CHAPTER 49

All-Cancers, Males, 1940-1988: Fractional Causation by Medical Radiation

The boxes and tables in Chapter 49 provide the model for the subsequent chapters where we evaluate the post-1940 Fractional Causation, by medical radiation, of mortality from cancer and Ischemic Heart Disease.

- Table A summarizes the findings, by decade, including the 1940 percentage from Section 2 of the book. The sources for Table A are shown in its Column G. In several chapters, the table for 1970 is not shown in order to reduce pages. 1970 was chosen because the 1970 MortRates are interpolations (Chapter 4, Part 2b).
- Box 1 determines whether or not a post-1940 adjustment is obligatory, in order to achieve matching of the Census Divisions for smoking (Chapter 48, Part 5b). If adjustment is required, Box 2 calculates the appropriate adjustment factors. Chapter 49 shows the steps.

Because male All-Cancers include male Respiratory-System Cancers, it is no surprise that Box 1, below, shows results consistent with the results in Box 3 of Chapter 48. Below, Columns D and I, as well as Columns F and K, indicate clearly that a carcinogenic co-actor (smoking), which can contribute to male MortRates from All-Cancers, is operating more strongly in the LowTrio than in the TopTrio. We must match the Census Divisions for smoking.

Table 49-A
All-Cancers, Males: Fractional Causation by Medical Radiation over Time

Year	Col.A Natl MR	Col.B Frac.C	Col.C R-Sq	Col.D X-Coef	Col.E StdErr	Col.F Coef/SE	Col.G Source
1940	115.0	90%	0.9508	0.7557	0.0650	11.6276	Chap.6
1950	132.8	84%	0.9330	0.8462	0.0857	9.8703	Tab 49-B
1960	145.7	83%	0.9407	0.9251	0.0878	10.5397	Tab 49-C
1970	155.1	79%	0.9415	0.9073	0.0855	10.6122	Tab 49-D
1980	164.5	75%	0.9386	0.8480	0.0820	10.3418	Tab 49-E
1988	162.7	74%	0.9348	0.7488	0.0748	10.1056	Tab 49-F

Box 1, Chap. 49
All-Cancers, Males: Post-1940 Change in MortRates by Census Trios

1960 vs. 1940, by Trios: Col.D expresses change by ratios. Col.F expresses change by subtraction.
1988 vs. 1940, by Trios: Col.I expresses change by ratios. Col.K expresses change by subtraction.
High-PhysPop Trio shows the lowest growth-ratio. Low-PhysPop Trio shows the highest growth-ratio.

	• 1940	>>> • Compare 1960 with 1940 • <<<					>>> • Compare 1988 with 1940 • <<<				
	Col.A 1940 MortRate Tab 6-A	Col.B 1960 MortRate Tab 6-A	Col.C Ratio Col.B /Col.A	Col.D Input from Col.C	Col.E Diff: Col.B minus A	Col.F Input from Col.E	Col.G 1988 MortRate Tab 6-A	Col.H Ratio Col.G /Col.A	Col.I Input from Col.H	Col.J Diff: Col.G minus A	Col.K Input from Col.J
Pacif	122.9	140.7	1.145	Avg Chg	17.8	Avg Chg	148.5	1.208	Avg Chg	25.6	Avg Chg
NewE	135.5	164.6	1.215	TopTrio	29.1	TopTrio	167.1	1.233	TopTrio	31.6	TopTrio
MidAtl	140.9	164.0	1.164	1.175	23.1	23.3	168.4	1.195	1.212	27.5	28.2
WNoCen	110.9	135.6	1.223	Avg Chg	24.7	Avg Chg	155.9	1.406	Avg Chg	45.0	Avg Chg
ENoCen	119.6	150.7	1.260	MidTrio	31.1	MidTrio	171.2	1.431	MidTrio	51.6	MidTrio
Mtn	99.8	118.7	1.189	1.224	18.9	24.9	139.1	1.394	1.410	39.3	45.3
WSoCen	86.9	133.8	1.540	Avg Chg	46.9	Avg Chg	172.9	1.990	Avg Chg	86.0	Avg Chg
ESoCen	73.6	125.1	1.700	LowTrio	51.5	LowTrio	188.2	2.557	LowTrio	114.6	LowTrio
SoAtl	88.9	137.1	1.542	1.594	48.2	48.9	175.8	1.978	2.175	86.9	95.8

• Part 1. Overview, and Purpose of Box 1

Although Box 1 and Table 49-A appear on the first page of this chapter, Box 2 and Tables 49-B through 49-F are located in the usual place --- AFTER the text, at the end of the chapter.

1a. Chapter 49 as the Model for Subsequent Chapters

The text will explain how we make the Smoking Adjustment and how we then calculate Fractional Causation, by medical radiation, of the post-1940 Observed National MortRates for Cancer and Ischemic Heart Disease. The same steps will be used without further explanation in Chapters 50 through 65. Each chapter has its own Table-A, in which Column B summarizes the findings on Fractional Causation by medical radiation. The findings very strongly support Hypotheses 1+2. Chapter 66 summarizes the findings from Chapters 49 - 65, for easy comparison.

1b. The Purpose of Box 1

Box 1 of this chapter follows the model of Box 3 in Chapter 48, where its columns are explained in detail. Here, in Box 1 of Chapter 49, we look first at the findings in Columns D and I:

• - Col.D: The 1960 MortRates in the TopTrio of Census Divisions are 1.175 times their values in 1940, whereas the 1960 MortRates in the LowTrio of Census Divisions are 1.594 times their values in 1940.

• - Col.I: The 1988 MortRates in the TopTrio are 1.212 times their values in 1940, whereas the 1988 MortRates in the LowTrio are 2.175 times their values in 1940.

• - Columns F and K provide confirmation that a carcinogenic co-actor (smoking), which can contribute to male MortRates from All-Cancers, is operating more strongly in the LowTrio than in the TopTrio (Chapter 48, Part 5b). We must match the Census Divisions for smoking.

