CHAPTER 17

Respiratory-System Cancers, Females: Relation with Medical Radiation

• Part 1. Introduction

Respiratory-System Cancers include cancers of the larynx, bronchus and trachea, of lung specified as primary, of lung unspecified as to whether primary or secondary, and of other parts of the respiratory-system (see Chapter 4, Part 5, Number 7). Although the 1940 female MortRates present a severe "small numbers problem," we analyze these data here because the "small numbers" will not persist --- as shown in Table 17-A.

• Part 2. How the Dose-Response Develops, 1921-1940

• - Part 2a.	1921 PhysPop	1940 MortRate
Pacific	165.11	3.8
New England	142.24	4.1
West North Central	140.93	3.1
Mid-Atlantic	137.29	4.2
East North Central	136.06	3.2
Mountain	135.38	2.9
West South Central	125.15	2.4
East South Central	119.76	2.4
South Atlantic	110.32	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	-1.4119
Std Err of Y Est	0.5265
R Squared	0.5358
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0340
Std Err of Coef.	0.0120
Coefficient / S.E.	2.8427

• - Part 2b.	1923 PhysPop	1940 MortRate
Pacific	163.06	3.8
New England	137.39	4.1
West North Central	138.31	3.1
Mid-Atlantic	138.92	4.2
East North Central	131.82	3.2
Mountain	130.51	2.9
West South Central	119.16	2.4
East South Central	113.16	2.4
South Atlantic	106.79	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	-1.2648
Std Err of Y Est	0.4823
R Squared	0.6104
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0338
Std Err of Coef.	0.0102
Coefficient / S.E.	3.3120

• - Part 2c.	1925 PhysPop	1940 MortRate
Pacific	161.67	3.8
New England	138.31	4.1
West North Central	133.92	3.1
Mid-Atlantic	134.36	4.2
East North Central	127.54	3.2
Mountain	122.30	2.9
West South Central	112.83	2.4
East South Central	107.22	2.4
South Atlantic	103.61	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	-0.9861
Std Err of Y Est	0.4473
R Squared	0.6649
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0327
Std Err of Coef.	0.0088
Coefficient / S.E.	3.7266

• - Part 2d.	1927 PhysPop	1940 MortRate
Pacific	157.83	3.8
New England	137.50	4.1
West North Central	131.54	3.1
Mid-Atlantic	138.40	4.2
East North Central	126.18	3.2
Mountain	118.75	2.9
West South Central	108.25	2.4
East South Central	102.07	2.4
South Atlantic	102.13	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	-1.0503
Std Err of Y Est	0.3685
R Squared	0.7726
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0338
Std Err of Coef.	0.0069
Coefficient / S.E.	4.8768

• - Part 2e.	1929 PhysPop	1940 MortRate
Pacific	156.64	3.8
New England	138.46	4.1
West North Central	128.72	3.1
Mid-Atlantic	138.49	4.2
East North Central	126.51	3.2
Mountain	118.68	2.9
West South Central	105.60	2.4
East South Central	99.41	2.4
South Atlantic	100.86	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	-0.9727
Std Err of Y Est	0.3379
R Squared	0.8088
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0335
Std Err of Coef.	0.0061
Coefficient / S.E.	5.4408

• - Part 2f.	1931 PhysPop	1940 MortRate
Pacific	159.97	3.8
New England	142.35	4.1
West North Central	126.50	3.1
Mid-Atlantic	140.82	4.2
East North Central	128.59	3.2
Mountain	118.89	2.9
West South Central	105.95	2.4
East South Central	96.73	2.4
South Atlantic	99.59	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	-0.6736
Std Err of Y Est	0.3206
R Squared	0.8279
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0309
Std Err of Coef.	0.0053
Coefficient / S.E.	5.8033

