ICRP PUBLICATION 14

VS

THE GOFMAN-TAMPLIN REPORT

by

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INTRODUCTION

Subsequent to the presentation of our testimony (The Gofman-Tamplin Report) before the Senate Sub-Committee on Air and Water Pollution, Committee on Public Works, we have obtained a copy of ICRP Publication 14. The purpose of this report is to discuss the similarities and differences between these two documents (1,2).

It is shown that both documents come to the same conclusion and that the one major difference between the documents results from an oversight on the part of the authors of ICRP Publication 14.

LINEAR THEORY, THRESHOLD, LOW DOSE, LOW DOSE RATE

Gofman-Tamplin

We assume that the dose-response relationship is linear down to very low doses and dose rates. We contend there is no threshold. We show that these are more than reasonable assumptions in references 3 and 4.

ICRP Publication 14

The same assumptions have always been employed by the ICRP and are again used in Publication 14.

INDUCTION OF VARIOUS FORMS OF CANCER BY RADIATION, SIMILARITY OF THE DOUBLING DOSE.

Gofman-Tamplin

We indicate that the data suggest that all forms of cancer can be induced by radiation. Furthermore, we indicate that the data suggest that, for a given dose of radiation, the various cancers will be induced in proportion to their spontaneous occurrence rate; i.e., if cancer X occurs 10 times more frequently than cancer Y, a given dose will induce 10 times more cancers of the X variety than of the Y variety.

ICRP Publication 14

The authors state that existing evidence does not confirm the validity of this concept. On page 23, it is stated: "It has been suggested that irradiation may have a multiplicative effect, a given exposure leading to the same proportional increase in incidence for a variety of different tumours independently of the actual levels of incidence in the absence of irradiation. Numerical estimates of the relative radiosensitivity to tumour induction of all the different parts of the body would have been provided by such a general hypothesis but a survey of the available evidence did not confirm its validity."

In the purest scientific sense they are correct but they fail to state that the available data do not prove this concept to be wrong. Quite the contrary, the available data show this to be a significant public health concept. In fact, they present data which indicate that among the cancers studied, the great majority of them fit this hypothesis. Those which fit the hypothesis now represent some 90% of the expected cancer mortality. Table I is a reproduction of Table III.1 from page 60 of the ICRP Publication 14.

TABLE I

Table III.1 from ICRP Publication 14

Cancer of heavily irradiated sites in ankylosing spondylitics at 1st January, 1963 (from table III, VI and VII of Court Brown, W.M. and Doll, R., 1965)

Sub-group in which the difference between the observed and expected cancer incidence was statistically significant ($P < 0.025$ on a one-tailed test)	No. of cases observed	No. of cases expected	Excess over expected: No. of cases	Excess over expected: Rate per thousand persons
Leukaemia	60	7	53.3	4.7
Aplastic anaemia	16	1	15.4	
Cancer of bronchus	96	54	41.8	2.9
Other cancers (mostly carcinomatosis, primary unknown)	24	7	17.2	1.2
Cancer of stomach	38	24	14.4	1.0
Malignant disease of lymphatic and haematopoietic tissues other than leukaemia[a]	10	3	6.6	0.3-0.5
Cancer of pancreas	12	6	6.3	
Cancer of pharynx	5	1	4.0	
Bone cancer	5	1	3.9[c]	
Sub-group in which the difference between the observed and expected cancer incidence was not statistically significant				
Cancer of ovary	4	2	1.8	(0.8)
larynx	2	2	0.2	0.02 or less
oesophagus	3	3	-0.4	
skin	0	1	-1.4	
Hodgkin's disease	1	2	-1.5	
Cancer which may be clinically associated with ankylosing spondylitis				
Cancer of colon	25	15	5.0[b]	0.4

(a) Lymphosarcoma, reticulosarcoma, lymphoma unspecified (8 cases altogether) and myelomatosis (2 cases) as compared with 2.9 cases expected.

(b) An excess of 10.2 was recorded but Court Brown and Doll (1965) reckoned that at least one-half of the excess might be attributed to the associations of cancer of the colon with ulcerative colitis and of ulcerative colitis with ankylosing spondylitis.

(c) The reliability of the diagnosis of primary bone tumours on a death certificate is not high. The excess of confirmed deaths due to bone sarcoma was 2.4.

They make the following statements on page 61 of Publication 14 concerning the data in this table.

"The data on cancer incidence in different organs can be used to assess the relative sensitivity of the different organs to cancer induction if the ratio of the doses received by the different organs is known. Dolphin and Eve (1968)* deduced that the dose in the stomach was about 10 per cent of the overlying spinal marrow dose and that the mean dose to the stomach was about 7 per cent of the mean spinal marrow dose because the dorsal spine was sometimes not in the radiation field. Let it be assumed that the leukaemia occurring in ankylosing spondylitics was due to direct irradiation of the bone marrow just as cancer of the stomach was due to direct irradiation of the stomach. The dose ratio for bone marrow/stomach was 100/7, whereas the ratio of induced malignancies for bone marrow/stomach was 4.7. The irradiated spinal marrow constituted about 40 per cent of the total active marrow (ICRP Publication 8, 1966) so that the relative sensitivities of bone marrow and stomach to cancer induction by irradiation were in the ratio $\frac{4.7}{0.4} \times \frac{7}{100} = 0.8$. Thus the data at present available can be interpreted to suggest that the stomach and the whole bone marrow may have approximately the same sensitivity (Dolphin and Eve, 1968)*. Under the same conditions of spinal irradiation the dose to colon, pancreas, bronchi or pharynx is likely to be similar to the dose to stomach and, judging by the observed excess of tumours, these organs may also seem to have a similar sensitivity to each other and to bone marrow and stomach."

