



## **ADDITIONAL MATERIALS AVAILABLE ON THE HEI WEB SITE**

### **Special Report 19**

#### **Diesel Emissions and Lung Cancer: An Evaluation of Recent Epidemiological Evidence for Quantitative Risk Assessment**

**HEI Diesel Epidemiology Panel**

#### **Additional Materials 2. Analytical Data Sets for the Cohort (Attfield et al. 2012) and Case–Control (Silverman et al. 2012) Studies, and HEI Diesel Epidemiology Panel Replication of Selected Analyses in the DEMS Case–Control Study**

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Although this document was produced with partial funding by the United States Environmental Protection Agency under Assistance Award CR-83467701 to the Health Effects Institute, it has not been subjected to the Agency's peer and administrative review and therefore may not necessarily reflect the views of the Agency, and no official endorsement by it should be inferred. The contents of this document also have not been reviewed by private party institutions, including those that support the Health Effects Institute; therefore, it may not reflect the views or policies of these parties, and no endorsement by them should be inferred.

This document was reviewed by the HEI Diesel Epidemiology Panel but did not undergo the HEI scientific editing and production process.

**DEMS COHORT MORTALITY STUDY EXTERNAL ANALYTICAL SET\***  
**(Attfield et al. 2012)\*\***

**VARIABLES**

ID - Record Number

Date of Birth (MM/DD/YYYY)

Sex Code: 0=Female; 1=Male

Race Code: 0=Unknown; 1=White; 2=Non-white

Vital Status: 0=Unknown; 1=Living; 2=Dead

International Classification of Diseases (ICD) Version - ICD at time of death (XX)

Underlying Cause of Death ICD Code (XXX.X)

Contributing Cause of Death ICD Codes 1–10 (XXX.X)

Last Observed Date (MM/DD/YYYY)

State (worked the longest): 1=Ohio; 2=Missouri; 3=New Mexico; 4=Wyoming

Exposure Begin Date (MM/DD/YYYY) - at study facilities

Exposure End Date (MM/DD/YYYY) - at study facilities

Location Code: 1=Underground; 2=Surface; 3=Surface/Underground; 4=Inactive/Offsite

\* Source: <http://www.cdc.gov/niosh/topics/cancer/diesel/DEMSCohortVariables.html>

\*\* Attfield MD, Schleiff PL, Lubin JH, Blair A, Stewart PA, Vermeulen R, et al. 2012. The diesel exhaust in miners study: A cohort mortality study with emphasis on lung cancer. J Natl Cancer Inst 104:869–883.

**DEMS COHORT MORTALITY STUDY INTERNAL ANALYTICAL SET\***  
**(Attfield et al. 2012)\*\***

**VARIABLES**

ID - Record Number

Date of Birth (MM/DD/YYYY)

Sex Code: 0=Female; 1=Male

Race Code: 0=Unknown; 1=White; 2=Non-white

Vital Status: 0=Unknown; 1=Living; 2=Dead

Underlying Lung Cancer Mortality: 0=No; 1=Yes

Contributing Lung Cancer Mortality: 0=No; 1=Yes

Underlying Esophageal Cancer Mortality: 0=No; 1=Yes

Contributing Esophageal Cancer Mortality: 0=No; 1=Yes

Last Observed Date (MM/DD/YYYY)

State (worked the longest): 1=Ohio; 2=Missouri; 3=New Mexico; 4=Wyoming

Mine Type Code (worked the longest): 1=Lime; 2=Potash; 3=Salt; 4=Trona

Hired Date (MM/DD/YYYY)

Exposure Begin Date (MM/DD/YYYY) - at study facilities

Exposure End Date (MM/DD/YYYY) - at study facilities

Location Code: 1=Underground; 2=Surface; 3=Surface/Underground; 4=Inactive/Offsite

Underground Percent

Respirable Elemental Carbon Metric ( $\mu\text{g}/\text{m}^3$ )

Respirable Elemental Carbon Alternative Metrics (5-year Means, Power Model, Medians)

Respirable Dust Metric ( $\text{mg}/\text{m}^3$ )

Radon Metric (WL=Working Level)

Silica Level Code: 0=None; 1=Low; 2=Medium; 3=High

Asbestos Level Code: 0=None; 1=Low; 2=Medium; 3=High

Non-Diesel Polycyclic Aromatic Hydrocarbons Level Code: 0=Absent; 1=Present

\* Source: <http://www.cdc.gov/niosh/topics/cancer/diesel/DEMSCohortVariables.html>

\*\* Attfield MD, Schleiff PL, Lubin JH, Blair A, Stewart PA, Vermeulen R, et al. 2012. The diesel exhaust in miners study: A cohort mortality study with emphasis on lung cancer. J Natl Cancer Inst 104:869–883.

Table 2.1 - C-C Analytic Variables (Silverman et al. 2012)\*

Variable Order In Data File	Description	Format	Notes / Warnings
Variable 1	Variable indicating case or control status	1 = Case 2 = Control	
Variable 2	Number assigned to case and controls in a given cluster (i.e. matched set).	3 Digit Number	
Variable 3	First respiratory disease(excluding asthma and pneumonia) diagnosed 5 years or more before case death	0 = No respiratory disease, or less than five years prior to case death 1 = Yes, respiratory disease five or more years prior to case death 2 = Don't know	
Variable 4	First respiratory disease(excluding asthma and pneumonia) diagnosed before case death, grouped	0 = No respiratory disease 1 = Yes, respiratory disease less than five years prior to case death 2 = Yes, respiratory disease five or more years prior to case death 9 = Don't know	
Variable 5	Physical activity, grouped	1 = Exercise once or more per day 2 = Exercise less than once per day 9 = Don't know	
Variable 6	Body mass index , grouped according to WHO categories	1 = Less than 18.5 (kg/m <sup>2</sup> ) (Underweight) 2 = 18.5 to less than 25 (kg/m <sup>2</sup> ) (Normal Weight) 3 = 25 to less than 30 (kg/m <sup>2</sup> ) (Overweight) 4 = 30 (kg/m <sup>2</sup> ) or more (Obese) 9 = Don't know	
Variable 7	Family history of lung cancer	0 = No family history of lung cancer 1 = Yes, family history of lung cancer 9 = Don't know	
Variable 8	Overall indicator for combined high risk jobs (Checklist # - 1-Miner/Outside study Mine,2-Truck Driver,8-Machinery Mechanic,12-Welder,22-Painter), with ten or more years of duration	0 = No high-risk jobs with ten or more years duration 1 = Yes, high-risk jobs with ten or more years duration 2 = Don't Know	Checklist numbers refer to job titles in jobs checklist in subject questionnaire
Variable 9	Outside of study mine diesel work indicator	0 = No, did not work with diesel outside of study mine work 1 = Yes, worked with diesel outside of study mine work 2 = Don't Know	
Variable 10	Cumulative REC exposure, lagged 15 years combined with outside study mine diesel exposure	2 = Cum. Exp. Lag 15 Quartile 1 (0 to <3.37)/Yes, worked with diesel outside of study mine work 3 = Cum. Exp. Lag 15 Quartile 1 (0 to <3.37)/No, did not work with diesel outside study mine work 4 = Cum. Exp. Lag 15 Quartile 2 (3.37 to < 71.58)/Don't Know 5 = Cum. Exp. Lag 15 Quartile 2 (3.37 to < 71.58)/Yes, worked with diesel outside of study mine work 6 = Cum. Exp. Lag 15 Quartile 2 (3.37 to < 71.58)/No, did not work with diesel outside study mine work 7 = Cum. Exp. Lag 15 Quartile 3 (71.58 to < 535.65)/Don't Know 8 = Cum. Exp. Lag 15 Quartile 3 (71.58 to < 535.65)/Yes, worked with diesel outside of study mine work 9 = Cum. Exp. Lag 15 Quartile 3 (71.58 to < 535.65)/No, did not work with diesel outside study mine work	Quartile ranges are shown for each quartile (μ/m3-years). Quartile cut points created using cases only.
Variable 11	Duration for high risk jobs(Checklist # - 1-Miner/Outside study Mine,2-Truck Driver,8-Machinery Mechanic,12-Welder,22-Painter), grouped	0 = 0 Years 1 = Less than 5 Years 2 = 5 to less than 10 years 3 = 10 to less than 15 years 4 = 15 or more years	Checklist numbers refer to job titles in jobs checklist in subject questionnaire
Variable 12	Education level	1 = Vocational Training 2 = Less than High School 3 = Completed high school or GED 4 = Any College 9 = Don't Know	
Variable 13	Cumulative respirable dust (mg/m3-years).	Continuous Value	
Variable 14	Cumulative respirable dust (mg/m3-years) in quartiles.	1 = Quartile one (0 to < 5.66079) 2 = Quartile two (5.66079 to < 14.0777 ) 3 = Quartile three (14.0777 to < 29.5353) 4 = Quartile four (≥29.5353 )	Quartile ranges are shown for each quartile (mg/m3-years). Quartile cut points created using cases only.
Variable 15	Cumulative weighted asbestos score. (Cumulative exposure(continuous) derived from intensity scores (0–3) multiplied by years at each job, summed across jobs.)	Continuous Value 0 = No exposure (0)	
Variable 16	Cumulative weighted asbestos score in quartiles. (Quartiles of cumulative exposure derived from intensity scores (0–3) multiplied by years at each job, summed across jobs.)	1 = Quartile one (0 < < 1.15) 2 = Quartile two ( 1.15 to < 5.94 ) 3 = Quartile three (5.94 to < 13.72) 4 = Quartile four (≥ 13.72 )	Quartile ranges are shown for each quartile. Quartile cut points created using cases only and excluding those without exposure (equal to 0).
Variable 17	Cumulative weighted PAH score. (Cumulative exposure(continuous) derived from the presence or absence of non-diesel PAHs based on job title tasks (0,1) multiplied by years at each job, summed across jobs.)	Continuous Value 0 = No exposure (0)	
Variable 18	Cumulative weighted PAH score in quartiles. (Quartiles of cumulative exposure derived from the presence or absence of non-diesel PAHs based on job title tasks (0,1) multiplied by years at each job, summed across jobs.)	1 = Quartile one (0 < < 1.18) 2 = Quartile two (1.18 <= < 5.11) 3 = Quartile three ( 5.11 <= < 12.34) 4 = Quartile four (≥= 12.34)	Quartile ranges are shown for each quartile. Quartile cut points created using cases only and excluding those without exposure (equal to 0).
Variable 19	Cumulative weighted silica score. (Cumulative exposure (continuous) derived from intensity scores (0–3) multiplied by years at each job, summed across jobs.)	Continuous Value 0 = No exposure (0)	
Variable 20	Cumulative weighted silica score in quartiles. (Quartiles of cumulative exposure derived from intensity scores (0–3) multiplied by years at each job, summed across jobs.)	1 = Quartile one (0 < < 4.57) 2 = Quartile two (4.57 <= < 12.56 ) 3 = Quartile three (12.56 <= < 20.50) 4 = Quartile four (≥= 20.50)	Quartile ranges are shown for each quartile. Quartile cut points created using cases only and excluding those without exposure (equal to 0).
Variable 21	Cumulative radon (WL-months) in quartiles. (Cumulative radon(continuous) exposure derived from estimated levels in WL multiplied by months at each job, summed across jobs.)	Continuous Value 0 = No exposure (0)	
Variable 22	Cumulative radon (WL-months) in quartiles. (Quartiles of cumulative radon exposure derived from estimated levels in WL multiplied by months at each job, summed across jobs.)	1 = Quartile one (0 < < 0.64) 2 = Quartile two ( 0.64 <= < 1.87) 3 = Quartile three ( 1.87 <= < 2.98) 4 = Quartile four (≥= 2.98)	Quartile ranges are shown for each quartile. Quartile cut points created using cases only and excluding those without exposure (equal to 0).

\*Silverman DT, Samanic CM, Lubin JH, Blair AE, Stewart PA, Vermeulen R, et al. 2012. The diesel exhaust in miners study: a nested case-control study of lung cancer and diesel exhaust. J Natl Cancer Inst 104:(11):855–868.

Table 2.1 - C-C Analytic Variables (Silverman et al. 2012)

Variable 23	Smoking status with packs per day and underground status, grouped	1 = Don't know or occasional smoker with surface only study mine work 2 = Don't know or occasional smoker with any underground study mine work 3 = Non-smoker with surface only study mine work 4 = Non-smoker with any underground study mine work 5 = Former less than one pack per day smoker with any underground study mine work 6 = Former less than one pack per day smoker with surface only study mine work 7 = Current less than one pack per day smoker with any underground study mine work 8 = Current less than one pack per day smoker with surface only study mine work 9 = Former one to less than two packs per day smoker with any underground study mine work 10 = Former one to less than two packs per day smoker with surface only study mine work 11 = Current one to less than two packs per day smoker with any underground study mine work 12 = Current one to less than two packs per day smoker with surface only study mine work 13 = Former two or more packs per day smoker with any underground study mine work 14 = Former two or more packs per day smoker with surface only study mine work 15 = Current two or more packs per day smoker with any underground study mine work 16 = Current two or more packs per day smoker with surface only study mine work	
Variable 24	Smoking, packs per day, grouped	1 = Don't know or occasional smoker 2 = Non-smoker 3 = Less than one pack per day 4 = One to less than two packs per day 5 = Two or more packs per day	
Variable 25	Smoking status with packs per day, grouped	1 = Don't know or occasional smoker 2 = Non-smoker 3 = Former less than one pack per day smoker 4 = Current less than one pack per day smoker 5 = Former one to less than two packs per day smoker 6 = Current one to less than two packs per day smoker 7 = Former two or more packs per day smoker 8 = Current two or more packs per day smoker	
Variable 26	Smoking status (occasional smoking as a separate level) with packs per day, grouped	1 = Non-smoker 2 = Occasional smoker 3 = Former less than one pack per day smoker 4 = Former one to less than two packs per day smoker 5 = Former two or more packs per day smoker 6 = Current less than one pack per day smoker 7 = Current one to less than two packs per day smoker 8 = Current two or more packs per day smoker 9 = Don't know	
Variable 27	Smoking status and packs per day combined with cumulative REC exposure, truncated 15 years prior to case death in tertiles	1 = Don't know or occasional smoker /Cum. Exp. Lag 15 Tertile 1 (0 <= - < 8.37) 2 = Don't know or occasional smoker /Cum. Exp. Lag 15 Tertile 2 (8.37 <= - <304.23) 3 = Don't know or occasional smoker /Cum. Exp. Lag 15 Tertile 3 (>=304.23) 4 = Non-smoker/Cum. Exp. Lag 15 Tertile 1 (0 <= - < 8.37) 5 = Non-smoker /Cum. Exp. Lag 15 Tertile 2 (8.37 <= - <304.23) 6 = Non-smoker /Cum. Exp. Lag 15 Tertile 3 (>=304.23) 7 = Less than one pack per day/ Cum. Exp. Lag 15 Tertile 1 (0 <= - < 8.37) 8 = Less than one pack per day/ Cum. Exp. Lag 15 Tertile 2 (8.37 <= - <304.23) 9 = Less than one pack per day/ Cum. Exp. Lag 15 Tertile 3 (>=304.23) 10 = One to less than two packs per day/Cum. Exp. Lag 15 Tertile 1 (0 <= - < 8.37) 11 = One to less than two packs per day/Cum. Exp. Lag 15 Tertile 2 (8.37 <= - <304.23) 12 = One to less than two packs per day/Cum. Exp. Lag 15 Tertile 3 (>=304.23) 13 = Two or more packs per day//Cum. Exp. Lag 15 Tertile 1 (0 <= - < 8.37) 14 = Two or more packs per day//Cum. Exp. Lag 15 Tertile 2 (8.37 <= - <304.23) 15 = Two or more packs per day//Cum. Exp. Lag 15 Tertile 3 (>=304.23)	Tertile ranges are shown for each tertile ( $\mu$ /m3-years). Tertile cut points created using cases only.
Variable 28	Cigar smoking duration in years, grouped	0 = No cigar smoking 1 = Less than ten years smoking cigars 2 = Ten to less than twenty years smoking cigars 3 = Twenty or more years smoking cigars 9 = Don't know	
Variable 29	Pipe smoking as pipefuls per week, grouped	0 = No Pipe Smoking 1 = Less than ten pipefuls per week 2 = Ten to less than twenty pipefuls per week 3 = Twenty or more pipefuls per week 9 = Don't know	
Variable 30	Numbers of smokers in residence at any subject's childhood and adulthood homes	0 = Zero smokers in adult and childhood homes 1 = One smoker in adult and childhood homes 2 = Two or more smokers in adult and childhood homes 9 = Don't know	
Variable 31	Any underground study mine work or study mine surface only work indicator	0 = Surface work only at study mines 1 = Any underground work at study mines	
Variable 32	Duration exposed, grouped	0 = 0 Years 1 = Less than 5 Years 2 = 5 to less than 10 years 3 = 10 to less than 15 years 4 = 15 or more years	

