Reprinted from RADIATION RESEARCH, Supplement 1
Academic Press Inc. *Printed in U.S.A.*

RADIATION RESEARCH, SUPPLEMENT 1, 280–295 (1959)

Effects of Fallout Radiation on a Human Population[1]

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I. INTRODUCTORY REMARKS

This report concerns the status of the 82 Marshallese people from Rongelap Atoll 4 years after their accidental exposure to significant amounts of fallout radiation.

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The accident occurred after the detonation of a large thermonuclear device during experiments at Bikini in the Pacific Proving Grounds. An unpredicted shift in winds caused deposition of significant amounts of fallout on four nearby inhabited Marshall Islands and on 23 Japanese fisherman aboard their fishing vessel, the Lucky Dragon. Sixty-four inhabitants of the island of Rongelap, 105 nautical miles away from the detonation, received the largest fallout—an estimated dose of 175 r whole-body γ-radiation, β-ray lesions of the skin and epilation from contamination of the skin, and slight internal absorption of radioactive material. Eighteen Rongelap people away on a nearby island (Alinginae), where less fallout occurred, received about 69 r. [Discussed in earlier reports (*10*, *12*) but not in this report were 28 American servicemen on Rongerik Atoll who received about 70 r and 157 Marshallese on Utirik Atoll who received about 14 r.] The people were evacuated to Kwajalein in the Marshall Islands by air and sea about 2 days after the accident. Extensive examinations were carried out during the first 3 months after exposure, and these findings have been reported in detail (*12*). In view of the radioactive contamination at their home island of Rongelap, the people were subsequently moved to a village provided for them at Majuro Atoll where further follow-up medical surveys were carried out and reported on at the following periods after exposure: 6 months (*5*), 1 year (*13*), 2 years (*9*), and 3 years (*10*). Details of the 4-year findings are being published (*11*). By June, 1957, the radioactivity levels on Rongelap were considered safe for habitation, and the people were returned to their home island where the present examinations were carried out.

The medical team for the four-year survey consisted of 22 doctors and technicians including personnel from Brookhaven National Laboratory, the U. S. Public Health Service, the Naval Medical Research Institute, the Naval Radiological Defense Laboratory, and Marshallese from the Trust Territory medical group.[6]

II. EXAMINATIONS

A. History and Physical Examinations

Histories were taken by a Marshallese practitioner, with particular emphasis on the interval history during the past year. Complete physical examinations carried out on both exposed and comparison populations included examination of the skin, with color photography of selected lesions; ophthalmological studies including slit-lamp observations, visual acuity, and accommodation; growth and development studies in children (less than 20 years of age) including anthropometric studies; electrocardiographic records on all subjects over 40 years of age; and X-ray examinations as deemed necessary.

[6] Survey material presented represents findings of the entire team. This paper was not written by all members of the team, and the conclusions presented do not necessarily represent their point of view. Detailed findings of the 4-year survey are being published (*11*).

B. Laboratory Examinations

Hematological examinations included three complete blood analyses (total white counts, differential, platelet counts by phase microscopy, and hematocrit by the microhematocrit method) done at about weekly intervals. Sera were obtained for total protein determinations by proteinometer, protein-bound iodine, and starch electrophoresis studies. An intestinal parasite survey of the population was carried out by examining the stools of 190 people for ova and parasites. Pooled urines and a few sufficiently large samples from single individuals were obtained from both the exposed and the unexposed groups for radiochemical analyses of Cs^{137} and Sr^{90}. Whole-body counts with γ-ray spectroscopy were obtained on board the ship by placing the individuals in a steel room with 4-inch-thick walls, with the necessary crystals and electronic equipment attached.

C. Difficulties Associated with Examinations

Several difficulties associated with the examinations of the Marshallese should be mentioned:

1. *The language barrier* made the examinations difficult, since very little English is spoken by the Marshallese. Sufficient interpreters were available to assist the medical team, however.

2. *The lack of vital statistics* to be found on the Marshallese imposes a serious difficulty in interpretation and evaluation of the medical data.

