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## TWELVE - MONTH POSTEXPOSURE SURVEY ON MARSHALLESE EXPOSED TO FALLOUT RADIATION

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## ABSTRACT

The Marshallese who were accidentally exposed to fallout radiation were studied for a one-week period 12 months after exposure. Complete physical examinations were made. Special eye examinations with photographic recording of the lens were performed. In addition, blood counts and selected laboratory studies were accomplished. The skin of some show slight depigmentation and scarring at the site of previous beta burns. Eyes revealed no lesions attributable to radiation. The neutrophil counts were back to the normal range. The platelets and lymphocytes showed a further increase above the six-month level but still were below the values for the control population.

# TWELVE-MONTH POSTEXPOSURE SURVEY ON MARSHALLESE EXPOSED TO FALLOUT RADIATION

## Introduction

On March 1, 1954, inhabitants of Rongelap and Utirik Atolls were exposed to significant amounts of radiation from fallout that occurred after detonation of a large nuclear device. The initial studies on the exposed human beings have been reported (1). The primary studies were terminated approximately 75 days after exposure at a time when skin lesions had healed; hematopoietic recovery was advancing rapidly; and the general health of the most heavily exposed group was excellent. At an earlier date, the least exposed group from Utirik (14 r) had been returned to their home atoll and further studies, other than intermittent collections of urine, were considered unnecessary. However, it was decided that intermittent continuing studies were essential on the more heavily exposed Rongelap group (175 r). At a meeting in the Division of Biology and Medicine, AEC, during July 1954, it was decided that a complete 6- and 12-month postexposure study should be performed (2). Intervals of subsequent studies would then be determined. The 6-month studies were performed by Bond et al. and reported (3).

At the 6-month follow-up study, all individuals were well. The skin lesions had healed. Only a few scars with little atrophy were observed. Three pregnancies had terminated with normal births. However, the mean values of all members of the leukocyte series and the platelets remained below the mean values for the control population, though the counts had increased somewhat over the last counts performed in May 1954.

## General History and Physical Examinations

### Procedures

Two physicians performed the physical examination, taking interval histories or enlarging on the past histories of the patients with the able help of English speaking Marshallese nurses. Examination included pelvic and rectal examination where indicated by history, age, or associated findings. Present weight and any change since the last examination were recorded for each individual. The special measurements for growth and development studies were again recorded for all children and adolescents through the age of 19 years. Three physicians conducted the examination of the skin of each subject. In this way, joint agreement was reached on the description and significance of all lesions. All lesions referable to the fallout were photographed, and other skin lesions of interest were photographed for comparison. In all, 87 individuals were examined.

### Clinical Findings

The interval histories revealed that the measles epidemic which had begun at about the time of the previous survey had run its course by November 1954, ultimately involving one-third of the nonadult population. There had been sporadic cases of chicken pox and a widespread incidence of impetigo. Nearly every youngster showed some evidence of recent impetigo, although only the cases with extensive involvement were listed on the chart.

The growth and development studies thus far reveal an interesting finding. The youngest children tend to fall within the average norms for their age groups when compared to the growth and development of American children as shown in Mitchell Nelson (4). However, in early childhood the children of this study tend to fall

behind so that most of them are in the low and very low percentiles for their age groups from the age of 5 or 6 years on.

Two children appeared to have chronic disease with primary findings of malaise and failure to gain weight. No diagnoses were immediately apparent. There was nothing to suggest irradiation as the cause. They were referred to the hospital for further study, particularly for parasitic infestation.