**Table 2.1 - C-C Analytic Variables (Silverman et al. 2012)**

			Trends created using the median of controls within duration groups and assigning resulting value to all cases/controls in a given duration group.
Variable 33	Duration exposed as a trend of the grouped variable	Continuous Value	
Variable 34	Cumulative REC exposure ( $\mu$ /m3-years)	Continuous Value	
Variable 35	Cumulative REC exposure ( $\mu$ /m3-years) in quartiles	1 = Quartile one (0 <= - < 18.74) 2 = Quartile two (18.74 <= - < 245.79) 3 = Quartile three (245.79 <= - < 963.91) 4 = Quartile four (>= 963.91)	Quartile ranges are shown for each quartile ( $\mu$ /m3-years). Quartile cut points created using cases only.
Variable 36	Cumulative REC exposure ( $\mu$ /m3-years) as a trend of the quartiles	Continuous Value	Trends created using the median of controls within quartiles and assigning resulting value to all cases/controls in a given quartile.
Variable 37	Average REC exposure ( $\mu$ /m3)	Continuous Value	
Variable 38	Average REC exposure ( $\mu$ /m3) in quartiles	1 = Quartile one (0 <= - < 1.37) 2 = Quartile two (1.37 <= - < 3 2.28) 3 = Quartile three (32.28 <= - < 98.39) 4 = Quartile four (>= 98.39)	Quartile ranges are shown for each quartile ( $\mu$ /m3). Quartile cut points created using cases only.
Variable 39	Average REC exposure ( $\mu$ /m3) as a trend of the quartiles	Continuous Value	Trends created using the median of controls within quartiles and assigning resulting value to all cases/controls in a given quartile.
Variable 40	Cumulative REC exposure ( $\mu$ /m3-years), truncated 3 years prior to case death	Continuous Value	
Variable 41	Average REC exposure ( $\mu$ /m3), truncated 3 years prior to case death	Continuous Value	
Variable 42	Cumulative REC exposure ( $\mu$ /m3-years), truncated 5 years prior to case death	Continuous Value	
Variable 43	Average REC exposure ( $\mu$ /m3), truncated 5 years prior to case death	Continuous Value	
Variable 44	Cumulative REC exposure ( $\mu$ /m3-years), truncated 7 years prior to case death	Continuous Value	
Variable 45	Average REC exposure ( $\mu$ /m3), truncated 7 years prior to case death	Continuous Value	
Variable 46	Cumulative REC exposure ( $\mu$ /m3-years), truncated 9 years prior to case death	Continuous Value	
Variable 47	Average REC exposure ( $\mu$ /m3), truncated 9 years prior to case death	Continuous Value	
Variable 48	Cumulative REC exposure ( $\mu$ /m3-years), truncated 11 years prior to case death	Continuous Value	
Variable 49	Average REC exposure ( $\mu$ /m3), truncated 11 years prior to case death	Continuous Value	
Variable 50	Cumulative REC exposure ( $\mu$ /m3-years), truncated 13 years prior to case death	Continuous Value	
Variable 51	Average REC exposure ( $\mu$ /m3), truncated 13 years prior to case death	Continuous Value	
Variable 52	Cumulative REC exposure ( $\mu$ /m3-years), truncated 15 years prior to case death	Continuous Value	
Variable 53	Cumulative REC exposure ( $\mu$ /m3-years) truncated 15 years prior to case death in quartiles	1 = Quartile one (0 to <3.37) 2 = Quartile two (3.37 to < 71.58) 3 = Quartile three (71.58 to < 535.65) 4 = Quartile four ( $\geq$ 535.65)	Quartile ranges are shown for each quartile ( $\mu$ /m3-years). Quartile cut points created using cases only.
Variable 54	Cumulative REC exposure ( $\mu$ /m3-years) truncated 15 years prior to case death in quartiles, using cohort cut points	1 = Quartile one (0 to <107.67) 2 = Quartile two (107.67 to < 444.92) 3 = Quartile three (444.92 to < 945.81) 4 = Quartile four ( $\geq$ 945.81)	Quartile ranges are taken from cohort paper
Variable 55	Cumulative REC exposure ( $\mu$ /m3-years) truncated 15 years prior to case death in tertiles	1 = Tertile one (0 to < 8.37) 2 = Tertile two (8.37 to <304.23) 3 = Tertile three ( $\geq$ 304.23)	Tertile ranges are shown for each tertile ( $\mu$ /m3-years). Tertile cut points created using cases only.
Variable 56	Average REC exposure ( $\mu$ /m3), truncated 15 years prior to case death in quartiles	1 = Quartile one (0 to < 0.86) 2 = Quartile two (0.86 to < 5.78) 3 = Quartile three (5.78 to < 56.99) 4 = Quartile four ( $\geq$ 56.99)	Quartile ranges are shown for each quartile ( $\mu$ /m3). Quartile cut points created using cases only.
Variable 57	Cumulative REC exposure ( $\mu$ /m3-years) truncated 15 years prior to case death in quartiles, with fourth or top quartile split by the median of that quartile	1 = Quartile one (0 to <3.37) 2 = Quartile two (3.37 to < 71.58) 3 = Quartile three (71.58 to < 535.65) 4 = Quartile four and less than median quartile value (535.65 to <1004.51) 5 = Quartile four and greater than or equal to median quartile value ( $\geq$ 1004.51)	Quartile ranges are shown for each quartile ( $\mu$ /m3-years). Quartile cut points created using cases only. Fourth quartile median created using only cases in the fourth quartile.
Variable 58	Cumulative REC exposure ( $\mu$ /m3-years) truncated 15 years prior to case death in quartiles, with fourth or top quartile split by the median of that quartile as a trend of the quartiles	Continuous Value	Trends created using the median of controls within quartiles and assigning resulting value to all cases/controls in a given quartile. In this case we are also using the median split categories of the fourth quartile to create the trend.
Variable 59	Cumulative REC exposure ( $\mu$ /m3-years) truncated 15 years prior to case death as a trend of the quartiles	Continuous Value	Trends created using the median of controls within quartiles and assigning resulting value to all cases/controls in a given quartile.
Variable 60	Average REC exposure ( $\mu$ /m3), truncated 15 years prior to case death	Continuous Value	
Variable 61	Average REC exposure ( $\mu$ /m3), truncated 15 years prior to case death as a trend of the quartiles	Continuous Value	Trends created using the median of controls within quartiles and assigning resulting value to all cases/controls in a given quartile.
Variable 62	Cumulative REC exposure ( $\mu$ /m3-years), truncated 17 years prior to case death	Continuous Value	
Variable 63	Average REC exposure ( $\mu$ /m3), truncated 17 years prior to case death	Continuous Value	
Variable 64	Cumulative REC exposure ( $\mu$ /m3-years), truncated 19 years prior to case death	Continuous Value	
Variable 65	Average REC exposure ( $\mu$ /m3), truncated 19 years prior to case death	Continuous Value	
Variable 66	Cumulative REC exposure ( $\mu$ /m3-years), truncated 20 years prior to case death	Continuous Value	
Variable 67	Average REC exposure ( $\mu$ /m3), truncated 20 years prior to case death	Continuous Value	
Variable 68	Cumulative REC exposure ( $\mu$ /m3-years), truncated 21 years prior to case death	Continuous Value	
Variable 69	Average REC exposure ( $\mu$ /m3), truncated 21 years prior to case death	Continuous Value	
Variable 70	Cumulative REC exposure ( $\mu$ /m3-years), truncated 23 years prior to case death	Continuous Value	
Variable 71	Average REC exposure ( $\mu$ /m3), truncated 23 years prior to case death	Continuous Value	
Variable 72	Cumulative REC exposure ( $\mu$ /m3-years), truncated 25 years prior to case death	Continuous Value	
Variable 73	Average REC exposure ( $\mu$ /m3), truncated 25 years prior to case death	Continuous Value	

**Table 2.1 - C-C Analytic Variables (Silverman et al. 2012)**

		1 = <20 ug/m3 2 = 20-<40 ug/m3 3 = 40-<80 ug/m3 4 = 80-<160 ug/m3 5 = 160-<320 ug/m3 6 = 320-<640 ug/m3 7 = 640-<1280 ug/m3 8 = 1280-<2560 ug/m3 9 = >=2560 ug/m3	
Variable 74	Cumulative REC exposure (μ/m3), truncated 15 years prior to case death in categories		
Variable 75	Cumulative REC exposure (μ/m3), truncated 15 years prior to case death as a trend of the categorical variable	Continuous Value	Trends created using the median of controls within categories and assigning resulting value to all cases/controls in a given category.
Variable 76	Average REC exposure (μ/m3), truncated 15 years prior to case death in categories	1 = <2 ug/m3 2 = 2-<4 ug/m3 3 = 4-<8 ug/m3 4 = 8-<16 ug/m3 5 = 16-<32 ug/m3 6 = 32-<64 ug/m3 7 = 64-<128 ug/m3 8 = 128-<256 ug/m3 9 = >=256 ug/m3	
Variable 77	Average REC exposure (μ/m3), truncated 15 years prior to case death as a trend of the categorical variable	Continuous Value	Trends created using the median of controls within categories and assigning resulting value to all cases/controls in a given category.
Variable 78	Eligible cluster indicator - subjects from trona mines	0 = Not a valid cluster - Subjects without study mine work in trona mines or in unbalanced clusters after exclusion 1 = Valid cluster - Subjects with study mine work in trona mines in balanced clusters	Balanced clusters have a case and at least one control. This variable must be used in conjunction with variables 79 and 80 for exclusion purposes or those variables will be incorrect.
Variable 79	Average REC exposure (μ/m3), truncated 15 years prior to case death as a trend of the quartiles, for eligible trona clusters only	Continuous Value	Trends created using the median of eligible trona cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  <b>Must exclude ineligible clusters using variable 78 (trona_clust) in order to use this variable</b>
Variable 80	Cumulative REC exposure (μ/m3-years) truncated 15 years prior to case death as a trend of the quartiles, for eligible trona clusters only	Continuous Value	Trends created using the median of eligible trona cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  <b>Must exclude ineligible clusters using variable 78 (trona_clust) in order to use this variable</b>
Variable 81	Eligible cluster indicator - subjects from potash mines	0 = Not a valid cluster - Subjects without study mine work in potash mines or in unbalanced clusters after exclusion 1 = Valid cluster - Subjects with study mine work in potash mines in balanced clusters	Balanced clusters have a case and at least one control. This variable must be used in conjunction with variables 82 and 82 for exclusion purposes or those variables will be incorrect.
Variable 82	Average REC exposure (μ/m3), truncated 15 years prior to case death as a trend of the quartiles, for eligible potash clusters only	Continuous Value	Trends created using the median of eligible potash cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  <b>Must exclude ineligible clusters using variable 81 (potash_clust) in order to use this variable</b>
Variable 83	Cumulative REC exposure (μ/m3-years) truncated 15 years prior to case death as a trend of the quartiles, for eligible potash clusters only	Continuous Value	Trends created using the median of eligible potash cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  <b>Must exclude ineligible clusters using variable 81 (potash_clust) in order to use this variable</b>
Variable 84	Eligible cluster indicator - subjects with any underground study mine work	0 = Not a valid cluster - Subjects without any underground study mine work or in unbalanced clusters after exclusion 1 = Valid cluster - Subjects with any underground study mine work in balanced clusters	Balanced clusters have a case and at least one control. This variable must be used in conjunction with variables 84-94 for exclusion purposes or those variables will be incorrect.
Variable 85	Cumulative REC exposure (μ/m3-years) as a trend of the quartiles, for eligible any underground clusters	Continuous Value	Trends created using the median of eligible any underground cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  <b>Must exclude ineligible clusters using variable 84 (any_ug_clust) in order to use this variable.</b>
Variable 86	Cumulative REC exposure (μ/m3-years) truncated 15 years prior to case death as a trend of the quartiles, for eligible any underground clusters	Continuous Value	Trends created using the median of eligible any underground cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  <b>Must exclude ineligible clusters using variable 84 (any_ug_clust) in order to use this variable.</b>

**Table 2.1 - C-C Analytic Variables (Silverman et al. 2012)**

Variable 87	Average REC exposure ( $\mu\text{m}^3$ ) as a trend of the quartiles, for eligible any underground clusters	Continuous Value	Trends created using the median of eligible any underground cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  Must exclude ineligible clusters using variable 84(any Ug_clust) in order to use this variable
Variable 88	Average REC exposure ( $\mu\text{m}^3$ ), truncated 15 years prior to case death as a trend of the quartiles, for eligible any underground clusters	Continuous Value	Trends created using the median of eligible any underground cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  Must exclude ineligible clusters using variable 84(any Ug_clust) in order to use this variable
Variable 89	Cumulative REC exposure ( $\mu\text{m}^3\text{-years}$ ) in quartiles, for eligible any underground clusters	1 = Quartile one ( $0 \leq - < 298.23$ ) 2 = Quartile two ( $298.23 \leq - < 674.81$ ) 3 = Quartile three ( $674.81 \leq - < 1464.56$ ) 4 = Quartile four ( $\geq 1464.56$ )	Quartile ranges are shown for each quartile ( $\mu\text{m}^3\text{-years}$ ). Quartile cut points created using eligible any underground cluster cases only.  Must exclude ineligible clusters using variable 84(any Ug_clust) in order to use this variable
Variable 90	Cumulative REC exposure ( $\mu\text{m}^3\text{-years}$ ) truncated 15 years prior to case death in quartiles, for eligible any underground clusters	1 = Quartile one ( $0 \leq - < 81.35$ ) 2 = Quartile two ( $81.35 \leq - < 325.34$ ) 3 = Quartile three ( $325.34 \leq - < 878.37$ ) 4 = Quartile four ( $\geq 878.37$ )	Quartile ranges are shown for each quartile ( $\mu\text{m}^3\text{-years}$ ). Quartile cut points created using eligible any underground cluster cases only.  Must exclude ineligible clusters using variable 84(any Ug_clust) in order to use this variable
Variable 91	Average REC exposure ( $\mu\text{m}^3$ ) in quartiles, for eligible any underground clusters	1 = Quartile one ( $0 \leq - < 39.13$ ) 2 = Quartile two ( $39.13 \leq - < 70.95$ ) 3 = Quartile three ( $70.95 \leq - < 146.70$ ) 4 = Quartile four ( $\geq 146.70$ )	Quartile ranges are shown for each quartile ( $\mu\text{m}^3$ ). Quartile cut points created using eligible any underground cluster cases only.  Must exclude ineligible clusters using variable 84(any Ug_clust) in order to use this variable
Variable 92	Average REC exposure ( $\mu\text{m}^3$ ), truncated 15 years prior to case death in quartiles, for eligible any underground clusters	1 = Quartile one ( $0 \leq - < 7.87$ ) 2 = Quartile two ( $7.87 \leq - < 48.76$ ) 3 = Quartile three ( $48.76 \leq - < 103.50$ ) 4 = Quartile four ( $\geq 103.50$ )	Quartile ranges are shown for each quartile ( $\mu\text{m}^3$ ). Quartile cut points created using eligible any underground cluster cases only.  Must exclude ineligible clusters using variable 84(any Ug_clust) in order to use this variable
Variable 93	Duration exposed, grouped, for eligible any underground clusters	0 = 0 Years 1 = Less than 5 Years 2 = 5 to less than 10 years 3 = 10 to less than 15 years 4 = 15 or more years	Must exclude ineligible clusters using variable 84(any Ug_clust) in order to use this variable
Variable 94	Duration exposed as a trend of the grouped variable, for eligible any underground clusters	Continuous Value	Trends created using the median of eligible any underground cluster controls within duration groups and assigning resulting value to all cases/controls in a given duration group.  Must exclude ineligible clusters using variable 84(any Ug_clust) in order to use this variable
Variable 95	Eligible cluster indicator - subjects with surface only study mine work	0 = Not a valid cluster - Subjects without surface only study mine work or in unbalanced clusters after exclusion 1 = Valid cluster - Subjects with surface only study mine work in balanced clusters	Balanced clusters have a case and at least one control. This variable must be used in conjunction with variables 96-105 for exclusion purposes or those variables will be incorrect.
Variable 96	Cumulative REC exposure ( $\mu\text{m}^3\text{-years}$ ) as a trend of the quartiles, for eligible surface only clusters	Continuous Value	Trends created using the median of eligible surface only cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable
Variable 97	Cumulative REC exposure ( $\mu\text{m}^3\text{-years}$ ) truncated 15 years prior to case death as a trend of the quartiles, for eligible surface only clusters	Continuous Value	Trends created using the median of eligible surface only cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable
Variable 98	Average REC exposure ( $\mu\text{m}^3$ ) as a trend of the quartiles, for eligible surface only clusters	Continuous Value	Trends created using the median of eligible surface only cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable



**Table 2.1 - C-C Analytic Variables (Silverman et al. 2012)**

Variable 99	Average REC exposure ( $\mu\text{m}^3$ ), truncated 15 years prior to case death as a trend of the quartiles, for eligible surface only clusters	Continuous Value	Trends created using the median of eligible surface only cluster controls within quartiles and assigning resulting value to all cases/controls in a given quartile.  Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable
Variable 100	Cumulative REC exposure ( $\mu\text{m}^3\text{-years}$ ) in quartiles, for eligible surface only clusters	1 = Quartile one ( $0 \leq - < 6.51$ ) 2 = Quartile two ( $6.51 \leq - < 12.53$ ) 3 = Quartile three ( $12.53 \leq - < 22.46$ ) 4 = Quartile four ( $\geq 22.46$ )	Quartile ranges are shown for each quartile ( $\mu\text{m}^3\text{-years}$ ). Quartile cut points created using eligible surface only cluster cases only.  Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable
Variable 101	Cumulative REC exposure ( $\mu\text{m}^3\text{-years}$ ) truncated 15 years prior to case death in quartiles, for eligible surface only clusters	1 = Quartile one ( $0 \leq - < 0.70$ ) 2 = Quartile two ( $0.70 \leq - < 4.37$ ) 3 = Quartile three ( $4.37 \leq - < 14.34$ ) 4 = Quartile four ( $\geq 14.34$ )	Quartile ranges are shown for each quartile ( $\mu\text{m}^3\text{-years}$ ). Quartile cut points created using eligible surface only cluster cases only.  Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable
Variable 102	Average REC exposure ( $\mu\text{m}^3$ ) in quartiles, for eligible surface only clusters	1 = Quartile one ( $0 \leq - < 0.86$ ) 2 = Quartile two ( $0.86 \leq - < 0.95$ ) 3 = Quartile three ( $0.95 \leq - < 1.91$ ) 4 = Quartile four ( $\geq 1.91$ )	Quartile ranges are shown for each quartile ( $\mu\text{m}^3$ ). Quartile cut points created using eligible surface only cluster cases only.  Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable
Variable 103	Average REC exposure ( $\mu\text{m}^3$ ), truncated 15 years prior to case death in quartiles, for eligible surface only clusters	1 = Quartile one ( $0 \leq - < 0.57$ ) 2 = Quartile two ( $0.57 \leq - < 0.86$ ) 3 = Quartile three ( $0.86 \leq - < 1.36$ ) 4 = Quartile four ( $\geq 1.36$ )	Quartile ranges are shown for each quartile ( $\mu\text{m}^3$ ). Quartile cut points created using eligible surface only cluster cases only.  Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable
Variable 104	Duration exposed, grouped , for eligible surface only clusters	0 = 0 Years 1 = Less than 5 Years 2 = 5 to less than 10 years 3 = 10 to less than 15 years 4 = 15 or more years	Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable
Variable 105	Duration exposed as a trend of the grouped variable , for eligible surface only clusters	Continuous Value	Trends created using the median of eligible surface only cluster controls within duration groups and assigning resulting value to all cases/controls in a given duration group.  Must exclude ineligible clusters using variable 95(surf_only_clust) in order to use this variable
Variable 106	Eligible cluster indicator - Subjects (cases) with a contributing lung cancer cause	0 = Not an eligible cluster - Cases with a non-contributing lung cancer cause or subjects in unbalanced clusters after exclusion 1 = Eligible cluster - Cases with contributing lung cancer causes in balanced clusters	Balanced clusters have a case and at least one control
Variable 107	Eligible cluster indicator - Subjects using protective equipment	0 = Not an eligible cluster - Subjects not using protective equipment or subjects in unbalanced clusters after exclusion 1 = Eligible cluster - Subjects using protective equipment in balanced clusters	Balanced clusters have a case and at least one control
Variable 108	Gender of subject - reported	1 = Male 2 = Female	Sex reported from questionnaire
Variable 109	Analytic age of subject (Death or Interview)	Continuous Value	For subjects still alive this is age at interview. For subjects that are dead, this is age at death. The age is based on the analytic birthdate derived during data collection.
Variable 110	Selected Race	0 = Unknown 1 = White 2 = Black 3 = Hispanic 4 = American Indian 5 = Asian 6 = Other	The race used at data collection and subsequently in matching.
Variable 111	Case/Control Randomized ID number	5-digit string	ID for matching to case/control data