* Reference 6 of this report

The authors of ICRP Publication 14 seem to have overlooked the implications of the above paragraph. Since the dosage to the other organs was only 7% of the dosage to the spinal marrow, if the dosages were comparable, 14 times as many cancers would have been induced in the other organs. In other words, at the same dosage, the number of induced cancers at other sites would be proportional to their spontaneous occurrence rate. This is illustrated in Table II where we have corrected the excess leukaemia cases to correspond to irradiation of the entire marrow by dividing the observed excess by the fraction of the marrow irradiated (53.3/0.4).

TABLE II

Data from Table III.1 of ICRP Publication 14 corrected for difference in dosage.

Cancer	Spontaneous incidence (no. cases expected)	Excess over expected no. of cases	Ratio Excess/Spontaneous
Leukaemia	7	133	19.0
Bronchus	54	585	10.8
Other cancers	7	241	34.6
Stomach	24	202	8.4
Lymphatic and haematopoietic	3	93	31.0
Pancreas	6	88	14.7
Pharynx	1	56	56.0
Bone	1	10	10.0
Colon	15	140	9.3

The same type of correction was applied to the bone. The excess of the remaining cancers was multiplied by 14 to correct for the dosage difference. We have used all of the excess colon cancers. In Table II, except for cancer of the pharynx, all of the ratios (excess/spontaneous) fall within a factor of 2 of the value 17. Because of the closeness of the pharynx to the cervical spine, the factor of 14 was most likely too large a correction. The same might be true for the lymphatic hematopoietic tissues and possibly the group designated as the other cancers. In short, Table II indicates, as we suggested, that the dosage required to double the spontaneous incidence of these diverse forms of cancer is similar. We have presented evidence elsewhere (4,5) which shows that the same is true for breast and lung cancer. This relationship is also established with thyroid cancer. In other words, this relationship is supported by the data for those cancers which comprise 90% of cancer mortality. Certainly this is a significant concept in terms of setting public health standards. The following section on latency discusses one reason why the remaining 10% of the cancer mortality may not yet be shown to fit this concept.

THE IMPORTANCE OF LATENCY

Gofman-Tamplin

We stated that the earlier interpretations of the ABCC data and other data were incorrect because many of the major forms of cancer were still in their latency period. We indicated that the most important data from the ABCC studies were just beginning to be collected. We indicated that as the observation period was extended, the other forms of cancer would begin to dominate the leukemia cases.

ICRP Publication 14

The authors of Publication 14 make the same conclusions. They state on page 22: "It had also to be recognized that the time which has elapsed since exposure is still much too short for it to be possible to assess the full tumour incidence in the spondylitics and the Japanese: the following table shows that evidence collected during the first 15 years or so after exposure could be regarded as covering only the beginning of the period in which neoplasms other than leukaemia might be expected to appear. If so, relatively small differences in the latent period of neoplasms arising in different tissues could lead to quite erroneous ideas about relative tissue susceptibility."

Change in rate of induced malignant disease with duration of time since exposure in irradiated ankylosing spondylitics (from data in Table VI of Court Brown and Doll, 1965)

Years after irradiation	Cases per 10,000 man-years at risk	
	Leukaemia + aplastic anaemia	Cancers at heavily irradiated sites
0-2	2.5	3.0
3-5	6.0	0.7
6-8	5.2	3.6
9-11	3.6	13
12-14	4.0	17
15-27	0.4	20
Total of expected cases in 10,000 persons in 27 years calculated from the rates given	67	369

DOUBLING DOSE FOR CANCER INDUCTION

Gofman-Tamplin

We stated that the use of the doubling dose is a valid approach for estimating cancer induction by radiation. It was definitely a valid approach in our estimates of cancer induction in the United States population since the doubling dose was derived from data where the spontaneous incidence was comparable to that in the United States.

ICRP Publication 14

The following is taken from page 58 of Publication 14. "In radiological protection the radiation dose required to double the natural cancer incidence is sometimes used in assessing acceptable risks from somatic exposure by analogy with the concept of doubling dose used in assessing the genetic risks from exposure of the gonads. This concept of doubling dose for somatic hazards is a specific example of the misuse of the ratio of cancer rates. The natural incidence of stomach cancer in men or women in five different countries varies between 65 and 706 per million living (Segi and Kurihara, 1963, cited by Dolphin and Eve, 1968) so that for a fixed risk per rad the doubling dose varies more than ten-fold and will induce between 65 to 706 additional cases of stomach cancer per million persons depending on the particular population to which attention happens to be drawn."