The findings shown in Table 1 give little indication of the actual improvement in the residual lesions. Of the 36 youngsters having initial lesions of the skin or scalp, only 11 had residual changes on the last survey. Although 10 youngsters still retained residua at this time, in every case the lesions were reduced in size and pigment variation, and in only one of these cases was there any suggestion of atrophy or scarring. This case, a 13-year-old boy, #26, has a 3-cm depigmented residual lesion

		Adults		Children	
		Male	Female	Male	Female
Skin lesions	initial	17	18	15	21
	first resurvey	2	3	5	6
	present	1	1	5	5
Interval disease	measles	0	0	6	8
	chickenpox	0	0	2	0
	impetigo	0	0	6	4
Generalized atherosclerosis	with heart disease and/or hypertension	2	3		
Luetic heart disease (?)			1		
Leprosy	arrested	1			
	(?) reactivated	1			
Bronchial asthma		1	1		
Pneumonitis	(?) Tbc.	1	2		
Pyorrhea		5	1		
Diabetes		1			
Mental deficiency		1			
Leukoplakia of oral mucosa		1			
Abdominal mass of unknown etiology		1			
Helix valgus		1			
Chronic otitis media		1			
Fungus disease	Tinea Cruris long standing	1			
	(?) Tinea versicolor 8 months duration				1
Eczematoid skin rash unknown etiology			1		
Failure to gain and malaise (?) parasites				1	1
Acute tonsillitis					1
Pulmonic systolic murmur grade ii (?) etiology					1
Lingua Nigra					1

on the dorsum of the right foot in which the skin is taut with a loss of the normal markings, suggesting atrophy. This lesion has decreased in size since the last survey.

Among the 17 of the 22 adult males who initially developed skin lesions from the fallout, all but 2 had cleared entirely by the time of the last resurvey. On this examination the individual, #79, who was initially felt to have had the most extensive lesions still showed residual changes. Nearly the entire scalp had initially epilated. At the time of the last survey, regrowth of hair was felt to be complete. However, on this examination, it was felt that the suboccipital hair was relatively sparse compared with the rest of the hair growth. No other abnormalities of this area were noted. The skin overlying the helix and occupying the fold behind the auricle of the ear remains depigmented, atrophic, and tightly bound down. A small central area 3 cm in diameter is rough and scaling.

There are 3 males with additional findings or diagnoses not related to the fallout which were noted since the last examination. A 38-year-old male, #16, had findings suggestive of pneumonitis, possibly of an acid-fast origin. Leukoplakia of the oral mucosa was found in a 66-year-old male, #29. The third instance of recent findings occurred in Lemmon, the oldest male in the series, #55. He was found to have a 4- x 6-cm hypogastric abdominal mass, the nature of which could not be determined at this time.

Initially, 18 adult females had skin lesions attributed to fallout. Only 3 of these individuals had visible lesions on the last examination. At present, only one of these women has any remaining skin change. She is a 35-year-old woman, #59, who has a 7- x 10-cm residual area of slight lichenification and hyperpigmentation on the back of her neck. This same woman was found to have signs of pneumonitis, possibly of acid-fast origin. She is now undergoing studies to identify the organism. An unusual papular eczematoid lesion was found on the back of the neck of a 68-year-old woman, #43. Initially, she had a fairly large lesion in this area attributed to the fallout. However, it had appeared well healed on the last survey, and the history was that the lesion had disappeared within 2 months of its onset.

The 2 women who were noted to be pregnant on the last survey have since delivered healthy babies without complications. The last baby was born January 3, 1955, after a full-term pregnancy, which indicates the time of conception to be about 3 or 4 weeks after the fallout. Of particular interest is the 39-year-old woman, #63, who had suffered a spontaneous abortion of a first trimester pregnancy in August 1954. She has since conceived and is at present in the fifth month of a normal pregnancy.

In summary, it was felt that the skin and scalp lesions which have persisted to this date have continued to regress satisfactorily except in 2 cases. These cases are the ones in which atrophy appears to be taking place. The present appearance of these lesions suggests the possibility of ulceration at a later date.

An interesting question is raised by the fact that in the 35 adults with initial lesions, only 2 have detectable residual lesions; whereas in the 36 youngsters originally involved, 10 have persisting, though clearing, lesions.

There were no other clinical findings evident on this examination which could be attributed to irradiation fallout of the Castle tests.

