

MEDICAL SURVEY OF THE PEOPLE OF RONGELAP
ISLAND, ELEVEN YEARS AFTER
EXPOSURE TO FALLOUT RADIATION (MARCH, 1965)

Interim Report

Robert A. Conard, M.D.,¹ Leo M. Meyer, M.D.,²
Wataru W. Sutow, M.D.,³ James S. Robertson, M.D., Ph.D.,¹
John E. Jesseph, M.D.,¹ Joseph E. Rall, M.D., Ph.D.,⁴
Maynard Eicher,⁵ Ernest A. Gusmano,¹
Arobati Hicking, Practitioner,⁶ Isaac Lanwi, Practitioner⁶

with the technical assistance of

William A. Scott,¹ Douglas Clareus,¹ Lawrence M. Cook,¹
Ernest Libby,³ Kosang Mizutoni,⁶ Sebio Shoniber,⁶ W. Gays,⁶
and Kalman Kittien⁶

- ¹Brookhaven National Laboratory, Upton, New York.
²Long Island Jewish Hospital, Queen's Hospital Center Affiliation, New York.
³M.D. Anderson Hospital, University of Texas, Houston, Texas.
⁴National Institutes of Health, Bethesda, Maryland.
⁵Naval Medical Research Institute, Bethesda, Maryland.
⁶Department of Public Health, Trust Territory of the Pacific Islands.

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The Medical Research Center
Brookhaven National Laboratory
Upton, L. I., New York

This interim report represents a summary of the major findings of the medical survey of the peoples of Rongelap Atoll carried out in March 1965, 11 years after exposure to fallout radiation, and a thyroid survey carried out in September 1965. Complete data for the surveys, including a complete review of past findings, individual findings, and appendices will be published in a report to be combined with complete data of the 12-year post-exposure survey to be carried out in March 1966.

Brief Summary of Past Findings

These people had been accidentally exposed to fallout radiation following a detonation of a high yield thermonuclear device during experiments at Bikini in the Pacific Proving Grounds in March 1954. Of the inhabitants of the Island of Rongelap, 105 miles away from detonation, 64 people received the largest fallout exposure, an estimated dose of 175 roentgens (r) whole body gamma radiation, contamination of the skin sufficient to result in "beta burns", and significant internal absorption of radioactive materials through inhalation and ingestion. Other Rongelap people away on a nearby island (Ailingnae), where less fallout occurred, received only an external gamma dose of 69 r.* The people of Utirik Island about 200 miles east of Rongelap, received an estimated dose of 14 r whole body radiation.* Fallout was not visible on this Island, and no beta burns developed.

The exposed people were evacuated by planes and ships about two days after the accident. Because of contamination of their home island, the people of Rongelap were not moved back until 1957, when radioactivity had subsided to a safe level. On their return, they were established in a new village built for them. The Utirik people were returned to their island after several months, (following initial medical examinations), since contamination levels there were not considered hazardous. Annual medical examinations have been carried out on the Rongelap people. The Utirik people have been examined four times since the accident, at two to three year intervals. A group of over 200 unexposed Rongelap men, women, and children, who have moved back to Rongelap Island, serve as a comparison population.

Detailed information on past findings of the effects of fallout radiation exposure on these people may be found in published survey reports (1-11). Past examinations of the Utirik people showed only a minimal early effect on their blood levels, but with no other findings at any time suggestive of radiation effects. The Rongelap people, on the other hand, had slight transitory gastrointestinal and skin symptoms during the first two days due to radiation exposure, followed by significant depression of blood elements, the development of widespread "beta burns" to the skin with some loss of hair, and measurable internal absorption of radionuclides. However, the gamma dose (175 r) received

* There were 18 people on Ailingnae (16 of whom are now living) and 157 people on Utirik (about 140 now living).

by the more heavily exposed 64 people of Rongelap was not lethal, since no deaths have occurred in the group that appeared to be related to their exposure. In spite of some early loss of weight in a number of the group, and the depression of their blood elements, none showed any signs of illness, infections, or bleeding that might be related to the penetrating gamma effect, and no special therapy was necessary. The "beta burns" healed within several months without complications, though residual pigmentation changes and scarring remain in some cases. The hair regrew by six months. Radiochemical urine analyses showed that probably only isotopes of radioiodine exceeded the maximum permissible levels during the first two days. Rapid excretion of the radionuclides occurred, the levels not being distinguishable from the nonexposed Marshallese by two years after exposure. Subsequent return to their home island resulted in slight increases in body burdens of radionuclides, but the levels attained have remained far below the stated maximum permissible levels. During the first five years after exposure, a somewhat higher incidence of miscarriages and stillbirths were noted in the exposed women. Effects believed to be related to radiation exposure were the slightly retarded growth and development in some of the exposed children, and thyroid nodules detected in 1963 and 1964. These findings will be discussed later in the report. Fertility did not appear to be significantly impaired, since the birth rate in the exposed group has been comparable to that of the comparison population. Mortality in the exposed group remained about the same as the comparison population, and no evidence of premature aging was recognized, and no leukemia developed. Two deaths from cancer in older exposed women have occurred. The first at five years post exposure--too early it is believed to be related to radiation exposure--and the second at eight years post exposure. One control woman is believed to have died with cancer of the cervix. No skin malignancies have been noted as a sequelae to "beta burns," but there appears to be an increase in the number of pigmented nevi in the beta irradiated skin areas. No specific genetic studies have been carried out, but no increase in congenital malformations has been noted in the children of exposed parents.

THE 1965 SURVEY

The survey team consisted of 12 physicians and technicians from the United States and 6 from the Trust Territory.

Examinations were carried out on 73 Rongelap people in the exposed group, 48 children of exposed parent(s) and 193 unexposed Rongelap people (adults and children) comprising the comparison population. A Trust Territory cargo ship was used to transport part of the team and equipment between Rongelap and Kwajalein. In addition, air support was furnished by the Search and Rescue Detachment, U. S. Navy, stationed at Kwajalein. The team lived ashore at

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Rongelap Island during the period of the examinations. Smaller groups of Rongelap people were also examined at Ebeye, (Kwajalein Atoll), and Majuro. The attitude of the people as usual was most cordial and cooperative.

Interval Medical History

During the past year the Rongelap people have been generally in good health, and their nutritional status appears to have been satisfactory. An epidemic of what is believed to have been Asiatic influenza with acute upper respiratory manifestations occurred in about half of the population in the spring of 1964. An outbreak of diarrhea, cause unknown, involved a large segment of the population during January and February, 1965. On Ebeye Island, where about 100 Rongelap people live, an outbreak of conjunctivitis occurred during the year, but this responded to antibiotic treatment. Four children with varying degrees of paralysis, following a polio myelitis epidemic in 1963, were treated and fitted with braces at Majuro. Surgery was performed on four cataract cases and one fistula in ano. Deaths occurred in one 76 year old exposed woman and three unexposed people (see below). The most outstanding finding since the 1964 survey has been the increasing number of cases of thyroid nodules to be described below.

During the March 1965 survey and again in September, meetings with the people were held in order to explain the survey procedures and discuss the thyroid cases. They seemed to have accepted the situation in regard to the thyroid lesions calmly, and there has been no expression of great concern.

Deaths. No. 43, a 77 year old exposed woman died of pneumonia. She had had arteriosclerotic heart disease, asthma, and marked peripheral sclerosis with occlusion of the right radial artery. She was quite senile.