**Table 2.2.** Odds ratios (ORs) and 95% confidence intervals (CIs) for smoking status/smoking intensity by location of employment\*

Smoking status/smoking intensity (packs per day)	OR (95% CI), No. of case subjects/No. of control subjects			AIC Surf/Ever underground	AIC All subjects
	Surface only†, average REC intensity (0-8 µg/m³ REC)	Ever underground†, average REC intensity (1-423 µg/m³ REC)	All subjects‡		
ORIGINAL STUDY					
Never smoker	1.0 (referent), 5/87	0.90 (0.26 to 3.09), 9/91	1.0 (referent), 14/178		
Former, < 1	1.36 (0.24 to 7.59), 2/31	2.51 (0.78 to 8.11), 17/62	2.87 (1.30 to 6.33), 19/93		
Former, 1 to < 2	6.66 (2.07 to 21.50), 14/40	1.97 (0.61 to 6.37), 16/68	3.56 (1.72 to 7.40), 30/108		
Former, ≥ 2	16.30 (3.55 to 74.82), 6/7	2.70 (0.72 to 10.12), 9/29	5.40 (2.23 to 13.06), 15/36		
Current, < 1	5.22 (1.16 to 23.39), 4/15	5.71 (1.63 to 20.01), 12/21	5.91 (2.47 to 14.10), 16/36		
Current, 1 to < 2	13.34 (4.50 to 39.53), 26/41	4.51 (1.50 to 13.58), 32/78	7.36 (3.71 to 14.57), 58/119		
Current, ≥ 2	26.60 (7.14 to 99.08), 12/9	7.13 (2.12 to 23.99), 17/27	12.41 (5.57 to 27.66), 29/36		
Unknown§	2.86 (0.71 to 11.64), 5/24	2.65 (0.76 to 9.24), 12/36	3.10 (1.33 to 7.26), 17/60		
Replication					
Never smoker	1.0 (referent), 5/87	0.904 (0.264 to 3.091), 9/91	1.0 (referent), 14/178	505.065	503.688
Former, < 1	1.356 (0.242 to 7.587), 2/31	2.514 (0.779 to 8.114), 17/62	2.871 (1.302 to 6.332), 19/93	B and C are same model, from same logistic regression model	
Former, 1 to < 2	6.663 (2.065 to 21.499), 14/40	1.968 (0.608 to 6.373), 16/68	3.562 (1.715 to 7.400), 30/108		
Former, ≥ 2	16.297 (3.550 to 74.820), 6/7	2.697 (0.719 to 10.117), 9/29	5.400 (2.232 to 13.061), 15/36		
Current, < 1	5.218 (1.164 to 23.386), 4/15	5.710 (1.630 to 20.005), 12/21	5.905 (2.473 to 14.104), 16/36		
Current, 1 to < 2	13.342 (4.504 to 39.526), 26/41	4.510 (1.497 to 13.585), 32/78	7.356 (3.714 to 14.567), 58/119		
Current, ≥ 2	26.598 (7.140 to 99.083), 12/9	7.130 (2.119 to 23.986), 17/27	12.409 (5.568 to 27.660), 29/36		
Unknown§	2.864 (0.705 to 11.640), 5/24	2.645 (0.757 to 9.238), 12/36	3.102 (1.325 to 7.264), 17/60		
LAG 0					
Never smoker	1.0 (referent), 5/87	1.123 (0.314 to 4.010), 9/91	1.0 (referent), 14/178	513.978	511.994
Former, < 1	1.218 (0.222 to 6.670), 2/31	3.147 (0.946 to 10.474), 17/62	2.748 (1.265 to 5.970), 19/93		
Former, 1 to < 2	6.278 (1.973 to 19.976), 14/40	2.646 (0.809 to 8.658), 16/68	3.601 (1.753 to 7.399), 30/108		
Former, ≥ 2	15.126 (3.399 to 67.320), 6/7	3.520 (0.927 to 13.357), 9/29	5.459 (2.290 to 13.013), 15/36		
Current, < 1	5.474 (1.222 to 24.533), 4/15	6.398 (1.764 to 23.209), 12/21	5.655 (2.381 to 13.431), 16/36		
Current, 1 to < 2	12.693 (4.343 to 37.098), 26/41	5.340 (1.716 to 16.612), 32/78	6.974 (3.559 to 13.664), 58/119		
Current, ≥ 2	24.881 (6.731 to 91.969), 12/9	8.643 (2.498 to 29.912), 17/27	11.733 (5.308 to 25.938), 29/36		
Unknown§	2.874 (0.719 to 11.279), 5/24	3.125 (0.863 to 11.318), 12/36	3.015 (1.309 to 6.943), 17/60		
LAG 3					
Never smoker	1.0 (referent), 5/87	1.252 (0.354 to 4.424), 9/91	1.0 (referent), 14/178	514.796	512.799
Former, < 1	1.235 (0.225 to 6.770), 2/31	3.514 (1.068 to 11.563), 17/62	2.761 (1.269 to 6.004), 19/93		
Former, 1 to < 2	6.280 (1.978 to 19.938), 14/40	2.846 (0.870 to 9.312), 16/68	3.533 (1.723 to 7.244), 30/108		
Former, ≥ 2	14.646 (3.302 to 64.954), 6/7	3.960 (1.055 to 14.864), 9/29	5.453 (2.284 to 13.015), 15/36		
Current, < 1	5.238 (1.163 to 23.593), 4/15	7.192 (2.042 to 25.334), 12/21	5.620 (2.363 to 13.371), 16/36		
Current, 1 to < 2	12.398 (4.252 to 36.150), 26/41	5.897 (1.917 to 18.144), 32/78	6.877 (3.512 to 13.465), 58/119		
Current, ≥ 2	24.120 (6.513 to 89.326), 12/9	9.248 (2.659 to 32.168), 17/27	11.323 (5.126 to 25.011), 29/36		
Unknown§	2.778 (0.699 to 11.048), 5/24	3.389 (0.940 to 12.216), 12/36	2.937 (1.275 to 6.768), 17/60		

<b>LAG 5</b>					
Never smoker	1.0 (referent), 5/87	1.369 (0.385 to 4.872), 9/91	1.0 (referent), 14/178	512.403	509.87
Former, < 1	1.260 (0.230 to 6.911), 2/31	3.718 (1.118 to 12.371), 17/62	2.705 (1.244 to 5.884), 19/93		
Former, 1 to < 2	6.425 (2.012 to 20.517), 14/40	3.033 (0.918 to 10.020), 16/68	3.482 (1.695 to 7.153), 30/108		
Former, ≥ 2	14.209 (3.205 to 62.991), 6/7	4.168 (1.092 to 15.910), 9/29	5.242 (2.195 to 12.516), 15/36		
Current, < 1	5.440 (1.204 to 24.571), 4/15	7.918 (2.234 to 28.069), 12/21	5.731 (2.419 to 13.575), 16/36		
Current, 1 to < 2	12.102 (4.128 to 35.482), 26/41	6.229 (2.018 to 19.223), 32/78	6.683 (3.403 to 13.125), 58/119		
Current, ≥ 2	21.856 (5.854 to 81.598), 12/9	10.138 (2.922 to 35.174), 17/27	10.917 (4.933 to 24.159), 29/36		
Unknown\$	2.778 (0.695 to 11.099), 5/24	3.601 (0.987 to 13.143), 12/36	2.864 (1.243 to 6.602), 17/60		
<b>LAG 7</b>					
Never smoker	1.0 (referent), 5/87	1.246 (0.346 to 4.495), 9/91	1.0 (referent), 14/178	508.723	506.205
Former, < 1	1.261 (0.230 to 6.922), 2/31	3.456 (1.036 to 11.526), 17/62	2.722 (1.246 to 5.949), 19/93		
Former, 1 to < 2	6.391 (1.995 to 20.472), 14/40	2.796 (0.841 to 9.297), 16/68	3.501 (1.700 to 7.209), 30/108		
Former, ≥ 2	14.007 (3.153 to 62.217), 17/27	3.916 (1.020 to 15.036), 9/29	5.326 (2.224 to 12.753), 15/36		
Current, < 1	5.075 (1.119 to 23.019), 4/15	7.972 (2.238 to 28.405), 12/21	5.921 (2.496 to 14.046), 16/36		
Current, 1 to < 2	12.096 (4.112 to 35.580), 26/41	5.883 (1.888 to 18.331), 32/78	6.828 (3.469 to 13.438), 58/119		
Current, ≥ 2	21.793 (5.834 to 81.405), 12/9	9.635 (2.747 to 33.801), 17/27	11.210 (5.076 to 24.757), 29/36		
Unknown\$	2.750 (0.686 to 11.031), 5/24	3.290 (0.889 to 12.172), 12/36	2.854 (1.235 to 6.596), 17/60		
<b>LAG 9</b>					
Never smoker	1.0 (referent), 5/87	1.068 (0.299 to 3.823), 9/91	1.0 (referent), 14/178	509.492	507.116
Former, < 1	1.288 (0.234 to 7.095), 2/31	3.143 (0.953 to 10.362), 17/62	2.849 (1.299 to 6.249), 19/93		
Former, 1 to < 2	6.605 (2.059 to 21.189), 14/40	2.536 (0.776 to 8.290), 16/68	3.671 (1.777 to 7.583), 30/108		
Former, ≥ 2	14.950 (3.347 to 66.775), 6/7	3.495 (0.920 to 13.275), 9/29	5.561 (2.324 to 13.310), 15/36		
Current, < 1	5.184 (1.148 to 23.405), 4/15	7.155 (1.992 to 25.693), 12/21	6.088 (2.552 to 14.520), 16/36		
Current, 1 to < 2	12.367 (4.202 to 36.403), 26/41	5.512 (1.797 to 16.908), 32/78	7.246 (3.663 to 14.332), 58/119		
Current, ≥ 2	22.989 (6.157 to 85.831), 12/9	8.383 (2.429 to 28.929), 17/27	11.569 (5.222 to 25.631), 29/36		
Unknown\$	2.787 (0.967 to 11.151), 5/24	2.996 (0.829 to 10.820), 12/36	2.959 (1.278 to 6.848), 17/60		
<b>LAG 11</b>					
Never smoker	1.0 (referent), 5/87	0.975 (0.280 to 3.392), 9/91	1.0 (referent), 14/178	507.01	504.882
Former, < 1	1.239 (0.223 to 6.878), 2/31	2.925 (0.900 to 9.502), 17/62	2.866 (1.302 to 6.309), 19/93		
Former, 1 to < 2	6.547 (2.042 to 20.988), 14/40	2.241 (0.690 to 7.278), 16/68	3.592 (1.731 to 7.455), 30/108		
Former, ≥ 2	15.421 (3.432 to 69.302), 6/7	3.381 (0.897 to 12.743), 9/29	5.867 (2.423 to 14.210), 15/36		
Current, < 1	4.991 (1.106 to 22.517), 4/15	6.607 (1.886 to 23.144), 12/21	6.016 (2.513 to 14.399), 16/36		
Current, 1 to < 2	12.644 (4.276 to 37.388), 26/41	5.118 (1.689 to 15.505), 32/78	7.313 (3.691 to 14.487), 58/119		
Current, ≥ 2	23.015 (6.129 to 86.420), 12/9	7.787 (2.288 to 26.511), 17/27	11.717 (5.271 to 26.044), 29/36		
Unknown\$	2.859 (0.711 to 11.492), 5/24	2.750 (0.777 to 9.735), 12/36	2.976 (1.279 to 6.923), 17/60		
<b>LAG 13</b>					
Never smoker	1.0 (referent), 5/87	0.846 (0.243 to 2.947), 9/91	1.0 (referent), 14/178	506.041	503.833
Former, < 1	1.353 (0.244 to 7.491), 2/31	2.521 (0.781 to 8.136), 17/62	2.943 (1.336 to 6.484), 19/93	2.017	0.628
Former, 1 to < 2	6.472 (2.014 to 20.801), 14/40	2.017 (0.628 to 6.485), 16/68	3.686 (1.769 to 7.681), 30/108		
Former, ≥ 2	16.238 (3.617 to 72.905), 6/7	2.711 (0.721 to 10.191), 9/29	5.667 (2.347 to 13.686), 15/36		
Current, < 1	5.202 (1.158 to 23.358), 4/15	5.593 (1.589 to 19.686), 12/21	6.074 (2.536 to 14.548), 16/36		

HEI Diesel Epidemiology Panel

Current, 1 to < 2	13.297 (4.488 to 39.401), 26/41	4.529 (1.504 to 13.636), 32/78	7.621 (3.829 to 15.170), 58/119
Current, ≥ 2	26.049 (6.932 to 97.887), 12/9	7.108 (2.113 to 23.908), 17/27	12.742 (5.688 to 28.543), 29/36
Unknown§	2.974 (0.735 to 12.041), 5/24	2.466 (0.699 to 8.703), 12/36	3.113 (1.328 to 7.299), 17/60

**LAG 15**

Never smoker	1.0 (referent), 5/87	0.904 (0.264 to 3.091), 9/91	1.0 (referent), 14/178	505.065	503.688
Former, < 1	1.356 (0.242 to 7.587), 2/31	2.514 (0.779 to 8.114), 17/62	2.871 (1.302 to 6.332), 19/93		
Former, 1 to < 2	6.663 (2.065 to 21.499), 14/40	1.968 (0.608 to 6.373), 16/68	3.562 (1.715 to 7.400), 30/108		
Former, ≥ 2	16.297 (3.550 to 74.820), 6/7	2.697 (0.719 to 10.117), 9/29	5.400 (2.232 to 13.061), 15/36		
Current, < 1	5.218 (1.164 to 23.386), 4/15	5.710 (1.630 to 20.005), 12/21	5.905 (2.473 to 14.104), 16/36		
Current, 1 to < 2	13.342 (4.504 to 39.526), 26/41	4.510 (1.497 to 13.585), 32/78	7.356 (3.714 to 14.567), 58/119		
Current, ≥ 2	26.598 (7.140 to 99.083), 12/9	7.130 (2.119 to 23.986), 17/27	12.409 (5.568 to 27.660), 29/36		
Unknown§	2.864 (0.705 to 11.640), 5/24	2.645 (0.757 to 9.238), 12/36	3.102 (1.325 to 7.264), 17/60		

**LAG 17**

Never smoker	1.0 (referent), 5/87	0.973 (0.292 to 3.241), 9/91	1.0 (referent), 14/178	504.531	503.53
Former, < 1	1.512 (0.270 to 8.479), 2/31	2.671 (0.845 to 8.445), 17/62	2.906 (1.315 to 6.418), 19/93		
Former, 1 to < 2	7.625 (2.322 to 25.034), 14/40	12.113 (0.673 to 6.636), 16/68	3.726 (1.801 to 7.706), 30/108		
Former, ≥ 2	17.357 (3.728 to 80.811), 6/7	3.065 (0.846 to 11.110), 9/29	5.738 (2.372 to 13.878), 15/36		
Current, < 1	6.408 (1.417 to 28.976), 4/15	6.399 (1.860 to 22.017), 12/21	6.380 (2.653 to 15.338), 16/36		
Current, 1 to < 2	15.557 (5.136 to 47.125), 26/41	5.016 (1.694 to 14.854), 32/78	7.823 (3.933 to 15.564), 58/119		
Current, ≥ 2	30.700 (8.077 to 116.696), 12/9	8.054 (2.458 to 26.391), 17/27	13.212 (5.914 to 29.513), 29/36		
Unknown§	3.175 (0.778 to 12.950), 5/24	3.106 (0.909 to 10.617), 12/36	3.367 (1.437 to 7.888), 17/60		

**LAG 19**

Never smoker	1.0 (referent), 5/87	1.057 (0.321 to 3.485), 9/91	1.0 (referent), 14/178	506.906	505.752
Former, < 1	1.502 (0.268 to 8.419), 2/31	2.910 (0.930 to 9.105), 17/62	2.941 (1.334 to 6.483), 19/93		
Former, 1 to < 2	7.765 (2.365 to 25.497), 14/40	2.282 (0.730 to 7.133), 16/68	3.745 (1.810 to 7.749), 30/108		
Former, ≥ 2	16.946 (3.675 to 78.136), 6/7	3.322 (0.930 to 11.865), 9/29	5.714 (2.380 to 13.715), 15/36		
Current, < 1	6.493 (1.440 to 29.289), 4/15	6.236 (1.820 to 21.362), 12/21	6.134 (2.563 to 14.680), 16/36		
Current, 1 to < 2	15.507 (5.120 to 46.965), 26/41	5.352 (1.815 to 15.781), 32/78	7.777 (3.909 to 15.473), 58/119		
Current, ≥ 2	30.934 (8.164 to 117.212), 12/9	8.327 (2.543 to 27.265), 17/27	13.011 (5.821 to 29.083), 29/36		
Unknown§	3.274 (0.803 to 13.352), 5/24	3.278 (0.967 to 11.114), 12/36	3.396 (1.451 to 7.949), 17/60		

**LAG 20**

Never smoker	1.0 (referent), 5/87	1.312 (0.399 to 4.319), 9/91	1.0 (referent), 14/178	514.565	512.393
Former, < 1	1.234 (0.223 to 6.829), 2/31	<b>3.549 (1.128 to 11.167), 17/62</b>	2.696 (1.235 to 5.885), 19/93		
Former, 1 to < 2	6.481 (2.025 to 20.746), 14/40	2.849 (0.908 to 8.936), 16/68	3.484 (1.702 to 7.133), 30/108		
Former, ≥ 2	14.002 (3.135 to 62.533), 6/7	<b>4.113 (1.153 to 14.675), 9/29</b>	5.363 (2.261 to 12.725), 15/36		
Current, < 1	5.604 (1.266 to 24.815), 4/15	<b>7.350 (2.173 to 24.852), 12/21</b>	5.649 (2.394 to 13.334), 16/36		
Current, 1 to < 2	13.232 (4.472 to 39.152), 26/41	6.244 (2.132 to 18.287), 32/78	7.101 (3.614 to 13.952), 58/119		
Current, ≥ 2	25.474 (6.824 to 95.089), 12/9	10.411 (3.173 to 34.158), 17/27	12.141 (5.475 to 26.924), 29/36		
Unknown§	3.064 (0.766 to 12.262), 5/24	<b>3.831 (1.132 to 12.960), 12/36</b>	3.160 (1.361 to 7.335), 17/60		

