004	0.00	0.00	0	0.00	0.0625	0
## Respiratory Tract Infection	0.00	0.00	0	0.00	0.0850	0
## % Female Medicare Benef. 2004	0.00	0.00	0	0.00	0.2650	1
## % Black Medicare Benef. 2004	0.00	0.00	0	0.00	0.0350	0
## Ischemic Heart Disease	0.00	0.00	0	0.00	0.2925	1
## All CVD	0.00	0.00	0	0.00	0.2200	0
## Heart Failure	0.00	0.00	0	0.00	0.2225	0
## HRD	0.00	0.00	0	0.00	0.0825	0
## % HS Grad.	0.00	0.79	0	0.79	0.4150	1
## % Poor	0.00	0.00	0	0.00	0.2050	0

```
## Avg. Rel. Humidity      0.62 0.00 0 0.00 0.2200      1
## Avg. Dew Point         0.00 0.00 0 0.74 0.2525      1
## 5-Year Migration Rate  0.00 0.00 0 0.00 0.2775      1
## Avg. Temperature       0.00 0.00 0 0.73 0.2475      1
## Completely Rural Area   0.00 0.00 0 0.00 0.0950      0

## [1] "Variables with residual imbalance that are included for direct covariate adjustment:"

## [1] "logpop"      "PctBlack"    "PctHisp"
## [4] "PctHighSchool" "PctMovedIn5" "smokerate2000"
## [7] "avgdewpt"    "avgtemp"     "avgrelhum"
## [10] "Female_rate.2004"
```

Maps of Monitoring Locations (Figure 1)



Results (Section 3)

```
## [1] "Total number of locations retained after pruning = 373"

## [1] "Total number of fee-for-service Medicare beneficiaries in pruned sample = 1892915"

## [1] "Total number of managed care Medicare beneficiaries in pruned sample = 474050"

## a
## 0 1
## 219 154

## [1] "The number of nonattainment locations in the pruned sample = 154"
```

Missing Data Description (Appendix C.3)

```
## [1] "The number of locations with missing baseline pollution = 131"

## [1] "The number of nonattainment locations with missing baseline pollution = 40"

## [1] "The number of retained locations with missing baseline pollution = 62"

## [1] "The number of retained nonattainment locations with missing baseline pollution = 17"

## [1] "The number of locations with missing follow up pollution = 263"

## [1] "The number of nonattainment locations with missing follow up pollution = 74"

## [1] "The number of retained locations with missing follow up pollution = 113"

## [1] "The number of retained nonattainment locations with missing follow up pollution = 48"
```

Pollution Analysis Results

```
## [1] "The posterior mean effect on ambient PM2.5 = -0.098"

## [1] "with 95% posterior interval = ( -0.713 , 0.466 )"

## [1] "The posterior probability that ATTy < 0 = 0.585"
```

Analysis of Health Outcomes

```
## [1] "Table summarizing average effects on health outcomes:"
```