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Three deaths occurred in the unexposed group: No. 893, a 61 year old woman died of acute cellulitis of the neck and face complicating diabetes; No. 894, a 68 year old woman died of pneumonia complicating Asiatic influenza; No. 862, a 91 year old male died presumably of cardiovascular disease. He was quite senile and bed-ridden for the past few years. During the past 11 years, 11 deaths have occurred in the exposed group. This represents 12.2 deaths per 1,000 compared with 8.3 per 1,000 for the Marshall Islands as a whole in 1960. This slightly greater mortality in the exposed Rongelap people may be related to the larger percentage of older people in the group. No cases of leukemia have appeared in the exposed population. Two earlier deaths from cancer in exposed women and the recent development of a malignant thyroid nodule, to be described below, makes it necessary to keep in mind the possible causal relationship with radiation exposure.

Births, Miscarriages, Stillbirths, and Neonatal Deaths. Seven healthy babies were born to exposed parents and six to unexposed parents during the past year. The birth rate in the exposed group parallels fairly closely that in the unexposed group. Three miscarriages occurred during the past year in unexposed women. No miscarriages occurred in exposed women. Two unexposed women had abnormal babies, one a hydrocephalic and one a mongoloid.

Adult Examinations

As noted in previous surveys the variety and distribution of physical abnormalities (with the exception of thyroid nodules to be described below) did not appear to be significantly different in the exposed people as compared with the unexposed population. The varying incidence from year to year of such findings as cervicitis, prostatic hypertrophy, and arteriosclerosis probably to some extent reflects differences in clinical criteria of judgment among

the examiners. With the exception of a malignant thyroid nodule, to be described below, no malignant lesions were detected, and only a few benign soft-tissue tumors were found. There was a marked tendency for extensive dental caries in young adults. On the whole, both exposed and unexposed populations have an evidently good nutrition, and give the impression of good general health. Physical abnormalities in the adults are tabulated in Table I.

Residual Skin Lesions. The residual skin lesions in both adults and children are presented in Table II. There were few changes in the skin lesions compared with the report of last year. There were no cases of chronic radiation dermatitis or cancer of the skin noted.

Pediatric Examinations

The pediatric examinations followed the patterns established in previous years and included a brief interval history, routine clinical examination, photograph, a roentgenogram of the left hand and wrist, and physical anthropometry. Special attention was directed this year to the palpatory findings in the neck and thyroid gland areas.

The numbers of children examined in 1965 are summarized below:

Exposed group	23
Unexposed group (800-900 series)	108
Children born to exposed parents	<u>48</u>
Total	179

The steady decrease in the size of the exposed group from one examination to the next merely reflects the transfer of the older subjects from the pediatric to the adult studies.

TABLE I

Physical Findings in Rongelap Adults, 1965

	<u>R*</u>	<u>C*</u>
No. examined	48	83
Anemia, anemic tendency**	7	7
Arteriosclerosis, peripheral, mild	7	6
Arteriosclerosis, peripheral, moderate to severe	6	4
Asthma		1
Cardiac enlargement***	4	3
Cervical erosion, bleeding	2	2
Cervical lacerations	2	
Claudication, intermittent	1	
Congenital defects		
a) dislocation of hip		1
b) prominent head of ulna	2	4
c) bilateral shortening of 5th finger	1	1
d) polydactylism		1
e) shortened left thumb	1	
f) flexion deformity, fingers		1
Cystocele	2	1
Diabetes mellitus		6
Dermatitides		4
Epilepsy (grand mal)		1
Gynecomastia	1	
Hallux valgus		1
Hypertension >(140/90)	12	6
Kyphosis, scoliosis	5	1
Lenticular opacities, cataracts	11	9
Leprosy, arrested	1	
Leukoplakia		1
Liver, palpable	1	2
Myocardial damage or insufficiency (EKG)	1	10
Obesity	8	5
Osteoarthritis	3	3
Pharyngitis, acute	4	
Pinguecula	3	3
Prostatic hypertrophy	3	
Pregnancies	5	6
Proteinuria****		1
Pterygium	18	23
Rheumatic heart disease	2	2
Senility	2	
Syphilis (?) arrested	1	
Thyroid nodule	see table	
Tumor, benign	2	2
Urinary tract infection	1	

* R - Rongelap exposed (including Ailingnae)

* C - Rongelap unexposed

** RBC female <3.9; male <4.3 Million
Hemoglobin female <11.0g; male <13.0g
Hematocrit female <35%; male <38%

*** By x-ray and/or physical examinations

**** >100 mg

TABLE II
Residual "Beta Burns"

<u>Subject No.</u>	<u>Age</u>	<u>Sex</u>	<u>Data</u>
2	13	M	Roughening and pigment variation on front of neck. Several pigmented macules ACF.* Perianal depigmentation.
3	12	M	Mottled pigmentation both axillae. Pigmented area behind left ear.
11	61	M	Pigment changes left ACF; pigment variation with many moles in and beneath axillae.
12	29	F	Two pigmented moles on back of the neck. Small keloid at site of mole removal on right shoulder.
17	14	F	Scarring and pigmentation left ACF.
20	18	M	Pigmented patch back of neck.
23	15	M	Pigmented macules left axilla, front of neck, and chest. Depigmented spots shaft of penis.
24	24	F	Slight pigment variation on front of neck; several pigmented macules dorsum left foot.
34	56	F	Moles on front of neck particularly on left side.
39	26	F	Slight roughening and pigmentation back of neck; pigment variations and slight hyperpigmentation dorsum right foot.
49	26	F	Numerous pigmented macules on both sides of neck and a few on arms and ACF.
54	12	M	Mottled pigmentation and depigmentation on front of neck.
58	71	F	Increasing number of moles over the front and side of the neck and on the left side of the face.
59	46	F	Mottled pigmentation and depigmentation on back of neck.
63	47	F	Slight rugosity and pigmented ridges on back of neck.
64	41	F	Mole back of neck; slight pigment variation and a few macules front of neck.
65	12	F	Pigment variation and roughening front of neck.
67	25	F	Depigmented scars dorsum left foot.
74	23	F	Slight roughening and pigmentation back of neck.
75	28	F	Slight pigmented area dorsum right first toe.
78	48	F	Numerous pedunculated moles on sides and front of neck.
79	50	M	Pigmented and depigmented scar on posterior surface of the left ear.

*ACF = antecubital fossa.

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Table III summarizes the frequency of abnormal findings from physical examination in the children. Additional nodules of the thyroid gland were found in exposed children, both in March 1965 and in the following September thyroid resurvey. These will be described below. One child (No. 1061) born to nonexposed parents had hydrocephalis, developmental retardation, and hepatosplenomegaly. Another child (No. 1055), also born to nonexposed parents had diagnostic stigmata of mongolism.

Growth hormone determinations from blood samples following insulin injections proved to be unsatisfactory. The period of hypoglycemia was apparently not sustained long enough to produce maximum growth hormone levels. Goodenough "Draw-A-Man" Tests⁽¹²⁾ were done on a number of children and are being analyzed with the hope that numerical scores will provide some measure of mental development in the growth retarded children. Conduction of such tests are difficult to carry out and interpret due to language barriers, uncertainty of cultural, social, and educational background, as well as possible family influences.