### Ophthalmological Survey

#### Historical Background

Ocular lesions produced by gamma and x-rays have been well known for many years (5, 6). These consist of epilation of brows and lashes, erythema and varying degrees of burns of the skin of the lids with subsequent scarring, conjunctivitis, and

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the formation of radiation lens opacities. In general, ocular lesions may be produced by either regional or whole-body radiation. However, the cataractogenic dose is greater than the minimum whole-body dose of gamma radiation (7). The cataracts produced tend to occur 2 to 4 years after radiation, are morphologically distinct, and begin as small plaque-like opacities beneath the posterior capsule at the posterior pole of the lens (8). The lesions seen clinically are thought to be due to the ionizing effects of radiation on the equatorial lens epithelium with migration of the injured cells to the posterior pole of the lens (9).

Ocular lesions produced by the therapeutic use of beta emitters have also been recently described (8, 10). These are blanching, scarring, and late telangiectasia of the conjunctival and episcleral vessels and the formation of radiation cataracts. These cataracts tend to occur from 2-1/2 to 6 years after treatment and are indistinguishable from those produced by gamma and x-rays. They are produced by relatively small doses of rather hard beta with as little as 4 g/sec having been reported (11). It is of interest here that beta applicators have been widely used in the treatment of recurrent pterygia (12).

The ocular lesions occurring in the survivors of the Hiroshima and Nagasaki explosions have been reviewed and reported from time to time since 1945 (13-17). The immediate lesions were thought to be those due to blast and those secondary to bone marrow damage and for the most part consisted of retinal hemorrhages. The lesions occurring later were confined entirely to those in the lens and occurred from 6 months to 2-1/2 years after exposure. In a recent report, Sinskey has recorded an incidence of lens opacities of 47 percent in those exposed at 400 to 1800 meters from ground zero and only 10 percent in the control groups (18). He considered radiation cataract to consist of any plaque-like opacity beneath the posterior capsule without regard to its effect on vision. Of 154 survivors with lens changes, 129 had vision of 20/25 or better. He states further that many of the opacities could be seen only with the slit lamp and could not be seen with the ophthalmoscope. He attempted to correlate the development of lens opacities with the degree of epilation and the type of shielding and, thus, to establish the dosimetry of radiation received.

Cogan, Donaldson, and Reese reviewed the histology of radiation cataracts produced by x-rays and gamma rays, and induced by atomic explosions and cyclotrons. They found no substantial difference in cataracts produced by these four means, but were able to distinguish cataracts due to radiation from those due to other causes (9).

### Present Study

This report is concerned with the results of the eye examinations of 86 natives of the Marshall Islands exposed to a fallout of radioactive material and 94 controls of similar age groups who were not exposed. The exposed individuals had been previously examined 2 months after the accident by Colonel Austin Lowery, MC, USA, who found no lesions present which might be attributed to radiation.

### Methods

All exposed personnel as well as controls were examined on Majuro. The controls for eye and blood were identical.

Vision was tested in adults with the standard Snellen letter chart, and in children and adults unable to read English, with the E chart. All patients were examined grossly with a hand light and ophthalmoscope, and their pupils dilated with a combination of 1 percent cyclogyl and 10 percent neosynephrine. When maximum dilatation had been attained, the patients were re-examined with the Goldman slit lamp and the giant

ophthalmoscope. All anterior segment lesions of any significance were photographed with the Donaldson stereoscopic camera. The findings were recorded and 2 percent pilocarpine was instilled in both eyes. Eighty-six people from Rongelap and Ailinginae and 94 controls from Majuro of similar age groups were thus examined.

### Results

The results of these examinations for the patient and control groups are shown in Tables 2 and 3. No clinical disorder was present in the eyes of 48 or 55.8 percent of the patients and in 43 or 45.7 percent of the controls.

Pterygia and Pinguecula -- Pterygia, either unilateral or bilateral, were the most common findings and occurred in 23 or 26.7 percent of the exposed patients and in 18 or 19.1 percent of the control group. Pterygium occurred most commonly in the age groups ranging from 40 to 65, and in no instance did it occur in individuals less than 20 years of age. Pinguecula, which are sometimes considered to be precursors of pterygia, occurred in 8 patients and 5 controls. These appeared most common in the age group 31 to 40 years and, again, were not seen in individuals less than 20 years of age.