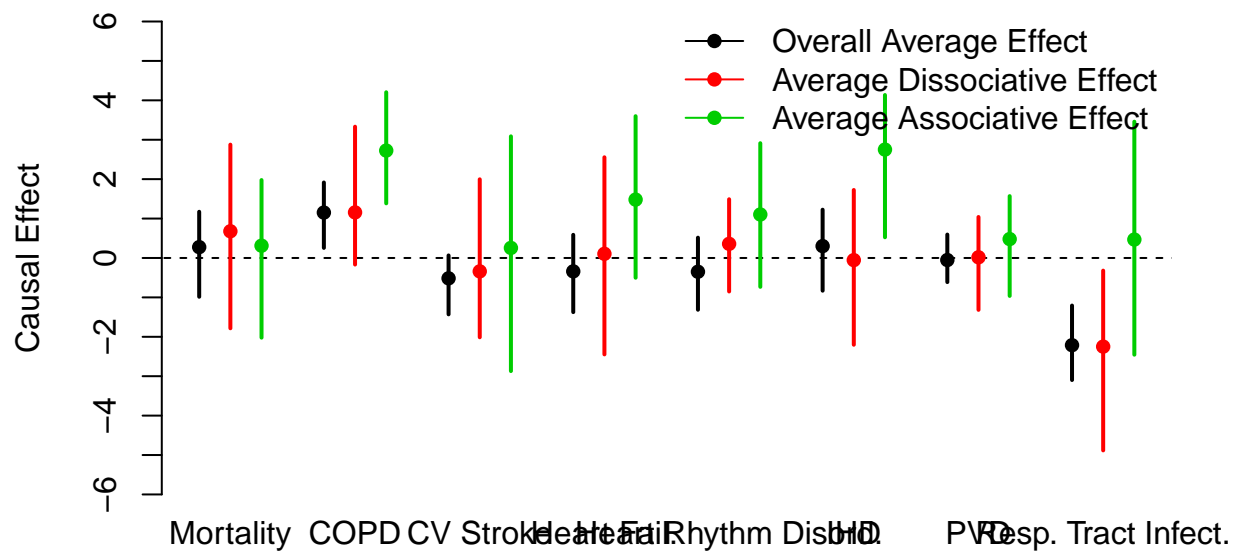
##	Mean	SD	2.5%	97.5%	P(<0)
## mort	0.276	0.612	-0.985	1.173	0.341
## copd	1.152	0.449	0.256	1.916	0.000
## cvstroke	-0.516	0.477	-1.431	0.065	0.927
## hf	-0.340	0.593	-1.374	0.588	0.683
## hrd	-0.349	0.461	-1.314	0.516	0.805
## ihd	0.301	0.556	-0.830	1.225	0.293
## pvd	-0.052	0.330	-0.612	0.594	0.634
## rti	-2.212	0.543	-3.097	-1.207	1.000

```
## [1] "Table summarizing average dissociative effects:"
```

##	Mean	SD	2.5%	97.5%	P(<0)
## mort	0.678	1.250	-1.784	2.876	0.220
## copd	1.157	0.967	-0.167	3.331	0.049
## cvstroke	-0.340	1.098	-2.012	1.996	0.610
## hf	0.106	1.371	-2.447	2.555	0.512
## hrd	0.359	0.793	-0.851	1.490	0.317
## ihd	-0.054	1.285	-2.202	1.726	0.415
## pvd	0.017	0.633	-1.317	1.040	0.463
## rti	-2.249	1.323	-4.883	-0.321	1.000

```
## [1] "Table summarizing average associative effects:"
```

