All–Cancers–Combined, Females: Relation with Medical Radiation

● **Part 1. Introduction**

Chapter 7 follows the model of Chapter 6, bur eliminates the text.

For everyone's convenience, Chapter 22, Box 1, tabulates the results from Chapters 6 through 21 --- for easy comparison with each other.

● **Part 2. How the Dose–Response Develops, 1921–1940**

In Part 2, we regress the 1940 MortRates (from Table 7-A) upon the non-interpolated sets of PhysPop values 1921-1940 (from the Universal PhysPop Table 3-A). The summary-results of all the regression analyses are presented in Box 1.

● – Part 2a.

	1921 PhysPop	1940 MortRate
Pacific	165.11	127.4
New England	142.24	145.3
West North Central	140.93	120.1
Mid-Atlantic	137.29	142.9
East North Central	136.06	131.4
Mountain	135.38	111.8
West South Central	125.15	99.8
East South Central	119.76	102.5
South Atlantic	110.32	106.9

All-Cancers, Females
Regression Output:

Constant	33.3847
Std Err of Y Est	14.5247
R Squared	0.3566
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.6497
Std Err of Coef.	0.3299
Coefficient / S.E.	1.9695

● – Part 2b.

	1923 PhysPop	1940 MortRate
Pacific	163.06	127.4
New England	137.39	145.3
West North Central	138.31	120.1
Mid-Atlantic	138.92	142.9
East North Central	131.82	131.4
Mountain	130.51	111.8
West South Central	119.16	99.8
East South Central	113.16	102.5
South Atlantic	106.79	106.9

All-Cancers, Females
Regression Output:

Constant	34.9732
Std Err of Y Est	13.8135
R Squared	0.4180
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.6559
Std Err of Coef.	0.2925
Coefficient / S.E.	2.2423

● – Part 2c.

	1925 PhysPop	1940 MortRate
Pacific	161.67	127.4
New England	138.31	145.3
West North Central	133.92	120.1
Mid-Atlantic	134.36	142.9
East North Central	127.54	131.4
Mountain	122.30	111.8
West South Central	112.83	99.8
East South Central	107.22	102.5
South Atlantic	103.61	106.9

All-Cancers, Females
Regression Output:

Constant	37.9005
Std Err of Y Est	13.0106
R Squared	0.4837
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.6542
Std Err of Coef.	0.2555
Coefficient / S.E.	2.5609

● – Part 2d.

	1927 PhysPop	1940 MortRate
Pacific	157.83	127.4
New England	137.50	145.3
West North Central	131.54	120.1
Mid-Atlantic	138.40	142.9
East North Central	126.18	131.4
Mountain	118.75	111.8
West South Central	108.25	99.8

All-Cancers, Females
Regression Output:

Constant	33.8179
Std Err of Y Est	11.4512
R Squared	0.6001
No. of Observations	9
Degrees of Freedom	7
X Coefficient(s)	0.6981

East South Central	102.07	102.5	Std Err of Coef.	0.2154
South Atlantic	102.13	106.9	Coefficient / S.E.	3.2407

● - Part 2e.

	1929 PhysPop	1940 MortRate	All-Cancers, Females Regression Output:	
Pacific	156.64	127.4	Constant	34.0646
New England	138.46	145.3	Std Err of Y Est	10.7394
West North Central	128.72	120.1	R Squared	0.6482
Mid-Atlantic	138.49	142.9	No. of Observations	9
East North Central	126.51	131.4	Degrees of Freedom	7
Mountain	118.68	111.8		
West South Central	105.60	99.8	X Coefficient(s)	0.7019
East South Central	99.41	102.5	Std Err of Coef.	0.1954
South Atlantic	100.86	106.9	Coefficient / S.E.	3.5916

● - Part 2f.

	1931 PhysPop	1940 MortRate	All-Cancers, Females Regression Output:	
Pacific	159.97	127.4	Constant	39.7540
New England	142.35	145.3	Std Err of Y Est	10.3504
West North Central	126.50	120.1	R Squared	0.6732
Mid-Atlantic	140.82	142.9	No. of Observations	9
East North Central	128.59	131.4	Degrees of Freedom	7
Mountain	118.89	111.8		
West South Central	105.95	99.8	X Coefficient(s)	0.6524
East South Central	96.73	102.5	Std Err of Coef.	0.1718
South Atlantic	99.59	106.9	Coefficient / S.E.	3.7978

● - Part 2g.