In the chapters which follow, Smoking Adjustments are made only if Box 1 demonstrates that they are required. The requirement is not assumed. For example, Box 1 of Chapter 62 does NOT produce a clear indication that a Smoking Adjustment is required.

• Part 2. Co-Action among Carcinogens, Such as Xrays and Cigarettes

Co-action among carcinogenic agents has been discussed already in the Introduction (Parts 4 + 5), and in Chapter 6 (Part 6). Co-action is a widely (but not universally) accepted expectation, which is supported by several lines of evidence.

Cigarette smoking and exposure to ionizing radiation are each well established causes of Cancer. And smoking is specifically identified as a CO-ACTOR with radiation by the National Research Council's BEIR-5 and BEIR-6 Committees (BEIR 1990, p.152, + BEIR 1999, p.33) --- meaning that smoking and radiation can make necessary contributions to the same fatal cases of Cancer and that the two carcinogens modify each other's carcinogenic potency.

2a. The 1990 BEIR Report's List of Co-Actors with Radiation

For the readers' convenience, we repeat BEIR 1990's list of co-actors with ionizing radiation (from BEIR 1990, p.152; already presented in our Chapter 6, Part 6): "As discussed in the preceding section, the carcinogenic process includes the successive stages of initiation and promotion. The latter phase, promotion, appears to be particularly susceptible to modulation, with cigarette smoking being a conspicuous example of a modulating factor. Susceptibility to the carcinogenic effects of radiation can

thus be affected by a number of factors, such as genetic constitution, sex, age at initiation, physiological state, smoking habits, drugs, and various other physical and chemical agents (UNSCEAR 1982)." (BEIR 1990 is citing the 1982 UNSCEAR Report in support of these statements.) Some of the confirmatory experimental evidence, of alteration of radiation's per-rad potency by other agents, is presented in BEIR 1990 also (pp.145-147).

The 1999 BEIR Committee (BEIR-6), which has almost no overlapping membership with the 1990 BEIR Committee (BEIR-5), embraces the same expectation of co-action among carcinogenic (and anti-carcinogenic) agents: "Radiation carcinogenesis, in common with any other form of cancer induction, is likely to be a complex multi-step process that can be influenced by other agents and genetic factors at each step" (BEIR 1999, p.5).

The BEIR 1990 list, of co-actors with ionizing radiation, embraces co-actors which may themselves be mutagens and explicitly embraces inherited mutations ("genetic constitution"). The list also calls the co-actors "factors" --- meaning that co-actors modify the carcinogenic per-rad potency of ionizing radiation by multiplication.

2b. Two Illustrations: How Co-Actors Can Biologically Alter the Potency of Xrays

How could exposure to non-xray co-actors (for instance, smoking-induced co-actors) multiply the carcinogenic potency of medical radiation, per rad of dose? Two illustrations suffice here. One way would be by interfering with correct repair of xray-induced damage to the genetic molecules. The result would be a higher frequency of xray-induced mutations per rad of dose. A different way would be by intensifying the carcinogenic CONSEQUENCES of xray-induced mutations --- for example, by blocking a signal for apoptosis (cell suicide), and leaving the cancer-prone cell alive. (Chapter 67, Part 2b, provides an additional type of illustration.) There is no reason to imagine that medical radiation is the only carcinogenic agent whose potency is affected by other agents.

2c. Implications of Co-Action for Changes in Cancer MortRates over Time

In the monograph's Introduction (Part 5), our illustrations reflect the expectation that all carcinogenic co-actors can interact with each other, and that each case of Cancer may have multiple co-actors. Therefore, if exposures to various co-actors change over time, the subsequent observed cancer MortRates reflect the NET effect of upward pressure from some agents and downward pressure from others.

The impact of nonradiation agents, upon the per-rad potency of radiation, means that we should expect that per-rad potency of xrays and gamma rays may vary from organ to organ. Although xrays and gamma rays have access to every cell of every organ, the chemical and infectious co-actors may not have "universal access" and, even when they have access, they may not have identical activity in cells of different types. Therefore, rising (or falling) exposure to a specific non-xray co-actor can be irrelevant, with respect to the subsequent cancer MortRates of any organ where that particular co-actor has little access or little activity.

2d. How Co-Action Determines the Approach to a Smoking Adjustment

Our Smoking Adjustment applies the expectations of co-action among carcinogenic agents, and modulation of radiation's per-rad potency by interaction with smoking and other carcinogenic agents. In our opinion, it would be irrational for anyone to propose that virtually all carcinogenic agents EXCEPT smoking co-act with each other.

Nonetheless, rejection of co-action is the assumption in Appendix-M, which is included in this monograph in order to show that support for Hypothesis-1 does not depend on co-action. In Appendix-M, we make the post-1940 Smoking Adjustment by assuming that smoking and medical radiation do not contribute to causing the same cases of Cancer. The rejection of co-action implies that, if smoking had been matched across the Census Divisions (emphasis on "if"), smoking would have simply added the same number of post-1940 cancer-deaths in every Census Division to the baseline cancer MortRate (the Constant). Such post-1940 additions do not degrade the tight and positive linear dose-responses, observed in 1940, between PhysPop and cancer MortRates (discussion in Chapter 5, Part 6a). The Fractional Causations calculated in Appendix-M support Hypothesis-1 for All-Cancers-Combined and Hypothesis-2 for Ischemic Heart Disease. But since we do NOT embrace

the denial of co-action assumed in Appendix-M, we proceed in Part 3 (below) with a Smoking Adjustment which incorporates the premises of co-action and modulation of radiation's potency by co-actors. Additional implications, of the Smoking Adjustment employed in Chapters 49 through 65, are discussed in Appendix-M, Parts 3 and 4..