3. *The uncertainty of exact ages* of some of the Marshallese, largely due to lack of written birth records, came to light during the past examinations. It is hoped that these ages may be established more firmly so that the growth and development studies in the children may be placed on a firmer basis.

4. *Difficulties arose in obtaining what could be considered as entirely adequate populations to act as comparison groups* for the irradiated people. Three separate groups have been used for comparison in the past. Though each group matched well for age and sex, the first two groups proved unsatisfactory owing to difficulties in locating the people for subsequent examinations. Fortunately, by 3 years post-exposure, it was found that a large group of Rongelap people who had been away from their home island at the time of the accident had returned to live with their fellow Rongelap people. Because they were of the same stock and matched reasonably well for age and sex, these people were uniquely appropriate to serve as a comparison population. They returned to Rongelap with the other Rongelapese and were used again as the comparison population for the 4-year survey.

III. RESULTS

The description of the present status of the Marshallese people will be preceded by a brief summary of the past findings. During the first 24 to 48 hours after exposure, about two-thirds of the Rongelap people experienced anorexia and nausea. A few vomited and had diarrhea. At this time many also experienced itching and

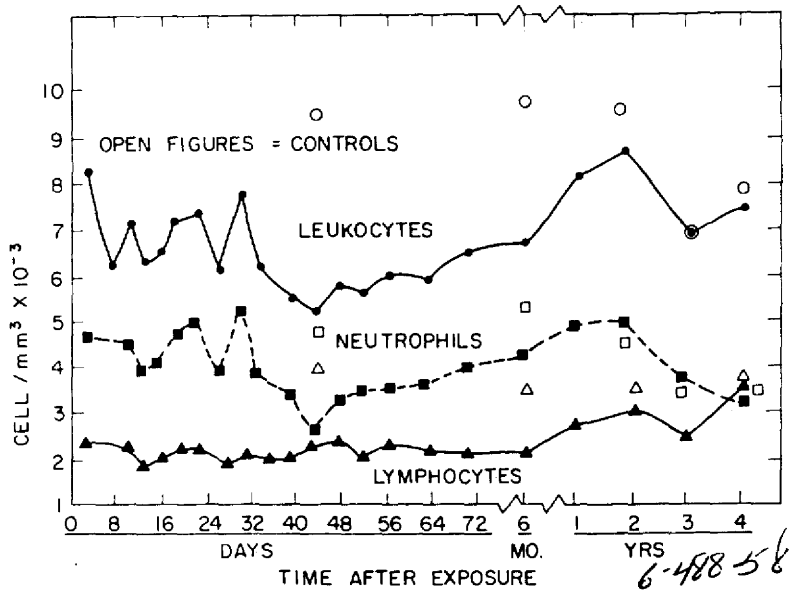

FIG. 1. Chronological changes in leukocytes, neutrophils, and lymphocytes in Rongelap people after exposure to 175 r of whole-body radiation from fallout. Points represent mean counts of population >5 years of age. Open points are mean counts of comparison population used at that time.

burning of the skin, and a few complained of lacrimation and burning of the eyes. Subsequent to this, the people remained asymptomatic until about 2 weeks after the accident, when cutaneous lesions and patchy loss of hair developed owing to β-irradiation of the skin. Hematological examinations showed increasing depression of peripheral blood elements, and radiochemical examinations of the urine revealed the presence of detectable radioactivity in the samples.

During the first few months many of the people showed a slight weight loss. It is not known if this was associated with irradiation effect or environmental change.

A. Hematological Findings

Figures 1 and 2 show chronologically the changes (in absolute mean counts) that have occurred in peripheral blood elements of the 64 Rongelap people who received the largest dose of radiation. Similar but less marked changes have occurred in the 18 Rongelap people who were on Alinginae Atoll at the time of exposure.