• - Part 2g.	1934 PhysPop	1940 MortRate
Pacific	160.09	3.8
New England	148.60	4.1
West North Central	125.96	3.1
Mid-Atlantic	149.62	4.2
East North Central	129.36	3.2
Mountain	117.16	2.9
West South Central	104.68	2.4
East South Central	92.00	2.4
South Atlantic	98.41	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	-0.3885
Std Err of Y Est	0.2381
R Squared	0.9051
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0284
Std Err of Coef.	0.0035
Coefficient / S.E.	8.1685

• - Part 2h.	1936 PhysPop	1940 MortRate
Pacific	158.44	3.8
New England	150.18	4.1
West North Central	126.14	3.1
Mid-Atlantic	155.05	4.2
East North Central	130.42	3.2
Mountain	119.80	2.9
West South Central	103.52	2.4
East South Central	89.94	2.4
South Atlantic	99.16	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	-0.3215
Std Err of Y Est	0.2032
R Squared	0.9309
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0277
Std Err of Coef.	0.0029
Coefficient / S.E.	9.7080

• - Part 2i.	1938 PhysPop	1940 MortRate
Pacific	157.62	3.8
New England	154.08	4.1
West North Central	124.95	3.1
Mid-Atlantic	160.69	4.2
East North Central	131.98	3.2
Mountain	119.88	2.9
West South Central	102.79	2.4
East South Central	88.21	2.4
South Atlantic	99.26	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	-0.1666
Std Err of Y Est	0.1681
R Squared	0.9527
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0263
Std Err of Coef.	0.0022
Coefficient / S.E.	11.8728

• - Part 2j.	1940 PhysPop	1940 MortRate
Pacific	159.72	3.8
New England	161.55	4.1
West North Central	123.14	3.1
Mid-Atlantic	169.76	4.2
East North Central	133.36	3.2
Mountain	119.89	2.9
West South Central	103.94	2.4
East South Central	85.83	2.4
South Atlantic	100.74	2.4

Respiratory-System Ca, Females Regression Output:	
Constant	0.1019
Std Err of Y Est	0.1496
R Squared	0.9625
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.0238
Std Err of Coef.	0.0018
Coefficient / S.E.	13.4046

Box 1 of Chap. 17

Summary: Regression Outputs, Respiratory-System Cancers, Females.

Below are the summary-results from regressing the 1940 cancer MortRates upon the ten sets of PhysPops (1921-1940), as presented in Parts 2a-2j of this chapter.

Part	PhysPop	R-squared	Constant	X-Coef	Std Err	X-Coef/SE
2a	1921	0.5358	-1.41	0.0340	0.0120	2.8427
2b	1923	0.6104	-1.26	0.0338	0.0102	3.3120
2c	1925	0.6649	-0.99	0.0327	0.0088	3.7266
2d	1927	0.7726	-1.05	0.0338	0.0069	4.8768
2e	1929	0.8088	-0.97	0.0335	0.0061	5.4408
2f	1931	0.8279	-0.67	0.0309	0.0053	5.8033
2g	1934	0.9051	-0.39	0.0284	0.0035	8.1685
2h	1936	0.9309	-0.32	0.0277	0.0029	9.7080
2i	1938	0.9527	-0.17	0.0263	0.0022	11.8728
2j --->	1940 Max	0.9625	0.10	0.0238	0.0018	13.4046

Box 2 of Chap. 17

Input-Data for Figure 17-A. Respiratory-System Cancers. Females.

Part 2j, Best-Fit Equation: Calc. MortRate = (0.0238 * PhysPop) + (0.10)

Census Divisions	1940 Observed PhysPops	1940 Observed MortRates	Best-Fit Calc. MortRates
Pacific	159.72	3.8	3.901
New England	161.55	4.1	3.945
West No. Central	123.14	3.1	3.031
Mid-Atlantic	169.76	4.2	4.140
East No. Central	133.36	3.2	3.274
Mountain	119.89	2.9	2.953
West So. Central	103.94	2.4	2.574
East So. Central	85.83	2.4	2.143
South Atlantic	100.74	2.4	2.498
Additional PhysPops	70.00		1.766
--- not "observed" ---	60.00		1.528
down to zero PhysPop	50.00		1.290
(zero medical radiation).	40.00		1.052
For each, we calculate	30.00		0.814
a best-fit MortRate.	20.00		0.576
These additional x,y pairs	10.00		0.338
are also part of the	0		0.100
best-fit line (Chap 5, Part 5e).			