Although it is not stated in the above quotation, Dolphin and Eve (6) point out that using a fixed risk per rad to calculate a doubling dose includes the assumption, "that the agents which produce the differences in the natural incidence of cancer of the stomach between countries do not act synergetically with radiation and thus cause

changes in radiation sensitivity of the stomach." In other words, it is quite possible that the same dosage can produce 65 cancers per million in one country and 706 cancers per million in another country. The data on respiratory cancer in uranium miners shown in Table III illustrate this quite well (7).

TABLE III

Respiratory Cancer Death in Uranium Miners

	Smokers	Non-Smokers
Person years	26,392	9047
Cancers observed	60	2
Cancers expected	15.5	0.5

Table III shows that radiation induced a four-fold increase in cancer in non-smokers and that acting synergetically with smoking, radiation induced the same four-fold increase in cancer in the smokers. The rate was increased by the same proportion in both populations although the spontaneous rates differed by a factor of 10.

SHOULD THE FRC GUIDELINES BE REDUCED

Gofman-Tamplin

We stated that, since the present data strongly suggested that all forms of cancer would be induced by radiation in proportion to their spontaneous occurrence, the FRC guideline of 170 mrem/yr exposure of the population-at-large should be reduced by at least a factor of 10.

ICRP Publication 14

In Appendix IV on page 114 using the marrow dose limit as an acceptable standard, they indicate that the whole body dose limit (it is now equal to the marrow dose limit) should be reduced to 0.14 to 0.17 of the marrow dose limit. They state, "On the other hand, the induced cancer rates in spondylitics for the first 27 years after first exposure (Table 2, page 22) may suggest (with considerable statistical uncertainty) that the number of other fatal malignancies will be 5-6 times the number of leukaemias. If so, the dose limit for uniform whole body exposure should be $\frac{1}{1+(5 \text{ or } 6)}$ i.e. 0.14-0.17 units."

In making this calculation they did not correct for the lower dosage received by the other organs in comparison to the bone marrow. The corrected data in Table II of this report show that the results of the proper calculation would have been $\frac{1}{1+(10 \text{ or } 11)} = 0.083$ or 0.091

On page 115 they indicate that genetic consideration should further reduce the whole body dose limit. In other words, they are suggesting at least a factor of 10 reduction also.

SUMMARY

There is substantial agreement between Gofman-Tamplin and ICRP Publication 14. We believe, however, that they missed the important implication of the spondylitic data (see page 5) and as a result are underestimating the effects of radiation on major cancer sites other than the marrow by a factor of 2 to 3.

Since the ICRP is not a standard setting body but mainly a group that makes recommendations to such bodies, it is reasonable for them (and even essential) to qualify risk estimates in terms of absolute scientific validity. It may also be reasonable for them to await fairly substantial scientific evidence before making a recommendation.

However, the same does not apply to the standard setting bodies such as the Federal Radiation Council. Those bodies who are directly charged with protecting the public health should by necessity be conservative. In interpreting the available data, they should always weight their analysis in favor of the public health.

As the follow-up time of the irradiated populations is being extended, the new data are demonstrating that the major forms of human cancer are being induced in proportion to their spontaneous occurrence rate. This strongly suggests that the dose limit to all organs should be comparable to that of the bone marrow or even lower and that the whole body dose limit should be at least a factor of 10 lower than the marrow dose limit. The ICRP may be able to wait 10 to 20 years to make such a recommendation but the health of the public and the workers in the nuclear industry cannot wait.

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2. ICRP. Radiation Protection. Radiosensitivity and spatial distribution of dose. Reports prepared by two Task Groups of Committee 1 of the International Commission on Radiological Protection. N. Y. Pergamon Press, 1969. ICRP-PUBL-14, 1969.

3. Gofman, J. W. and A. R. Tamplin. The mechanism of radiation carcinogenesis. Testimony presented at Hearings of the Joint Committee on Atomic Energy, 91st Congress, January 28, 1970. GT-109-70, 1970.

4. Gofman, J. W. and A. R. Tamplin. Radiation-induction of human lung cancer. Testimony presented at Hearings of the Joint Committee on Atomic Energy, 91st Congress, January 28, 1970. GT-108-70, 1970.

5. Tamplin, A. R. and J. W. Gofman. Radiation-induction of human breast cancer. Testimony presented at Hearings of the Joint Committee on Atomic Energy, 91st Congress, January 28, 1970. GT-107-70, 1970.

6. Dolphin, G. W. and I. S. Eve. Some aspects of the radiological protection and dosimetry of the gastrointestinal tract. In Gastrointestinal Radiation Injury, M. F. Sullivan, editor. (Excerpta Medica Foundation, Amsterdam) pp: 465-474, 1968.

7. Lundin, F. E., W. Lloyd, E. M. Smith, V. E. Archer, and D. A. Holaday. Mortality of uranium miners in relation to radiation exposure, hard-rock mining and cigarette smoking-1950 through September 1967. Health Phys. 16: 571-578, 1969.