	1934 PhysPop	1940 MortRate	All-Cancers, Females Regression Output:	
Pacific	160.09	127.4	Constant	44.2545
New England	148.60	145.3	Std Err of Y Est	8.7564
West North Central	125.96	120.1	R Squared	0.7661
Mid-Atlantic	149.62	142.9	No. of Observations	9
East North Central	129.36	131.4	Degrees of Freedom	7
Mountain	117.16	111.8		
West South Central	104.68	99.8	X Coefficient(s)	0.6127
East South Central	92.00	102.5	Std Err of Coef.	0.1279
South Atlantic	98.41	106.9	Coefficient / S.E.	4.7888

● - Part 2h.

	1936 PhysPop	1940 MortRate	All-Cancers, Females Regression Output:	
Pacific	158.44	127.4	Constant	44.9599
New England	150.18	145.3	Std Err of Y Est	8.0257
West North Central	126.14	120.1	R Squared	0.8035
Mid-Atlantic	155.05	142.9	No. of Observations	9
East North Central	130.42	131.4	Degrees of Freedom	7
Mountain	119.80	111.8		
West South Central	103.52	99.8	X Coefficient(s)	0.6034
East South Central	89.94	102.5	Std Err of Coef.	0.1128
South Atlantic	99.16	106.9	Coefficient / S.E.	5.3509

● - Part 2i.

	1938 PhysPop	1940 MortRate	All-Cancers, Females Regression Output:	
Pacific	157.62	127.4	Constant	47.4535
New England	154.08	145.3	Std Err of Y Est	7.1875
West North Central	124.95	120.1	R Squared	0.8424
Mid-Atlantic	160.69	142.9	No. of Observations	9
East North Central	131.98	131.4	Degrees of Freedom	7
Mountain	119.88	111.8		
West South Central	102.79	99.8	X Coefficient(s)	0.5801
East South Central	88.21	102.5	Std Err of Coef.	0.0948
South Atlantic	99.26	106.9	Coefficient / S.E.	6.1177

● - Part 2j.

	1940 PhysPop	1940 MortRate	All-Cancers, Females Regression Output:	
Pacific	159.72	127.4	Constant	52.9840
New England	161.55	145.3	Std Err of Y Est	6.7550

West North Central	123.14	120.1	R Squared	0.8608
Mid-Atlantic	169.76	142.9	No. of Observations	9
East North Central	133.36	131.4	Degrees of Freedom	7
Mountain	119.89	111.8		
West South Central	103.94	99.8	X Coefficient(s)	0.5279
East South Central	85.83	102.5	Std Err of Coef.	0.0802
South Atlantic	100.74	106.9	Coefficient / S.E.	6.5801

Box 1 of Chap. 7
Summary: Regression Outputs for All-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. We are searching for the maximum correlation. Even the maximum will tend to understate the true correlation (Chapter 5, Part 8b).

Part	PhysPop	R-squared	Constant	X-Coef	Std Err	X-Coef/SE
2a	1921	0.3566	33.38	0.6497	0.3299	1.9695
2b	1923	0.4180	34.97	0.6559	0.2925	2.2423
2c	1925	0.4837	37.90	0.6542	0.2555	2.5609
2d	1927	0.6001	33.82	0.6981	0.2154	3.2407
2e	1929	0.6482	34.06	0.7019	0.1954	3.5916
2f	1931	0.6732	39.75	0.6524	0.1718	3.7978
2g	1934	0.7661	44.25	0.6127	0.1279	4.7888
2h	1936	0.8035	44.96	0.6034	0.1128	5.3509
2i	1938	0.8424	47.45	0.5801	0.0948	6.1177
2j --->	1940 Max	0.8608	52.98	0.5279	0.0802	6.5801

Box 2 of Chap. 7
Input-Data for Figure 7-A. All-Cancers. Females.

Part 2j, Best-Fit Equation: Calc. MortRate = (0.5279 * PhysPop) + (52.98)

Census Divisions	1940 Observed PhysPops	1940 Observed MortRates	Best-Fit Calc. MortRates
Pacific	159.72	127.4	137.296
New England	161.55	145.3	138.262
West No. Central	123.14	120.1	117.986
Mid-Atlantic	169.76	142.9	142.596
East No. Central	133.36	131.4	123.381
Mountain	119.89	111.8	116.270
West So. Central	103.94	99.8	107.850
East So. Central	85.83	102.5	98.290
South Atlantic	100.74	106.9	106.161
Additional PhysPops	70.00		89.933
--- not "observed" ---	60.00		84.654
down to zero PhysPop	50.00		79.375
(zero medical radiation).	40.00		74.096
For each, we calculate	30.00		68.817
a best-fit MortRate.	20.00		63.538
These additional x,y pairs	10.00		58.259
are also part of the	0		52.980
best-fit line (Chap 5, Part 5e).			