A detailed analysis of the growth and development data on the Marshallese children during the period of 1958 through 1963 has been published.⁽¹³⁾ Further analysis will be undertaken when additional results related to the following two aspects of the study become available. First, the results of administration of thyroid hormone to the exposed Rongelap population, begun in September, will be helpful in evaluation of the possible existence of hypothyroidism as related to growth retardation. Second, the four youngest exposed children are now 11 years old. Within a short time, therefore, all of the exposed group will be well into or past the adolescent age, and a comprehensive analysis of growth in each of the children will be possible.

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TABLE III

Physical Findings, Pediatric Examination, 1965
(Thyroid Cases Listed in Table IV)

	<u>Exposed Children</u>	<u>Unexposed Children Born Before 1 Jan. '55</u>	<u>Unexposed Children Born After 1 Jan. '55</u>	<u>Children Born to Exposed Parents</u>
Number examined	23	39	69	48
Hypertension	0/21	0/29	0/18	-
Vitiligo	1	1	-	-
Cafe-au-lait spots	2	-	3	2
Acute skin infection	2	3	5	2
Thrush	-	-	-	1
Umbilical hernia	-	-	1	-
Papilloma	1	-	-	-
Otitis media				
Acute	3	5	7	7
Chronic	-	1	1	2
Eczema	-	-	-	1
Adenopathy	-	-	4	8
Palpable spleen	-	1	-	-
Palpable liver	-	-	2	3
Malformation, toes (No. 112)	-	-	-	1
Systolic murmur	9	14	20	16
Keloids	1	-	-	-
Conjunctivitis	1	1	2	2
Bullous lesion, lips	1	-	-	-
Hypoparathyroidism (No. 21)	1	-	-	-
Unilateral breast development (No. 65)	1	-	-	-
Tonsils, hypertrophy	2	7	12	6
Molluscum	-	-	2	4
Dermatitis, nonspecific	-	-	1	-
Nevi	2	5	3	1
Polio, residual	-	5	3	1
Cheilosis	-	-	1	1
Nystagmus	-	-	1	-
Thoracotomy scar	-	1	-	-
Mongolism (No. 1058)	-	-	1	-
Hydrocephalus (No. 1061)	-	-	1	-
Deformed hand (burns)	-	-	1	-
Cystic mass, sole of foot (No. 807)	-	-	1	-
Congenital heart disease (Nos. 1032, 1058)	-	-	2	-
Tracheostomy scar	1	-	-	-
Warts	2	-	-	2

Further Development of Thyroid Nodules

A detailed presentation of the thyroid lesions in the Marshallese is being published separately, (14) and only a brief review of the data is presented here.

Table IV A below summarizes the thyroid lesions in the exposed Rongelap people. In Table IV B the incidence of such lesions in the more heavily exposed group (55 living of 64) as a function of age is presented. (The one case in the Ailingnae group is not included in the table.) The first three cases (, , and) (Table IV) in teenage girls who were operated on in Guam in 1964 have been described (10,11). In the March 1965 survey, three additional cases of thyroid nodules, two in exposed boys (and), and one in an exposed woman () were discovered. In addition, two boys (and) were found to be hypothyroid with PBI's less than 2 μ gm%.

The three nodule cases were brought to Brookhaven National Laboratory in June 1965 for study (see Fig. 1), and surgery was later performed at the New England Baptist Hospital by Dr. Bentley P. Colcock. The two boys had partial thyroidectomies, and the nodules were diagnosed as benign adenomatoid goiters (as in the first three cases). The woman had a subtotal thyroidectomy, and she was found to have mixed papillary and follicular carcinoma with localized metastasis. She later had complete ablation of the thyroid gland with radioiodine. Figs. 2 and 3 show the gross and histological appearance of these lesions.

In September another thyroid survey was conducted at Rongelap and Ebeye by two of us (and). This survey turned up five other cases with nodules greater than 1 mm. in size, and also five other

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TABLE IV A

THYROID ABNORMALITIES, EXPOSED MARSHALLESE*

<u>Case</u>	<u>Present Age</u>	<u>Age at Exposure</u>	<u>Sex</u>	<u>Date Abnormality Noted</u>	
	14	3	F	3/63	Benign nodules, complete thyroidectomy 1964.
	14	3	F	3/64	Benign nodules, complete thyroidectomy, parathyroidectomy 1964.
	15	4	F	3/64	Benign nodules, partial thyroidectomy 1964.
	18	7	M	3/65	Benign nodule, partial thyroidectomy 1965.
	12	1	M	3/65	Benign nodule, partial thyroidectomy 1965.
	41	30	F	3/65	Malignant nodule, thyroidectomy - surgical and with radioiodine 1965.
	17	6	F	9/65	3 mm. nodule left lobe.
	14	3	F	9/65	2 mm. nodule right lower lobe.
	19	8	F	9/65	6-8 mm. smooth nodule left lower pole.
	40	29	M	9/65	2 mm. nodule right lower pole.
**	45	36	F	9/65	5 mm. nodule midline.
	12	1	M	3/65	Hypothyroid, PBI less than 2 μ gm% March, 1965, marked retardation of growth.
	12	1	M	3/65	Hypothyroid, PBI less than 2 μ gm% March, 1965, marked retardation of growth.

* Does not include 5 cases believed to have minimal thyroid irregularities. (Two were 12 year old girls, one a 26 year old woman, and two men 31 and 37 years of age.) No thyroid nodules have been detected in over 200 unexposed Rongelap people.

**See text - exposed to only 69 r whole-body radiation.

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Table IV B

THYROID ABNORMALITIES, MORE HEAVILY EXPOSED MARSHALLESE GROUP*

(a) Age Specific Incidence

<u>Age at Exposure</u>	<u>No Exposed</u>	<u>Nodules</u>		<u>Hypothyroidism</u>		<u>Total Abnormalities</u>	
		<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>	<u>No.</u>	<u>% of Group</u>
0-5	12	5	41.7	2	16.7	7	58.3
6-10	6	3	50.0	-	-	3	50.0
11-15	5	0	0.0	-	-	0	0.0
16-20	6	0	0.0	-	-	0	0.0
>20	26	2	7.7	-	-	2	7.7

(b) Incidence Per Cumulative Population

<u>Age at Exposure</u>	<u>No. Exposed</u>	<u>Nodules</u>		<u>Hypothyroidism</u>		<u>Total Abnormalities</u>	
		<u>No.</u>	<u>%</u>	<u>No.</u>	<u>%</u>	<u>No.</u>	<u>% of Group</u>
0-5	12	5	41.7	2	16.7	7	58.3
6-10	18	8	44.4	2	11.1	10	55.6
11-15	23	8	34.8	2	8.7	10	43.5
16-20	29	8	27.6	2	6.9	10	34.5
>20	55	10	18.2	2	3.6	12	21.8

* Five cases with minimal thyroid abnormalities not included. One 45 year old woman in the lesser exposed group who developed a thyroid nodule not included in this table.

cases in which minimal changes were believed to have been palpated (see Table IVA). A consultation with several thyroid experts had been held during the summer in view of the seriousness of the thyroid development in the Marshallese. The concensus was that the exposed people should receive thyroid hormone treatment for the remainder of their lives, in order to attempt prevention of further development of nodules, and possibly induce regression of existing nodules.