Cataracts -- Lens opacities were noted in the eyes of 14 or 16.2 percent of the exposed individuals and in 14 or 14.9 percent of the control group. In both groups, the lens opacities were most common at age 51 to 65 years and were predominantly of the senile type. All the lens opacities seen could be classified as either congenital, presenile, or senile. There was no instance of cataract characteristic of those seen following known radiation injury of the lens.

Corneal Pigmentation -- Corneal pigmentation was present in 4 of the exposed individuals and in 22 of the controls. The pigment was brown and seemed to lie in the epithelial cells of the cornea. It usually occurred either as a mottled peripheral band around the lower half of the cornea, decreasing in density towards the center of the cornea, or as two triangles in the palpebral portion of the cornea, with the bases of the triangles adjoining the limbus and the apices pointing towards the center of the cornea.

	Patients*		Controls**	
	No.	Percent	No.	Percent
1. No clinical disorder	48	55.8	43	45.7
2. Corneal pigmentation	4	4.6	22	23.4
3. Pterygium	23	26.7	18	19.1
4. Pinguecula	8	9.2	5	5.3
5. Cataract	14	16.2	14	14.9
6. Healed choroiditis	2		2	
7. Strabismus	1		0	
8. Retinal scars	1		2	
9. Macular degeneration	3		0	
10. Arcus senilis	4		4	
11. Corneal scars	2		2	
12. Corneal dystrophy	0		1	
13. Diabetic retinopathy	0		2	
14. Traumatic ptosis	0		1	
15. Pigmented nevus	0		1	
16. Retinal arteriosclerosis	1		1	

\*Total patients examined - 86.  
\*\*Total controls examined - 94.

In many instances, the pigment extended 2 to 3 mm out onto the cornea from either side. The appearance in general was no different from that seen in corneal pigmentation occurring in American negroes.

Miscellaneous Findings -- The remainder of the findings were essentially what one would expect in examining patients of a comparable age group sample from the general population. There were 2 corneal scars, 3 cases of senile macular degeneration, 4 with arcus senilis, 2 with healed choroiditis, and 1 case each of strabismus and retinal scarring. There was nothing unusual or distinctive about any of these lesions. Evidence for retinal burns due to direct observation of the fireball was lacking.

Disorder		Age in years						
		0 - 10	11 - 20	21 - 30	31 - 40	41 - 50	51 - 65	>66
Number examined	patients	30	13	10	12	8	5	8
	controls	28	15	16	12	9	7	7
1. No clinical disorder	patients	30	8	6	4	0	0	0
	controls	24	6	8	3	1	1	0
2. Corneal pigmentation	patients	0	2	0	1	0	1	0
	controls	3	7	3	4	4	1	0
3. Pterygia	patients	0	0	1	5	8	3	6
	controls	0	0	3	3	4	4	4
4. Pinguecula	patients	0	0	1	5	1	0	1
	controls	0	0	1	3	1	0	0
5. Cataract	patients	0	0	0	2	1	4	7
	controls	1	0	2	0	2	5	4
6. Healed choroiditis	patients		1			0		1
	controls		0			1		1
7. Strabismus	patients						1	
	controls						0	
8. Retinal scars	patients		0		1		0	0
	controls		0		0		1	1
9. Macular degeneration	patients					2		1
	controls					0		0
10. Arcus senilis	patients				1		0	3
	controls				0		1	3
11. Corneal scars	patients		1		1			
	controls		2		0			
12. Corneal dystrophy	patients					0		
	controls					1		
13. Diabetic retinopathy	patients			0				0
	controls			1				1
14. Traumatic ptosis	patients		0					
	controls		1					
15. Pigmented nevus	patients		0					
	controls		1					
16. Retinal arteriosclerosis	patients						1	0
	controls						0	1

## Comment

The high incidence of negative examinations occurring in the age group of less than 21 years and the low incidence of negative examinations after age 40 in both the exposed patients and control group indicate that the majority of the lesions encountered are those accompanying the aging process. In general, this is what one finds in our population.