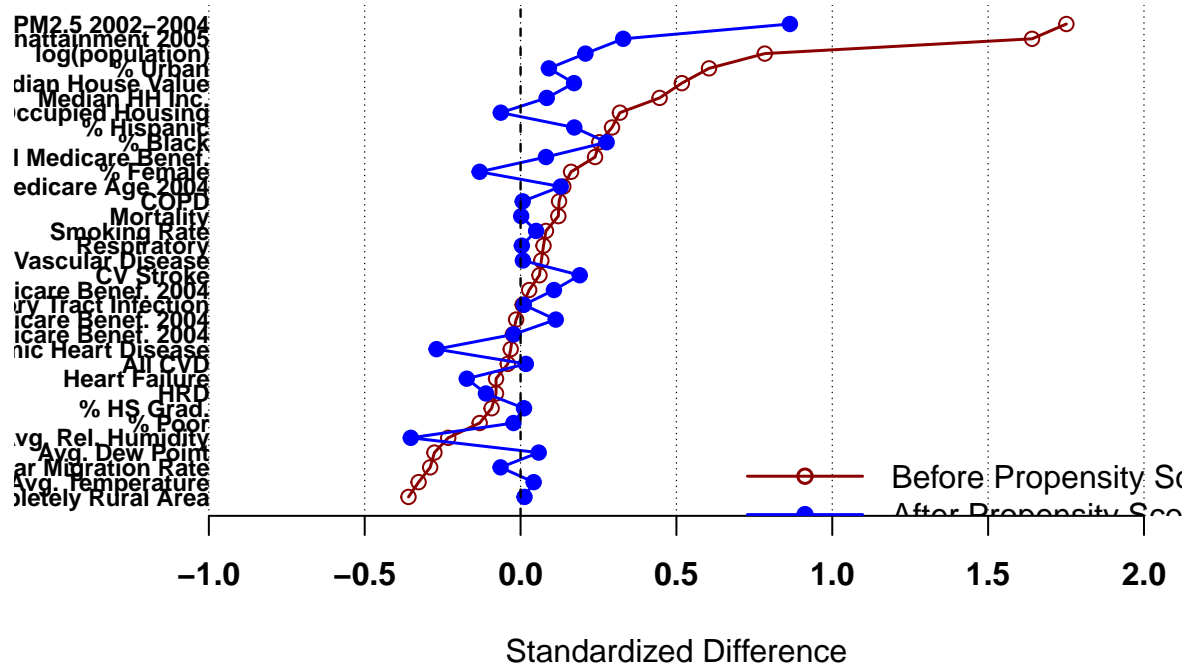
```
##           Mean      SD    2.5% 97.5% P(<0)
## mort      0.312  1.217  -2.022  1.978  0.317
## copd      2.725  0.714   1.386  4.205  0.000
## cvstroke   0.255  1.477  -2.870  3.086  0.341
## hf        1.482  1.226  -0.501  3.598  0.122
## hrd       1.103  1.038  -0.733  2.913  0.146
## ihd       2.751  1.121   0.525  4.135  0.000
## pvd       0.480  0.638  -0.963  1.570  0.195
## rti       0.468  1.428  -2.455  3.459  0.293
```



Sensitivity analysis without pruning

```
## [1] "Table showing number of attainment, nonattainment locations in each propensity score group:"
```

```
##      pscat
## a      1   2   3   4
## 0 462  41  21  11
## 1  19  21  26 224
```

##	a	b	c	d	include	var
## Ambient PM2.5 2002-2004	1.12	0	0.00	0.75	0.5600	1
## \\% Ozone nonattainment 2005	0.64	0	0.00	0.00	0.2575	1
## log(population)	0.00	0	0.00	0.59	0.2700	1
## % Urban	0.00	0	0.00	0.00	0.1875	0
## Median House Value	0.00	0	0.00	0.00	0.1500	0
## Median HH Inc.	0.00	0	0.00	0.00	0.1050	0
## % Occupied Housing	0.00	0	0.00	0.00	0.2400	0
## % Hispanic	0.00	0	0.00	0.00	0.1550	0
## % Black	0.00	0	0.00	0.59	0.2850	1
## Total Medicare Benef.	0.00	0	0.00	0.00	0.1725	0
## % Female	0.00	0	0.00	0.00	0.2000	0
## Avg. Medicare Age 2004	0.00	0	0.00	0.00	0.2200	0
## COPD	0.00	0	0.00	0.00	0.1825	0
## Mortality	0.00	0	0.00	0.00	0.1075	0
## Smoking Rate	0.00	0	0.00	0.00	0.2025	0
## Respiratory	0.00	0	0.00	0.00	0.1825	0
## Peripheral Vascular Disease	0.00	0	0.85	0.00	0.4200	1
## CV Stroke	0.00	0	0.00	0.00	0.2925	1
## % White Medicare Benef. 2004	0.00	0	0.00	0.00	0.1625	0
## Respiratory Tract Infection	0.00	0	0.00	0.00	0.1725	0
## % Female Medicare Benef. 2004	0.00	0	0.00	0.00	0.2350	0
## % Black Medicare Benef. 2004	0.00	0	0.00	0.00	0.1800	0
## Ischemic Heart Disease	0.00	0	0.00	0.00	0.2550	1
## All CVD	0.00	0	0.00	0.00	0.2225	0
## Heart Failure	0.00	0	0.00	0.00	0.2100	0
## HRD	0.00	0	0.00	0.00	0.0850	0
## % HS Grad.	0.00	0	0.00	0.56	0.3700	1
## % Poor	0.00	0	0.00	0.00	0.1650	0
## Avg. Rel. Humidity	0.77	0	0.00	0.00	0.2975	1
## Avg. Dew Point	0.00	0	0.00	0.00	0.1925	0
## 5-Year Migration Rate	0.00	0	0.00	0.00	0.2150	0

```
## Avg. Temperature          0.00 0 0.00 0.00 0.1400          0
## Completely Rural Area     0.00 0 0.00 0.00 0.0950          0
```

```
## [1] "Variables with residual imbalance that are included for direct covariate adjustment:"
```

```
## [1] "pmbase"          "a_ozone"          "logpop"           "PctBlack"
## [5] "PctHighSchool"  "avgrelhum"
```