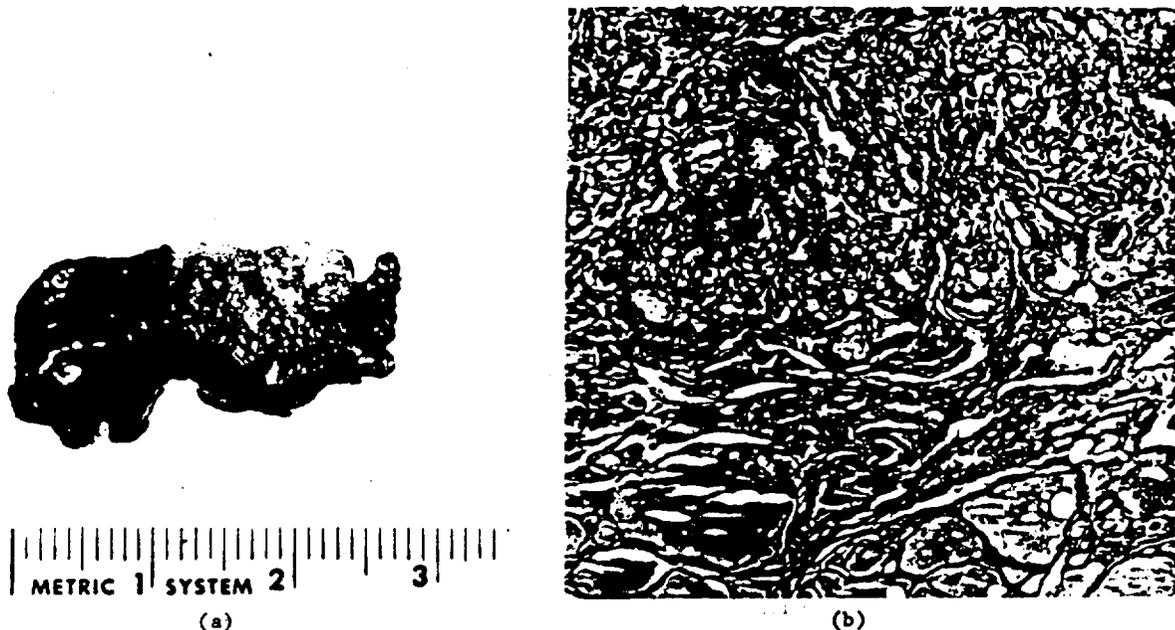
Accordingly, at the time of the September survey, the 55 people in the more heavily exposed group were begun on synthetic hormone, L-Thyroxin (Synthroid^{*}). A daily dose of 0.3 mg. was given to all people under 50 years of age in the group, and 0.2 mg. per day to all people over 50 years of age. It was decided to leave the new cases with thyroid nodules in the Islands under hormone treatment, and, if at the time of the forthcoming survey in March 1966, the nodules had not regressed or further nodules had developed, serious consideration would be given to returning them to the United States for study and possible surgery.

* Synthroid: Sodium levothyroxine, Flint Laboratories, Morton Grove, Illinois.

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FIGURE 1. Marshallese thyroid cases at Medical Research Center, Brookhaven National Laboratory. Left to right: R. A. Conard, case (13 year old boy), case (41 year old woman), case (18 year old boy), and John Iaman, Marshallese medical practitioner and interpreter.



(a) (b)
FIGURE 2. Mixed papillary and follicular thyroid cancer in 41 year old exposed woman (case). (a) shows gross appearance of malignant nodule; (b) microscopic appearance of area showing follicular cancer and adjoining more normal follicles.



(a) (b)
FIGURE 3. Benign adenomatoid thyroid nodules in 14 year old girl (case). (a) gross appearance of sectioned gland showing nodular character; (b) microscopic appearance showing wide variation in follicle sizes: some small, atrophic, others large and cystic. Nodule at upper right shows hyperplasia with papillary infolding of epithelium.

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Cases With Hypothyroidism

The development of hypothyroidism in the two boys (with the greatest retardation in growth), as evidenced by PBI values dropping to below 2 $\mu\text{gm}\%$, the nonpalpable thyroids, and the Achilles reflex with sluggish return, suggests defective thyroid function in the etiology of the retarded children, even though PBI levels have remained in the normal range in the other children in the group. However, two of the boys, cases _____ and _____, with thyroid nodules were in the group that showed retardation of growth and development.

Protein-Bound Iodine Determinations

Protein-bound iodine determinations were carried out on 31 exposed and 19 unexposed Rongelap people. No significant differences were noted between the exposed and unexposed groups. Again, however, the values were high compared with American levels. PBI levels in $\mu\text{gm}\%$ were: Marshallese exposed, 7.6 (4.1-11.9); Marshallese controls, 7.0 (3.9-10.7); medical team (Americans), 4.9 (2.5-6.9). An evaluation of the elevated Marshallese PBI levels over the past eight years as well as ^{132}I uptake studies of the thyroid is being published.⁽¹⁵⁾ Elevated PBI's were found in 20-40% of the Marshallese people. None showed evidence of hyperthyroidism. The elevation is seen generally throughout the population. Column chromatography of serum iodine has revealed high iodoprotein levels in the Marshallese which appear to at least partly account for the elevation in the serum PBI's.

^{132}I Uptake and Excretion Studies

^{132}I uptake and excretion studies were done on 12 people in the exposed and 9 in the unexposed population. The rate of thyroid uptake and the rate of urinary excretion were both depressed to about one-half normal. This depression was noted in both the exposed and the unexposed people. The explanation

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is not apparent. The amount of iodine secreted by the thyroid was calculated to be 76 $\mu\text{gm}/\text{day}$.⁽¹⁵⁾

Urinary Iodine Excretion Determinations

Urinary iodine excretion determinations were carried out on 28 samples. The average value of 105 $\mu\text{g}/\text{day}$ (range 19.5-279 $\mu\text{g}/\text{day}$) is similar to values found in the Eastern United States. It was expected that the Marshallese values would have been somewhat higher in view of their mainly oceanic environment and available sea food.

Determinations of Body Burdens of Radionuclides

Gamma spectrographic analyses were carried out on 158 Rongelap people using the Hanford shadow shield type whole body counter for the first time in these surveys. This counter, along with the electronic equipment, was set up in a newly-acquired air-conditioned trailer brought to Rongelap village. The background count with this counter was somewhat higher than that recorded from the 21 ton steel room previously used, but the ^{40}K and the ^{137}Cs peaks were easily recognized.

The results of these analyses are still being processed. Preliminary results indicate that though there are a few individuals with relatively high values for ^{137}Cs (nearly twice average), in general both exposed and control groups had body burdens for this isotope about the same as was determined four years previously. In μmc per kg body weight the levels were about 11.5 for females greater than 15 years of age and about 15.6 for males greater than 15 years of age. (These values are slightly greater than those obtained four years ago, but since different techniques were used, this difference would not appear to be significant.) These results indicate that, as noted four years

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previously, people living on Rongelap Island have levels of ^{137}Cs which have evidently reached a plateau and are therefore probably in equilibrium with their environmental sources of ^{137}Cs . Individual variations are probably related to corresponding variation in their diets. Those Rongelapese who had recently returned from prolonged stays at other atolls had markedly lower counts, which were comparable to those of the medical team.

^{65}Zn is no longer readily detectable in the gamma ray spectrographs and therefore appears to be an insignificant contribution at this time to the body burdens of the Marshallese.

Figure 4 compares the gamma ray spectrographs of ^{137}Cs in Marshallese with a high level, an average level, and a member of the AEC medical team.

Radiochemical analyses of urine samples for ^{90}Sr are being done by the AEC Health and Safety Laboratory in New York City. They will be reported later.