• Part 3. The Essence of the Smoking Adjustment

The goal of the Smoking Adjustment is not to eliminate all of the post-1940 impact of cigarette smoking upon the MidTrio and LowTrio cancer MortRates. Rather, the goal is to eliminate only the post-1940 impact of EXTRA smoking in the MidTrio and LowTrio Census Divisions, compared with the TopTrio Census Divisions. Note: We use the phrase "post-1940 impact" as a reminder that exposure to a carcinogen or atherogen may precede some of the impact (the fatal consequences) by decades. All of Part 3 applies also to Chapters 64 and 65 (Ischemic Heart Disease).

3a. An Uncomplicated Method

In each decade after 1940, the average All-Cancer MortRate in the TopTrio changed, relative to its 1940 value. For each decade, we can ascertain by what factor the 1940 cancer MortRate changed in the TopTrio (Examples from Box 1, Columns D and I: 1960 change-factor = 1.175, and 1988 change-factor = 1.212). Then --- one decade at a time --- we can multiply the Observed 1940 Cancer MortRates, of the MidTrio and LowTrio Census Divisions, by the SAME change-factor which is observed in the TopTrio during each post-1940 decade. That is the method.

The resulting MidTrio and LowTrio MortRate values, for each decade, are reasonable approximations of the post-1940 cancer MortRates which would have been observed in the MidTrio and LowTrio Census Divisions, if there had not been EXTRA smoking (relative to the TopTrio) in the MidTrio and LowTrio Census Divisions. Part 3b explains what makes them reasonable approximations. The adjusted values become even better approximations, logically, after we apply a second change-factor for the post-1940 behavior of PhysPop itself (Part 4b).

3b. Why We Should Use the Same Change-Factor for All Census Divisions

Part 3a states that we multiply the Observed 1940 Cancer MortRates in the MidTrio and LowTrio by SAME change-factor observed in the TopTrio. Why are we entitled to say that the SAME change-factor would operate in all Nine Census Divisions, if the post-1940 impact of the cigarette co-actor had been alike (matched) across Census Divisions?

(A) We start with the observation that, in 1940, the impact of cigarettes and other nonxray co-actors with medical radiation was well matched across the Nine Census Divisions. The evidence for this statement consists of the very strong and positive LINEAR dose-responses observed between cancer MortRates and PhysPop (dose) in 1940. By definition (Chapter 5, Part 5a), the nearly perfect linear dose-responses mean that potency per dose-unit (PhysPop-unit) was nearly equal in all Nine Census Divisions. Such equality requires well matched co-actors (potency-modulators).

(B) In the ABSENCE of degraded matching during the post-1940 decades, we would necessarily expect that the nearly perfect and positive linear correlations observed in 1940, between medical radiation (PhysPop) and cancer MortRates, would persist indefinitely --- even if the slopes and National Cancer MortRates were to change (as many of them did) during the post-1940 decades. To expect otherwise (i.e., to expect 1940's tight, positive linear dose-responses to disappear) would be to expect repeal of the well-established causal relationship between ionizing radiation and cancer induction.

(C) The requirement here, for transferring the tight positive linear correlation observed in 1940 to the post-1940 decades, is to multiply the Observed 1940 Cancer MortRates by the SAME change-factor in all Nine Census Divisions. This operation is illustrated in Chapter 5, Part 6c. In regression #3 of that illustration, the original correlation persists unchanged AFTER every MortRate has been multiplied by the same change-factor. If the change-factor were 1.2 (for example) instead of 0.8, then the equation for the linear dose-response ($y = mx + c$) would become $1.2y = 1.2mx + 1.2c$. The operation is valid not only for perfect correlations, but also for R-squared values below 1.0. Biologically, these relationships make sense. When smoking increases all the MortRates by the same

factor, it is because smoking has increased radiation's potency per dose-unit ("m") and also has raised the Constant (because smoking will increase the potency of the non-xray co-actors interacting with each other, too).

(D) When our Smoking Adjustment ensures that Post-1940 Cancer MortRates in all Nine Census Divisions change by the SAME change-factor, the adjustment ensures that post-1940 dose-responses, between PhysPop and Adjusted Cancer MortRates, will retain a tight, positive linear dose-response (Paragraph B). This is the rational expectation in the absence of extra smoking in the MidTrio and LowTrio Census Divisions, relative to the TopTrio. By making the post-1940 MortRate change-factor the same in all Nine Census Divisions, the adjustment ensures equal potency per dose-unit in all Nine Census Divisions (Paragraph C), and thus eliminates the unequal potency per dose-unit which results from extra smoking in the MidTrio and LowTrio Census Divisions.

Summary: Our Smoking Adjustment provides reasonable sets of Post-1940 Cancer MortRates because it (a) retains all the impact of smoking upon the TopTrio's MortRates, whose Post-1940 Observed Cancer MortRates are retained without any adjustment at all, and (b) adjusts the MidTrio and LowTrio MortRates to the values they would have had, if there had not been EXTRA smoking in those Census Divisions. After we obtain Post-1940 Adjusted MortRates for the MidTrio and LowTrio Census Divisions, we proceed to calculate Post-1940 Fractional Causations by medical radiation (Part 5c).

• Part 4. Explanation of Box 2

Because the Census Divisions were NOT properly matched for smoking, a Smoking Adjustment for the cancer MortRates is required. We must ascertain by WHAT factors the TopTrio's 1940 All-Cancer MortRates changed in subsequent decades. Then we can apply these reality-based factors to the Observed 1940 All-Cancer MortRates of the MidTrio and LowTrio.

4a. Part 1 of Box 2: TopTrio's Population-Weighted MortRates

Box 1 already provides 1.175 as the MortRate change-factor in the TopTrio for 1960 vs. 1940, and provides 1.212 as the factor for 1988 vs. 1940. But these factors were calculated, as an approximation, without obtaining population-weighted MortRates for the Top Trio. Now Part 1 of Box 2 provides average MortRates which are population-weighted for the TopTrio.

