

MEDICAL GRAND ROUNDS
PARKLAND MEMORIAL HOSPITAL
October 19, 1961

BIOLOGIC EFFECTS OF NUCLEAR WEAPONS

Table 1

Number of Casualties

	Population	Total Casualties (%)	Died 1st Day (%)	Died 4 months (%)	Surviving Casualties (%)	Uninjured
Hiroshima	225,000	136,000 (53)	45,000 (17)	64,000 (25)	72,000 (28)	119,000
Nagasaki	174,000	64,000 (37)	22,000 (13)	39,000 (22)	25,000 (14)	110,000
Operation Sentinel (US - 250 weapons - 1950 population)	151,000,000	93,000,000 (61)	36,000,000 (24)	72,000,000 (48)	21,000,000 (14)	58,000,000

Table 2

Distribution of Types of Injury Among Survivors (Hiroshima)

Injury	Per cent of Survivors
Mechanical	70
Burns	65 - 85
Nuclear Radiation	30

Table 3

Wound Distribution

Conventional Warfare		Atomic Warfare	
		Rural	Urban
16%	Head, face and neck	12%	35%
8%	Thorax	15%	10%
6%	Abdomen	14%	5%
26%	Upper extremities	22%	27%
44%	Lower extremities	37%	23%

Table 4

Thermal Energies Required to Ignite Houses and Material

Material	Ignition Energy, cal/cm ²	
	20 kt	10 Mt
Wooden Houses:		
Weathered	12	
Freshly painted white	25	
Newspaper	3	6
Cotton shirting, tan	7	13

Table 5

Thermal Energies for Burns of Bare White Skin

Degree of Burn	Thermal energy for the indicated explosive yields, cal/cm ²					
	1 kt	20 kt	100 kt	1 Mt	10 Mt	20 Mt
First degree	2.0	2.5	2.7	3.2	3.7	3.8
Second degree	4.1	4.9	5.4	6.2	7.2	7.5
Third degree	6.0	7.3	8.1	9.4	10.8	11.4

Table 6

Mortality in Treated Burn Cases Related to Percentage of Body Area Burned*

Average mortality read from probit curve, %	Area burned, % of total body area
1	22
10	41
20	49
30	55
40	60
50	65
60	70
70	75
80	81
90	89
95	96

* Number of cases, 405

Table 7

Probable Effects in Humans of Acute Exposure
to Ionizing Radiation Over the Whole Body

Acute dose, r	Probable Effect
0-25	No obvious injury
25-50	No serious injury; possible blood changes
50-100	Blood-cell changes; some injury; no disability
100-200	Injury; possible disability
200-400	Injury and disability certain; death possible
400	Fatal to 50 per cent
600 or more	Fatal

Table 8

Estimated Doses for Varying Degrees of Injury to Man

Dose rate, r/day	Period of Time	Effect
500	2 days	Mortality close to 100 per cent
100	Until death	Mean survival time approximately 15 days 100 per cent mortality in 30 days
60	10 days	Morbidity and mortality high with crippling disabilities
30	10 days	Disability moderate
10	365 days	Some deaths
3	Few months	No drop in efficiency
0.5	Many months	No large-scale drop in life span

Table 9

Estimated Clinical Course and Hospitalization Requirements
for Humans Exposed to Various Acute Doses of Penetrating Radiation

Dose, r	Individuals Following Indicated Clinical Symptoms, %						Individuals Needing Hospitalization %	Maximal Time of Hospitalization, weeks
	Trivial	Light	Moderate	Serious	Grave	Fatal		
0-200	98	2					None	0
200-300	1	33	64	2			2	6
300-400			6	68	26		94	7
400-500				3	58	39	100	9
500-600					6	94	100	11
Above 600						100	100	11

Table 10

Weapons-Effects Data for Selected Parameters

Selected Parameters	Explosive Yield					
	1 kt	20 kt	100 kt	1 Mt	10 Mt	20 Mt
	Range from GZ for Various Parameters, miles					
700 rem (initial)	0.42	0.70	0.96	1.44	2.04	2.27
30 rem (initial)	0.62	0.99	1.29	1.81	2.55	2.88
5 psi (surface burst)	0.28	0.77	1.32	2.85	6.14	7.74
Second-degree burns	0.48	1.72	3.40	9.00	23.8	31.9
Fireball	0.044	0.14	0.28	0.69	1.7	2.3

Table 11

Approximate Times of Fall of Various Sized Radioactive Particulates From 80,000 Ft. and Distance Traveled in a 15-Mile Wind (at All Altitudes) as Related to Proportion of Initial Gamma Activity at Altitude and at Surface Corrected for Decay During Transport

Particle Diameter, μ	Time of Fall, hr.	Distance Traveled in 15-mph wind, miles	Percentage of Initial Activity	Percentage of Initial Activity Deposited
>340	Up to 0.75	Up to 11	3.8	0.0394
340-250	0.75-1.4	11-21	12.6	0.0964
250-150	1.4-3.9	21-59	14.5	0.0460
150-75	3.9-16	59-240	18.1	0.0154
75-33	16-80	240-1200		
33-16	80-340	1200-5100		
16-8	340-1400	5100-21,000		
8-5	1400-3400	21,000-51,000		

Table 12

Seven-Tenths Rule for Approximating Decay of Residual Gamma Radiation

Time After Burst		Time Factor	Dose Rate, r/hr.	Dose-Rate Factor
Hours	Days			
1	0.04	1	1000	1
7	0.29	7	100	1/10
49	2.04	7 ²	10	1/100
343	14.3	7 ³	1	1/1000
2401	100	7 ⁴	0.1	1/10,000