Hematological Examinations

The hematological findings are summarized in Table 5 and in Figures 5-8. As has previously been done, the data in Table 5 have been broken down by sex into age groups. In general the exposed Rongelap people who through the years since the accident had continued to show slightly lower mean levels for total leukocytes, neutrophils, and lymphocytes now appear to have values as high as in the unexposed population. Slight drop in total leukocytes noted in both groups is reflected in the lower lymphocyte values as compared to 1964. For the first time since the accident platelet levels for the exposed (both male and female) are equal to the levels in the unexposed group. Platelet counts were 20-25% lower in both groups compared to last year. The erythrocytic

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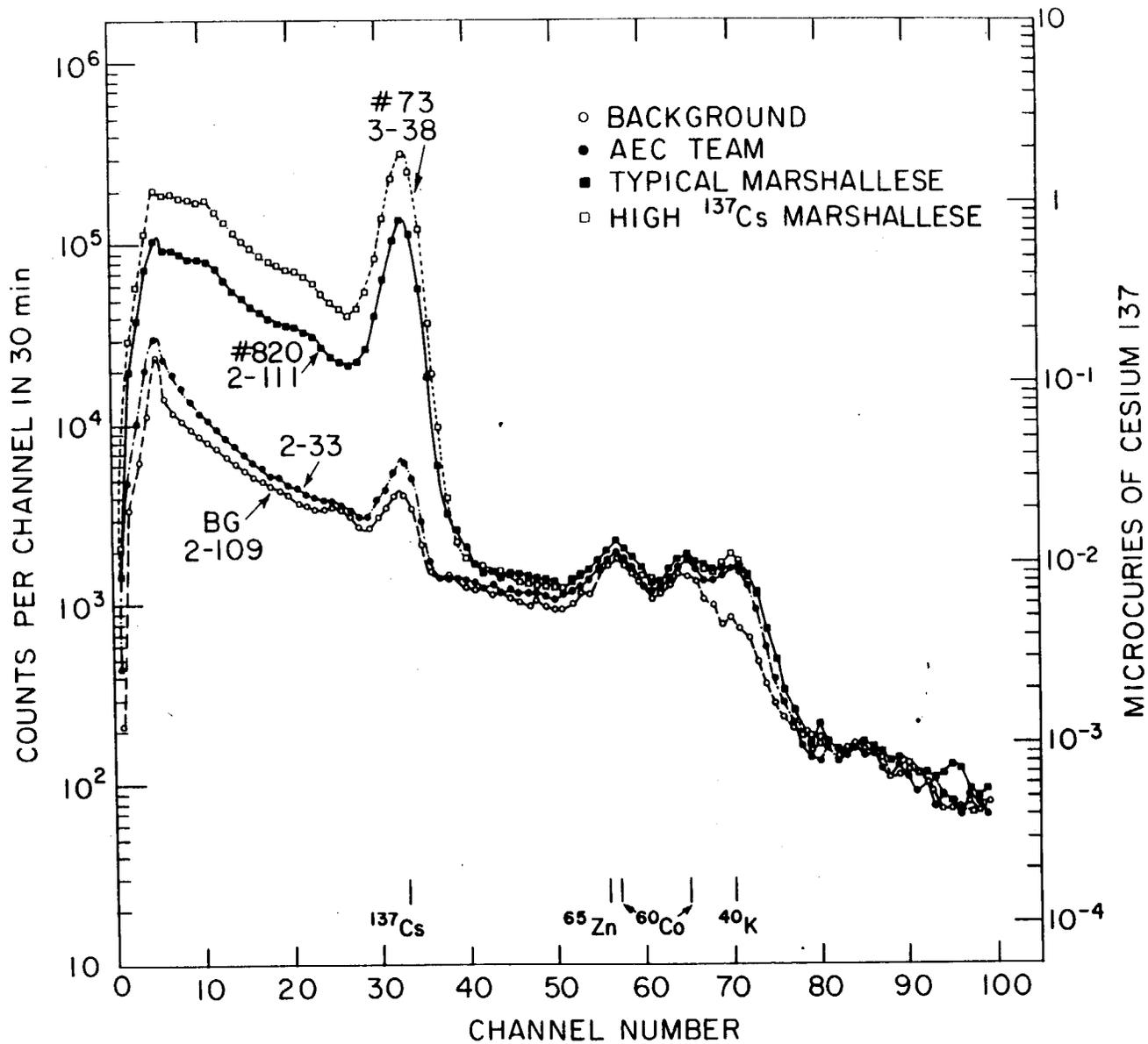


FIGURE 4. Unprocessed gamma-ray spectrographs obtained with an 11-1/2 inch Na-I(Tl) crystal in a shadow-shield type whole body counter. The channel width was 20 Kev. Traces of ¹³⁷Cs and ⁶⁰Co are apparent in the background spectrum. The right hand scale was obtained by calibration with a standard-man phantom, and requires correction for other body sizes; it is adjusted for the ¹³⁷Cs peak.

TABLE V

Mean Levels of Peripheral Blood Elements of Exposed Groups Compared with Those of the Unexposed Group by Age and Sex

1965

	Plate ($\times 10^{-3}$)	WBC ($\times 10^{-3}$)	Neut. ($\times 10^{-3}$)	Lymph. ($\times 10^{-3}$)	HCT (%)	RBC ($\times 10^{-4}$)	HGB (g)	Serum Protein (g)
<u>Males 11-15 yr.</u>								
Rongelap exposed*	300	8.71	4.20	3.21	39.9	465	13.1	7.9
Ailingnae exposed**	449	7.09	2.34	3.66	37.5	433	12.3	7.6
Rongelap unexposed	326	7.16	3.66	2.71	39.6	465	13.3	7.6
<u>Females 11-15 yr</u>								
Rongelap exposed**	318	8.17	4.06	3.52	37.6	408	12.5	7.8
Ailingnae exposed	383	6.52	4.50	1.50	38.0	411	13.6	7.0
Rongelap unexposed	300	8.39	4.52	2.98	38.6	441	12.6	8.0
<u>Males >15-40 yr</u>								
Rongelap exposed	247	7.48	3.94	2.93	46.0	488	14.5	7.6
Ailingnae exposed	-	-	-	-	-	-	-	-
Rongelap unexposed	247	7.86	4.10	3.05	46.3	496	14.9	7.6
<u>Females >15-40 yr</u>								
Rongelap exposed	258	7.37	3.83	2.84	38.2	401	12.5	7.7
Ailingnae exposed	347	7.62	4.87	2.36	36.0	418	11.7	8.2
Rongelap unexposed	269	6.98	3.86	2.59	36.6	400	12.2	7.4
<u>Males >40 yr</u>								
Rongelap exposed	245	6.03	2.62	2.88	41.3	432	12.7	7.4
Ailingnae exposed	278	7.40	4.07	2.66	46.0	509	15.0	7.7
Rongelap unexposed	248	6.98	3.78	2.56	42.5	449	14.0	7.9
<u>Females >40 yr</u>								
Rongelap exposed	306	6.44	3.18	2.67	37.1	371	12.1	7.4
Ailingnae exposed	338	6.40	2.63	3.10	39.5	403	13.0	8.2
Rongelap unexposed	284	6.77	3.27	3.04	38.0	407	12.6	7.8
<u>Males <11 yr</u>								
Of exposed parent(s)	426	9.74	4.45	4.41	36.9	438	11.9	7.3
Of unexposed parent(s)	365	9.94	4.55	4.38	36.5	445	11.8	7.6
<u>Females <11 yr</u>								
Of exposed parent(s)	410	10.48	4.38	5.04	37.3	443	11.8	7.2
Of unexposed parent(s)	367	9.87	4.43	4.44	36.3	430	11.9	7.7

* Includes 2 children exposed in utero.