Example (1940), from the upper-left corner of Box 2, Part 1: Col.A presents the Observed MortRates from Table 6-A for the Pacific, New England, and Mid-Atlantic Census Divisions. Col.B presents the population of each Division from Table 3-B. The sum (45,710,039) is the 1940 population of the TopTrio. Then Col.C divides Col.B by 45,710,039, in order to find out what fraction of the TopTrio's population is contributed by each Census Division. That share is the weighting factor. Col.D multiplies each Observed MortRate by its own weighting factor, and the sum (136.070) is the population-weighted All-Cancer MortRate for TopTrio males in 1940. Box 2 follows the same procedure in all six sections of its Part 1.

4b. Part 2 of Box 2: Obtaining the Adjustment Factors

In Part 2 of Box 2, the Col.A presents the population-weighted MortRates for 1950-1988, obtained in Part 1. Col.B presents the 1940 population-weighted MortRate, also obtained in Part 1. Then Col.C divides each MortRate in Col.A by the 1940 MortRate, to obtain the factor by which the 1940 MortRates changed in each subsequent decade.

The change-factors in Col.C describe what was observed only in the TopTrio --- not in the MidTrio or LowTrio.

How different are results in Box 2, compared with the approximations used in Box 1? The population-weighted factor for 1960 is 1.151 (Box 2, Part 2, Col.C), whereas the non-weighted factor for 1960 is 1.175 (Box 1, Col.D) --- a ratio of 0.98 (for PopWeighted / NonWeighted). For 1988, the comparison is 1.174 (Box 2) versus 1.212 (Box 1, Col.I) --- a ratio of 0.97 (for PopWeighted / NonWeighted). Although the differences between population-weighted and non-weighted values turn out to be negligible here, the determination makes population-weighted values available, and so we use

them.

Col.C: The Change-Factors in the Top Trio, during 50 Years

In Col.C of Part 2, the change-factors contain no assumptions whatsoever. They report on the MortRate changes which were observed in the TopTrio (high-dose) Census Divisions over time.

If we multiplied each of the 1940 MortRates, observed in the six Census Divisions of the MidTrio and LowTrio, by 1.085 (from Col.C, for the year 1950), we would obtain six 1950 Adjusted MortRates which would no longer be elevated by the post-1940 impact from EXTRA smoking in those six Census Divisions. The 1950 Adjusted MortRates would incorporate approximately the SAME smoking effect observed in the Top Trio --- but they would not yet register some of the PhysPop effect, as explained below.

In eliminating the effect of unmatched cigarette smoking, we must NOT eliminate the effect of post-1940 growth (or decline) in Averaged PhysPops in the MidTrio and LowTrio, relative to the TopTrio. So, we must consult Table 47-B, which quantifies what happened after 1940. There are no assumptions in Table 47-B.

Column D: The PhysPop Adjustment

Col.D of Part 2 presents the ratios (from Table 47-B) which show that, relative to Averaged PhysPops in the TopTrio, Averaged PhysPop values fell a little in the MidTrio and rose a little in the LowTrio during the 1940-1990 years. Because radiation-induced cancer MortRates are proportional to radiation dose, we must also adjust the 1940 MortRates for these slightly uneven post-1940 changes in Averaged PhysPop over time.

Therefore, we plan to multiply the MidTrio and LowTrio 1940 MortRates by TWO adjustment factors (from Col.C and Col.D). Of course the sequence makes no difference. So we can multiply Col.C by Col.D ahead of time, and obtain a combined Adjustment Factor in Col.E. The Col.E Adjustment Factors for the year 1950 get used in Table 49-B, the 1960 Adjustment Factors get used in Table 49-C, and so forth.

• Part 5. Explanation of Table 49-B and Every Similar Table

There are three parts in Table 49-B and similar tables:
- - Calculation of the Adjusted MortRates for MidTrio and LowTrio.
- - Linear regression-analysis: MortRates upon Averaged PhysPops.
- - Calculation of estimated Fractional Causation, by medical radiation, of the Observed National MortRates for Cancer (Chapters 49 - 63) and for Ischemic Heart Disease (Chapters 64, 65).

5a. Part 1 of Table 49-B: Adjusted MortRates for the Year 1950

COLUMN C. Col.C is included just as an easy error-check on the entries in Col.A and Col.B. If the sum of Col.C is NOT a close match for the Observed 1950 National MortRate from Table 6-B, then we know that we have made an entry-error somewhere.

COLUMN F. Although this column is labeled "Adjusted MortRates," the MortRates for the TopTrio are not adjusted in any manner. They are identical with the Observed 1950 MortRates in Col.B. By contrast, the six entries for the MidTrio and LowTrio are their Observed 1940 MortRates (in Col.D) times the Adjustment Factor in Col.E (which comes from Box 2, Part 2, Col.E). This set of Adjusted MortRates retains all of the smoking-effect on the TopTrio MortRates, and retains a comparable amount of smoking-effect on the MidTrio and Low Trio MortRates. Only the effect of EXTRA smoking has been eliminated from the MidTrio and LowTrio MortRates. Note: Column F of Table 49-B differs in one small way from the illustration discussed in Part 3b of the text. The 1950 cancer Mortrates in Col. F, for the three census divisions of TopTrio, are the cancer MortRates OBSERVED in 1950, directly from Table 6-A. If they were the observed 1940 rates times the 1950 change-factor of 1.085 (from Box 2, Part 2, Col.C, then the top three entries in Col.F would be calculated from Table 6-A as follows: Pacific = 122.9 * 1.085 = 133.3; and New England = 135.5 * 1.085 = 147.0; and Mid-Atlantic = 140.9 * 1.085 = 152.9.

COLUMN G. In order to obtain a population-weighted National Adjusted MortRate, we multiply the values in Col.F by their own population-fraction in Col.A.