The high incidence of pterygium and pinguecula encountered in both groups has been noted previously in the inhabitants of coral islands and also in service personnel who have returned from duty on these islands. It is thought that the combination of intense sunlight, salt water, and coral dust serve as an irritant to produce the lesions. It is of interest that beta applicators have been widely used in this country in the treatment of pterygia. Had the exposed individuals suffered an appreciable ocular effect from the beta component of the fallout, one might expect either a decreased incidence of pterygium or a characteristic change in the appearance of the lesion. However, such was not the case. Pterygia were present in 26.7 percent of the exposed group and in only 19.1 percent of the control group. In addition, there was no evidence of shrinkage or avascularity of the lesion in the exposed group as might be expected.

The over-all incidence of cataract in the groups examined seemed quite high but there was agreement between the two, an incidence of 16.2 percent being observed in the exposed population and 14.9 percent in the control group. Although there are no figures available giving the incidence of cataract in the population of these islands, we had been previously told that a high incidence should be expected (15). All lens opacities seen could be classified as congenital, presenile, or senile. There was no instance of radiation cataract. It seems unlikely that any of these patients will develop lens opacities from a total-body dose of 175 r of gamma irradiation. The contribution of beta to this gamma dose is small when the rapid fall off in beta dose at the depth of the lens is considered.

The corneal pigmentation was an interesting finding, particularly in view of the transient pigmentation of the finger and toenails previously noted. However, it seems much more likely that this is a racial characteristic of pigmented individuals rather than a product of radiation.

## Summary

1. The results of the eye examinations of 86 natives of Groups I and II exposed to a fallout of radioactive material as a result of the recent incident are reviewed.
2. These results are compared with those of the examinations of 94 native Marshallese of similar age groups who were not exposed.
3. No significant difference in the incidence of ocular lesions was noted between the two groups.
4. No evidence of ocular injury due to fallout could be demonstrated in the exposed individuals.
5. There was no evidence of retinal burns due to possible observation of the fireball.

## Hematologic Survey

### Methods

Procedures used were identical to those described in the initial report (1). It was not possible to get the same control population for study again. Accordingly, with the exception of some platelet studies, the 6-month survey hematologic values of the control population are used for comparison.

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Table 4. Rongelap group and control blood counts by day and by age.

Postexposure day	WBC ( $\times 10^3$ )		Neutrophils ( $\times 10^3$ )		Lymphocytes ( $\times 10^3$ )		Platelets ( $\times 10^4$ )			Monocytes ( $\times 10^2$ )		Eosinophils ( $\times 10^2$ )	
	<5	>5	<5	>5	<5	>5	Male		Female	<5	>5	<5	>5
							<10	>10					
3	9.0	8.2	6.4	4.7	1.8	2.2	-	-	-	0.8	0.3	0.1	0.7
7	4.9	6.2	-	-	-	-	-	-	-	-	-	-	-
10	6.6	7.1	3.5	4.5	2.6	2.1	28.2	22.7	24.9	2.9	1.7	1.6	1.6
12	5.9	6.3	3.5	3.9	2.1	1.7	-	-	-	4.2	5.4	1.9	1.9
15	5.9	6.5	3.2	4.1	2.4	1.9	27.1	21.3	21.7	3.0	2.3	1.1	1.3
18	6.7	7.2	3.4	4.7	2.4	2.1	21.8	19.1	21.8	2.7	1.7	3.5	1.6
22	7.0	7.4	4.3	5.0	2.6	2.1	16.8	14.6	15.2	1.9	2.0	2.3	1.8
26	5.7	6.1	3.0	3.9	2.3	1.8	13.2	12.9	10.9	1.9	1.6	1.8	1.3
30	7.6	7.8	4.0	5.3	3.2	2.1	14.1	12.3	11.8	1.5	0.9	3.4	2.2
33	6.5	6.2	3.1	3.8	3.2	2.0	17.9	16.6	15.1	1.7	1.6	2.6	2.2
39	5.7	5.5	3.0	3.3	2.6	2.0	25.5	22.0	22.4	0.9	0.9	0.5	1.0
43	5.2	5.2	2.0	2.6	2.9	2.3	26.8	20.9	23.2	1.1	1.1	1.4	0.8
47	5.9	5.8	2.6	3.3	3.1	2.4	24.6	20.6	23.9	1.0	1.0	1.1	0.5
51	6.7	5.6	2.6	3.5	3.4	2.1	22.1	17.5	21.2	2.5	1.6	0.8	0.7
56	7.0	6.0	3.5	3.5	3.7	2.4	-	-	-	1.7	1.2	-	-
63	7.7	6.0	3.9	3.6	3.7	2.3	23.1	18.2	20.2	0.5	0.9	0.3	0.6
70	7.6	6.5	3.8	4.0	3.3	2.2	-	-	-	-	-	3.4	1.9
74	-	-	-	-	-	-	26.2	21.7	24.7	-	-	-	-
185	8.5	6.6	4.6	4.2	3.6	2.2	24.4	20.3	23.2	1.4	1.1	2.5	1.6
Initial Majuro controls	13.2	9.7	4.8	4.8	7.4	4.1	41.2	25.8	36.5	2.0	2.0	9.5	4.7
6-mo. survey controls	-	-	-	-	-	-	35.0	27.3	30.9	-	-	-	-
12-mo. survey controls	-	-	-	-	-	-	37.5	24.5	29.4* (24.0)**	-	-	-	-
Day 400	10.1	8.1	4.7	4.8	4.6	2.8	26.6	19.5	27.6	0.7	1.3	6.7	2.8