Box 3 of Chap. 7
Presumptive Fraction of Cancer MortRate Attributable to Medical Radiation.

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

All-Cancers. FEMALES.   * denotes multiplication.

- FEMALE National MortRate (MR) 1940, from Table 7-B   126.1 National MortRate
- Constant, from regression, Part 2j   52.9840 Constant
- Fractional Causation, Best Est. = (Natl MR − Constant) / Natl MR   58.0% Frac. Causation

....

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

X-Coefficient, from Part 2j   0.5279 X-Coef., Best Est.
Standard Error (SE) of X-Coefficient, from Part 2j   0.0802 Standard Error

Upper 90% C.L. on X-Coef. = (Coef) + (1.645 * SE) =   0.6598 New X-Coefficient
New Constant = (Natl MR) − (New X-Coef * 1940 Natl PhysPop) = 38.9762 New Constant
Frac. Causation, High-Limit = (Natl MR − New Constant) / Natl MR = 69.1% New Frac. Caus'n.

Lower 90% C.L. on X-Coef. = (Coef) − (1.645 * SE) =   0.3960 New X-Coefficient
New Constant = (Natl MR) − (New X-Coef * 1940 Natl PhysPop) = 73.8160 New Constant
Frac. Causation, Low-Limit = (Natl MR − New Constant) / Natl MR = 41.5% New Frac. Caus'n.

Box 4 of Chap. 7
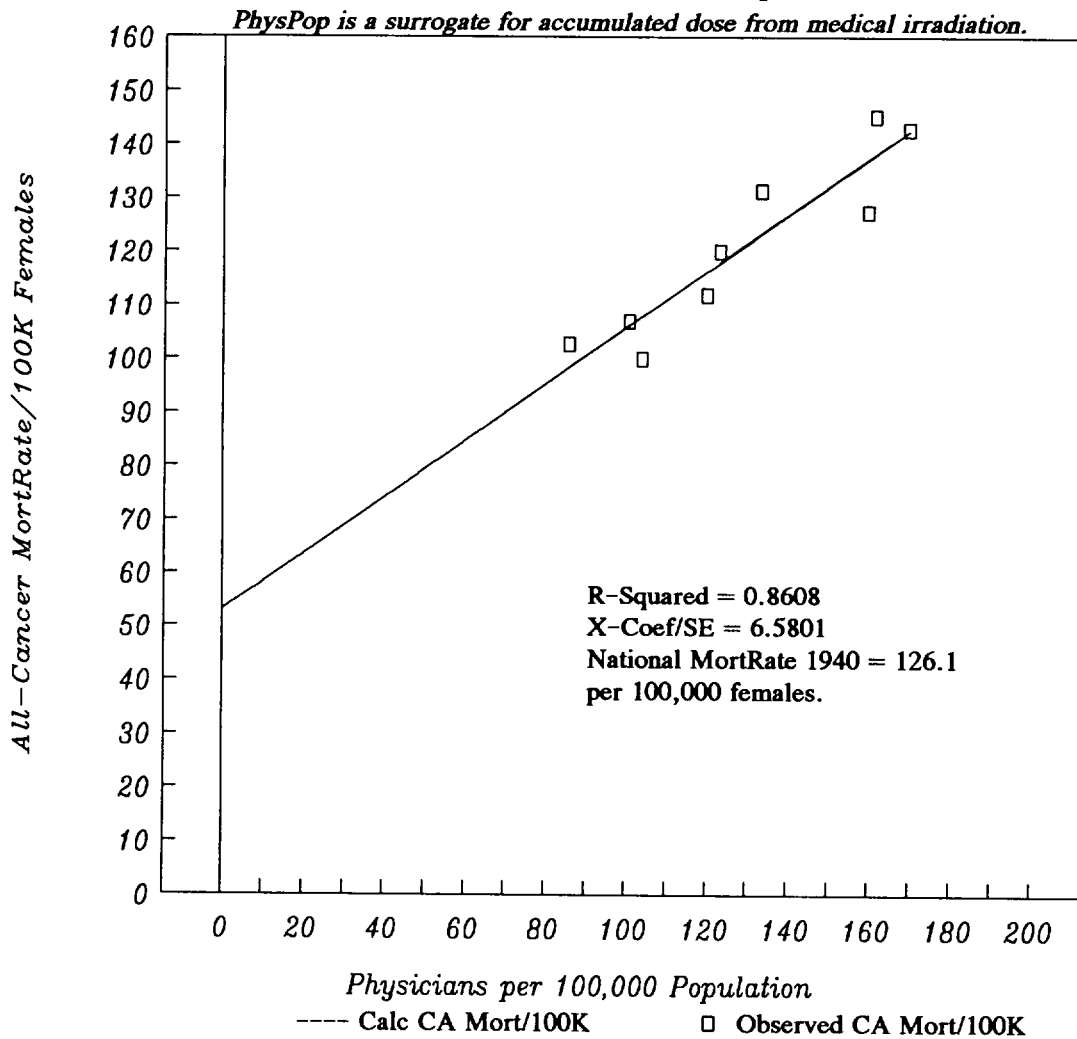### Error-Check on Our Own Work: All-Cancers, Females.