Return to a Promise Made at the End of Chapter 48

We promised, at the end of Chapter 48, that readers would be able easily to compare the "before and after" MortRate values, each time we make a MortRate adjustment in any chapter. The "before" rates are always in Col.B, and the "after" rates are always in Col.F. As noted above, the TopTrio MortRates are not adjusted at all --- and are the same in Col.B and in Col.F.

Eliminating the effect of EXTRA smoking on MortRates, in the MidTrio and LowTrio, always produces Adjusted MortRates which are lower than the Observed MortRates in those six Census Divisions. And, consequently, the National Adjusted MortRate is always lower than the National Observed MortRate. The difference between the two rates quantifies the part of the Observed National MortRate which results from the co-action, of the UNMATCHED share of smoking, with medical radiation and with other carcinogenic agents.

5b. Part 2 of Table 49-B: Linear Regression Analysis

COLUMN C. This is the output from linear regression analysis, so familiar from earlier chapters. The very high R-squared value in Column C matches expectation and confirms that the Adjustment achieves the tight linear correlation which would occur if co-actors were matched (text, Part 3c). INPUT: The Averaged PhysPop values come from Table 47-A. The 1950 Adjusted MortRates come from the same Table 49-B: Part 1, Col.F.

COLUMN E. This regression-output comes from substituting the 1940 PhysPop values (Col.D) for the 1940-1950 Averaged PhysPops. We do this as another easy error-check. The PhysPop rankings are so stable over time that, even in 1990, the correlation between Mean 1940-1990 PhysPops and 1940 PhysPops has an R-squared value of 0.91 (Chapter 47, Part 3b). Therefore, we must expect that this extra regression will produce similar output to the main regression in Col.C. If it does NOT, then we know that we have made an entry-error somewhere.

5c. Part 3-A of Table 49-B: Fractional Causation

Here, the calculation of post-1940 Fractional Causation is essentially the same as the calculation in Chapters 6 through 21, and Chapters 40 and 41. Here, too, the radiation-induced MortRate is divided by the entire OBSERVED National Cancer MortRate.

The Smoking Adjustment permits us to estimate what the national radiation-induced Cancer MortRate would have been, if Cancer MortRates in the MidTrio and LowTrio had not been elevated by EXTRA smoking. Then we ask, "And what share does the estimated radiation-induced MortRate contribute to the ENTIRE Observed National Cancer MortRate, which INCLUDES the consequences of extra smoking in the MidTrio and LowTrio?" Paragraph 3 of Part 3-A provides the answer (with Part 3-B as an error-check):

Medical radiation accounts for about 84 percent of the entire Observed National All-Cancer MortRate for males in 1950.

5d. Approximations: A Characteristic of Epidemiology

Our post-1940 Smoking Adjusted MortRates in the MidTrio and LowTrio Census Divisions are necessarily approximations --- as are all the statistical adjustments for matching which fill the peer-reviewed epidemiological literature.

A reminder here is appropriate. Approximations can suffice, in epidemiology, in answering some questions definitively. Here, the question is: Did medical radiation cease, after mid-century, to be a major cause of mortality rates for Cancer and Ischemic Heart Disease in the USA, or did it CONTINUE to be a necessary co-actor in a very large share of the national mortality rates for these two diseases? The estimated post-1940 Fractional Causations, from the tables in Chapters 49 through 65, provide a clear answer.

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Box 2, Chap. 49

All-Cancers, Males: Calculation of Adjustment Factor

This adjustment is discussed fully in Chapter 49.

• Part1: Calculate average population-weighted MortRate for the combined TopTrio Census Divs.

Census Div.	Col.A 1940 MR Tab 6-A	Col.B 1940 Pop'n Tab 3-B	Col.C 1940 Popn /45,710,039	Col.D Col.A * Col.C
Pacific	122.9	9,733,262	0.2129	26.17
NewEng	135.5	8,437,290	0.1846	25.01
Mid-Atl	140.9	27,539,487	0.6025	84.89
1940		Sum TopTrio 45,710,039	Sum 1.0000	TopTrio 136.070

Census Div.	Col.A 1950 MR Tab 6-A	Col.B 1950 Pop'n Tab 3-B	Col.C 1950 Popn /53,964,513	Col.D Col.A * Col.C
Pacific	127.2	14,486,527	0.2684	34.15
NewEng	152.4	9,314,453	0.1726	26.30
Mid-Atl	156.0	30,163,533	0.5590	87.20
1950		Sum TopTrio 53,964,513	Sum 1.0000	TopTrio 147.647

Census Div.	Col.A 1960 MR Tab 6-A	Col.B 1960 Pop'n Tab 3-B	Col.C 1960 Popn /65,875,863	Col.D Col.A * Col.C
Pacific	140.7	21,198,044	0.3218	45.28
NewEng	164.6	10,509,367	0.1595	26.26
Mid-Atl	164.0	34,168,452	0.5187	85.06
1960		Sum TopTrio 65,875,863	Sum 1.0000	TopTrio 156.598

Census Div.	Col.A 1970 MR Tab 6-A	Col.B 1970 Pop'n Tab 3-B	Col.C 1970 Popn /75,017,000	Col.D Col.A * Col.C
Pacific	147.2	26,087,000	0.3477	51.19
NewEng	167.5	11,781,000	0.1570	26.30
Mid-Atl	167.9	37,149,000	0.4952	83.15
1970		Sum TopTrio 75,017,000	Sum 1.0000	TopTrio 160.639

Census Div.	Col.A 1980 MR Tab 6-A	Col.B 1980 Pop'n Tab 3-B	Col.C 1980 Popn /80,615,000	Col.D Col.A * Col.C
Pacific	153.7	31,523,000	0.3910	60.10
NewEng	170.3	12,322,000	0.1528	26.03
Mid-Atl	171.8	36,770,000	0.4561	78.36
1980		Sum TopTrio 80,615,000	Sum 1.0000	TopTrio 164.493

Census Div.	Col.A 1988 MR Tab 6-A	Col.B 1990 Pop'n Tab 3-B	Col.C 1990 Popn /88,495,000	Col.D Col.A * Col.C
Pacific	148.5	37,837,000	0.4276	63.49
NewEng	167.1	12,998,000	0.1469	24.54
Mid-Atl	168.4	37,660,000	0.4256	71.66
1988		Sum TopTrio 88,495,000	Sum 1.0000	TopTrio 159.701

• Part 2: Take ratios of these TopTrio MortRates, with 1940 as the denominator of each ratio.
Col.D modifies Col.C by separate PhysPop adjustments for MidTrio and LowTrio Census Divisions.

