An increase in leukemia deaths in South Dakota associated with thirty-two radioactive fallout plumes that traversed the State from nuclear bomb tests at the Nevada Test Site

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A series of radioactive fallout plumes from thirty-two nuclear bomb detonations (576 kilotons, total) at the Nevada Test Site traversed South Dakota between 1951 and 1962[1]. Three crossed South Dakota in 1951, 3 in 1952, 4 in 1953, 4 in 1955, 14 in 1957, 2 in 1961 and 2 in 1962. The larger of these bomb tests were Sedan (104 kilotons, 7/6/62); Hood (74 kilotons, 7/5/57); Climax (61 kilotons, 6/4/63); and Mitt (22 kilotons, 4/15/55). The amount of fallout received by various communities within South Dakota from each fallout plume would depend on the amount of precipitation at the time that the plume passed through an area and the height of the plume above ground (some plumes travel along near ground level).

There was a national effect on cancer and leukemia mortality [2, 3]. The leukemia mortality rates for men increased from 8.5/100,000 for white males in the 50s (1950–59), to 9.5 in the 60s (1960–69) and was 9.1 in the 70s (1970–79)[3]. The corresponding rates for total cancer mortality was 176.6, 190.0 and 204.1 per 100,000. These increases occurred despite marked improvement in treatment of leukemia and other types of cancer. In contrast to the upper trend in males, in females the rate for all cancer was 141.6 in the 50s; 132.4 in the 60s; and 131.7 in the 70s. Corresponding leukemia mortality rates were 5.7, 5.9 and 5.4.

Although Leukemia death rates nationally were surely affected by the nuclear bomb testing program, I compared leukemia death rates in South Dakota to the national rates since South Dakota is one of the states more likely to have been affected by fallout. South Dakota is one of the most rural states in the country. Rural areas are known to have lower cancer rates than urban areas and so would be expected to have less cancer than many states with larger urban populations. In fact, South Dakota did have a mortality rate for all cancer about 10% lower than national rates in the 50s; about 10% lower than the national rates in the 60s and about 12.5% lower than national rates in the 70s (Table 1). Despite these significantly lower rates for mortality from all cancer over this 30-year period, the mortality rates for leukemia were significantly higher than the national rates. White males in South Dakota in the 50s had a mortality rate of leukemia 17.6% higher than the national rate. White females had a smaller excess of 3.5%, or for both sexes, an excess of 12.2% above national rates despite a rate of total cancer deaths in South Dakota 10% smaller than the national rate. The higher rate of leukemia in males in rural states may reflect the much larger amount of time men spend outdoors and greater exposures to agricultural dust which would have been contaminated by radioactive fallout.

In the 60s white males in South Dakota had a leukemia mortality rate 10.5% greater than the national rate; white females had a rate 10.2% above the national rate. Both sexes together had a leukemia mortality rate of 10.4% higher than the national rate even though the total rate of cancer in South Dakota was 10.6% smaller than for the national population. In the 1970s, white males in South Dakota had leukemia mortality rate 3.2% higher than the national rate even though the mortality rate for all cancer was 16.6% lower than the national rate. However, for white females in South Dakota, the leukemia death rate was now about 14% smaller than the national rate and the total cancer death rate was 9% smaller than the national rate.

This pattern suggests an epidemic curve for leukemia similar to that in Japan which peaked between 5 and 9 years after exposure to the nuclear bombs, after which leukemia death rates slowly fell [4]. However, solid tumors increased after 10–12 years (earlier for some cancers like cancer of thyroid, etc.). In the end there were many more cancer deaths other than leukemia among Japanese. The rate of excess deaths from cancers other than leukemia increased over the years after the first 10–12 years and between 27 and 32 years after the bomb the death rate from other cancers increased by 2.4 times, in other words, increasing more rapidly with advancing age.

In addition, the pattern of rising and falling leukemia death rates would appear to minimize any possible influence from exposure to pesticides. While pesticide use increased sharply over the past 30 years (1950-79), leukemia death rates have fallen, suggesting more epidemic curve of leukemia after the period of radiation exposure (1951–1962) from atmospheric testing of nuclear bombs.

In South Dakota over the 20-year period of 1950–69 there were 1102 deaths from leukemia, 111 deaths (10%) more than expected in white males and females compared to national rates. This surely is an understatement, because South Dakota is a very rural area and the death rate from cancer in South Dakota over this period was about 10% less than national cancer mortality rates. Further, the national rates must be higher than they would be otherwise because of some exposure to fallout in most states. These effects have been estimates by the Nuclear Regulatory

continued on page 4...

Increase in Leukemia Deaths
Continued from page 3...