** Includes 1 child exposed in utero.

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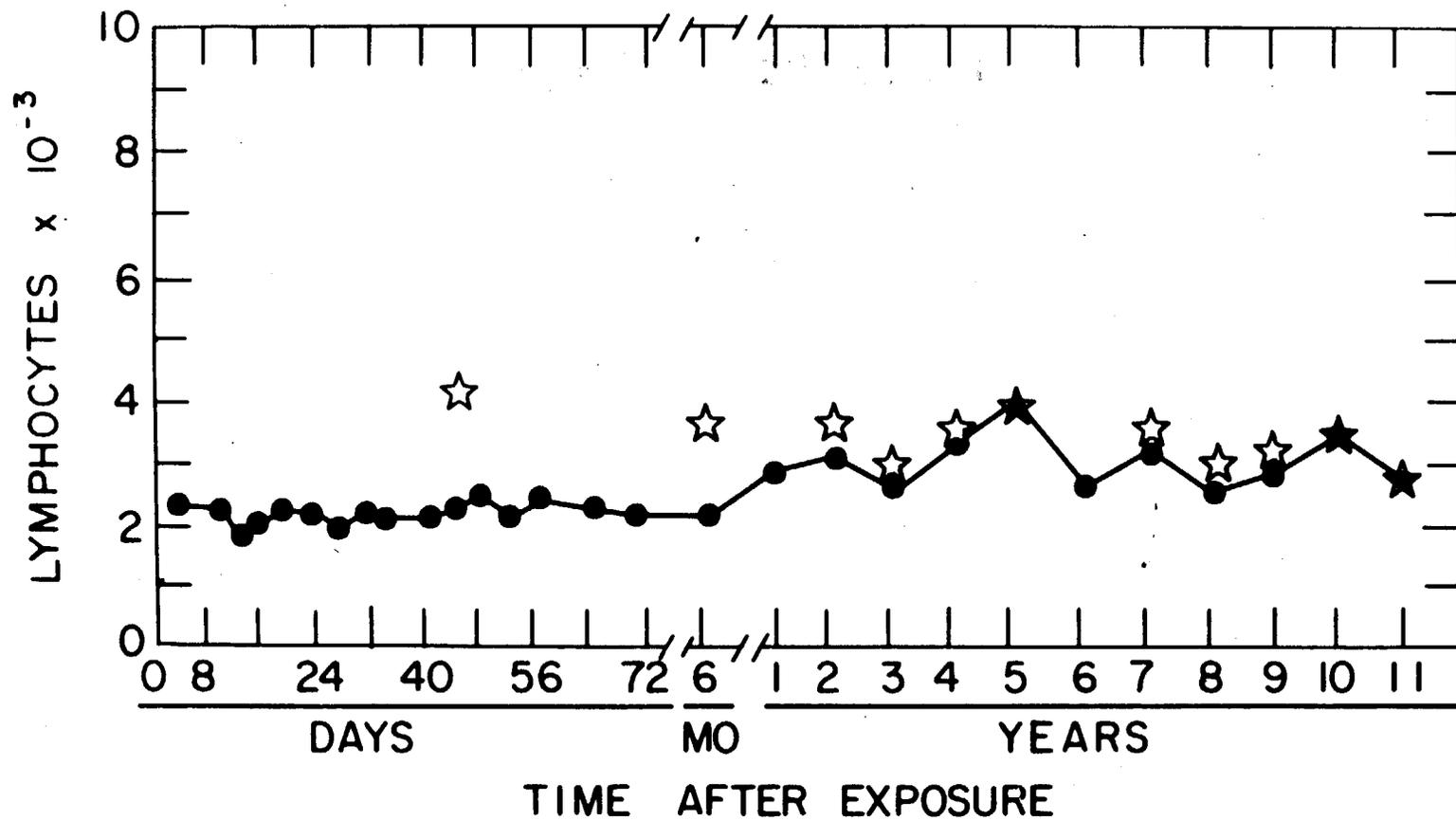


FIGURE 5. Mean lymphocyte counts of exposed Rongelap people from time of exposure through 11 years post exposure. Stars represent mean values of comparison population.

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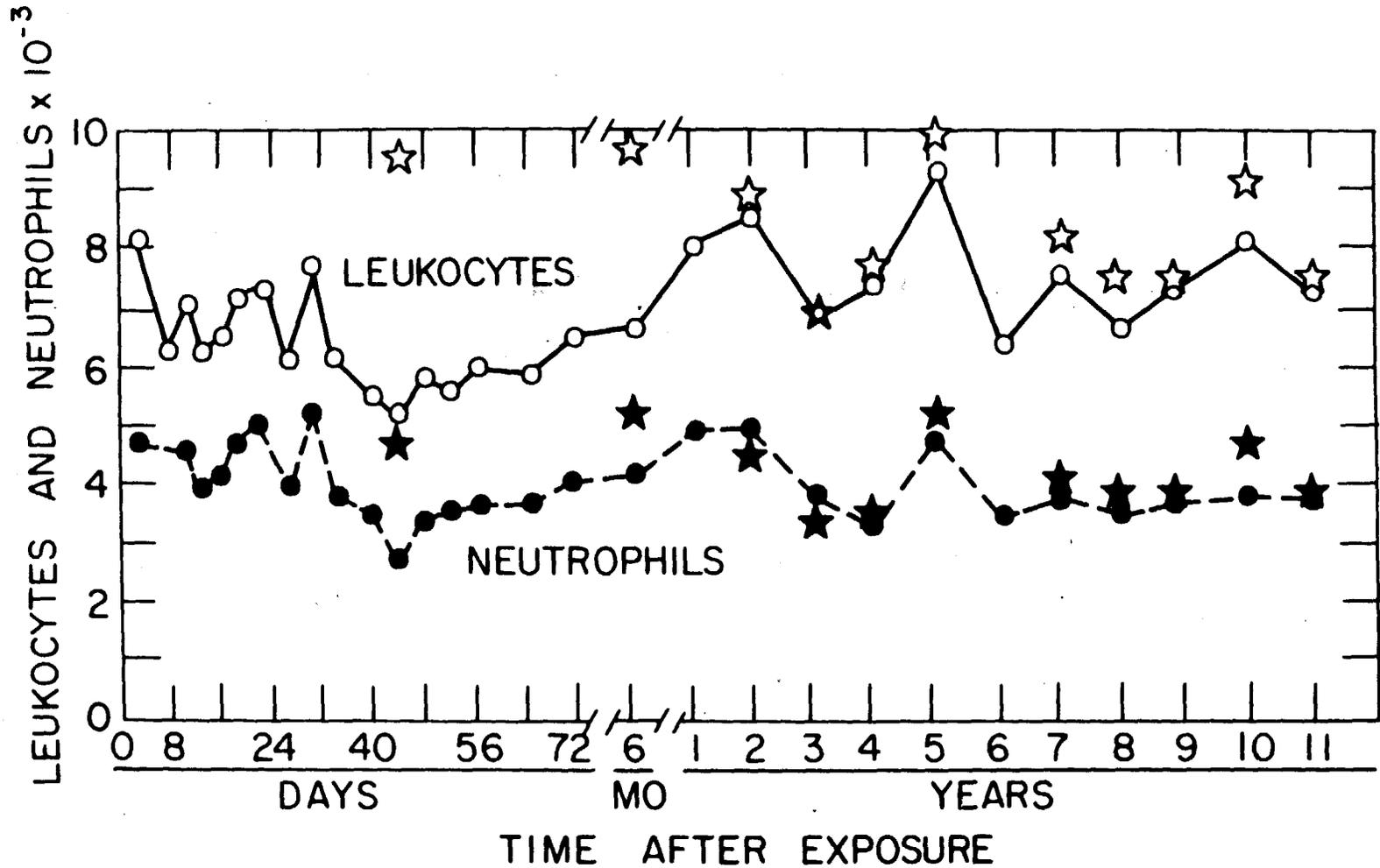


FIGURE 6. Mean neutrophil and white blood counts of exposed Rongelap people from time of exposure through 11 years post exposure. Stars represent mean values of comparison population.