<b>LAG 21</b>					
Never smoker	1.0 (referent), 5/87	1.417 (0.436 to 4.613), 9/91	1.0 (referent), 14/178	513.108	510.588
Former, < 1	1.245 (0.224 to 6.916), 2/31	<b>3.963 (1.284 to 12.232), 17/62</b>	2.754 (1.259 to 6.026), 19/93		
Former, 1 to < 2	6.425 (2.005 to 20.589), 14/40	<b>3.239 (1.063 to 9.869), 16/68</b>	3.571 (1.744 to 7.313), 30/108		
Former, ≥ 2	13.577 (3.029 to 60.849), 6/7	4.638 (1.323 to 16.264), 9/29	5.434 (2.291 to 12.886), 15/36		
Current, < 1	5.807 (1.314 to 25.654), 4/15	7.954 (2.368 to 26.719), 12/21	5.720 (2.420 to 13.518), 16/36		
Current, 1 to < 2	13.350 (4.514 to 39.483), 26/41	<b>7.072 (2.446 to 20.449), 32/78</b>	7.304 (3.697 to 14.432), 58/119		
Current, ≥ 2	26.426 (7.079 to 98.644), 12/9	<b>11.754 (3.609 to 38.282), 17/27</b>	12.538 (5.637 to 27.890), 29/36		
Unknown§	2.994 (0.752 to 11.917), 5/24	4.393 (1.320 to 14.621), 12/36	3.260 (1.406 to 7.562), 17/60		
<b>LAG 23</b>					
Never smoker	1.0 (referent), 5/87	1.448 (0.446 to 4.701), 9/91	1.0 (referent), 14/178	516.865	514.745
Former, < 1	1.211 (0.218 to 6.716), 2/31	<b>3.987 (1.292 to 12.297), 17/62</b>	2.703 (1.238 to 5.903), 19/93		
Former, 1 to < 2	6.302 (1.976 to 20.101), 14/40	<b>3.260 (1.070 to 9.928), 16/68</b>	3.516 (1.721 to 7.186), 30/108		
Former, ≥ 2	14.257 (3.176 to 64.001), 6/7	<b>4.615 (1.316 to 16.184), 9/29</b>	5.410 (2.270 to 12.892), 15/36		
Current, < 1	5.700 (1.287 to 25.252), 4/15	<b>8.112 (2.426 to 27.124), 12/21</b>	5.700 (2.411 to 13.479), 16/36		
Current, 1 to < 2	12.954 (4.407 to 38.078), 26/41	6.923 (2.402 to 19.956), 32/78	7.070 (3.595 to 13.904), 58/119		
Current, ≥ 2	25.478 (6.812 to 95.301), 12/9	11.419 (3.557 to 36.656), 17/27	11.955 (5.385 to 26.540), 29/36		
Unknown§	3.011 (0.758 to 11.964), 5/24	<b>4.333 (1.306 to 14.379), 12/36</b>	3.195 (1.375 to 7.420), 17/60		
<b>LAG 25</b>					
Never smoker	1.0 (referent), 5/87	1.341 (0.412 to 4.363), 9/91	1.0 (referent), 14/178	514.747	512.715
Former, < 1	1.217 (0.218 to 6.780), 2/31	<b>3.744 (1.212 to 11.571), 17/62</b>	2.729 (1.245 to 5.979), 19/93		
Former, 1 to < 2	6.289 (1.981 to 19.964), 14/40	<b>3.045 (0.998 to 9.288), 16/68</b>	3.546 (1.734 to 7.250), 30/108		
Former, ≥ 2	14.024 (3.143 to 62.573), 6/7	<b>4.351 (1.237 to 15.307), 9/29</b>	5.454 (2.293 to 12.972), 15/36		
Current, < 1	5.759 (1.307 to 25.372), 4/15	7.533 (2.243 to 25.298), 12/21	5.707 (2.416 to 13.482), 16/36		
Current, 1 to < 2	12.802 (4.360 to 37.595), 26/41	6.612 (2.291 to 19.079), 32/78	7.176 (3.648 to 14.116), 58/119		
Current, ≥ 2	27.272 (7.286 to 102.085), 12/9	10.632 (3.318 to 34.070), 17/27	12.295 (5.528 to 27.346), 29/36		
Unknown§	2.968 (0.747 to 11.797), 5/24	4.220 (1.268 to 14.043), 12/36	3.275 (1.411 to 7.600), 17/60		

\* REC = respirable elemental carbon.

† ORs relative to never smokers who worked only surface jobs, adjusted for cumulative REC, lagged 15 years (quartiles: 0 to <3  $\mu\text{g}/\text{m}^3$  -y; 3 to <72  $\mu\text{g}/\text{m}^3$  -y, 72 to <536  $\mu\text{g}/\text{m}^3$  -y, ≥ 536  $\mu\text{g}/\text{m}^3$  -y), history of respiratory disease 5 or more years before date of death/reference date, and history of a high-risk job for lung cancer for at least 10 years. ***P value for interaction between smoking status and location of employment based on likelihood ratio test = .082.***

‡ ORs for intensity smoked relative to never smokers, adjusted for cumulative REC, lagged 15 years (quartiles: 0 to <3  $\mu\text{g}/\text{m}^3$  -y; 3 to <72  $\mu\text{g}/\text{m}^3$  -y, 72 to <536  $\mu\text{g}/\text{m}^3$  -y, ≥ 536  $\mu\text{g}/\text{m}^3$  -y), location of employment (surface only, ever underground), history of respiratory disease 5 or more years before date of death/reference date, and history of a high-risk job for lung cancer for at least 10 years.

§ Unknown includes subjects with unknown smoking status, and subjects considered occasional smokers, who smoked at least 100 cigarettes during their lifetimes, but never smoked regularly (≥ 1 cigarette per day for at least 6 months).

**Table 2.3.** Odds ratios (ORs) and 95% confidence intervals (CIs) for average and cumulative REC and total duration REC exposure\*

Exposure metric	Case subject	Control subject	OR (95% CI)	P trend	AIC
ORIGINAL AVERAGE REC					
Average REC intensity, quartiles, unlagged, µg/m³					
0 to < 1	49	166	1.0 (referent)	.025	
1 to <32	50	207	1.03 (0.50 to 2.09)		
32 to < 98	49	145	1.88 (0.76 to 4.66)		
≥ 98	50	148	2.40 (0.89 to 6.47)		
Quartiles, lagged 15 years, µg/m³					
0 to < 1	47	190	1.0 (referent)	.062	
1 to < 6	52	187	1.11 (0.59 to 2.07)		
6 to < 57	49	141	1.90 (0.90 to 3.99)		
≥ 57	50	148	2.28 (1.07 to 4.87)		
REPLICATION AVERAGE REC					
Average REC intensity, quartiles, unlagged, µg/m³					
0 to < 1	49	166	1.0 (referent)	.	512.334
1 to <32	50	207	1.027 (0.503 to 2.094)		
32 to < 98	49	145	1.881 (0.759 to 4.663)		
≥ 98	50	148	2.398 (0.889 to 6.465)		
Quartiles, lagged 15 years, µg/m³					
0 to < 1	47	190	1.0 (referent)	.	513.61
1 to < 6	52	187	1.109 (0.593 to 2.073)		
6 to < 57	49	141	1.899 (0.904 to 3.988)		
≥ 57	50	148	2.280 (1.067 to 4.872)		
LAG 0 AVERAGE REC					
0 to < 1	49	166	1.0 (referent)		512.334
1 to <32	50	207	1.027 (0.503 to 2.094)		
32 to < 98	49	145	1.881 (0.759 to 4.663)		
≥ 98	50	148	2.398 (0.889 to 6.465)		
LAG 3 AVERAGE REC					
0 to < 1.01	49	137	1.0 (referent)		510.057
1.01 to <28.39	50	227	0.494 (0.245 to 0.996)		
28.39 to < 84.05	49	143	0.990 (0.409 to 2.395)		
≥ 84.05	50	159	1.005 (0.380 to 2.653)		
LAG 5 AVERAGE REC					
0 to < 0.94	46	125	1.0 (referent)		512.184
0.94 to <21.40	53	229	0.513 (0.271 to 0.970)		
21.40 to < 80.22	49	145	0.935 (0.401 to 2.178)		
≥ 80.22	50	167	0.888 (0.359 to 2.199)		
LAG 7 AVERAGE REC					
0 to < 0.94	49	132	1.0 (referent)		513.421
0.94 to <14.95	50	207	0.509 (0.273 to 0.949)		
14.95 to < 79.51	49	168	0.707 (0.311 to 1.607)		

≥ 79.51	50	159	0.819 (0.344 to 1.954)	
<b>LAG 9 AVERAGE REC</b>				
0 to < 0.94	49	151	1.0 (referent)	514.492
0.94 to <14.95	50	199	0.716 (0.385 to 1.331)	
14.95 to < 79.51	49	167	1.140 (0.511 to 2.544)	
≥ 79.51	50	149	1.491 (0.634 to 3.510)	
<b>LAG 11 AVERAGE REC</b>				
0 to < 0.91	43	152	1.0 (referent)	514.073
0.91 to <9.34	56	205	0.629 (0.342 to 1.157)	
9.34 to < 73.04	49	159	1.071 (0.487 to 2.354)	
≥ 73.04	50	150	1.284 (0.574 to 2.869)	
<b>LAG 13 AVERAGE REC</b>				
0 to < 0.91	48	183	1.0 (referent)	508.809
0.91 to <7.88	51	191	0.716 (0.383 to 1.338)	
7.88 to < 69.22	49	156	1.528 (0.707 to 3.304)	
≥ 69.22	50	136	2.346 (1.052 to 5.231)	
<b>LAG 15 AVERAGE REC</b>				
0 to < 0.86	46	179	1.0 (referent)	513.707
0.86 to <5.78	53	198	1.029 (0.547 to 1.937)	
5.78 to < 56.99	49	141	1.826 (0.870 to 3.832)	
≥ 56.99	50	148	2.195 (1.028 to 4.686)	
<b>LAG 17 AVERAGE REC</b>				
0 to < 0.59	49	180	1.0 (referent)	510.482
0.59 to <3.24	50	200	0.872 (0.443 to 1.719)	
3.24 to < 55.28	49	154	1.500 (0.703 to 3.201)	
≥ 55.28	50	132	2.471 (1.131 to 5.397)	
<b>LAG 19 AVERAGE REC</b>				
0	53	184	1.0 (referent)	504.438
0 to <2.21	46	199	0.658 (0.326 to 1.330)	
2.21 to < 49.17	49	154	1.699 (0.810 to 3.563)	
≥ 49.17	50	129	2.914 (1.334 to 6.364)	
<b>LAG 20 AVERAGE REC</b>				
0	58	203	1.0 (referent)	510.341
0 to <1.91	41	169	0.803 (0.389 to 1.660)	
1.91 to < 42.38	49	157	1.552 (0.781 to 3.085)	
≥ 42.38	50	137	2.264 (1.109 to 4.622)	
<b>LAG 21 AVERAGE REC</b>				
0	62	232	1.0 (referent)	513.044
0 to <1.74	37	144	1.207 (0.581 to 2.507)	
1.74 to < 33.98	49	142	1.811 (0.929 to 3.532)	
≥ 33.98	50	148	2.252 (1.098 to 4.615)	
<b>LAG 23 AVERAGE REC</b>				
0	77	261	1.0 (referent)	515.879
0 to <0.94	20	93	0.826 (0.379 to 1.803)	
0.94 to < 18.33	51	155	1.131 (0.715 to 2.398)	

HEI Diesel Epidemiology Panel

≥ 18.33	50	157	1.530 (0.800 to 2.925)	
<b>LAG 25 AVERAGE REC</b>				
0	88	297	1.0 (referent)	517.149
0 to <0.64	11	45	1.244 (0.470 to 3.290)	
0.64 to < 10.93	49	160	1.357 (0.725 to 2.541)	
≥ 10.93	50	164	1.504 (0.800 to 2.827)	
<b>ORIGINAL CUMULATIVE REC</b>				
Cumulative REC, quartiles, unlagged, µg/m³				
0 to < 19	49	151	1.0 (referent)	.083
19 to < 246	50	214	0.87(0.48 to 1.59)	
246 to < 964	49	147	1.50 (0.67 to 3.36)	
≥ 964	50	154	1.75 (0.77 to 3.97)	
Quartiles, lagged 15 years, µg/m³-y				
0 to < 3	49	158	1.0 (referent)	0.001
3 to < 72	50	228	0.74 (0.40 to 1.38)	
72 to < 536	49	157	1.54 (0.74 to 3.20)	
≥ 536	50	123	2.83 (1.28 to 6.26)	
<b>REPLICATION CUMULATIVE REC</b>				
Cumulative REC, quartiles, unlagged, µg/m³				
0 to < 19	49	151	1.0 (referent)	.513.978
19 to < 246	50	214	0.871 (0.476 to 1.594)	
246 to < 964	49	147	1.501 (0.671 to 3.356)	
≥ 964	50	154	1.745 (0.767 to 3.967)	
Quartiles, lagged 15 years, µg/m³-y				
0 to < 3	49	158	1.0 (referent)	.505.065
3 to < 72	50	228	0.740 (0.398 to 1.375)	
72 to < 536	49	157	1.538 (0.740 to 3.195)	
≥ 536	50	123	2.831 (1.279 to 6.263)	
<b>LAG 0 CUMULATIVE REC</b>				
0 to < 19	49	151	1.0 (referent)	513.978
19 to < 246	50	214	0.871 (0.476 to 1.594)	
246 to < 964	49	147	1.501 (0.671 to 3.356)	
≥ 964	50	154	1.745 (0.767 to 3.967)	
<b>LAG 3 CUMULATIVE REC</b>				
0 to < 15.45	49	145	1.0 (referent)	514.796
15.45 to < 194.21	50	212	0.793 (0.440 to 1.429)	
194.21 to < 922.97	49	155	1.185 (0.539 to 2.602)	
≥ 922.97	50	154	1.503 (0.669 to 3.376)	
<b>LAG 5 CUMULATIVE REC</b>				
0 to < 11.56	49	130	1.0 (referent)	512.403
11.56 to < 167.50	50	222	0.615 (0.344 to 1.100)	
167.50 to < 880.23	49	166	<b>0.919 (0.419 to 2.018)</b>	



≥ 880.23	50	148	1.250 (0.550 to 2.839)	
<b>LAG 7 CUMULATIVE REC</b>				
0 to < 9.38	49	127	1.0 (referent)	508.723
9.38 to < 158.64	50	229	0.563 (0.313 to 1.010)	
158.64 to < 859.49	49	174	0.875 (0.392 to 1.954)	
≥ 859.49	50	136	1.388 (0.598 to 3.220)	
<b>LAG 9 CUMULATIVE REC</b>				
0 to < 7.69	49	140	1.0 (referent)	509.492
7.69 to < 146.98	50	222	0.732 (0.412 to 1.299)	
146.98 to < 750.96	49	171	1.110 (0.509 to 2.423)	
≥ 750.96	50	133	1.954 (0.854 to 4.470)	
<b>LAG 11 CUMULATIVE REC</b>				
0 to < 6.88	49	138	1.0 (referent)	507.01
6.88 to < 120.34	50	231	0.666 (0.368 to 1.204)	
120.34 to < 662.47	49	166	1.139 (0.524 to 2.474)	
≥ 662.47	50	131	2.103 (0.935 to 4.731)	
<b>LAG 13 CUMULATIVE REC</b>				
0 to < 5.79	49	154	1.0 (referent)	506.041
5.79 to < 91.22	50	227	0.813 (0.446 to 1.484)	
91.22 to < 582.64	49	153	1.699 (0.815 to 3.540)	
≥ 582.64	50	132	2.879 (1.314 to 6.309)	
<b>LAG 15 CUMULATIVE REC</b>				
0 to < 3.37	49	158	1.0 (referent)	505.065
3.37 to < 71.58	50	228	0.740 (0.398 to 1.375)	
71.58 to < 535.65	49	157	1.538 (0.740 to 3.195)	
≥ 535.65	50	123	2.831 (1.279 to 6.263)	
<b>LAG 17 CUMULATIVE REC</b>				
0 to < 1.81	49	173	1.0 (referent)	504.531
1.81 to < 32.74	50	204	0.870 (0.450 to 1.682)	
32.74 to < 479.34	49	163	1.955 (0.932 to 4.100)	
≥ 479.34	50	126	3.400 (1.505 to 7.679)	
<b>LAG 19 CUMULATIVE REC</b>				
0	53	184	1.0 (referent)	506.906
0 to < 23.06	46	189	0.770 (0.392 to 1.512)	
23.06 to < 398.05	49	165	1.839 (0.863 to 3.920)	
≥ 398.05	50	128	2.689 (1.235 to 5.853)	
<b>LAG 20 CUMULATIVE REC</b>				
0	58	203	1.0 (referent)	514.565
0 to < 14.13	41	139	<b>1.161 (0.591 to 2.278)</b>	

# HEI Diesel Epidemiology Panel

14.13 to < 315.77	33	133	1.175 (0.568 to 2.431)	
≥ 315.77	66	191	1.980 (0.959 to 4.089)	
<b>LAG 21 CUMULATIVE REC</b>				
0	62	232	1.0 (referent)	513.108
0 to < 11.79	37	114	0.522 (0.763 to 3.033)	
11.79 to < 228.34	49	179	1.456 (0.725 to 2.925)	
≥ 228.34	50	141	2.359 (1.137 to 4.891)	
<b>LAG 23 CUMULATIVE REC</b>				
0	77	261	1.0 (referent)	516.865
0 to < 5.86	22	68	1.141 (0.552 to 2.357)	
5.86 to < 124.67	49	181	1.152 (0.625 to 2.122)	
≥ 124.67	50	156	1.626 (0.818 to 3.232)	
<b>LAG 25 CUMULATIVE REC</b>				
0	88	297	1.0 (referent)	514.747
0 to < 2.36	11	38	0.866 (0.329 to 2.281)	
2.36 to < 86.54	49	184	1.343 (0.741 to 2.433)	
≥ 86.54	50	147	1.942 (0.984 to 3.831)	
<b>DURATION REC</b>				
Unexposed†	48	165	1.0 (referent)	0.043
0 to < 5	51	169	1.16 (0.53 to 2.55)	
5 to < 10	20	95	0.88 (0.38 to 2.03)	
10 to < 15	31	107	0.93 (0.39 to 2.21)	
≥ 15	48	130	2.09 (0.89 to 4.90)	
<b>REPLICATION DURATION REC</b>				
Duration of REC exposure, y				
Unexposed‡	48	165	1.0 (referent)	.
0 to < 5	51	169	1.159 (0.527 to 2.548)	
5 to < 10	20	95	0.883 (0.383 to 2.034)	
10 to < 15	31	107	0.927 (0.389 to 2.211)	
≥ 15	48	130	2.087 (0.890 to 4.895)	

\* P values based on two-sided Wald test for linear trend; adjusted for smoking status/mine location combination (surface work only/never smoker, surface work only/unknown/occasional smoker, surface work only/former smoker/<1 pack per day, surface work only/former smoker/1 to <2 packs per day, surface work only/former smoker/ ≥ 2 pack s per day, surface work only /current smoker/<1 pack per day, surface work only/current smoker/1 to <2 packs per day, surface work only/current smoker/ ≥ 2 packs per day, ever underground work/never smoker, ever underground work/unknown/occasional smoker, ever underground work/former smoker/<1 pack per day, ever underground work/former smoker/1 to <2 pack s per day, ever underground work/former smoker/ ≥ 2 pack s per day, ever underground work/current smoker/<1 pack per day, ever underground work/current smoker/1 to <2 pack s per day, ever underground work/current smoker/ ≥ 2 pack s per day); history of respiratory disease 5 or more years before date of death/reference date; and history of a high-risk job for lung cancer for at least 10 years. REC =respirable elemental carbon.

