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ESTIMATE OF RADIATION DOSE TO THYROIDS OF THE RONGELAP
CHILDREN FOLLOWING THE BRAVO EVENT

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ABSTRACT

[illegible] following the Bravo event of March [illegible] the available [illegible] dental data are used to estimate the dose under two alternate assumptions of mode of intake. [illegible] the intake was by inhalation [illegible] the intake was by normal ingestion [illegible] concluded that [illegible] rad to the thyroid [illegible] in the range 100 to 1400 rad.

[illegible]

The residents of Rongelap Atoll were evacuated on March 3, 1954, 48 hours after the Bravo detonation. No dose rate measurements were obtained at that time, but the gamma dose rate 3 feet above the ground was measured as 375 mR/hour 7 days after the detonation. Assuming $t^{-1.2}$ decay, the H + 24 hour dose rate was then about 3.8 R/hour.

The sources of exposure to the thyroid which must be considered are

(1) Whole-body gamma dose.

(2) Internal deposition of iodine isotopes.

Whole-Body Gamma Dose

The whole body dose was estimated[1] to be 175 R. The exact method of making this estimate is not given, so an independent estimate is made below. In particular, it appears that this estimate does not include the dose from the cloud but only from fallout.

If we assume a linear buildup of fallout from H + 6 to H + 18, $t^{-1.2}$ decay during this interval, and use the reading of 375 mR/hour at 7 days, the estimated dose from fallout during cloud passage is 47 R. The dose from the fallout from H + 18 to evacuation at H + 51 is 114 R. Experience from Sedan indicates that the dose from the cloud itself is approximately equal to the dose from fallout during cloud passage. The total estimated dose is then [illegible] 47 + 114 = 208 R.

[illegible] this estimate [illegible] the small [illegible] 25 R.

[illegible]

[illegible] no direct measurement was possible [illegible] the radioactive [illegible] content of individuals from Rongelap [illegible] urine samples [illegible] which the average thyroid burden of I^{131} has been estimated. [illegible] 24-hour samples [illegible] days post detona[illegible] [2] [illegible] content as [illegible] NRDL [illegible] days [illegible] estimate the average [illegible] NRDL [illegible] this estimate was based [illegible] 6 [illegible] 0.1% of the maximum thyroid burden being excreted in the urine on the 15th day. Variation in the biological half life and other factors indicate that a range of 0.05 to 0.2% should be placed on this number[5] (see appendix). We therefore, take 5.6 to 22.4 µCi as the range of adult I^{131} thyroid burden.

The pooled samples represent all age groups. The number of individuals in these age groups and the volume of urine from each age group is approximately as follows:[3,4]

Age Group	Number of Individuals	Volume of Urine (ml)	% of Total Volume
< 5	7	1,155	4.8
5 - 16	11	4,829	20.1
> 16	31	18,011	75.0

The urine samples are typical of adults and the calculated thyroid burdens are presumably also those of adults.

[illegible] I^{131} [illegible] I^{132}, I^{133} [illegible] I^{135} [illegible] inhalation, the time of intake was [illegible] were the principal [illegible] ingestion [illegible] extended from H [illegible] from the various [illegible] iodine isotopes [illegible] inhalation [illegible] ingestion, (2) differences in the [illegible] yields of the chains[6] and (3) the average energy [illegible] These factors are presented in Table [illegible] I^{133} [illegible] I^{135} [illegible] inhalation, uniform [illegible] the [illegible] was assumed. For oral ingestion it was assumed that [illegible] the average [illegible] one third of the intake [illegible]

[illegible] intake

[illegible]	[illegible]	[illegible]	[illegible] 487	[illegible] 48
[illegible]			[illegible] 38	[illegible] 23
[illegible]ssion yield	[illegible]	[illegible]		
Energy	2.00	1.50	2.00	1.50
Net Factor	1.85	0.57	[illegible]	0.27

The dose to the thyroid in rads from all three isotopes is thus 3.4 times the dose due to I^{131} alone for inhalation and 2.6 times the I^{131} dose for oral ingestion. Delay in reaching the thyroid after inhalation or ingestion would lower these factors somewhat. However, the I^{132} daughter of the 78-hour Te^{132} has been neglected and would approximately compensate for decay of I^{133} and I^{135} before reaching the thyroid.

We can now proceed to estimate the dose to the thyroids of 3- to 4-year-old girls assuming (1) inhalation as the mode of intake and (2) oral ingestion.

1. Inhalation. The ratio of volume of air respired by a 3- to 4-year-old girl to that of an adult can be estimated in two ways: (a) from the maximum rate of oxygen intake[7] and (b) from the vital capacity[8] and maximum respiration rate.[7] Both methods give a ratio of about 0.3. The thyroid burden of these children would then be about 3.4 μCi with a range of 1.7 to 6.8 μCi.

Assuming the Rongelap children are similar [illegible] of New York children, the mass of the thyroid of the children is 2.5 ± 0.6 grams.[9]

The most probable dose from I^{131} is then 150 rad and the dose from [illegible] 270 rad. Considering a range [illegible] thyroid weight range of 1.9 to 3.1 grams, the range of total dose is 220 to 1300 rad.

Incidentally, LASL assumed this mode of infant and [illegible] of 150 rad.[2] The thyroid weight used was not given, but was probably 20 grams. We would calculate 160 rad, in very good agreement with the LASL estimate.

SUMMARY

Thyroid dose (rads) to Rongelap girls ages 3 to 4.

	Inhalation			Oral Ingestion		
	Min	Max	Most probable	Min	Max	Most probable
Whole body	150	200	175	150	200	175
Radioiodine	200	1350	510	520	3300	1270
Total	350	1550	685	670	3500	1445

[illegible] the range 200 – 400 rad.

[illegible]

[illegible] Effects of Nuclear Explosions, Annex J, Biological Effects of Internal Emitters and Determination of the Dose of Radiation, Chapter I of Title 10, "Some Effects of Ionizing Radiation on Human Beings."

[illegible] personal communication. Cited by both References 3 and 4.

[illegible] Rinehart, Lang, Robertson, Milne, Byrd, and Conkite, "Internal [illegible] (1958).

[illegible] Handbook of Biological Data, William S. Spector, Ed., p. 352 (W. B. Saunders, Philadelphia, 1956).

[8] Documenta Geigy Scientific Tables, 6th Ed., p. 564 (S. Karger, Basel, Switzerland, 1959).

[9] Mochizuki, Mowafy, and Pasternack, Health Physics, 9, 1299-1301 (1963).

[10] Sharp and Chapman, "Exposure of Marshall Islanders and American Military Personnel to Fallout," WT-938 (1957).

APPENDIX

CALCULATION OF URINARY RADIOIODINE EXCRETION

Yook C. Ng

Radioiodine appearing in urine, except for that during a relatively short period following exposure, originates from the thyroid. In the calcula-

time

A summary of the

Urinary radioiodine excretion at 15 days.

J day^{-1}	K $day^{-1} \times 10^3$	L $day^{-1} \times 10^2$	$\frac{dI_U}{dt}$ % of I_{Tf}/day
3.7	4.85	7.2	0.050
3.7	4.85	13.8	0.066
3.7	17.15	7.2	0.16
3.7	17.15	13.8	0.21