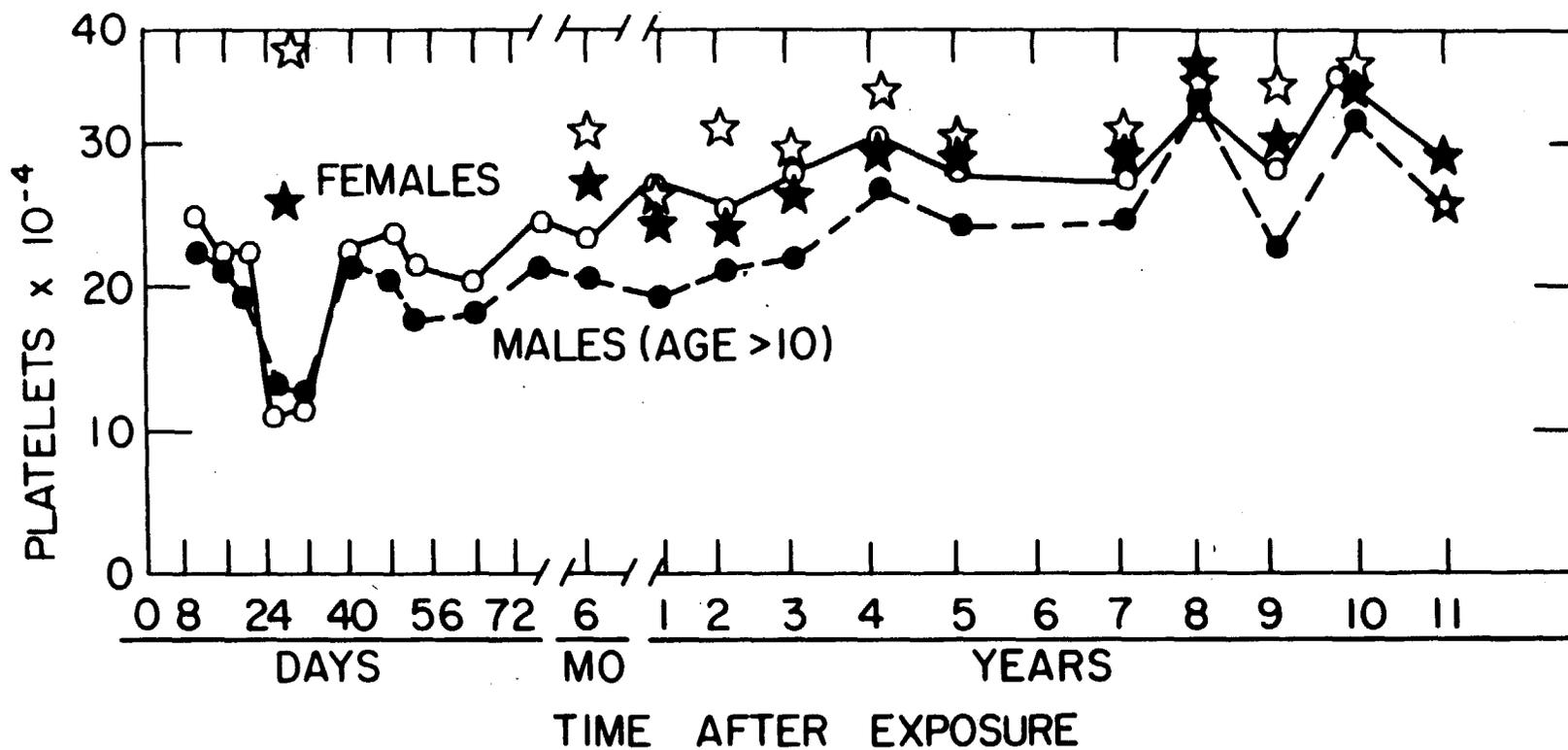


FIGURE 7. Mean platelet values of exposed Rongelap people from time of exposure through 11 years post exposure. Stars represent mean values of unexposed comparison population.