† The number of case subjects in the referent group for the 15-year lagged average REC analysis is 2 fewer than that in the unlagged analysis because rounded cut points are presented. The unrounded cut points are <0.86 and <1.37 μ g/m 3, respectively.

‡ Unexposed includes all subjects who worked surface jobs with either negligible or bystander exposure to REC, regardless of duration.

**Table 2.4.** Odds ratios (ORs) and 95% confidence intervals (CIs) for average and cumulative REC and total duration REC exposure for subjects who ever worked underground jobs\*

Exposure metric	Case subject	Control subject	OR (95% CI)	P <sub>trend</sub>	AIC
<b>ORIGINAL AVERAGE REC</b>					
Average REC intensity, quartiles, unlagged, µg/m <sup>3</sup>					
0 to < 39	29	89	1.0 (referent)	.010	
39 to < 71	29	57	1.91 (0.91 to 4.01)		
71 to < 147	29	66	2.38 (1.04 to 5.44)		
≥ 147	29	52	3.69 (1.40 to 9.70)		
Quartiles, lagged 15 years, µg/m <sup>3</sup>					
0 to < 8	29	81	1.0 (referent)	.001	
8 to < 49	29	73	1.04 (0.45 to 2.43)		
49 to < 104	29	58	2.19 (0.87 to 5.53)		
≥ 104	29	52	5.43 (1.92 to 15.31)		
<b>REPLICATION AVERAGE REC</b>					
Average REC intensity, quartiles, unlagged, µg/m <sup>3</sup>					
0 to < 39	29	89	1.0 (referent)	.	247.131
39 to < 71	29	57	1.905 (0.905 to 4.010)		
71 to < 147	29	66	2.383 (1.043 to 5.443)		
≥ 147	29	52	3.692 (1.405 to 9.703)		
Quartiles, lagged 15 years, µg/m <sup>3</sup>					
0 to < 8	29	81	1.0 (referent)	.	242.225
8 to < 49	29	73	1.041 (0.446 to 2.430)		
49 to < 104	29	58	2.191 (0.868 to 5.529)		
≥ 104	29	52	5.427 (1.924 to 15.305)		
<b>LAG 0 AVERAGE REC</b>					
0 to < 39.13	29	89	1.0 (referent)	.	247.131
39.13 to < 70.95	29	57	1.905 (0.905 to 4.010)		
70.95 to < 146.70	29	66	2.383 (1.043 to 5.443)		
≥ 146.70	29	52	3.692 (1.405 to 9.703)		
<b>LAG 3 AVERAGE REC</b>					
0 to < 34.68	29	82	1.0 (referent)		247.725
34.63 to < 67.32	29	62	1.662 (0.775 to 3.566)		
67.32 to < 147.22	29	58	<b>2.429 (1.027 to 5.746)</b>		
≥ 147.22	29	62	3.714 (1.388 to 9.940)		
<b>LAG 5 AVERAGE REC</b>					
0 to < 29.99	29	67	1.0 (referent)		250.649
29.99 to < 62.61	30	68	1.081 (0.496 to 2.355)		
62.61 to < 146.01	28	75	1.465 (0.633 to 3.391)		
≥ 146.01	29	54	2.863 (1.053 to 7.786)		

**LAG 7 AVERAGE REC**

0 to < 26.02	29	66	1.0 (referent)	252.61
26.02 to < 61.25	29	67	1.001 (0.453 to 2.215)	
61.25 to < 141.67	29	73	1.483 (0.652 to 3.371)	
≥ 141.67	29	58	<b>2.230 (0.813 to 6.113)</b>	

**LAG 9 AVERAGE REC**

0 to < 26.19	29	76	1.0 (referent)	248.616
26.19 to < 61.28	29	62	1.520 (0.650 to 3.555)	
61.28 to < 146.08	29	72	2.176 (0.944 to 5.017)	
≥ 146.08	29	54	4.055 (1.345 to 12.225)	

**LAG 11 AVERAGE REC**

0 to < 16.00	29	74	1.0 (referent)	251.178
16.00 to < 57.11	29	69	1.142 (0.449 to 2.904)	
57.11 to < 137.98	29	66	1.901 (0.781 to 4.630)	
≥ 137.98	29	55	<b>2.459 (0.912 to 6.632)</b>	

**LAG 13 AVERAGE REC**

0 to < 9.84	29	79	1.0 (referent)	242.24
9.84 to < 55.15	29	75	1.054 (0.426 to 2.610)	
55.15 to < 126.00	29	60	2.260 (0.875 to 5.834)	
≥ 126.00	29	50	5.550 (1.927 to 15.987)	

**LAG 15 AVERAGE REC**

0 to < 7.87	29	81	1.0 (referent)	242.225
7.87 to < 48.76	29	73	1.041 (0.446 to 2.430)	
48.76 to < 103.50	29	58	2.191 (0.868 to 5.529)	
≥ 103.50	29	52	5.427 (1.924 to 15.305)	

**LAG 17 AVERAGE REC**

0 to < 5.25	29	80	1.0 (referent)	247.903
5.25 to < 40.79	29	61	0.910 (0.349 to 2.375)	
40.79 to < 92.13	29	68	1.396 (0.540 to 3.612)	
≥ 92.13	29	55	3.129 (1.245 to 7.864)	

**LAG 19 AVERAGE REC**

0 to < 0.38	29	59	1.0 (referent)	249.289
0.38 to < 27.97	29	75	0.343 (0.107 to 1.106)	
27.97 to < 72.63	29	73	0.604 (0.199 to 1.832)	
≥ 72.62	29	57	<b>1.215 (0.440 to 3.357)</b>	

**LAG 20 AVERAGE REC**

0	33	69	1.0 (referent)	246.79
0 to < 20.13	25	63	0.284 (0.082 to 0.979)	
20.13 to < 65.24	29	78	0.353 (0.108 to 1.152)	
≥ 65.24	29	54	<b>1.236 (0.451 to 3.386)</b>	

**LAG 21 AVERAGE REC**

0	36	76	1.0 (referent)	249.087
0 to < 17.22	22	63	0.307 (0.090 to 1.047)	
17.22 to < 60.97	29	67	0.674 (0.215 to 2.112)	
≥ 60.97	29	58	<b>1.248 (0.463 to 3.367)</b>	

**LAG 23 AVERAGE REC**

0	45	89	1.0 (referent)	248.869
0 to < 5.97	13	34	0.307 (0.090 to 1.048)	
5.96 to < 47.89	29	80	<b>0.335 (0.116 to 0.963)</b>	
≥ 47.89	29	61	<b>0.821 (0.314 to 2.145)</b>	

**LAG 25 AVERAGE REC**

0	51	106	1.0 (referent)	246.651
0 to < 3.60	7	31	<b>0.141 (0.030 to 0.671)</b>	
3.60 to < 38.77	29	62	0.580 (0.199 to 1.692)	
≥ 38.77	29	65	<b>1.166 (0.468 to 2.907)</b>	

**ORIGINAL CUMULATIVE REC**

Cumulative REC, quartiles, unlagged, µg/m³-y

0 to < 298	29	81	1.0 (referent)	.123
298 to < 675	29	63	1.45 (0.68 to 3.11)	
675 to < 1465	29	57	1.81 (0.84 to 3.89)	
≥ 1465	29	63	1.93 (0.90 to 4.15)	

Quartiles, lagged 15 years, µg/m³-y

0 to < 81	29	92	1.0 (referent)	.004
81 to < 325	29	52	2.46 (1.01 to 6.01)	
325 to < 878	29	69	2.41 (1.00 to 5.82)	
≥ 878	29	51	5.10 (1.88 to 13.87)	

**REPLICATION CUMULATIVE REC**

Cumulative REC, quartiles, unlagged, µg/m³-y

0 to < 298	29	81	1.0 (referent)	.	251.909
298 to < 675	29	63	1.452 (0.677 to 3.114)		
675 to < 1465	29	57	1.810 (0.842 to 3.892)		
≥ 1465	29	63	1.933 (0.901 to 4.147)		

Quartiles, lagged 15 years, µg/m³-y

0 to < 81	29	92	1.0 (referent)	.	243.631
81 to < 325	29	52	2.462 (1.008 to 6.014)		
325 to < 878	29	69	2.411 (1.000 to 5.816)		
≥ 878	29	51	5.100 (1.875 to 13.872)		

**LAG 0 CUMULATIVE REC**

0 to < 298.23	29	81	1.0 (referent)	. 251.909
298.23 to < 674.81	29	63	1.452 (0.677 to 3.114)	
674.81 to < 1464.57	29	57	1.810 (0.842 to 3.892)	
≥ 1464.57	29	63	1.933 (0.901 to 4.147)	

**LAG 3 CUMULATIVE REC**

0 to < 278.49	29	78	1.0 (referent)	. 252.058
278.49 to < 584.93	29	63	<b>1.652 (0.765 to 3.567)</b>	
584.93 to < 1286.53	29	55	<b>1.948 (0.888 to 4.272)</b>	
≥ 1286.53	29	68	<b>1.801 (0.827 to 3.921)</b>	

**LAG 5 CUMULATIVE REC**

0 to < 197.24	29	66	1.0 (referent)	254.036
197.24 to < 581.35	29	75	<b>1.060 (0.495 to 2.272)</b>	
581.35 to < 1196.05	29	53	<b>1.439 (0.661 to 3.134)</b>	
≥ 1196.05	29	70	<b>1.407 (0.638 to 3.100)</b>	

**LAG 7 CUMULATIVE REC**

0 to < 181.57	29	68	1.0 (referent)	253.366
181.57 to < 541.85	29	73	<b>1.154 (0.528 to 2.522)</b>	
541.85 to < 1132.85	29	54	<b>1.643 (0.750 to 3.600)</b>	
≥ 1132.85	29	69	<b>1.535 (0.673 to 3.503)</b>	

**LAG 9 CUMULATIVE REC**

0 to < 169.95	29	70	1.0 (referent)	251.925
169.95 to < 524.02	29	79	<b>1.164 (0.523 to 2.589)</b>	
524.02 to < 1094.24	29	54	<b>1.669 (0.751 to 3.706)</b>	
≥ 1094.24	29	61	<b>1.989 (0.842 to 4.698)</b>	

**LAG 11 CUMULATIVE REC**

0 to < 149.69	29	80	1.0 (referent)	248.77
149.69 to < 455.69	29	66	<b>1.414 (0.648 to 3.085)</b>	
455.69 to < 1075.87	29	63	<b>1.657 (0.711 to 3.860)</b>	
≥ 1075.87	29	55	3.039 (1.234 to 7.484)	

**LAG 13 CUMULATIVE REC**

0 to < 109.93	29	83	1.0 (referent)	246.238
109.93 to < 424.20	29	70	<b>1.470 (0.666 to 3.246)</b>	
424.20 to < 966.28	29	58	<b>2.173 (0.913 to 5.170)</b>	
≥ 966.28	29	53	3.879 (1.505 to 9.999)	

**LAG 15 CUMULATIVE REC**

0 to < 81.35	29	92	1.0 (referent)	243.631
81.35 to < 325.34	29	52	2.462 (1.008 to 6.014)	
325.34 to < 878.37	29	69	2.411 (1.000 to 5.816)	
≥ 878.37	29	51	5.100 (1.875 to 13.872)	

**LAG 17 CUMULATIVE REC**

0 to < 18.92	29	75	1.0 (referent)	246.773
18.92 to < 305.13	29	77	<b>1.056 (0.404 to 2.756)</b>	
305.13 to < 740.92	29	60	<b>2.088 (0.749 to 5.819)</b>	
≥ 740.92	29	52	3.277 (1.160 to 9.254)	

**LAG 19 CUMULATIVE REC**

0 to < 3.79	29	67	1.0 (referent)	250.954
3.79 to < 159.71	29	74	<b>0.917 (0.312 to 2.693)</b>	
159.71 to < 582.65	29	70	<b>1.352 (0.454 to 4.028)</b>	
≥ 582.65	29	53	<b>2.247 (0.736 to 6.862)</b>	

**LAG 20 CUMULATIVE REC**

0	33	69	1.0 (referent)	249.564
0 to < 144.54	25	76	<b>0.409 (0.141 to 1.184)</b>	
144.54 to < 491.47	29	62	<b>0.904 (0.316 to 2.585)</b>	
≥ 491.47	29	57	<b>1.163 (0.396 to 3.416)</b>	

**LAG 21 CUMULATIVE REC**

0	36	76	1.0 (referent)	251.17
0 to < 117.99	22	65	<b>0.474 (0.164 to 1.363)</b>	
117.99 to < 441.50	29	63	<b>0.988 (0.345 to 2.829)</b>	
≥ 441.50	29	60	<b>1.241 (0.435 to 3.538)</b>	

**LAG 23 CUMULATIVE REC**

0	43	89	1.0 (referent)	251.283
0 to < 56.15	13	46	<b>0.337 (0.113 to 1.009)</b>	
56.15 to < 310.87	29	63	<b>0.577 (0.201 to 1.652)</b>	
≥ 310.87	29	66	<b>0.746 (0.270 to 2.058)</b>	

**LAG 25 CUMULATIVE REC**

0	51	106	1.0 (referent)	249.108
0 to < 22.38	7	33	0.288 (0.084 to 0.987)	
22.38 to < 170.01	29	55	1.140 (0.430 to 3.019)	
≥ 170.01	29	70	0.859 (0.318 to 2.317)	

**Duration of REC exposure, y**

< 5	37	92	1.0 (referent)	.062
5 to < 10	14	39	1.18 (0.52 to 2.68)	
10 to < 15	25	60	0.84 (0.39 to 1.82)	
≥ 15	40	73	2.08 (1.01 to 4.27)	

**REPLICATION DURATION REC**

< 5	37	92	1.0 (referent)	249.418
5 to < 10	14	39	1.180 (0.519 to 2.680)	
10 to < 15	25	60	0.842 (0.389 to 1.824)	
≥ 15	40	73	2.079 (1.011 to 4.274)	

\* P values based on two-sided Wald test for linear trend. Adjusted for smoking status (never smoker, unknown/occasional smoker, former smoker/<1 pack per day, former smoker/1 to <2 pack s per day, former smoker/≥ 2 pack s per day, current smoker/<1 pack per day, current smoker/1 to <2 packs per day, current smoker/≥ 2 packs per day); history of respiratory disease 5 or more years before date of death/reference date; and history of a high-risk job for lung cancer for at least 10 years. REC = respirable elemental carbon.

† Eight case subjects and 148 control subjects were excluded because they no longer belonged to a complete matched set after analysis was restricted to

**Table 2.5.** Odds ratios (ORs) and 95% confidence intervals (CIs) for average and cumulative REC and total duration REC exposure for subjects who ever worked surface jobs\*

Exposure metric	Case subject	Control subject	OR (95% CI)	P trend	AIC
ORIGINAL AVERAGE REC					
Average REC intensity, quartiles, unlagged, µg/m³					
0 to < 0.86	13	24	1.0 (referent)	.983	
0.86 to < 0.95	13	21	1.29 (0.18 to 9.33)		
0.95 to < 1.9	13	19	7.24 (0.23 to 228.53)		
≥ 1.9	14	36	3.28 (0.09 to 123.50)		
Quartiles, lagged 15 years, µg/m³					
0 to < 0.6	13	38	1.0 (referent)	.659	
0.6 to < 0.9	13	17	4.38 (0.56 to 34.24)		
0.9 to < 1.4	13	12	5.67 (0.77 to 42.06)		
≥ 1.4	14	33	1.31 (0.14 to 12.01)		
REPLICATION AVERAGE REC					
Average REC intensity, quartiles, unlagged, µg/m³					
0 to < 0.86	13	24	1.0 (referent)	.	95.568
0.86 to < 0.95	13	21	1.294 (0.179 to 9.333)		
0.95 to < 1.9	13	19	7.238 (0.229 to 228.518)		
≥ 1.9	14	36	3.282 (0.087 to 123.494)		
Quartiles, lagged 15 years, µg/m³					
0 to < 0.6	13	38	1.0 (referent)	.	92.619
0.6 to < 0.9	13	17	4.377 (0.560 to 34.237)		
0.9 to < 1.4	13	12	5.672 (0.765 to 42.059)		
≥ 1.4	14	33	1.310 (0.143 to 12.004)		
LAG 0 AVERAGE REC					
0 to < 0.86	13	24	1.0 (referent)	.	95.568
0.86 to < 0.95	13	21	1.294 (0.179 to 9.333)		
0.95 to < 1.91	13	19	7.238 (0.229 to 228.518)		
≥ 1.91	14	36	3.282 (0.087 to 123.494)		
LAG 3 AVERAGE REC					
0 to < 0.75	14	23	1.0 (referent)	.	93.782