1. White Blood Count

The leukocytes largely reflected the changes that occurred in the neutrophils (see Fig. 1) and will not be discussed separately. Unexplained changes in the mean

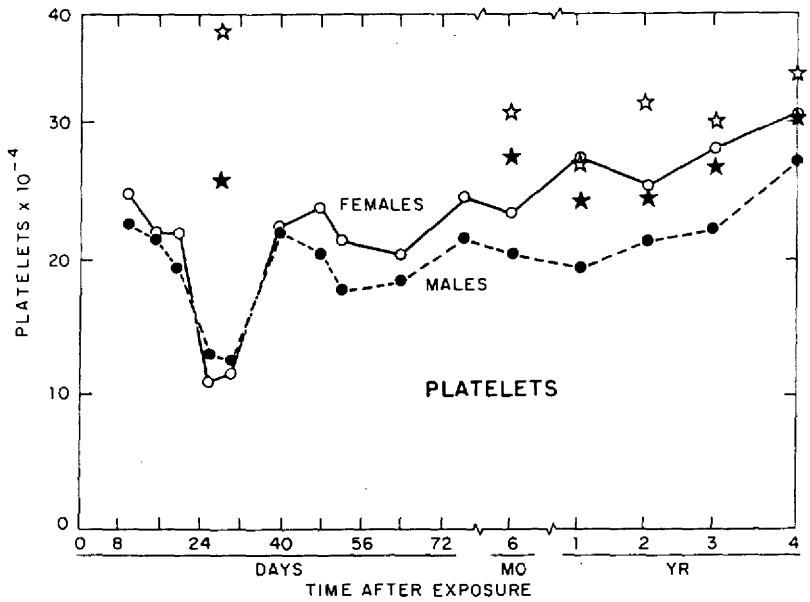

FIG. 2. Chronological changes in platelets of Rongelap people after exposure to 175 r of whole-body radiation from fallout. Points represent mean counts of males >10 years of age and females of all ages. Stars represent comparison population mean counts at that time.

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level of blood elements have occurred from year to year in both exposed and unexposed populations.

2. Neutrophils

During the first few weeks after exposure, the neutrophils fluctuated considerably, then gradually fell to a low of about 50% of the comparison population at about the sixth week (Fig. 1). Recovery was slow, and it was not until the 1-year examination that the counts returned to the comparison population level. They have been found to be essentially the same as the unexposed group at 1, 2, 3, and 4 years postexposure.

3. Lymphocytes

By the third day after exposure the mean lymphocyte level had fallen to about 55% in the adults and 25% in the children of the level of the unexposed comparison population (Fig. 1). The levels remained low longer than the neutrophils and have been very slow in recovering. There was little recovery by 6 months, but an upward trend has since occurred. After 3 years the lymphocytes were slightly below the mean level of the comparison population for all age groups, and distributional studies of individual counts showed more lower counts in the exposed groups. The 4-year study showed the highest level thus far attained (3600 cells/mm^3 compared

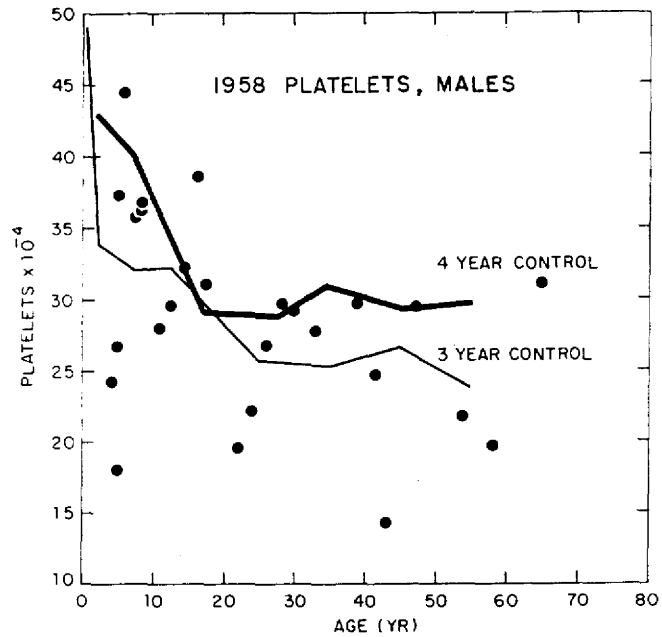

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FIG. 3. Scattergram of individual 1958 platelet counts, males, plotted against age with mean curves of the 3-year and 4-year comparison population males plotted according to age.

to 3700 cells/mm^3 in the unexposed people), and recovery of this blood element is considered almost complete. A scattergram of the individual counts plotted according to age and accumulative distribution curves, however, showed more of the counts to be low than in the unexposed population.