Box 3 of Chap. 17

Presumptive Fraction of Cancer MortRate Attributable to Medical Radiation.

Please see text in Chapter 6, Parts 4 and 6.

Respiratory-System Cancers. FEMALES.

• FEMALE National MortRate (MR) 1940, from Table 17-B	3.3	National MortRate
• Constant, from regression, Part 2j	0.1019	Constant
• Fractional Causation, Best Est. = (Natl MR - Constant) / Natl MR	96.9%	Frac. Causation

90% Confidence-Limits (C.L.) on Fractional Causation. See text in Chapter 6, Part 4b, please.

X-Coefficient, from Part 2j	0.0238	X-Coef., Best Est.
Standard Error (SE) of X-Coefficient, from Part 2j	0.0018	Standard Error
Upper 90% C.L. on X-Coef. = (Coef) + (1.645 * SE) =	0.0268	New X-Coefficient
New Constant = (Natl MR) - (New X-Coef * 1940 Natl PhysPop) =	-0.2335	New Constant
Frac. Causation, High-Limit = (Natl MR - New Constant) / Natl MR =	107.1% #	New Frac. Caus'n.
# The Upper-Limit is 100%. Negative Constants produce values > 100%.	See Chapter 22, Part 3.	
Lower 90% C.L. on X-Coef. = (Coef) - (1.645 * SE) =	0.0208	New X-Coefficient
New Constant = (Natl MR) - (New X-Coef * 1940 Natl PhysPop) =	0.5484	New Constant
Frac. Causation, Low-Limit = (Natl MR - New Constant) / Natl MR =	83.4%	New Frac. Caus'n.

Box 4 of Chap. 17

Error-Check on Our Own Work: Respiratory-System Cancer, Females.

Please see text in Chapter 6, Part 5.