0.75 to < 0.94	12	21	0.601 (0.087 to 4.161)	
0.94 to < 1.56	13	18	2.183 (0.228 to 20.894)	
≥ 1.56	14	38	0.419 (0.024 to 7.425)	
<b>LAG 5 AVERAGE REC</b>				
0 to < 0.74	14	23	1.0 (referent)	96.24
0.74 to < 0.92	12	23	1.150 (0.187 to 7.084)	
0.92 to < 1.55	14	16	1.979 (0.291 to 13.469)	
≥ 1.55	13	38	0.706 (0.075 to 6.686)	
<b>LAG 7 AVERAGE REC</b>				
0 to < 0.66	13	22	1.0 (referent)	95.292
0.66 to < 0.91	11	21	0.625 (0.114 to 3.435)	
0.91 to < 1.50	16	20	1.094 (0.216 to 5.545)	
≥ 1.50	13	37	0.330 (0.047 to 2.333)	
<b>LAG 9 AVERAGE REC</b>				
0 to < 0.61	14	29	1.0 (referent)	94.822
0.61 to < 0.91	10	19	0.802 (0.136 to 4.735)	
0.91 to < 1.48	15	18	2.107 (0.427 to 10.389)	
≥ 1.48	14	34	0.584 (0.088 to 3.875)	
<b>LAG 11 AVERAGE REC</b>				
0 to < 0.60	13	32	1.0 (referent)	94.194
0.60 to < 0.91	12	20	1.471 (0.278 to 7.789)	
0.91 to < 1.38	14	14	4.402 (0.668 to 29.003)	
≥ 1.38	14	34	1.468 (0.180 to 11.987)	
<b>LAG 13 AVERAGE REC</b>				
0 to < 0.60	13	36	1.0 (referent)	93.715
0.60 to < 0.91	13	18	4.042 (0.504 to 32.423)	
0.91 to < 1.38	13	12	4.575 (0.641 to 32.677)	
≥ 1.38	14	34	1.499 (0.174 to 12.900)	
<b>LAG 15 AVERAGE REC</b>				
0 to < 0.57	13	38	1.0 (referent)	92.519
0.57 to < 0.86	14	18	6.533 (0.725 to 58.903)	
0.86 to < 1.37	12	11	4.066 (0.551 to 30.022)	
≥ 1.37	14	33	0.993 (0.112 to 8.816)	
<b>LAG 17 AVERAGE REC</b>				

0	18	31	1.0 (referent)	. 95.874
0 to < 3.37	9	16	0.694 (0.048 to 10.120)	
3.37 to < 12.46	12	24	0.275 (0.044 to 1.737)	
≥ 12.46	14	29	0.348 (0.044 to 2.763)	
<b>LAG 19 AVERAGE REC</b>				
0	20	41	1.0 (referent)	. 97.894
0 to < 0.55	6	12	1.442 (0.104 to 20.008)	
0.55 to < 1.01	13	18	1.506 (0.259 to 8.753)	
≥ 1.01	14	29	0.765 (0.054 to 10.890)	
<b>LAG 20 AVERAGE REC</b>				
0	21	43	1.0 (referent)	. 95.055
0 to < 0.54	6	6	62.536 (0.231 to >999.999)	
0.54 to < 1.01	12	23	1.035 (0.127 to 8.440)	
≥ 1.01	14	28	1.201 (0.093 to 15.472)	
<b>LAG 21 AVERAGE REC</b>				
0	22	49	1.0 (referent)	. 94.503
0 to < 0.49	4	4	>999.999 (<0.001 to >999.999)	
0.49 to < 1.01	13	21	1.272 (0.168 to 9.648)	
≥ 1.01	14	26	1.816 (0.181 to 18.185)	
<b>LAG 23 AVERAGE REC</b>				
0	26	50	1.0 (referent)	. 92.19
0 to < 0.08	0	0	.	
0.08 to < 0.99	13	19	0.282 (0.035 to 2.310)	
≥ 0.99	14	31	3.487 (0.437 to 27.792)	
<b>LAG 25 AVERAGE REC</b>				
0	28	55	1.0 (referent)	. 95.063
0	0	0	.	
0 to < 0.86	11	25	0.577 (0.084 to 3.980)	
≥ 0.86	14	20	1.884 (0.323 to 10.989)	
<b>ORIGINAL CUMULATIVE REC</b>				
Cumulative REC, quartiles, unlagged, µg/m³-y				
0 to < 6.5	13	17	1.0 (referent)	.294

6.5 to < 12.5	13	27	0.78 (0.18 to 3.43)	
12.5 to < 22.5	13	23	0.60 (0.14 to 2.53)	
≥ 22.5	14	33	0.40 (0.07 to 2.40)	
Quartiles, lagged 15 years, $\mu\text{g}/\text{m}^3\text{-y}$				
0 to < 0.7	13	29	1.0 (referent)	.117
0.7 to < 4.4	13	9	3.98 (0.69 to 23.02)	
4.4 to < 14.3	13	32	0.76 (0.12 to 4.98)	
≥ 14.3	14	30	0.42 (0.05 to 3.59)	

**REPLICATION CUMULATIVE REC**Cumulative REC, quartiles, unlagged,  $\mu\text{g}/\text{m}^3\text{-y}$ 

0 to < 6.5	13	17	1.0 (referent)	.	96.968
6.5 to < 12.5	13	27	0.779 (0.177 to 3.429)		
12.5 to < 22.5	13	23	0.596 (0.140 to 2.525)		
≥ 22.5	14	33	0.395 (0.065 to 2.402)		
Quartiles, lagged 15 years, $\mu\text{g}/\text{m}^3\text{-y}$					
0 to < 0.7	13	29	1.0 (referent)	.	90.784
0.7 to < 4.4	13	9	3.981 (0.689 to 23.016)		
4.4 to < 14.3	13	32	0.764 (0.117 to 4.981)		
≥ 14.3	14	30	0.424 (0.050 to 3.588)		

**LAG 0 CUMULATIVE REC**

0 to < 6.50	13	17	1.0 (referent)	.	96.968
6.50 to < 12.52	13	27	0.779 (0.177 to 3.429)		
12.52 to < 22.46	13	23	0.596 (0.140 to 2.525)		
≥ 22.46	14	33	0.395 (0.065 to 2.402)		

**LAG 3 CUMULATIVE REC**

0 to < 4.86	14	16	1.0 (referent)	.	93.891
4.86 to < 11.82	13	26	0.876 (0.185 to 4.161)		
11.82 to < 21.92	12	24	0.277 (0.056 to 1.370)		
≥ 21.92	14	34	0.224 (0.037 to 1.368)		

**LAG 5 CUMULATIVE REC**

0 to < 4.28	14	17	1.0 (referent)	.	93.52
4.28 to < 10.30	13	22	1.833 (0.391 to 8.585)		

10.29 to < 21.92	12	29	0.253 (0.046 to 1.404)	
≥ 21.92	14	32	0.324 (0.052 to 2.027)	
<b>LAG 7 CUMULATIVE REC</b>				
0 to < 4.28	14	22	1.0 (referent)	. 94.687
4.28 to < 8.91	13	19	1.574 (0.322 to 7.700)	
8.91 to < 21.07	12	28	0.532 (0.119 to 2.383)	
≥ 21.07	14	31	0.241 (0.036 to 1.593)	
<b>LAG 9 CUMULATIVE REC</b>				
0 to < 3.37	13	23	1.0 (referent)	. 95.306
3.37 to < 7.28	14	19	2.101 (0.372 to 11.858)	
7.28 to < 19.98	12	29	0.717 (0.158 to 3.259)	
≥ 19.98	14	29	0.396 (0.067 to 2.350)	
<b>LAG 11 CUMULATIVE REC</b>				
0 to < 3.28	14	27	1.0 (referent)	. 95.609
3.28 to < 6.94	13	18	1.281 (0.284 to 5.786)	
6.94 to < 18.19	12	25	0.905 (0.186 to 4.407)	
≥ 18.19	14	30	0.318 (0.049 to 2.082)	
<b>LAG 13 CUMULATIVE REC</b>				
0 to < 1.61	13	27	1.0 (referent)	. 92.517
1.61 to < 6.57	14	13	2.587 (0.405 to 16.534)	
6.57 to < 16.22	12	30	0.599 (0.068 to 5.245)	
≥ 16.22	14	30	0.345 (0.040 to 3.174)	
<b>LAG 15 CUMULATIVE REC</b>				
0 to < 0.70	13	29	1.0 (referent)	. 90.784
0.70 to < 4.37	13	9	3.981 (0.689 to 23.016)	
4.37 to < 14.34	13	32	0.764 (0.117 to 4.981)	
≥ 14.34	14	30	0.424 (0.050 to 3.588)	
<b>LAG 17 CUMULATIVE REC</b>				
0	18	31	1.0 (referent)	. 96.051
0 to < 3.37	8	15	0.414 (0.063 to 2.741)	
3.37 to < 12.46	13	25	0.486 (0.060 to 3.950)	
≥ 12.46	14	29	0.266 (0.039 to 1.812)	
<b>LAG 19 CUMULATIVE REC</b>				
0	20	41	1.0 (referent)	. 96.271

0 to < 2.67	7	8	3.186 (0.337 to 30.124)	
2.67 to < 10.97	12	22	1.152 (0.178 to 7.443)	
≥ 10.97	14	29	0.690 (0.086 to 5.549)	
<b>LAG 20 CUMULATIVE REC</b>				
0	21	43	1.0 (referent)	. 96.863
0 to < 1.92	5	6	2.681 (0.222 to 32.389)	
1.92 to < 9.96	13	23	1.463 (0.235 to 9.089)	
≥ 9.96	14	28	0.645 (0.085 to 4.902)	
<b>LAG 21 CUMULATIVE REC</b>				
0	22	49	1.0 (referent)	. 93.235
0 to < 1.68	5	1	>999.999 (<0.001 to >999.999)	
1.68 to < 8.92	13	24	1.291 (0.212 to 7.853)	
≥ 8.92	13	26	0.790 (0.099 to 6.328)	
<b>LAG 23 CUMULATIVE REC</b>				
0	26	50	1.0 (referent)	. 95.218
0 to < 0.01	0	0	.	
0.01 to < 6.82	13	19	1.725 (0.270 to 11.014)	
≥ 6.82	14	31	0.623 (0.118 to 3.278)	
<b>LAG 25 CUMULATIVE REC</b>				
0	28	55	1.0 (referent)	. 93.613
0	0	0	.	
0 to < 5.08	11	16	4.295 (0.445 to 41.451)	
≥ 5.08	14	29	0.530 (0.093 to 3.040)	
<b>ORIGINAL DURATION REC</b>				
Duration of REC exposure, y				
Unexposed‡	34	61	1.0 (referent)	
0 to < 5	10	17	1.44 (0.26 to 8.17)	.152
5 to < 10	5	12	0.74 (0.10 to 5.21)	
10 to < 15	3	3	0.55 (0.05 to 6.17)	
≥ 15	1	7	0.22 (0.01 to 3.67)	

**REPLICATION DURATION REC**

## Duration of REC exposure, y

Unexposed‡	34	61	1.0 (referent)	97.578
0 to < 5	10	17	1.443 (0.255 to 8.166)	.
5 to < 10	5	12	0.736 (0.104 to 5.212)	
10 to < 15	3	3	0.546 (0.048 to 6.169)	
≥ 15	1	7	0.216 (0.013 to 3.665)	

\* P values based on two-sided Wald test for linear trend. Adjusted for smoking status (never smoker, unknown/occasional smoker, former smoker/<1 pack per day, former smoker/1 to <2 pack s per day, former smoker/ ≥ 2 pack s per day, current smoker/<1 pack per day, current smoker/1 to <2 pack s per day, current smoker/ ≥ 2 pack s per day); history of respiratory disease 5 or more years before date of death/reference date; and history of a high-risk job for lung cancer for at least 10 years. REC = respirable elemental carbon.

† Twenty-one case subjects and 154 control subjects were excluded because they no longer belonged to a complete matched set after analysis was restricted to surface workers.

‡ Unexposed includes subjects who worked surface jobs with either negligible or bystander exposure to REC.

Note: Average REC Lag analysis revealed that SE is about 1 in majority of the results, so results are unreliable.

Note: Cumulative REC Lag analysis revealed that SE is about 1 for lag 13, lag 15 lag 17, lag 19, lag20, lag21, lag23 and lag25 results, so results are unreliable.

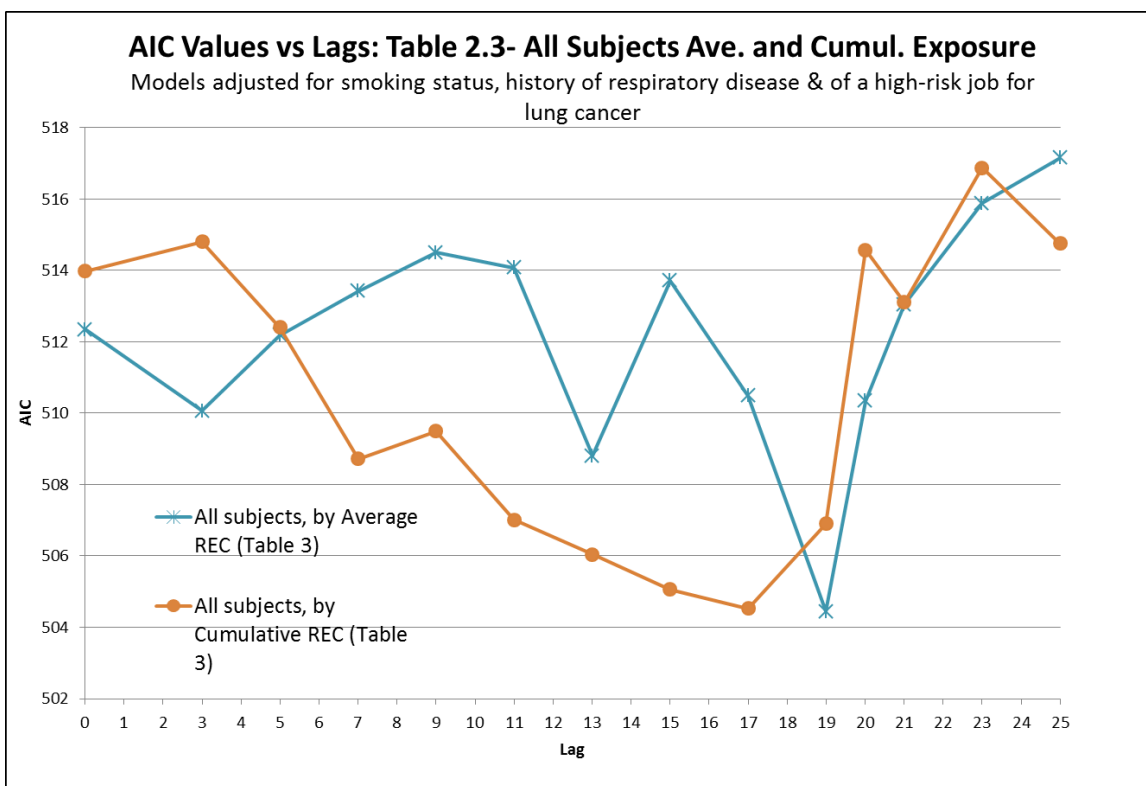
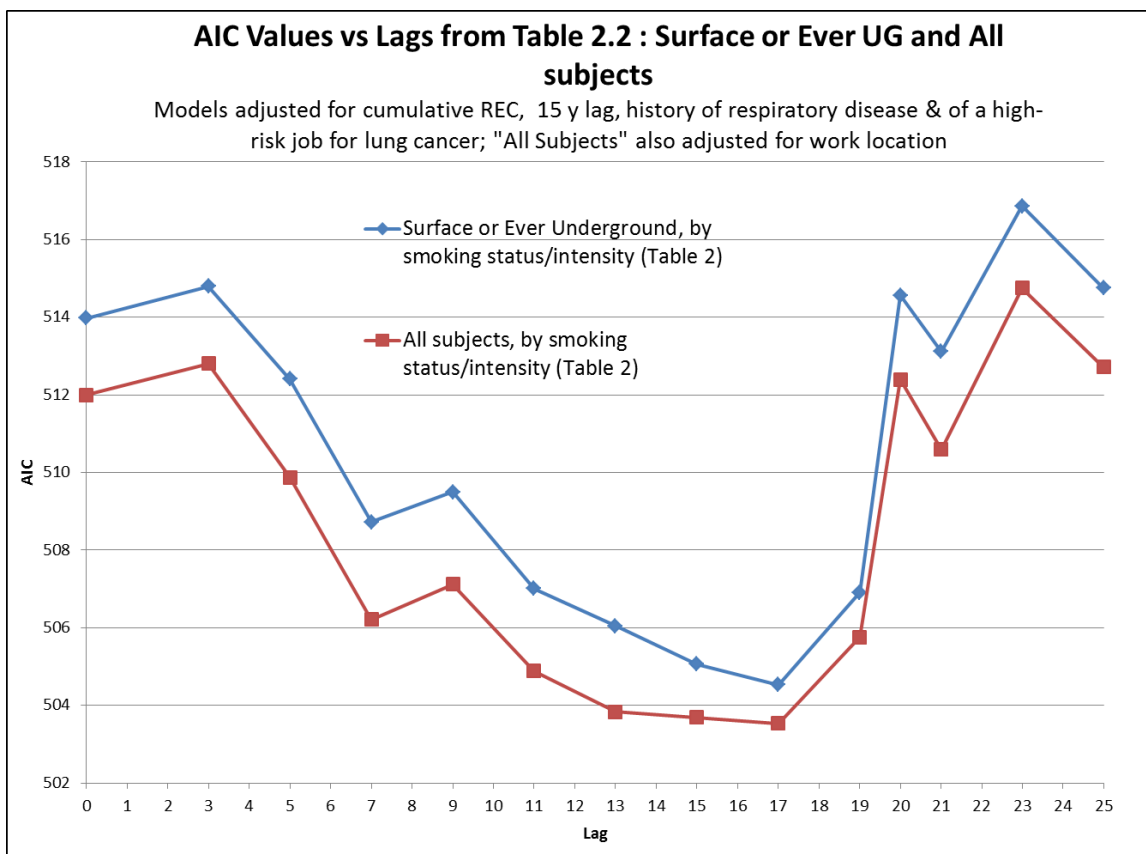
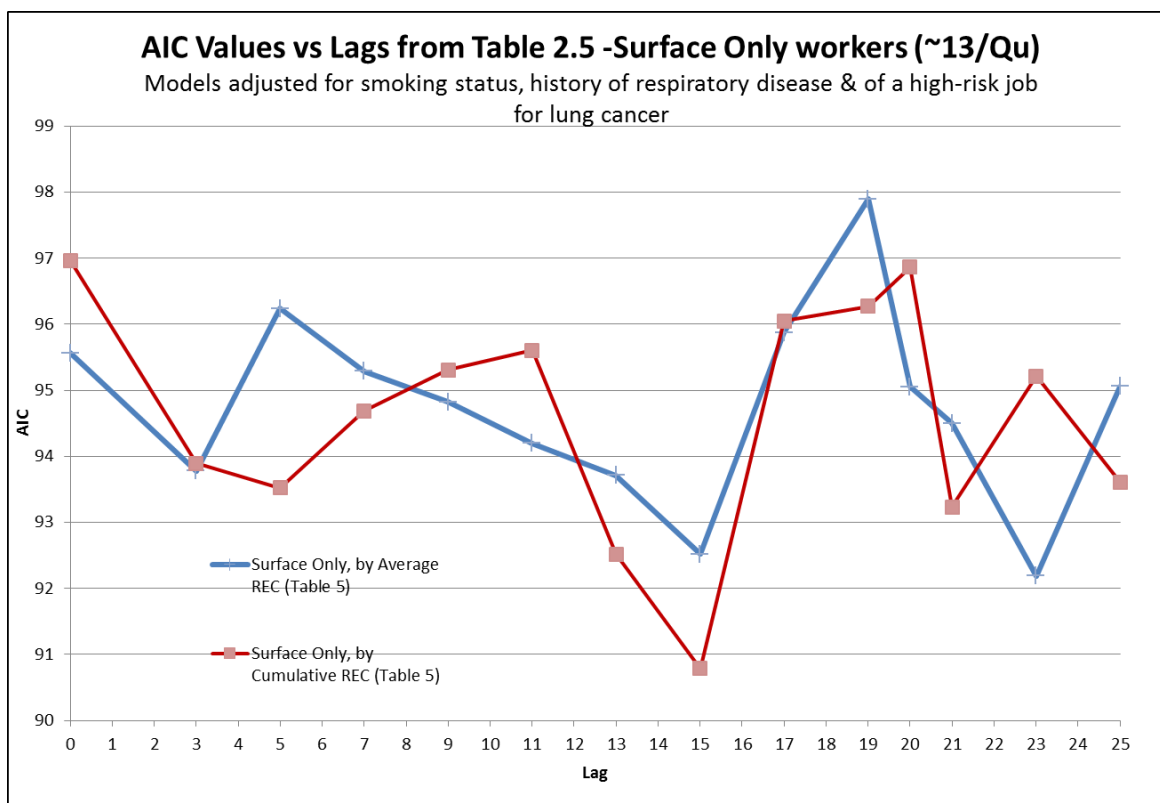
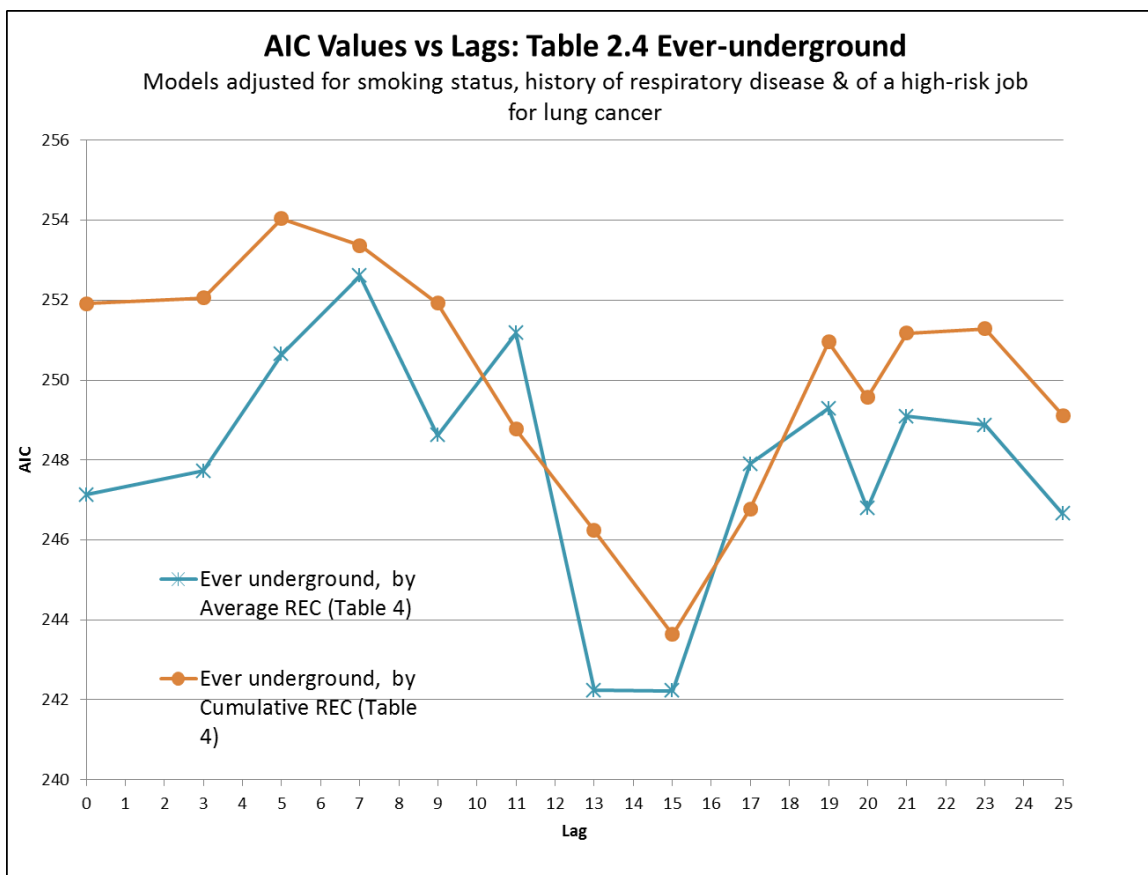
**Table 2.6 AIC Values vs Lags**