	Col.A TopTrio Mean MR	Col.B 1940 TopTrio Mean MR	Col.C = Col.A / Col.B	Col.D ppAdju Tab 47-B	Col.E = Col.C * Col.D	ALL CANCERS. Males.
				MidTrio		
1950	147.647	136.070	1.085	0.99	1.07	= MidTrio Adjustment Factor, 1950
1960	156.598	136.070	1.151	0.97	1.12	= MidTrio Adjustment Factor, 1960
1970	160.639	136.070	1.181	0.95	1.12	= MidTrio Adjustment Factor, 1970
1980	164.493	136.070	1.209	0.94	1.14	= MidTrio Adjustment Factor, 1980
1988	159.701	136.070	1.174	0.94	1.10	= MidTrio Adjustment Factor, 1988
				LowTrio		
1950	147.647	136.070	1.085	1.00	1.09	= LowTrio Adjustment Factor, 1950
1960	156.598	136.070	1.151	1.01	1.16	= LowTrio Adjustment Factor, 1960
1970	160.639	136.070	1.181	1.02	1.20	= LowTrio Adjustment Factor, 1970
1980	164.493	136.070	1.209	1.04	1.26	= LowTrio Adjustment Factor, 1980
1988	159.701	136.070	1.174	1.07	1.26	= LowTrio Adjustment Factor, 1988

Table 49-B

All Cancers, Males: Fractional Causation in 1950

Part 1.

Calculation of the 6 Adjusted MortRates (Col.F) and the National Adjusted MortRate (Col.G).

The last six entries in Part 1, Col.F, are the products of (Col.D * Col.E), as discussed in Chap. 49.

Trio-Sequence	Col.A 1950 PopFrac Tab 3-B	Col.B 1950 Obs MR Tab 6-A	Col.C A * B	Col.D 1940 MR Mid,Low Tab 6-A	Col.E AdjuFact Bx2,Pt2 Col.E	Col.F 1950 Adju MortRates	Col.G A * F
Pacific	0.0961	127.2	12.224			127.2	12.224
New England	0.0618	152.4	9.418			152.4	9.418
Mid-Atlantic	0.2002	156.0	31.231			156.0	31.231
WestNoCentral	0.0933	125.3	11.690	110.9	1.07	118.66	11.071
EastNoCentral	0.2017	138.3	27.895	119.6	1.07	127.97	25.812
Mountain	0.0337	108.1	3.643	99.8	1.07	106.79	3.599
WestSoCentral	0.0965	112.7	10.876	86.9	1.09	94.72	9.141
EastSoCentral	0.0762	104.7	7.978	73.6	1.09	80.22	6.113
SouthAtlantic	0.1406	116.3	16.352	88.9	1.09	96.90	13.624
		Sum =	131.3				Sum =
1950 Observed Natl MR from Table 6-B =			132.8	1950 Natl Adjusted MR =			122.2333

Part 2.

Trio-Seq.	Col.A Mean1940 thru1950 PPs from Tab 47-A x'	Col.B 1950 Adju MRs from Col.F Part 1	Col.C All Cancers, Males: 1950 Adjusted MortRates regressed on Mean 1940 thru 1950 PPs Regression Output:		Col.D 1940 PPs from Table 3-A (TrioSeq) x''	Col.E All Cancers, Males: 1950 Adjusted MortRates regressed on 1940 PhysPops Regression Output:	
Pac	154.16	127.2	Constant	10.4866	159.72	Constant	10.7576
NewEng	162.03	152.4	Std Err of Y Est	7.1588	161.55	Std Err of Y Est	7.9010
MidAtl	169.24	156.0	R Squared	0.9330	169.76	R Squared	0.9183
WNoCen	121.60	118.663	No. of Observation	9	123.14	No. of Observation	9
ENoCen	128.53	127.972	Degrees of Freedom	7	133.36	Degrees of Freedom	7
Mtn	119.64	106.786			119.89		
WSoCen	102.64	94.721	X Coefficient(s)	0.8462	103.94	X Coefficient(s)	0.8326
ESoCen	84.44	80.224	Std Err of Coef.	0.0857	85.83	Std Err of Coef.	0.0938
SoAtl	99.91	96.901	XCoef / S.E. =	9.8703	100.74	XCoef / S.E.	8.8729

Part 3-A.

Calculation of Fractional Causation from Averaged PhysPops

1. Nonradiation rate is Adjusted Constant (Part 2, Col.C) = 10.4866

2. Radiation rate is Natl Adjusted MortRate (Part 1, Col.G = 122.2333) minus Nonradiation rate (10.4866) = 111.7467

3. 1950 Fractional Causation is radiation rate (111.7467) divided by OBSERVED Natl MR Part 1,Col.C= 132.8 = 0.84

Part 3-B.

Calculation of Fractional Causation from 1940 PhysPops

1. Nonradiation rate is Adjusted Constant (Part 2, Col.E) = 10.7576

2. Radiation rate is Natl Adjusted MortRate (Part 1, Col.G = 122.2333) minus Nonradiation rate (10.7576) = 111.4757

3. 1950 Fractional Causation is radiation rate (111.4757) divided by OBSERVED Natl MR Part 1, Col.C= 132.8 = 0.84

Table 49-C

All Cancers, Males: Fractional Causation in 1960

Part 1.