\*Excluding pregnancy.

\*\*Pregnancy only.

Table 5. Ailinginae group mean blood counts by day and by age.

Postexposure day	WBC ( $\times 10^3$ )		Neutrophils ( $\times 10^3$ )		Lymphocytes ( $\times 10^3$ )		Platelets ( $\times 10^4$ )			Monocytes ( $\times 10^3$ )		Eosinophils ( $\times 10^3$ )	
	<5	>5	<5	>5	<5	>5	Male		All ages	<5	>5	<5	>5
							<10	>10					
3	6.0	7.0	3.0	5.0	2.8	2.2	-	-	-	0.8	1.6	0.5	0.4
7	5.5	6.8	-	-	-	-	-	-	-	-	-	-	-
10	6.3	7.3	4.2	4.2	1.9	2.2	22.5	22.6	20.9	3.8	2.1	2.6	1.6
12	6.3	7.6	1.8	4.7	3.1	2.2	-	-	-	3.4	5.8	4.4	2.6
15	7.1	7.0	2.3	4.5	4.2	2.2	29.0	20.2	24.6	3.7	2.6	2.3	1.4
18	6.8	7.8	2.9	5.0	3.5	2.4	27.5	21.7	24.9	2.3	1.5	3.2	2.3
22	8.9	8.7	5.3	5.4	2.7	2.9	23.5	17.0	22.9	1.5	2.4	5.8	2.4
26	8.4	7.0	4.8	4.4	3.2	2.2	20.0	13.8	17.4	2.3	2.4	0.6	1.6
30	9.6	8.6	5.3	6.2	3.7	2.0	19.5	12.8	18.2	1.9	1.9	4.1	2.0
33	7.7	7.8	3.3	5.2	3.5	2.2	24.0	15.8	22.7	2.8	2.2	6.0	1.9
39	7.5	6.2	2.9	4.2	4.7	1.9	26.5	20.8	27.0	1.1	1.7	2.7	1.6
43	6.9	6.5	2.7	3.6	3.9	2.7	28.0	19.6	25.3	0.6	1.4	2.8	0.6
47	7.3	6.7	3.5	3.8	3.4	2.7	27.0	20.0	26.1	2.2	1.9	1.5	0.7
51	8.4	6.3	3.8	3.6	4.0	2.2	32.0	18.2	25.0	2.7	2.8	2.2	1.0
54	4.6	6.3	2.8	3.5	3.2	2.5	37.0	19.8	23.8	1.5	1.9	1.8	0.8
185	7.7	6.5	4.8	3.9	2.7	2.2	25.2	19.2	23.9	1.1	1.4	1.5	2.2
Majuro controls	13.2	9.7	4.8	4.8	7.4	4.1	41.2	25.8	36.5	2.0	2.0	9.5	4.7
Day 400	11.1	7.8	4.2	4.7	6.5	5.6	38.7	21.4	28.3	1.0	1.1	1.7	2.2