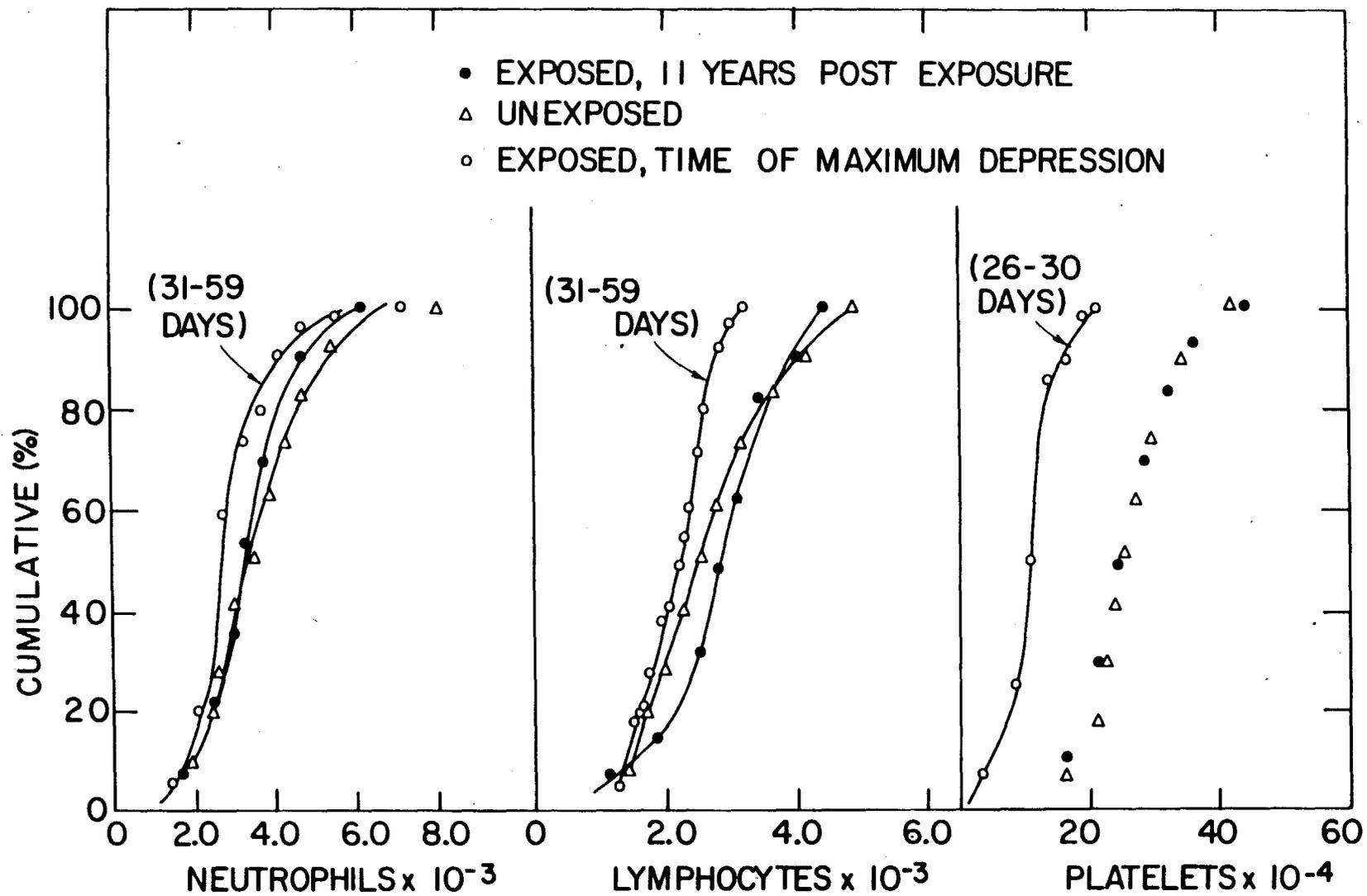


FIGURE 8. Cumulative percent distribution curves for neutrophils, lymphocytes, and platelets, 1965.

levels, hemoglobin, hematocrit, and RBC are similar in both groups. Sedimentation rates are faster than those seen in the Caucasian populations. The reasons for this are not readily apparent. Serum protein values continue to remain about the same for both groups. The only noticeable difference between the children of exposed and those of unexposed parents was in the slightly higher platelet levels in children of exposed parents. (Males +14%, and males +10%). Over the past four years this has been generally true, especially in the females.

Studies in Progress

Chromosome studies on a large number of smears obtained from peripheral blood cultures in the Marshallese are in the final stages of processing at the Cancer Research Institute in Boston. It is expected that a complete report of these findings will be forthcoming in the near future.

Further blood volume studies were done on 6 Caucasian people living in the Marshall Islands during the past survey. Tritiated water was used for determination of lean body mass as related to blood volume and ^{51}Cr for red cell mass determinations. These data continue to show that people living in the Islands, both Marshallese and Caucasians have reduced blood and red cell volumes.

SUMMARY AND CONCLUSIONS

The medical survey of the Rongelap people who had been exposed to radioactive fallout 11 years ago was conducted in March 1965, and during the following September a thyroid resurvey was carried out. This interim report summarizes the major findings, and details will be included in the more comprehensive 11 and 12 year report following the forthcoming survey in March 1966.

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The recent survey revealed that the general health and nutrition of the Rongelap people had been satisfactory, and that only minor epidemics of influenza and diarrhea had occurred. One death occurred in a 76 year old woman in the exposed group; pneumonia complicating arteriosclerotic heart disease and senility. No radiation connection was apparent. Three deaths occurred in older people in the unexposed population. Birth rate in the exposed group paralleled that in the unexposed group. Three miscarriages in the unexposed women had occurred, but none were reported in the exposed women. Physical abnormalities are tabulated for both adults and children in the report. There were no significant differences of diseases or abnormalities noted between the exposed and unexposed populations, except for the occurrence of additional thyroid lesions in the exposed population. Residual "beta burns" had changed little in appearance in the past few years, except for a slight increase in pigmented nevi in some cases in the burned areas. Hematological studies showed that for the first time since exposure the average white cell and platelet levels were about the same in the exposed as in the unexposed groups. Sedimentation rates were characteristically faster in the Marshallese than in Americans but with no differences noted between the exposed and unexposed groups. The cause of this faster sedimentation rate is not known. Chromosome studies are being completed and will be reported in the near future.

Preliminary analyses of whole body counts showed that ¹³⁷Cs levels were about the same this year as noted four years ago, indicating that equilibrium of body burdens for ¹³⁷Cs with environmental sources of this isotope had been attained.

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Elevated protein-bound iodine levels, characteristic of the Marshallese, have been further evaluated. The finding of an increased iodoprotein fraction in the serum of these people is believed to partly explain the increase in PBI levels. Urinary excretion of iodine was in the normal range in the Marshallese. ¹³²I thyroidal uptake studies showed a puzzling depression in uptake of the thyroid to the isotope to about one-half normal levels. There was also a decreased excretion of the isotope.

Definite nodules of the thyroid were noted in 11 people, minimal changes in five others, and hypothyroidism in two cases. All but one case occurred in the more heavily exposed population (55 living of the original 64 persons) who received about 175 rads of whole body gamma radiation, fallout burns of the skin, and internal absorption of fission products. One case with a nodule was noted in an adult woman in the smaller Rongelap group (16 of 18 living) that had received less than half the exposure of the other group. In the more heavily exposed group thyroid pathology developed in 58% of children exposed at less than five years of age. Five children and one adult (the first six cases) have had surgery. The nodules in the children proved to be benign adenomatous goiters, closely resembling goiter of iodine deficiency. The one adult case had a mixed papillary and follicular carcinoma with localized metastasis. She had a thyroidectomy (surgical plus radioiodine).

The radiation etiology in these cases appears to be reasonably certain in view of the following facts. (1) The thyroid glands received a substantial dose of radiation from radioiodines and external gamma radiation (adults about 300 rads, children about 700-1,400 rads). (2) The high incidence of thyroid pathology in the exposed group and lack of it in the unexposed people is most

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significant. (3) The diet is iodine sufficient with no known goitrogenic foods. In addition, it would be unusual to have such a high incidence of iodine deficiency goiter in the younger age group. (4) The correlation of thyroid pathology of the type reported here is well documented in animal and clinical studies. (16-26) The calculated average doses of radiation to the thyroid in the Marshallese appears to be somewhat low in relation to the incidence of thyroid pathology noted. However, variability of dose among the exposed must have been marked. A thyroid etiology for growth retardation noted in boys in the exposed group is strongly suggested by the finding of definite hypothyroidism in two of the most retarded boys in the exposed group. Growth response to thyroid hormone will test this hypothesis.

All of the more heavily exposed group, including the more recently discovered cases, have been started on prophylactic thyroid hormone treatment, in an attempt to prevent the development of further nodules and possibly induce regression of existing nodules. The rationale for this appears to be sound. (27-29)

The significance of the thyroid findings are twofold. First, in regard to radioactive fallout (close-in type), we are forced to modify our previous attitude in regard to the problem of internal absorption. Based on the fact that the Marshallese exposed to fallout had shown no detectible acute effects and until recently no late effects from absorption of fallout nuclides, the internal problem had been thought to be negligible compared with the external whole body gamma radiation. As a result of the present findings it will be necessary to revise upwards the seriousness of the internal hazard associated with fallout. Secondly, it has become increasingly evident that late effects

of irradiation of the thyroid gland (neoplasias, hypothyroidism) are much more common sequellae than had been previously supposed. The high incidence of thyroid pathology in the Marshallese emphasizes the caution with which radiation must be used clinically, particularly in regard to the use of radiiodines in children. The greater sensitivity of the child's gland to radiations is borne out by these findings.

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