Calculation of the 6 Adjusted MortRates (Col.F) and the National Adjusted MortRate (Col.G).
The last six entries in Part 1, Col.F, are the products of (Col.D * Col.E), as discussed in Chap. 49.

Trio-Sequence	Col.A 1960 PopFrac Tab 3-B	Col.B 1960 Obs MR Tab 6-A	Col.C A * B	Col.D 1940 MR Mid,Low Tab 6-A	Col.E AdjuFact Bx2,Pt2 Col.E	Col.F 1960 Adju MortRates	Col.G A * F
Pacific	0.1182	140.7	16.631			140.7	16.631
New England	0.0586	164.6	9.646			164.6	9.646
Mid-Atlantic	0.1905	164.0	31.242			164.0	31.242
WestNoCentral	0.0858	135.6	11.634	110.9	1.12	124.21	10.657
EastNoCentral	0.2020	150.7	30.441	119.6	1.12	133.95	27.058
Mountain	0.0382	118.7	4.534	99.8	1.12	111.78	4.270
WestSoCentral	0.0945	133.8	12.644	86.9	1.16	100.80	9.526
EastSoCentral	0.0672	125.1	8.407	73.6	1.16	85.38	5.737
SouthAtlantic	0.1448	137.1	19.852	88.9	1.16	103.12	14.932
		Sum =	145.0				Sum =
1960 Observed Natl MR from Table 6-B =			145.7	1960 Natl Adjusted MR =			129.6991

Part 2.

Trio-Seq.	Col.A Mean1940 thru1960 PPs from Tab 47-A x'	Col.B 1960 Adju MRs from Col.F Part 1	Col.C All Cancers, Males: 1960 Adjusted MortRates regressed on Mean 1940 thru 1960 PPs		Col.D 1940 PPs from Table 3-A (TrioSeq) x''	Col.E All Cancers, Males: 1960 Adjusted MortRates regressed on 1940 PhysPops	
			Regression Output:			Regression Output:	
Pac	155.69	140.7	Constant	8.7654	159.72	Constant	8.1440
NewEng	162.81	164.6	Std Err of Y Est	7.2600	161.55	Std Err of Y Est	6.9237
MidAtl	167.04	164.0	R Squared	0.9407	169.76	R Squared	0.9461
WNoCen	118.15	124.208	No. of Observation	9	123.14	No. of Observation	9
ENoCen	123.87	133.952	Degrees of Freedom	7	133.36	Degrees of Freedom	7
Mtn	117.40	111.776			119.89		
WSoCen	102.31	100.804	X Coefficient(s)	0.9251	103.94	X Coefficient(s)	0.9113
ESoCen	85.63	85.376	Std Err of Coef.	0.0878	85.83	Std Err of Coef.	0.0822
SoAtl	101.72	103.124	XCoef / S.E. =	10.5397	100.74	XCoef / S.E.	11.0832

Part 3-A.
Calculation of Fractional Causation from Averaged PhysPops

1. Nonradiation rate is Adjusted Constant (Part 2, Col.C) = 8.7654

2. Radiation rate is Natl Adjusted MortRate (Part 1, Col.G = 129.6991) minus Nonradiation rate (8.7654) = 120.9337

3. 1960 Fractional Causation is radiation rate (120.9337) divided by OBSERVED Natl MR Part 1,Col.C= 145.7 = 0.83

Part 3-B.
Calculation of Fractional Causation from 1940 PhysPops

1. Nonradiation rate is Adjusted Constant (Part 2, Col.E) = 8.1440

2. Radiation rate is Natl Adjusted MortRate (Part 1, Col.G = 129.6991) minus Nonradiation rate (8.1440) = 121.5551

3. 1960 Fractional Causation is radiation rate (121.5551) divided by OBSERVED Natl MR Part 1, Col.C= 145.7 = 0.83

• Table 49-D is not included. Its results, for 1970, are shown in Table 49-A (p.375).

Table 49-E

All Cancers, Males: Fractional Causation in 1980

Part 1.

Calculation of the 6 Adjusted MortRates (Col.F) and the National Adjusted MortRate (Col.G).

The last six entries in Part 1, Col.F, are the products of (Col.D * Col.E), as discussed in Chap. 49.

Trio-Sequence	Col.A 1980 PopFrac Tab 3-B	Col.B 1980 Obs MR Tab 6-A	Col.C A * B	Col.D 1940 MR Mid,Low Tab 6-A	Col.E AdjuFact Bx2,Pt2 Col.E	Col.F 1980 Adju MortRates	Col.G A * F
Pacific	0.1398	153.7	21.487			153.7	21.487
New England	0.0546	170.3	9.298			170.3	9.298
Mid-Atlantic	0.1630	171.8	28.003			171.8	28.003
WestNoCentral	0.0759	152.0	11.537	110.9	1.14	126.43	9.596
EastNoCentral	0.1846	169.5	31.290	119.6	1.14	136.34	25.169
Mountain	0.0502	134.7	6.762	99.8	1.14	113.77	5.711
WestSoCentral	0.1049	162.9	17.088	86.9	1.26	109.49	11.486
EastSoCentral	0.0646	174.1	11.247	73.6	1.26	92.74	5.991
SouthAtlantic	0.1624	171.4	27.835	88.9	1.26	112.01	18.191
		Sum =	164.5				Sum =
1980 Observed Natl MR from Table 6-B =			164.5	1980 Natl Adjusted MR =			134.9330

Part 2.