Table 2.6 AIC Values vs Lags





**Table 2.7.** Odds ratios (ORs) and 95% confidence intervals (CIs) by potential risk factors for lung cancer\*

Potential risk factor	Original Results			HEI Replication		
	Case subject	Control subject	OR (95% CI)	Case subject	Control subject	OR (95% CI)
<b>Employment in other high-risk occupations, ††</b>						
No	100	365	1.0 (referent)	100	365	1.0 (referent)
0 to <5y	24	90	0.90 (0.52 to 1.55)	24	90	0.897 (0.520 to 1.547)
5 to <10y	6	53	0.49 (0.19 to 1.21)	6	53	0.485 (0.194 to 1.214)
≥10y	39	68	1.75 (1.06 to 2.91)	39	68	1.752 (1.055 to 2.908)
Unknown	29	90	1.14 (0.67 to 1.92)	29	90	1.136 (0.674 to 1.916)
<b>History of respiratory disease †§</b>						
No	86	473	1.0 (referent)	86	473	1.0 (referent)
<5 y before death/reference date	26	16	5.97 (2.93 to 12.19)	26	16	5.971 (2.925 to 12.187)
≥5 y before death/reference date	28	58	2.15 (1.21 to 3.82)	28	58	2.150 (1.212 to 3.815)
Unknown	58	119	2.94 (1.87 to 4.63)	58	119	2.943 (1.869 to 4.632)
<b>Family history of lung cancer†</b>						
No	136	532	1.0 (referent)	136	532	1.0 (referent)
Yes	35	78	1.58 (0.97 to 2.57)	35	78	1.580 (0.971 to 2.571)
Unknown	27	56	1.65 (0.96 to 2.83)	27	56	1.646 (0.958 to 2.828)
<b>Cigar smoking duration, y†</b>						
Nonsmokers of cigars	176	564	1.0 (referent)	176	564	1.0 (referent)
<10	8	42	0.81 (0.36 to 1.86)	8	42	0.812 (0.355 to 1.859)
10 to <20	5	16	1.46 (0.49 to 4.39)	5	16	1.462 (0.487 to 4.385)
≥20	3	14	1.67 (0.42 to 6.73)	3	14	1.673 (0.416 to 6.727)
Unknown	6	30	0.64 (0.24 to 1.67)	6	30	0.635 (0.242 to 1.667)
<b>Pipe smoking, no. of pipefuls per week  </b>						
Nonsmokers of cigars	153	487	1.0 (referent)	153	487	1.0 (referent)
<10	11	39	0.89 (0.41 to 1.95)	11	39	0.890 (0.405 to 1.954)
10 to <20	6	24	0.66 (0.25 to 1.77)	6	24	0.663 (0.249 to 1.768)
≥20	5	35	0.50 (0.18 to 1.38)	5	35	0.495 (0.178 to 1.377)
Unknown	23	81	0.90 (0.52 to 1.57)	23	81	0.899 (0.517 to 1.565)
<b>Number of smokers living in participant's childhood/adult home†</b>						
0 smokers	28	164	1.0 (referent)	28	164	1.0 (referent)
1 smoker	75	201	1.99 (1.20 to 3.30)	75	201	1.994 (1.204 to 3.303)
≥2 smokers	70	230	1.43 (0.84 to 2.44)	70	230	1.427 (0.837 to 2.435)
Unknown	25	71	1.30 (0.67 to 2.52)	25	71	1.297 (0.667 to 2.521)
<b>Body mass index (kg/m<sup>2</sup>)†</b>						
<18.5 (underweight)	0	6		0	6	
18.5 to <25.0 (normal weight=referent)	105	285	1.0 (referent)	105	285	1.0 (referent)
25.0 to <30.0 (overweight)	71	268	0.75 (0.51 to 1.11)	71	268	0.752 (0.512 to 1.106)
≥30.0 (obese)	14	59	0.73 (0.36 to 1.45)	14	59	0.727 (0.363 to 1.454)
Unknown	8	48	0.52 (0.23 to 1.19)	8	48	0.523 (0.230 to 1.185)
<b>Physical activity†</b>						
Exercise ≥1/d	23	110	1.0 (referent)	23	110	1.0 (referent)
Exercise <1/d	162	515	1.46 (0.87 to 2.45)	162	515	1.458 (0.869 to 2.448)
Unknown	13	41	1.65 (0.70 to 3.89)	13	41	1.654 (0.704 to 3.886)
<b>Education†</b>						
Any college	22	88	1.0 (referent)	22	88	1.0 (referent)
Vocational school	14	35	1.49 (0.63 to 3.52)	14	35	1.489 (0.630 to 3.522)
High school/GED	48	176	0.94 (0.51 to 1.72)	48	176	0.937 (0.511 to 1.720)
Less than high school	100	325	1.09 (0.61 to 1.98)	100	325	1.094 (0.606 to 1.975)
Unknown	14	42	1.40 (0.62 to 3.18)	14	42	1.404 (0.619 to 3.182)
<b>Radon, quartiles (Working Level Months)†§§</b>						
No exposure	74	254	1.0 (referent)	74	254	1.0 (referent)
>0 to <0.6	31	117	0.73 (0.43 to 1.25)	31	117	0.733 (0.429 to 1.254)
0.6 to <1.9	31	123	0.86 (0.51 to 1.45)	31	123	0.859 (0.509 to 1.448)
1.9 to <3.0	31	80	1.08 (0.63 to 1.84)	31	80	1.077 (0.629 to 1.842)
≥3.0	31	92	1.32 (0.76 to 2.29)	31	92	1.316 (0.756 to 2.291)
<b>Asbestos, quartiles†§†</b>						
No exposure	122	402	1.0 (referent)	122	402	1.0 (referent)
>0 to <1.1	19	40	1.12 (0.59 to 2.10)	19	40	1.115 (0.591 to 2.101)
1.1 to <5.9	19	92	0.73 (0.41 to 1.29)	19	92	0.729 (0.411 to 1.292)
5.9 to <13.7	19	73	0.81 (0.44 to 1.48)	19	73	0.808 (0.442 to 1.479)
≥13.7	19	59	1.08 (0.59 to 2.01)	19	59	1.083 (0.585 to 2.006)
<b>Silica, quartiles†§†</b>						
No exposure	48	169	1.0 (referent)	48	169	1.0 (referent)
>0 to <4.6	37	111	0.68 (0.25 to 1.90)	37	111	0.682 (0.245 to 1.902)
4.6 to <12.6	37	155	0.56 (0.19 to 1.61)	37	155	0.558 (0.194 to 1.610)
12.6 to <20.5	38	86	1.07 (0.37 to 3.14)	38	86	1.072 (0.366 to 3.144)
≥20.5	38	145	0.78 (0.26 to 2.32)	38	145	0.782 (0.264 to 2.316)
<b>PAHs from non-diesel sources, quartiles†§†</b>						
No exposure	120	398	1.0 (referent)	120	398	1.0 (referent)
>0 to <1.2	19	49	1.03 (0.55 to 1.91)	19	49	1.028 (0.554 to 1.907)
1.2 to <5.1	20	74	0.94 (0.53 to 1.68)	20	74	0.944 (0.529 to 1.684)
5.1 to <12.3	19	81	0.87 (0.48 to 1.57)	19	81	0.868 (0.481 to 1.568)
≥12.3	20	64	1.06 (0.59 to 1.92)	20	64	1.063 (0.588 to 1.920)
<b>Cumulative respirable dust, quartiles, mg/m<sup>3</sup>-y*†§§</b>						
0 to <5.66	49	142	1.0 (referent)	49	142	1.0 (referent)
5.66 to <14.08	50	184	0.91 (0.52 to 1.57)	50	184	0.905 (0.523 to 1.567)
14.08 to <29.54	49	194	0.86 (0.49 to 1.52)	49	194	0.862 (0.488 to 1.522)
≥29.54	50	146	1.31 (0.70 to 2.46)	50	146	1.307 (0.695 to 2.457)

\* P values based on two-sided Wald test for linear trend; PAH = polycyclic hydrocarbon; WL = Working Level; WLM = Working Level Months .

† Adjusted for smoking status/mine location combination (surface work only/never smoker, surface work only/unknown/occasional smoker, surface work only/former smoker/&lt;1 pack per day, surface work only/former smoker/1 to &lt;2 pack s per day, surface work only/former smoker/ ≥ 2 pack s per day, surface work only/current smoker/&lt;1 pack s per day, surface work only/current smoker/1 to &lt;2 pack s per day, surface work only/current smoker/ ≥ 2 pack s per day, ever underground work/never smoker, ever underground work/unknown/occasional smoker, ever underground work/former smoker/&lt;1 pack per day, ever underground work/former smoker/1 to &lt;2 pack s per day, ever underground work/former smoker/ ≥ 2 pack s per day, ever underground work/current smoker/&lt;1 pack per day, ever underground work/current smoker/1 to &lt;2 packs per day, ever underground work/current smoker/ ≥ 2 pack s per day).

‡ Other high-risk occupations for lung cancer (ie, miner who worked outside the study mines, truck driver, welder, machinery mechanic, painter).

## HEI Diesel Epidemiology Panel

§ History of respiratory disease excluding asthma, pneumonia, and bronchitis.

|| Adjusted for cigarette smoking and education.

¶ Pertains only to exposures at study mines.

# Quartiles of cumulative radon exposure derived from estimated levels in WL multiplied by months at each job, summed across jobs. Thus, exposure to radon is expressed in units of WLM. One WL = 130 000 MeV alpha energy per liter of air, and one WLM is equivalent to 1 WL exposure for 170 hours.

\*\* Adjusted for smoking status: unknown, never smoker, occasional smoker, former smoker/<1 pack per day, former smoker/1 to <2 pack s per day, former smoker/ ≥ 2 pack s per day, current smoker/<1 pack per day, current smoker/1 to <2 pack s per day, current smoker/ ≥ 2 pack s per day.

† † Quartiles of cumulative exposure derived from intensity scores (0 – 3) multiplied by years at each job, summed across jobs.

‡ ‡ Quartiles of cumulative exposure derived from the presence or absence of non-diesel PAHs based on job title tasks (0,1) multiplied by years at each job, summed across jobs.

§§ Respirable dust in milligrams per cubic meter multiplied by years of exposure.

**Table 2. 8.** Odds ratios (ORs) and 95% confidence intervals (CIs) for smoking status/smoking intensity by location of employment\*

Smoking status/smoking intensity (packs per day)	OR (95% CI), No. of case subjects/No. of control subjects					
	Surface only†, average REC	Ever underground†, average		Surface only†, average REC intensity	Ever underground†, average REC	
		REC intensity (1-423 µg/m³			All subjects	
	intensity (0-8 µg/m³ REC)	REC)	All subjects	(0-8 µg/m³ REC)	intensity (1-423 µg/m³ REC)	All subjects
Never smoker	1.0 (referent), 5/87	0.90 (0.26 to 3.09), 9/91	1.0 (referent), 14/178	1.0 (referent), 5/87	0.904 (0.264 to 3.091), 9/91	1.0 (referent), 14/178
Former, < 1	1.36 (0.24 to 7.59), 2/31	2.51 (0.78 to 8.11), 17/62	2.87 (1.30 to 6.33), 19/93	1.356 (0.242 to 7.587), 2/31	2.514 (0.779 to 8.114), 17/62	2.871 (1.302 to 6.332), 19/93
Former, 1 to < 2	6.66 (2.07 to 21.50), 14/40	1.97 (0.61 to 6.37), 16/68	3.56 (1.72 to 7.40), 30/108	6.663 (2.065 to 21.499), 14/40	1.968 (0.608 to 6.373), 16/68	3.562 (1.715 to 7.400), 30/108
Former, ≥ 2	16.30 (3.55 to 74.82), 6/7	2.70 (0.72 to 10.12), 9/29	5.40 (2.23 to 13.06), 15/36	16.297 (3.550 to 74.820), 6/7	2.697 (0.719 to 10.117), 9/29	5.400 (2.232 to 13.061), 15/36
Current, < 1	5.22 (1.16 to 23.39), 4/15	5.71 (1.63 to 20.01), 12/21	5.91 (2.47 to 14.10), 16/36	5.218 (1.164 to 23.386), 4/15	5.710 (1.630 to 20.005), 12/21	5.905 (2.473 to 14.104), 16/36
Current, 1 to < 2	13.34 (4.50 to 39.53), 26/41	4.51 (1.50 to 13.58), 32/78	7.36 (3.71 to 14.57), 58/119	13.342 (4.504 to 39.526), 26/41	4.510 (1.497 to 13.585), 32/78	7.356 (3.714 to 14.567), 58/119
Current, ≥ 2	26.60 (7.14 to 99.08), 12/9	7.13 (2.12 to 23.99), 17/27	12.41 (5.57 to 27.66), 29/36	26.598 (7.140 to 99.083), 12/9	7.130 (2.119 to 23.986), 17/27	12.409 (5.568 to 27.660), 29/36
Unknown §	2.86 (0.71 to 11.64), 5/24	2.65 (0.76 to 9.24), 12/36	3.10 (1.33 to 7.26), 17/60	2.864 (0.705 to 11.640), 5/24	2.645 (0.757 to 9.238), 12/36	3.102 (1.325 to 7.264), 17/60

\* REC = respirable elemental carbon.

† ORs relative to never smokers who worked only surface jobs, adjusted for cumulative REC, lagged 15 years (quartiles: 0 to <3 µg/m³ -y; 3 to <72 µg/m³ -y, 72 to <536 µg/m³ -y, ≥ 536 µg/m³ -y), history of respiratory disease 5 or more years before date of death/reference date, and history of a high-risk job for lung cancer for at least 10 years. **P value for interaction between smoking status and location of employment based on likelihood ratio test = .082.**

‡ ORs for intensity smoked relative to never smokers, adjusted for cumulative REC, lagged 15 years (quartiles: 0 to <3 µg/m³ -y; 3 to <72 µg/m³ -y, 72 to <536 µg/m³ -y, ≥ 536 µg/m³ -y), location of employment (surface only, ever underground), history of respiratory disease 5 or more years before date of death/reference date, and history of a high-risk job for lung cancer for at least 10 years.