Sensitivity Analysis: Pollution Outcomes

```
## [1] "The number of MCMC iterations (after burn in) for the sensitivity analysis of pollution outcomes was 41"
```

```
## [1] "The posterior mean effect on ambient PM2.5 = -1.11"
```

```
## [1] "and 95% posterior interval = ( -1.72 , -0.525 )"
```

```
## [1] "The posterior probability that ATTy < 0 = 1"
```

Sensitivity Analysis: Health Outcomes

```
## [1] "The number of MCMC iterations (after burn in) for the sensitivity analysis of mort was 41"
## [2] "The number of MCMC iterations (after burn in) for the sensitivity analysis of copd was 41"
## [3] "The number of MCMC iterations (after burn in) for the sensitivity analysis of cvstroke was 41"
## [4] "The number of MCMC iterations (after burn in) for the sensitivity analysis of hf was 41"
## [5] "The number of MCMC iterations (after burn in) for the sensitivity analysis of hrd was 41"
## [6] "The number of MCMC iterations (after burn in) for the sensitivity analysis of ihd was 41"
## [7] "The number of MCMC iterations (after burn in) for the sensitivity analysis of pvd was 41"
## [8] "The number of MCMC iterations (after burn in) for the sensitivity analysis of rti was 41"
```

```
## [1] "Table summarizing average effects on health outcomes:"
```

##	Mean	SD	2.5%	97.5%	P(<0)
## mort	0.032	0.519	-0.718	1.008	0.488
## copd	0.411	0.447	-0.377	1.186	0.171
## cvstroke	-0.433	0.336	-1.016	0.269	0.878
## hf	0.640	0.429	-0.066	1.397	0.073
## hrd	0.839	0.351	0.340	1.482	0.000
## ihd	-1.698	0.463	-2.486	-1.042	1.000
## pvd	0.028	0.206	-0.371	0.396	0.488
## rti	-2.964	0.578	-4.049	-2.206	1.000

```
## [1] "Table summarizing average dissociative effects:"
```

##	Mean	SD	2.5%	97.5%	P(<0)
## mort	-1.016	1.020	-2.646	0.556	0.732
## copd	0.175	0.627	-1.076	1.169	0.341
## cvstroke	-0.042	0.855	-1.818	1.588	0.488
## hf	1.189	0.659	0.036	2.305	0.000
## hrd	0.992	0.702	-0.386	2.354	0.098
## ihd	-1.579	0.950	-3.625	-0.139	0.976
## pvd	0.449	0.473	-0.210	1.211	0.220
## rti	-3.067	0.832	-4.748	-1.664	1.000

[1] "Table summarizing average associative effects:"

##	Mean	SD	2.5%	97.5%	P(<0)
## mort	0.156	1.343	-2.025	2.821	0.488
## copd	1.228	0.547	-0.008	1.955	0.049
## cvstroke	-0.130	0.967	-1.870	1.457	0.512
## hf	1.735	0.901	0.201	3.251	0.024
## hrd	0.412	1.128	-1.695	2.153	0.341
## ihd	-1.057	1.711	-4.569	2.261	0.805
## pvd	-0.074	0.530	-1.173	0.793	0.610
## rti	-0.949	0.963	-3.094	0.436	0.878