Trio-Seq.	Col.A Mean1940 thru1980 PPs from Tab 47-A x'	Col.B 1980 Adju MRs from Col.F Part 1	Col.C All Cancers, Males: 1980 Adjusted MortRates regressed on Mean 1940 thru 1980 PPs		Col.D 1940 PPs from Table 3-A (TrioSeq) x''	Col.E All Cancers, Males: 1980 Adjusted MortRates regressed on 1940 PhysPops	
			Regression Output:			Regression Output:	
Pac	177.35	153.7	Constant	10.8567	159.72	Constant	12.5043
NewEng	185.86	170.3	Std Err of Y Est	7.4657	161.55	Std Err of Y Est	5.9915
MidAtl	186.11	171.8	R Squared	0.9386	169.76	R Squared	0.9604
WNoCen	128.82	126.43	No. of Observation	9	123.14	No. of Observation	9
ENoCen	133.71	136.34	Degrees of Freedom	7	133.36	Degrees of Freedom	7
Mtn	133.45	113.77			119.89		
WSoCen	114.66	109.49	X Coefficient(s)	0.8480	103.94	X Coefficient(s)	0.9276
ESoCen	99.46	92.74	Std Err of Coef.	0.0820	85.83	Std Err of Coef.	0.0712
SoAtl	124.62	112.01	XCoef / S.E. =	10.3418	100.74	XCoef / S.E.	13.0356

Part 3-A.

Calculation of Fractional Causation from Averaged PhysPops

1. Nonradiation rate is Adjusted Constant (Part 2, Col.C) = 10.8567

2. Radiation rate is Natl Adjusted MortRate (Part 1, Col.G = 134.9330) minus Nonradiation rate (10.8567) = 124.0763

3. 1980 Fractional Causation is radiation rate (124.0763) divided by OBSERVED Natl MR Part 1,Col.C= 164.5 = 0.75

Part 3-B.

Calculation of Fractional Causation from 1940 PhysPops

1. Nonradiation rate is Adjusted Constant (Part 2, Col.E) = 12.5043

2. Radiation rate is Natl Adjusted MortRate (Part 1, Col.G = 134.9330) minus Nonradiation rate (12.5043) = 122.4287

3. 1980 Fractional Causation is radiation rate (122.4287) divided by OBSERVED Natl MR Part 1, Col.C= 164.5 = 0.74

Table 49-F

All Cancers, Males: Fractional Causation in 1988

Part 1.

Calculation of the 6 Adjusted MortRates (Col.F) and the National Adjusted MortRate (Col.G).
The last six entries in Part 1, Col.F, are the products of (Col.D * Col.E), as discussed in Chap. 49.

Trio-Sequence	Col.A 1990 PopFrac Tab 3-B	Col.B 1988 Obs MR Tab 6-A	Col.C A * B	Col.D 1940 MR Mid,Low Tab 6-A	Col.E AdjuFact Bx2,Pt2 Col.E	Col.F 1988 Adju MortRates	Col.G A * F
Pacific	0.1535	148.5	22.795			148.5	22.795
New England	0.0527	167.1	8.806			167.1	8.806
Mid-Atlantic	0.1527	168.4	25.715			168.4	25.715
WestNoCentral	0.0721	155.9	11.240	110.9	1.10	121.99	8.795
EastNoCentral	0.1713	171.2	29.327	119.6	1.10	131.56	22.536
Mountain	0.0543	139.1	7.553	99.8	1.10	109.78	5.961
WestSoCentral	0.1087	172.9	18.794	86.9	1.26	109.49	11.902
EastSoCentral	0.0621	188.2	11.687	73.6	1.26	92.74	5.759
SouthAtlantic	0.1725	175.8	30.325	88.9	1.26	112.01	19.322
		Sum =	166.2				Sum =
1988 Observed Natl MR from Table 6-B =			162.7	1988 Natl Adjusted MR =			131.5917

Part 2.

Trio-Seq.	Col.A Mean1940 thru1990 PPs from Tab 47-A x'	Col.B 1988 Adju MRs from Col.F Part 1	Col.C All Cancers, Males: 1988 Adjusted MortRates regressed on Mean 1940 thru 1990 PPs		Col.D 1940 PPs from Table 3-A (TrioSeq) x''	Col.E All Cancers, Males: 1988 Adjusted MortRates regressed on 1940 PhysPops	
			Regression Output:			Regression Output:	
Pac	191.97	148.5	Constant	10.8756	159.72	Constant	16.4305
NewEng	208.20	167.1	Std Err of Y Est	7.3475	161.55	Std Err of Y Est	7.1662
MidAtl	204.72	168.4	R Squared	0.9348	169.76	R Squared	0.9379
WNoCen	141.14	121.99	No. of Observation	9	123.14	No. of Observation	9
ENoCen	146.19	131.56	Degrees of Freedom	7	133.36	Degrees of Freedom	7
Mtn	145.91	109.78			119.89		
WSoCen	126.28	109.49	X Coefficient(s)	0.7488	103.94	X Coefficient(s)	0.8754
ESoCen	113.28	92.74	Std Err of Coef.	0.0748	85.83	Std Err of Coef.	0.0851
SoAtl	142.93	112.01	XCoef / S.E. =	10.0156	100.74	XCoef / S.E.	10.2865

Part 3-A.
Calculation of Fractional Causation
from Averaged PhysPops

1. Nonradiation rate is Adjusted Constant (Part 2, Col.C) = 10.8756

2. Radiation rate is Natl Adjusted MortRate (Part 1, Col.G = 131.5917) minus Nonradiation rate (10.8756) = 120.7161

3. 1988 Fractional Causation is radiation rate (120.7161) divided by OBSERVED Natl MR Part 1,Col.C= 162.7 = 0.74

Part 3-B.
Calculation of Fractional Causation
from 1940 PhysPops

1. Nonradiation rate is Adjusted Constant (Part 2, Col.E) = 16.4305

2. Radiation rate is Natl Adjusted MortRate (Part 1, Col.G = 131.5917) minus Nonradiation rate (16.4305) = 115.1612

3. 1988 Fractional Causation is radiation rate (115.1612) divided by OBSERVED Natl MR Part 1, Col.C= 162.7 0.71