Commission to include some 29,000 to 72,000 deaths from cancer and as much as 170,000 cases of birth defects, all generations, from exposure to external radiation alone from worldwide fallout due to atmospheric testing [2]. Since only about one-half of cancer cases die of cancer, the number of casualties by this estimate is about 300,000 from external radiation exposures alone. The range of cancers induced in a population by exposure to radioactive plumes from nuclear bomb tests has been reported [5,6].

To take the conservative viewpoint and consider only the 111 excess leukemia deaths in South Dakota (assuming that the pattern of cancer in South Dakota is the same as the pattern nationally), we could apply to this a ratio of nine deaths from cancers not leukemia, caused by population

Table 1
Cancer Deaths in South Dakota, 1950–1979, by Sex, Cancer Class and Period for Whites [1]

	White Male					
Site	Deaths 50–59	Rate [2] 50–59	Deaths 60–69	Rate 60–69	Deaths 70–79	Rate 70–79
Lip	22	0.7	5	0.1	8	0.2
Salivary Gland	16	0.5	7	0.2	18	0.5
Nasopharynx	6	0.2	15	0.4	6	0.2
Oral Cavity	53	1.7	78	2.3	90	2.6
Esophagus	95	3.1	93	2.7	117	3.4
Stomach	677	22.0	492	14.4	307	8.6
Large Intestine	449	14.9	507	14.9	651	18.2
Rectum	205	6.6	220	6.5	197	5.5
Liver & Gallbladder	67	2.1	118	3.4	122	3.5
Pancreas	277	8.7	376	11.1	378	10.6
Nose	10	0.3	15	0.4	10	0.3
Larynx	32	1.0	62	1.8	73	2.1
Trachea	622	19.1	1022	30.2	1583	45.5
Breast	14	0.5	8	0.2	11	0.3
Prostate	677	23.5*	807	23.7*	853	22.8*
Testis	33	1.0	28	0.9	30	0.9
Kidney and Ureter	130	4.0	160	4.7	168	4.8
Bladder	193	6.5	224	6.6	227	6.2
Malignant Melanoma of Skin	29	0.9	29	0.9	45	1.3
Nonmelanoma Skin Cancer	50	1.7	42	1.3	27	0.8
Eye	6	0.2	15	0.5*	8	0.2
Brain	121	3.6	158	4.8	129	3.9
Thyroid Gland	11	0.3	12	0.3	17	0.5
Thymus	15	0.4	15	0.4	12	0.4
Bone	42	1.3	32	1.0	32	1.0
Connective and soft tissue	19	0.6	31	0.9	29	0.8
Hodgkin's Disease	86	2.7	83	2.5	63	1.9
Lymphosarcoma and Reticulum cell sarcoma	123	3.8	201	5.9	213	6.2
Multiple Myeloma	59	1.7	88	2.6	107	3.0
Leukemias	327	10.0*	358	10.5	322	9.2
Secondary, site unspecified	412	13.2	326	9.6	326	9.1
All Cancers	4878	156.8	5627	165.9	6179	174.4

[1] Ref. #3
[2] Age-adjusted
* Difference significant, $P<0.05$, relative to U.S. national rate.

Table 1 (continued)
Cancer Deaths in South Dakota, 1950–1979, by Sex, Cancer Class and Period for Whites [1]

	White Female					
Site	Deaths 50–59	Rate [2] 50–59	Deaths 60–69	Rate 60–69	Deaths 70–79	Rate 70–79
Lip	–	–	2	0.1	1	0.0
Salivary Gland	3	0.1	8	0.2	11	0.3
Nasopharynx	2	0.1	1	0.0	4	0.1
Oral Cavity	18	0.6	22	0.6	33	0.8
Esophagus	27	1.0	20	0.6	29	0.6
Stomach	362	12.6*	255	6.8	187	3.9
Large Intestine	447	15.1	559	15.1	759	16.8
Rectum	154	5.2	130	3.5	113	2.4
Liver & Gallbladder	131	4.4	180	4.8*	143	3.1
Pancreas	167	5.6	254	6.7	316	7.2
Nose	11	0.4	7	0.2	2	0.1
Larynx	4	0.1	9	0.3	13	0.3
Trachea	128	4.2	181	5.2	371	9.3
Breast	754	25.1	846	24.3	1051	26.9
Cervix	192	6.3	162	4.9	125	3.3
Chorion and Uterus	202	6.7	210	5.8	175	4.1
Ovary	210	6.8	311	9.0	361	9.3
Kidney and Ureter	79	2.6	102	2.8*	111	2.6*
Bladder	53	1.8	66	1.7	72	1.4
Malignant Melanoma of Skin	23	0.7	45	1.3	49	1.3
Nonmelanoma Skin Cancer	18	0.6	11	0.3	18	0.3
Eye	8	0.2	9	0.3	7	0.1
Brain	93	3.0	97	3.0	120	3.3
Thyroid Gland	23	0.7	26	0.7	24	0.5
Thymus	4	0.1	4	0.1	5	0.1
Bone	34	1.1	22	0.7	20	0.5
Connective and soft tissue	16	0.5	21	0.6	28	0.8
Hodgkin's Disease	50	1.6	60	1.8	31	0.8
Lymphosarcoma & Reticulum cell sarcoma	91	2.9	153	4.2	193	4.6
Multiple Myeloma	37	1.2	52	1.4	65	1.5
Leukemias	184	5.9	233	6.5	219	5.1
Secondary, site unspecified	450	15.2*	343	9.2	358	7.8
All Cancers	3975	132.5	4401	122.3	5014	119.5