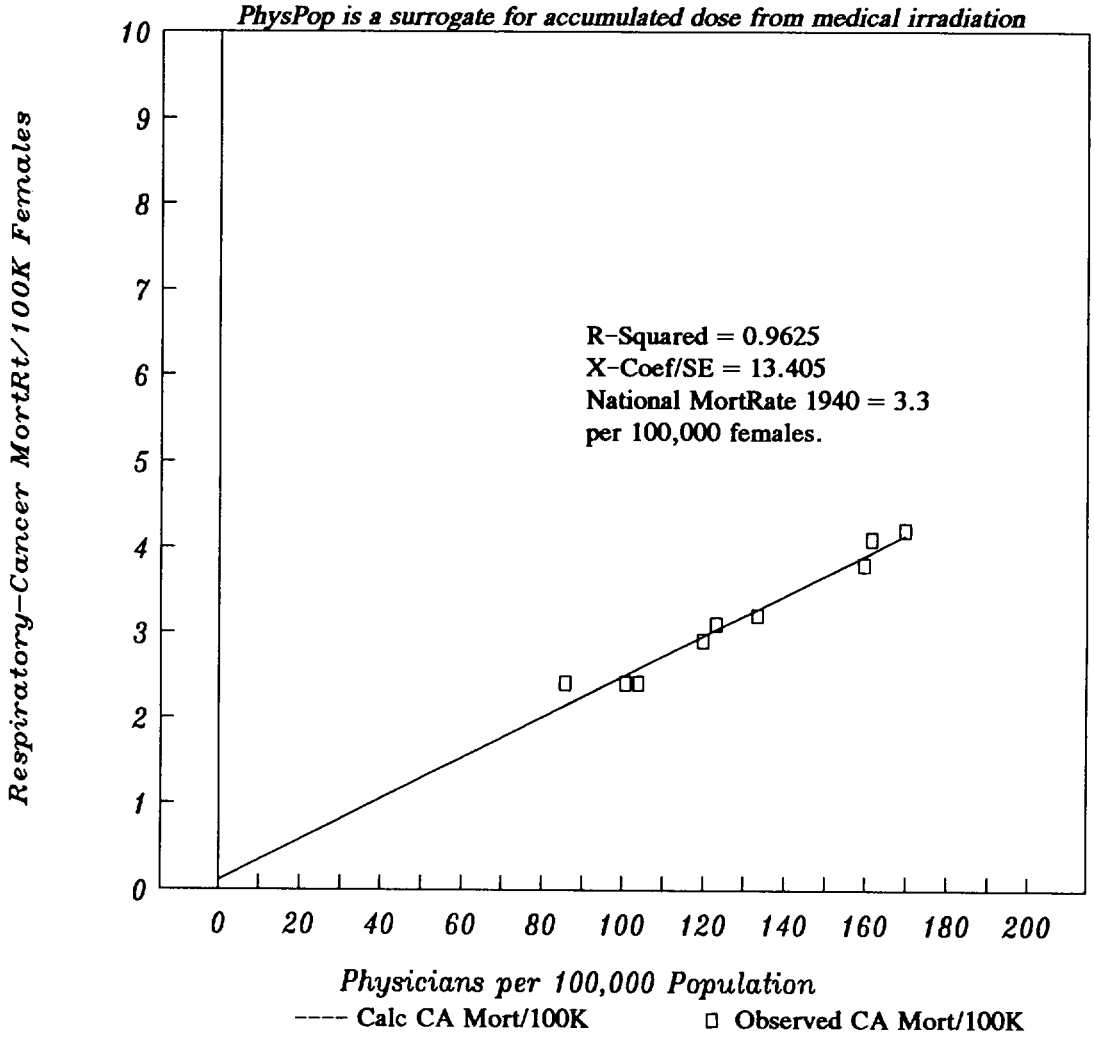
Below, Columns A, C, and E come directly from the regression input in Part 2j. Column B, the fraction of the whole 1940 population in each Census Division, comes from Table 3-B in Chapter 3. Each Column-D entry is the product of (B-entry times C-entry). Each Column-F entry is the product of (B-entry times E-entry). PhysPops and MortRates are each "per 100,000."

The Weighted-Avg. Nat'l PhysPop, 1940, is the sum of Column-D entries =	132.04
The Weighted-Avg. Nat'l Female MortRate, 1940, is sum of Col.F entries =	3.24
The Nat'l Female MortRate is also (X-Coef * Nat'l PhysPop) + Constant =	3.24
Comparison: The Nat'l Female MortRate, 1940, in Table 17-B =	3.30

(A) Census Division	(B) Pop'n Fraction	(C) PhysPop 1940	(D) Weighted PhysPop	(E) MortRate 1940	(F) Weighted MortRate
Pacific	0.0739	159.72	11.80	3.8	0.28
New England	0.0641	161.55	10.36	4.1	0.26
West No. Central	0.1027	123.14	12.65	3.1	0.32
Mid-Atlantic	0.2092	169.76	35.51	4.2	0.88
East No. Central	0.2022	133.36	26.97	3.2	0.65
Mountain	0.0315	119.89	3.78	2.9	0.09
West So. Central	0.0992	103.94	10.31	2.4	0.24
East So. Central	0.0819	85.83	7.03	2.4	0.20
South Atlantic	0.1354	100.74	13.64	2.4	0.32
Sums	1.0000		132.04		3.24

1940 Respiratory Cancer Mortality-Rates versus 1940 PhysPop Values for the 9 Census Divisions, USA.

Dose-Response Relationship



On the X-axis, PhysPop values = Physicians per 100,000 Population in the Nine Census Divisions of the USA Population, Year 1940. This variable is a surrogate for accumulated radiation dose --- the more physicians per 100,000 people, the more radiation procedures are done per 100,000 people.

On the Y-axis, Respiratory Cancer Mortality-Rate per 100,000 females = the reported rates in USA Vital Statistics for the Nine Census Divisions, Year 1940.