Table 13

Shielding Factors for Typical Light Residential Structures Against
Gamma Rays Simulating Penetrating Residual Radiation

Structure	Location	Protection Factor*
Two-story wood-frame house	2nd floor, center	1.7
	1st floor, center	1.7
	Basement, center	23**
	Basement, corner	40
	Basement, corner shelter	<100
One-story wood rambler	1st floor, center	1.6
Two-story brick veneer	1st floor, center	6+
	Basement, center	28**
Shelter (earth covered) 3 ft. below grade		1000 or more

* Protection factor represents the outside dose rate at 3 ft. above ground divided by the dose rate inside at the specified location

** Applies to basement with no exposed walls

+ Applies only for detector locations below window sill

Table 14

Approximate Attenuation Factors for Gamma Rays from Fission Products
as a Function of Shield Thickness for Indicated Materials

Attenuation Factor	Shield Thickness for Indicated Materials, inches					
	Lead	Iron and Steel	Concrete	Earth	Water	Wood (Fir)
2	0.28	0.7	2.5	3.5	4.8	9.2
4	0.64	1.8	6.6	8.9	13	25
10	1.0	2.7	9.7	13	19	36
50	1.6	4.2	14	20	29	55
100	1.9	4.8	16	23	33	62
1,000	2.7	6.8	22	32	45	88
10,000	3.5	8.8	27	39	56	110
100,000	4.3	11	32	46	70	140

Table 15

GROUP I - SURVIVAL IMPROBABLE

These will have received lethal amounts of radiation, probably in excess of 700r gamma dose of whole body irradiation, in a short period. Severe, and more or less continuous, vomiting will occur within a few hours, and will be followed by diarrhea, producing severe dehydration and apathy. Death may be expected to occur at any time from one day to two weeks. If dosages are in the supralethal range of several thousand roentgens, central nervous symptoms will predominate. Permanent tremors and convulsions will occur, followed by a period of profound prostration. Death may be expected within two days.

GROUP II - SURVIVAL QUESTIONABLE

These will have received a dose of probably 250r to 700 r. Vomiting will occur on the first day, but will subside within about 24 hours, to be followed by a period of relative well-being from one to three weeks. This quiescent period may be followed by the development of small subcutaneous hemorrhages, sore mouth and throat, loss of hair, bloody diarrhea, loss of weight, and infection of thermal burns and other wounds which had been healing. Few survivors may be expected among those receiving a dose over 550r, 50 per cent mortality may be expected at 450r and 20 per cent at 300r. Most of the deaths will occur within 6 weeks and convalescence for survivors will take from 3 to 6 months.

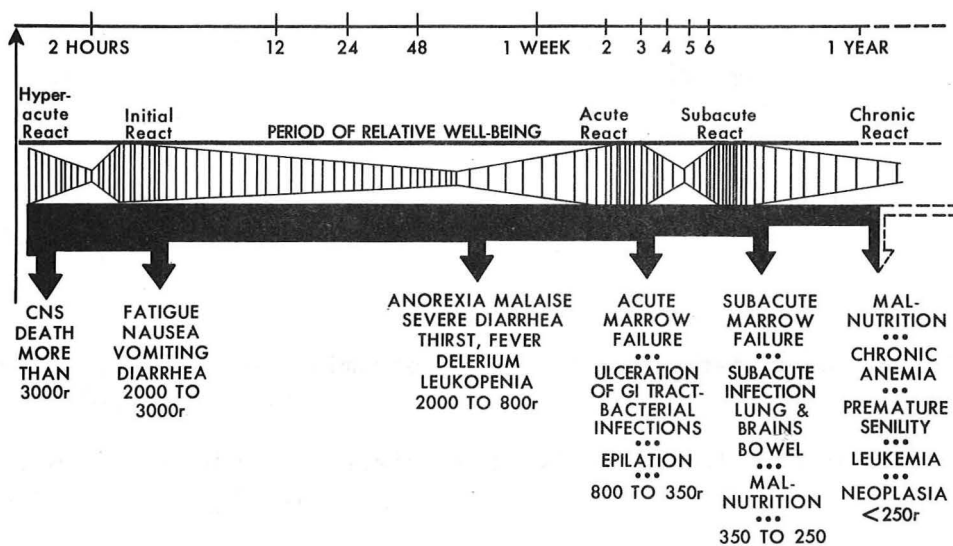
GROUP III - SURVIVAL PROBABLE

These will have received a dose of probably 100r to 250r. Nausea, vomiting, and diarrhea are likely to occur in the first few days. If they do, there is a subsequent latent period, up to 2 weeks or more, during which the patient has no disabling illness and can proceed with his regular activities. The usual symptoms, such as loss of appetite, malaise, loss of hair, diarrhea, and tendency to bleed, then appear, but are not very severe. If there are no complications, due to other injuries or infections, there will be recovery in nearly all cases.

GROUP IV - MINOR INJURY

These will have received a dose of probably 25r to 100r. Symptoms may be mild and indefinite, or there may be nothing other than blood changes to a minor extent. Disabling sickness is not to be expected and exposed individuals should be able to proceed with their usual activities. Without laboratory tests, individuals may not even know they have been exposed.

RADIATION SYNDROME IN MAN FOLLOWING ACUTE EXPOSURE



(Adapted from Court-Brown and Mahler.)

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