[1] Ref. #3
[2] Age-adjusted
* Difference significant, P<0.05

exposures to radiation that would induce one leukemia death [7]. This is the ratio of leukemia deaths to no-leukemia cancer deaths induced by radiation in exposed populations in a 1980 National Academy of Science report on radiation effects [7]. In other words, we would expect then to find about 1,000 deaths from cancers other than leukemia over time due to radioactive fallout plumes from the 32 nuclear bomb tests that passed over South Dakota (1951–1962), for a total of about 1100 deaths, counting leukemia deaths. If we consider that South Dakota is a rural state with much lower cancer rates than nationally, the actual excess number of radiation-induced cancer deaths could easily be twice as great, that is, about 2200 over time. Further, only about one-half of cancer cases die

continued on page 6...

Increase in Leukemia Deaths
Continued from page 5...

of cancer, so the actual number of cancer cases due to exposure to radioactive fallout may have been 4400. Applying the estimates of NRC for birth defects (2) we could expect a somewhat larger number of birth defects than cancer cases in South Dakota, about 5,000, a total of more than 9,000 casualties over time in South Dakota. Similar estimates should be developed for other states which have had many nuclear fallout plumes pass through the area using the National Cancer Institute data on leukemia and cancer mortality.

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EDITORIALS

Mordechai Vanunu

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Mordechai Vanunu was born in Morocco and moved with his family to Israel in 1963. He did three years military service from 1971–74 when he was given an 'honourable discharge' having served as a First Sergeant in a unit of sappers. He commenced a physics degree at Tel Aviv University but had to abandon this for economic reasons and became a technician at the Dimona nuclear plant in 1976. He underwent specialist training and advanced in his post there. In October 1979 he began studies at Ben Gurion University, Be'er-Sheva, in philosophy and geography, graduating in 1984/5, when he became in succession a post-graduate student, assistant lecturer and external lecturer in philosophy.

At university Vanunu became increasingly politically active calling for the equal rights for Palestinians within the state and for the inclusion of Palestinians in negotiations for the establishment of an independent and separate state for the Palestinians. He also advocated religious freedom and a separation of religion from the state. He also became increasingly disillusioned with Israel's military posture and opposed the 1982 Israeli invasion of Lebanon. In November 1985 he was part of a mass lay-off at Dimona. In September 1986 Vanunu talked to 'The Sunday Times' about the Dimona plant, revealing that Israel's probably has a stockpile of 100–200 nuclear weapons, can make thermonuclear devices of greater power than atomic bombs and that Israel also collaborated routinely with South Africa on nuclear matters. Soon after 'The Sunday Times' article on October 5th, Vanunu went missing. In November it transpired that he was lured to Rome by Israel's Secret Service, kidnapped and taken to Israel where he has been in gaol ever since. His trial for espionage and treason opened in Israel on August 30th 1987 under conditions of the most intense secrecy.

In prison Vanunu has been routinely denied normal human rights, being kept in solitary confinement in perpetual light with 24-hour video monitoring, and denied religious counsel (he is now a Christian) and visits by his girlfriend (his family can only see him for half-an-hour once a fortnight, and even this would have been denied had Vanunu not gone on hunger strike until the authorities relented after 33 days). He has also been subject to 'wholesale character assassination' in the Israeli press. It has been suggested that he is being subjected to deliberate psychological warfare to reduce him to the deranged psychotic the media have portrayed him to be. However, his morale remains high.

Vanunu's revelations were exhaustively checked by 'The Sunday Times' before their publication and they have not been seriously challenged. The seriousness of this nuclear capability in what is probably the most unstable area of the world is an issue which had received remarkably little world attention. In Israel the political obstacles and intense secrecy, which Vanunu attempted to break through, have meant that there is almost no activity or public information on these issues there.

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