Shown above is the strongest relationship between these two variables (Part 2j). The nine datapoints (boxy symbols) were collected long ago for other purposes, and are free from potential bias with respect to this dose-response study. Fractional causation is (Natl MortRate minus the Y-intercept) / (Natl MortRate).

Fractional Causation of Respiratory Cancer Mort-Rate (Female) by Medical Rad'n 97 % from Best Estimate (Box 3).

83 % at lower 90 % confidence limit (Box 3). ~100 % at upper 90 % confidence limit (Box 3).

Table 17-A.
Respiratory-System Cancer MortRates by Census Divisions: Females.

Rates are annual deaths per 100,000 female population, USA, age-adjusted to the 1940 reference year. There are no exclusions by color or "race." Sources are stated in Table 17-B, and described in Chap. 4, Part 2. The Nine Census-Division MortRates are population-weighted (Chap. 4, Part 2b). The averages below them are not.

Census Division	1940	1950	1960	1970	1980	1988
Pacific	3.8	4.4	5.9	13.6	21.2	27.8
New England	4.1	4.1	5.6	12.1	18.5	26.9
West North Central	3.1	4.8	4.4	9.7	15.0	23.1
Mid-Atlantic	4.2	5.0	6.0	12.3	18.5	25.8
East North Central	3.2	4.5	5.1	11.6	18.1	26.4
Mountain	2.9	4.2	4.1	9.5	14.9	22.2
West South Central	2.4	4.3	5.2	11.3	17.3	26.6
East South Central	2.4	4.7	4.7	10.9	17.0	26.6
South Atlantic	2.4	4.7	5.0	11.5	17.9	26.6
Average, ALL	3.2	4.5	5.1	11.4	17.6	25.8
Average, High-5	3.7	4.6	5.4	11.8	18.3	26.0
Average, Low-4	2.5	4.5	4.8	10.8	16.8	25.5
Ratio, Hi5/Lo4	1.46	1.02	1.14	1.10	1.09	1.02

• - 1940: Although the MortRates for WestSoCentral, EastSoCentral, and SouthAtlantic are identical, they are truly the entries for these Census Divisions in Grove 1968, Table 67, page 687.

• - 1950: These entries are such that the Hi5/Lo4 Ratio suddenly drops from 1.46 in 1940 to 1.02 in 1950. This seems unlikely to be correct, and may result from random fluctuations in small numbers, or from reporting-errors. On the other hand, the values may be accurate. In any case, the official values have been copied correctly by us from Grove 1968.

• - 1988: Although the MortRates for WestSoCentral, EastSoCentral, and SouthAtlantic are identical (again), we have double-checked the state-values from the government, as well as our own calculations which combined these various state-values into Census Divisions. We find no errors.

Table 17-B.
Respiratory-System Cancer Mortality Rates, USA National.

Rates are age-adjusted to the 1940 reference year. Both sexes: Deaths per 100,000 population (males + females). Males: Deaths per 100,000 male population. Females: Deaths per 100,000 female population. No exclusions by color or "race."
color or "race."

	Both Sexes	Male	Female
1940	7.2	11.0	3.3
1950	13.0	21.6	4.6
1960	19.5	35.2	5.3
1970	28.4	47.3	11.7
1979-81	36.1	59.4	18.0
1987-89	--	59.7	24.5

• - 1940, 1950, 1960: All rates come from Grove 1968, Table 67, p.686, "Malignant neoplasm of respiratory system, not specified as secondary (160-164)," ICD/7.

• - 1970: All rates by Divisions are interpolations (Chap. 4, Parts 2b, 2c), except that the 1970 National "Both Sexes" rate comes from PHS 1995, Table 30, p.110.

• - 1980: All rates (ICD/9, 160-165) come from the reference NatCtrHS 1980.

• - 1990: All rates for 1987 -1989 come from Monthly Vital Statistics Vol.41, No.7, December 1992. The 1988 rates are an acceptable approximation for 1990 (Chap.4, Part 2b.)