§ Unknown includes subjects with unknown smoking status, and subjects considered occasional smokers, who smoked at least 100 cigarettes during their lifetimes, but never smoked regularly (≥ 1 cigarette per day for at least 6 months).

**Table 2.9.** Odds ratios (ORs) and 95% confidence intervals (CIs) for average and cumulative REC and total duration REC exposure\*

Exposure metric					Replication			
	Case subject	Control subject	OR (95% CI)	P trend	Case subject	Control subject	OR (95% CI)	P trend
Average REC intensity, quartiles, unlagged, $\mu\text{g}/\text{m}^3$								
0 to < 1	49†	166	1.0 (referent)	.025	49	166	1.0 (referent)	.
1 to < 32	50	207	1.03 (0.50 to 2.09)		50	207	1.027 (0.503 to 2.094)	
32 to < 98	49	145	1.88 (0.76 to 4.66)		49	145	1.881 (0.759 to 4.663)	
$\geq 98$	50	148	2.40 (0.89 to 6.47)		50	148	2.398 (0.889 to 6.465)	
Quartiles, lagged 15 years, $\mu\text{g}/\text{m}^3$								
0 to < 1	47†	190	1.0 (referent)	.062	47	190	1.0 (referent)	.
1 to < 6	52	187	1.11 (0.59 to 2.07)		52	187	1.109 (0.593 to 2.073)	
6 to < 57	49	141	1.90 (0.90 to 3.99)		49	141	1.899 (0.904 to 3.988)	
$\geq 57$	50	148	2.28 (1.07 to 4.87)		50	148	2.280 (1.067 to 4.872)	
Cumulative REC, quartiles, unlagged, $\mu\text{g}/\text{m}^3\text{-y}$								
0 to < 19	49	151	1.0 (referent)	.083	49	151	1.0 (referent)	.
19 to < 246	50	214	0.87(0.48 to 1.59)		50	214	0.871 (0.476 to 1.594)	
246 to < 964	49	147	1.50 (0.67 to 3.36)		49	147	1.501 (0.671 to 3.356)	
$\geq 964$	50	154	1.75 (0.77 to 3.97)		50	154	1.745 (0.767 to 3.967)	
Quartiles, lagged 15 years, $\mu\text{g}/\text{m}^3\text{-y}$								
0 to < 3	49	158	1.0 (referent)	0.001	49	158	1.0 (referent)	.
3 to < 72	50	228	0.74 (0.40 to 1.38)		50	228	0.740 (0.398 to 1.375)	
72 to < 536	49	157	1.54 (0.74 to 3.20)		49	157	1.538 (0.740 to 3.195)	
$\geq 536$	50	123	2.83 (1.28 to 6.26)		50	123	2.831 (1.279 to 6.263)	
Duration of REC exposure, y								
Unexposed‡	48	165	1.0 (referent)	0.043	48	165	1.0 (referent)	.
0 to < 5	51	169	1.16 (0.53 to 2.55)		51	169	1.159 (0.527 to 2.548)	
5 to < 10	20	95	0.88 (0.38 to 2.03)		20	95	0.883 (0.383 to 2.034)	
10 to < 15	31	107	0.93 (0.39 to 2.21)		31	107	0.927 (0.389 to 2.211)	
$\geq 15$	48	130	2.09(0.89 to 4.90)		48	130	2.087 (0.890 to 4.895)	

\* P values based on two-sided Wald test for linear trend; adjusted for smoking status/mine location combination (surface work only/never smoker, surface work only/unknown/occasional smoker, surface work only/former smoker/<1 pack per day, surface work only/former smoker/1 to <2 packs per day, surface work only/former smoker/ $\geq 2$  pack s per day, surface work only /current smoker/<1 pack per day, surface work only/current smoker/1 to <2 packs per day, surface work only/current smoker/ $\geq 2$  packs per day, ever underground work/never smoker, ever underground work/unknown/occasional smoker, ever underground work/former smoker/<1 pack per day, ever underground work/former smoker/1 to <2 pack s per day, ever underground work/former smoker/ $\geq 2$  pack s per day, ever underground work/current smoker/<1 pack per day, ever underground work/current smoker/1 to <2 pack s per day, ever underground work/current smoker/ $\geq 2$  pack s per day); history of respiratory disease 5 or more years before date of death/reference date; and history of a high-risk job for lung cancer for at least 10 years. REC = respirable elemental carbon.

† The number of case subjects in the referent group for the 15-year lagged average REC analysis is 2 fewer than that in the unlagged analysis because rounded cut points are presented. The unrounded cut points are <0.86 and <1.37  $\mu\text{g}/\text{m}^3$ , respectively.

‡ Unexposed includes all subjects who worked surface jobs with either negligible or bystander exposure to REC, regardless of duration.

**Table 2.10.** Odds ratios (ORs) and 95% confidence intervals (CIs) for average and cumulative REC and total duration REC exposure for subjects who ever worked underground jobs\*

Exposure metric	Case subject	Control subject	OR (95% CI)	P trend	Replication			
					Case subject	Control subject	OR (95% CI)	P trend
Average REC intensity, quartiles, unlagged, $\mu\text{g}/\text{m}^3$								
0 to < 39	29	89	1.0 (referent)	.010	29	89	1.0 (referent)	
39 to < 71	29	57	1.91 (0.91 to 4.01)		29	57	1.905 (0.905 to 4.010)	
71 to < 147	29	66	2.38 (1.04 to 5.44)		29	66	2.383 (1.043 to 5.443)	
$\geq 147$	29	52	3.69 (1.40 to 9.70)		29	52	3.692 (1.405 to 9.703)	
Quartiles, lagged 15 years, $\mu\text{g}/\text{m}^3$								
0 to < 8	29	81	1.0 (referent)	.001	29	81	1.0 (referent)	
8 to < 49	29	73	1.04 (0.45 to 2.43)		29	73	1.041 (0.446 to 2.430)	
49 to < 104	29	58	2.19 (0.87 to 5.53)		29	58	2.191 (0.868 to 5.529)	
$\geq 104$	29	52	5.43 (1.92 to 15.31)		29	52	5.427 (1.924 to 15.305)	
Cumulative REC, quartiles, unlagged, $\mu\text{g}/\text{m}^3\text{-y}$								
0 to < 298	29	81	1.0 (referent)	.123	29	81	1.0 (referent)	
298 to < 675	29	63	1.45 (0.68 to 3.11)		29	63	1.452 (0.677 to 3.114)	
675 to < 1465	29	57	1.81 (0.84 to 3.89)		29	57	1.810 (0.842 to 3.892)	
$\geq 1465$	29	63	1.93 (0.90 to 4.15)		29	63	1.933 (0.901 to 4.147)	
Quartiles, lagged 15 years, $\mu\text{g}/\text{m}^3\text{-y}$								
0 to < 81	29	92	1.0 (referent)	.004	29	92	1.0 (referent)	
81 to < 325	29	52	2.46 (1.01 to 6.01)		29	52	2.462 (1.008 to 6.014)	
325 to < 878	29	69	2.41 (1.00 to 5.82)		29	69	2.411 (1.000 to 5.816)	
$\geq 878$	29	51	5.10 (1.88 to 13.87)		29	51	5.100 (1.875 to 13.872)	
Duration of REC exposure, y								
< 5	37	92	1.0 (referent)	.062	37	92	1.0 (referent)	
5 to < 10	14	39	1.18 (0.52 to 2.68)		14	39	1.180 (0.519 to 2.680)	
10 to < 15	25	60	0.84 (0.39 to 1.82)		25	60	0.842 (0.389 to 1.824)	
$\geq 15$	40	73	2.08 (1.01 to 4.27)		40	73	2.079 (1.011 to 4.274)	

\* P values based on two-sided Wald test for linear trend. Adjusted for smoking status (never smoker, unknown/occasional smoker, former smoker/<1 pack per day, former smoker/1 to <2 pack s per day, former smoker/  $\geq 2$  pack s per day, current smoker/<1 pack per day, current smoker/1 to <2 packs per day, current smoker/  $\geq 2$  packs per day); history of respiratory disease 5 or more years before date of death/reference date; and history of a high-risk job for lung cancer for at least 10 years. REC = respirable elemental carbon.

† Eight case subjects and 148 control subjects were excluded because they no longer belonged to a complete matched set after analysis was restricted to underground workers.

**Table 2.11.** Odds ratios (ORs) and 95% confidence intervals (CIs) for average and cumulative REC and total duration REC exposure for subjects who ever worked surface jobs\*

Exposure metric	Case subject	Control subject	OR (95% CI)	P trend	Replication			
					Case subject	Control subject	OR (95% CI)	P trend
Average REC intensity, quartiles, unlagged, $\mu\text{g}/\text{m}^3$								
0 to < 0.86	13	24	1.0 (referent)	.983	13	24	1.0 (referent)	
0.86 to < 0.95	13	21	1.29 (0.18 to 9.33)		13	21	1.294 (0.179 to 9.333)	
0.95 to < 1.9	13	19	7.24 (0.23 to 228.53)		13	19	7.238 (0.229 to 228.518)	
$\geq 1.9$	14	36	3.28 (0.09 to 123.50)		14	36	3.282 (0.087 to 123.494)	
Quartiles, lagged 15 years, $\mu\text{g}/\text{m}^3$								
0 to < 0.6	13	38	1.0 (referent)	.659	13	38	1.0 (referent)	
0.6 to < 0.9	13	17	4.38 (0.56 to 34.24)		13	17	4.377 (0.560 to 34.237)	
0.9 to < 1.4	13	12	5.67 (0.77 to 42.06)		13	12	5.672 (0.765 to 42.059)	
$\geq 1.4$	14	33	1.31 (0.14 to 12.01)		14	33	1.310 (0.143 to 12.004)	
Cumulative REC, quartiles, unlagged, $\mu\text{g}/\text{m}^3\text{-y}$								
0 to < 6.5	13	17	1.0 (referent)	.294	13	17	1.0 (referent)	
6.5 to < 12.5	13	27	0.78 (0.18 to 3.43)		13	27	0.779 (0.177 to 3.429)	
12.5 to < 22.5	13	23	0.60 (0.14 to 2.53)		13	23	0.596 (0.140 to 2.525)	
$\geq 22.5$	14	33	0.40 (0.07 to 2.40)		14	33	0.395 (0.065 to 2.402)	
Quartiles, lagged 15 years, $\mu\text{g}/\text{m}^3\text{-y}$								
0 to < 0.7	13	29	1.0 (referent)	.117	13	29	1.0 (referent)	
0.7 to < 4.4	13	9	3.98 (0.69 to 23.02)		13	9	3.981 (0.689 to 23.016)	
4.4 to < 14.3	13	32	0.76 (0.12 to 4.98)		13	32	0.764 (0.117 to 4.981)	
$\geq 14.3$	14	30	0.42 (0.05 to 3.59)		14	30	0.424 (0.050 to 3.588)	
Duration of REC exposure, y								
Unexposed†	34	61	1.0 (referent)		34	61	1.0 (referent)	
0 to < 5	10	17	1.44 (0.26 to 8.17)	.152	10	17	1.443 (0.255 to 8.166)	
5 to < 10	5	12	0.74 (0.10 to 5.21)		5	12	0.736 (0.104 to 5.212)	
10 to < 15	3	3	0.55 (0.05 to 6.17)		3	3	0.546 (0.048 to 6.169)	
$\geq 15$	1	7	0.22 (0.01 to 3.67)		1	7	0.216 (0.013 to 3.665)	

\* P values based on two-sided Wald test for linear trend. Adjusted for smoking status (never smoker, unknown/occasional smoker, former smoker/<1 pack per day, former smoker/1 to <2 pack s per day, former smoker/ $\geq 2$  pack s per day, current smoker/<1 pack per day, current smoker/1 to <2 pack s per day, current smoker/ $\geq 2$  pack s per day); history of respiratory disease 5 or more years before date of death/reference date; and history of a high-risk job for lung cancer for at least 10 years. REC = respirable elemental carbon.

† Twenty-one case subjects and 154 control subjects were excluded because they no longer belonged to a complete matched set after analysis was restricted to surface workers.

‡ Unexposed includes subjects who worked surface jobs with either negligible or bystander exposure to REC.

**Table 2.12.** Odds ratios (ORs) and 95% confidence intervals (CIs) for Cumulative REC lagged 15 years crossed with smoking intensity\*

Cumulative REC lagged 15 years				Replication		
OR (95% CI), No. of case subjects/No. of control subjects				Cumulative REC lagged 15 years		
Smoking intensity (packs per day)	Tertile 1, 0 to < 8 µg/m³-y	Tertile 2, 8 to < 304 µg/m³-y	Tertile 3, ≥ 304 µg/m³-y	Tertile 1, 0 to < 8 µg/m³-y	Tertile 2, 8 to < 304 µg/m³-y	Tertile 3, ≥ 304 µg/m³-y
Never smoker	1.0 (referent), 3/59	1.47 (0.29 to 7.50), 4/74	<b>7.30 (1.46 to 36.57), 7/45</b>	1.0 (referent), 3/59	1.465 (0.286 to <b>7.505</b> ), 4/74	<b>7.305 (1.459 to 36.575), 7/45</b>
< 1	<b>6.25 (1.42 to 27.60), 10/41</b>	7.42 (1.62 to 34.00), 10/49	<b>16.35 (3.45 to 77.63), 15/39</b>	<b>6.255 (1.417 to 27.605), 10/41</b>	7.422 (1.620 to 34.005), 10/49	<b>16.355 (3.445 to 77.641), 15/39</b>
1 to < 2	10.16 (2.55 to 40.53), 29/78	<b>11.58 (2.87 to 46.71), 32/86</b>	20.42 (4.52 to 92.36), 27/63	10.159 (2.546 to <b>40.535</b> ), 29/78	<b>11.586 (2.873 to 46.720), 32/86</b>	20.423 (4.515 to 92.375), 27/63
≥ 2	26.79 (6.15 to 116.63), 19/22	<b>22.17 (4.84 to 101.65), 15/22</b>	17.38 (3.48 to 86.73), 10/28	26.792 (6.153 to <b>116.651</b> ), 19/22	<b>22.175 (4.837 to 101.667), 15/22</b>	17.384 (3.484 to 86.750), 10/28
Unknown†	4.13 (0.74 to 23.22), 4/25	3.79 (0.64 to 22.41), 4/23	27.85 (5.03 to 154.31), 9/12	4.134 (0.736 to <b>23.226</b> ), 4/25	3.787 (0.640 to 22.418), 4/23	27.851 (5.026 to 154.339), 9/12

\* Adjusted for history of respiratory disease 5 or more years before date of death/reference date, history of a high-risk job for lung cancer for at least 10 years, and mine location ( surface- only vs any underground work). P value for interaction between smoking intensity and cumulative REC lagged 15 years = .086. REC = respirable elemental carbon.

† Unknown includes subjects with unknown smoking status, and subjects considered occasional smokers, who smoked at least 100 cigarettes during their lifetimes, but never smoked regularly ( ≥ 1 cigarette per day for at least 6 months).

**Table 2.13.** Odds ratios (ORs) and 95% confidence intervals (CIs) for average and cumulative REC lagged 15 years, by mining facility type\*

Table 2.13. Odds ratios (ORs) and 95% confidence intervals (CIs) for average and cumulative REC lagged 15 years, by mining facility type*					Replication			
Exposure by mine type	Case subject	Control subject	OR (95% CI)	P trend	Case subject	Control subject	OR (95% CI)	P trend
Potash								
Average REC intensity, lagged 15 years, quartiles, µg/m³								
0 to <1	25	95	1.0 (referent)	.058	25	95	1.0 (referent)	
1 to <6	20	51	1.16 (0.49 to 2.76)		20	51	1.163 (0.490 to 2.759)	
6 to <57	30	105	2.05 (0.70 to 6.01)		30	105	2.050 (0.700 to 6.010)	
≥57	27	85	3.01 (0.98-9.25)		27	85	3.014 (0.928 to 9.250)	
Cumulative REC, lagged 15 years, quartiles, µg/m³-y								
0 to <3	19	60	1.0 (referent)	.006	19	60	1.0 (referent)	
3 to <72	30	103	1.64 (0.67 to 3.98)		30	103	1.635 (0.671 to 3.983)	
72 to <536	25	105	2.50 (0.86 to 7.24)		25	105	2.496 (0.860 to 7.243)	
≥536	28	68	5.53 (1.68 to 18.21)		28	68	5.528 (1.678 to 18.206)	
Trona								
Average REC intensity, lagged 15 years, quartiles, µg/m³								
0 to <1	17	70	1.0 (referent)	.105	17	70	1.0 (referent)	
1 to <6	18	64	2.32 (0.52 to 10.40)		18	64	2.317 (0.516 to 10.397)	
6 to <57	2	6	1.71 (0.12 to 23.66)		2	6	1.710 (0.124 to 23.656)	
≥57	14	34	5.95 (0.92 to 38.37)		14	34	5.953 (0.924 to 38.365)	
Cumulative REC, lagged 15 years, quartiles, µg/m³-y								
0 to <3	24	72	1.0 (referent)	.062	24	72	1.0 (referent)	
3 to <72	11	64	0.23 (0.06 to 0.91)		11	64	0.233 (0.059 to 0.913)	
72 to <536	7	17	0.95 (0.16 to 5.72)		7	17	0.954 (0.159 to 5.721)	
≥536	9	21	2.38 (0.44 to 13.00)		9	21	2.381 (0.436 to 12.997)	

\* P values based on two-sided Wald test for linear trend. Adjusted for smoking status/mine location combination (surface work only/never smoker, surface work only/unknown/occasional smoker, surface work only/former smoker/<1 pack per day, surface work only/former smoker/1 to <2 pack s per day, surface work only/former smoker/ ≥ 2 packs per day, surface work only/current smoker/<1 pack per day, surface work only/current smoker/1 to <2 pack s per day, surface work only/current smoker/ ≥ 2 pack s per day, ever underground work/never smoker, ever underground work/unknown/occasional smoker, ever underground work/former smoker/<1 pack per day, ever underground work/former smoker/1 to <2 pack s per day, ever underground work/former smoker/ ≥ 2 pack s per day, ever underground work/current smoker/<1 pack per day, ever underground work/current smoker/1 to <2 pack s per day, ever underground work/current smoker/ ≥ 2 pack s per day); history of respiratory disease 5 or more years before date of death/reference date; and history of a high-risk job for lung cancer for at least 10 years. REC = respirable elemental carbon.