Day	Rongelap			Ailinginae			Utirik			Rongerik
	<15 (M)	>15 (M)	All ages (F)	<15 (M)	>15 (M)	All ages (F)	<15 (M)	>15 (M)	All ages (F)	Adults (M)
22	37.5	43.9	39.0	37.5	43.7	39.2				
23										45.7
26	36.3	41.6	37.5	36.5	43.2	36.8				
28										44.5
29							39.9	45.1	39.4	
30	37.9	42.2	37.1	36.0	44.6	36.7				
33	37.4	42.2	36.8	35.5	43.8	37.3				45.4
39	37.8	42.4	37.4	35.0	45.6	37.4				46.7
43	37.3	41.8	37.6	36.0	45.2	36.8				44.0
47	39.0	43.4	38.3		46.5	40.2				
185	38.0	41.7	38.2	37.5	40.1	37.3				
Controls	39.6	46.0	39.9	39.6	46.0	39.9	39.6	46.0	39.9	44.9
400	37.5	41.1	36.9	33.0	44.6	36.2				

	Sex	Age	Majuro control	Rita control	12-mo. survey
WBC ( $\times 10^3$ )	combination	<5	13.2	11.1	
		>5	9.7	9.6	
Neutrophils ( $\times 10^3$ )	combination	<5	4.8	5.5	
		>5	4.8	5.3	
Lymphocytes	combination	<5	7.4	4.9	
		>5	4.1	3.6	
Platelets ( $\times 10^4$ )	male	<10	41.2	35.0	37.5
		>10	25.8	27.3	24.5
		all ages	36.5	30.9	27.2
Monocytes ( $\times 10^3$ )	combination	<5	2.0	1.9	
		>5	2.0	1.8	
Eosinophils	combination	<5	9.5	4.3	
		>5	4.7	4.7	
Hematocrit (Percent)	male	<15	39.6	37.1	
		>15	46.0	43.5	
		all ages	39.9	39.6	
No. of individuals.					
		<5	Majuro 24	Rita 16	12-mo. survey 3
		All ages			
	Male	>5	91	66	47
		<10	16	13	5
		>10	40	26	12
		<15	17	15	5
		>15	39	24	12
	Female		59	43	33

## Results

In Tables 4 to 7, the findings of the previous and present studies are tabulated. The initial and 6-month studies are included so that it is not necessary to refer to previous reports.

Study of these tables reveals that the mean values for neutrophils have returned to the level of the control population. However, all other members of the leukocyte family are below the control population but higher than at the 6-month survey. The mean platelet count is still below that for the control population but also higher than at the 6-month survey.

Although the blood counts have not yet returned to normal levels, the levels are merely statistical expressions of differences and are not to be construed as representing a serious condition but only a manifestation of delayed recovery of peripheral blood counts in man.

## Conclusions

In general, the Marshallese have recovered satisfactorily from the radiation injury received during March 1954. Visible residual effects are limited to a few areas of depigmentation and two small, distinct scars from radiation burns, one of which will possibly require plastic repair.

Neutrophil values have returned to the normal range of the control population. All other members of the leukocyte population and the platelets remain below the levels for the control population; however, levels are higher than at 6 months and, presumably, will soon be in the normal range.

## Recommendations

Plastic consultation and possible plastic repair should be made available for the ear lesion.

Further large scale follow-up studies are recommended at approximately 18-month intervals. Intervals for excretions of radionuclides should be adjusted according to the 12-month study.

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The clinical studies were performed and written up by Lt. David Griffin (MC) USN, Major Kent Woodward (MC) USA, and Dr. C.L. Dunham. The ophthalmologic survey was conducted and written up by Lt. Cdr. S.D. McPherson (MC) USNR. The hematologic data were analyzed by Mr. Hymen Hechter of USNRDL.

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