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 = 123.82
The Nat'l Female MortRate is also (X-Coef * Nat'l PhysPop) + Constant = 122.68
Comparison: The Nat'l Female MortRate, 1940, in Table 7-B = 126.10

(A) Census Division	(B) Pop'n Fraction	(C) PhysPop 1940	(D) 1940 Weighted PhysPop	(E) MortRate 1940	(F) Weighted MortRate
Pacific	0.0739	159.72	11.80	127.4	9.41
New England	0.0641	161.55	10.36	145.3	9.31
West No. Central	0.1027	123.14	12.65	120.1	12.33
Mid-Atlantic	0.2092	169.76	35.51	142.9	29.89
East No. Central	0.2022	133.36	26.97	131.4	26.57
Mountain	0.0315	119.89	3.78	111.8	3.52
West So. Central	0.0992	103.94	10.31	99.8	9.90
East So. Central	0.0819	85.83	7.03	102.5	8.39
South Atlantic	0.1354	100.74	13.64	106.9	14.47
Sums	1.0000		132.04		123.82

1940 All-Cancer Mortality-Rates versus
1940 PhysPop Values for the 9 Census Divisions, USA.
Dose-Response Relationship

PhysPop is a surrogate for accumulated dose from medical irradiation.

R-Squared = 0.8608
X-Coef/SE = 6.5801
National MortRate 1940 = 126.1
per 100,000 females.

Physicians per 100,000 Population

---- Calc CA Mort/100K   □ Observed CA Mort/100K

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, All-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 All-Cancer Mortality-Rate in Females
by Medical Radiation = 58 % from Best Estimate (Box 3).
41.5% at Lower 90% Conf. Limit (Box 3).   69 % at Upper 90 % Conf. Limit (Box 3).

Table 7-A.
All-Cancer Mortality Rates 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 7-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	127.4	117.7	110.1	110.2	110.4	111.5
New England	145.3	132.1	122.4	119.4	116.4	116.4
West North Central	120.1	117.1	109.3	105.1	101.0	106.8
Mid-Atlantic	142.9	137.0	127.4	122.4	117.5	118.6
East North Central	131.4	127.5	119.8	115.9	112.0	116.5
Mountain	111.8	106.0	101.0	97.9	94.9	100.4
West South Central	99.8	109.3	102.9	101.5	100.1	109.8
East South Central	102.5	110.3	104.8	104.0	103.2	112.7
South Atlantic	106.9	113.3	107.4	106.2	105.0	111.6
Average, ALL	120.9	118.9	111.7	109.2	106.7	111.6
Average, High-5	133.4	126.3	117.8	114.6	111.5	114.0
Average, Low-4	105.3	109.7	104.0	102.4	100.8	108.6
Ratio, Hi5/Lo4	1.27	1.15	1.13	1.12	1.11	1.05

Table 7-B.
All-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."

	Both Sexes	Male	Female
1940	120.3	115.0	126.1
1950	127.7	132.8	123.2
1960	129.1	145.7	114.9
1970	129.8	155.1	111.7
1979-81	131.9	164.5	108.5
1987-89	135.0	162.7	111.3

● - 1940, 1950, 1960: All rates come from Grove 1968, Table 67, p.676, "Malignant neoplasms, including neoplasms of lymphatic and hematopoietic tissues (140-205)" ICD/7.

● - 1970: All rates 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, 140-208) come from the reference NatCtrHS 1980.

● - 1988 rates by Divisions and National come from Monthly Vital Statistics Vol.41, No.6, November 12, 1992. Exception: National "Both Sexes" is for 1990, and comes from PHS 1995, Table 39, p.132.