4. Platelets

There was a steady reduction in the platelets in the peripheral blood after exposure, reaching a low of about 30% of the unexposed group by the fourth week (Fig. 2). A rapid recovery trend was then followed by a fluctuating, slow recovery pattern, the males showing slower recovery than the females. Even at 4 years postexposure platelet production does not appear to have recovered completely. The counts were higher than a year ago, but compared with mean unexposed levels they were about 12% lower in the males (greater than 10 years of age) and 9% lower in the females. A scattergram (Fig. 3) shows individual counts in the males and the mean curve of the controls plotted against age. The counts are preponderantly below the control curve. This trend is not so marked in the females.

5. Eosinophils and Monocytes

Eosinophils and monocytes showed depression and recovery roughly paralleling that of the neutrophils. Eosinophilia is present in all the populations studied.

During the past survey the differential counts showed eosinophilia above 5% in about half of the people of both groups.

6. Hematocrit

Erythropoietic activity as evidenced by hematocrit readings has not shown any remarkable change since exposure. The values have been consistently on the low side of normal, according to American standards, particularly in the females in both exposed and unexposed people. The hematocrit readings after 4 years were about the same as found at 3 years and about equal to the comparison population level.

B. Physical Findings

1. Diseases

There have been no diseases, infectious or noninfectious, that could be related to irradiation effects. No antibiotics, blood transfusions, or other specific therapy has been used either prophylactically or therapeutically in the Marshallese, even during the acute period when maximum depression of the blood elements was noted. The incidence of diseases in both the exposed and comparison populations has been about the same. Even when leukocyte depression was greatest (the levels reaching about half of the levels of the comparison population at about 5 to 6 weeks postexposure) there was apparently no increased susceptibility to infection. An epidemic of upper respiratory infection that occurred at this time showed no greater incidence or severity in the exposed people compared to the unexposed. There was no bleeding associated with a maximum depression of platelets (11 individuals had platelet counts between 35,000 and 65,000). The people have since sustained epidemics of measles, chicken pox, upper respiratory infections, and gastroenteritis without untoward reactions. A limited study of the immune response at 3 years postexposure showed that the antibody response to tetanus toxoid antigenic stimulus was not significantly different in the exposed and unexposed people at that time. During the past year 5 exposed children and 1 unexposed child presumably had infectious hepatitis. No other serious illnesses were reported.

Three deaths have occurred in the exposed people. The first was in a 46-year-old man who died of hypertensive heart disease 1 year postexposure. He had had the disease at the time of irradiation. The second death occurred in a 78-year-old man at 2 years postexposure. He was a diabetic of long standing and died apparently of coronary heart disease. A third death occurred in April, 1958, in a 38-year-old man. (He was in the group that received 69 r.) Death was due to pneumonia complicating a severe case of chicken pox. In none of these cases was there any evidence that death was due to irradiation exposure.

2. Growth and Development Studies

Data on height and weight and bone age determinations for the 2- and 3-year surveys gave an impression of lag in growth and development in the exposed

children compared with unexposed children. In an attempt to obtain more accurate birth dates of the children on the 4-year survey, however, it was found that ages of some of the children which were thought to be established were in question. The absence of recorded birth information seriously complicates the determination of the accuracy of given chronological ages and dates of birth. More definitive evaluation of the data will be possible when verification of the birth dates is completed. Detailed geneological and biological histories are being compiled to establish the most probable birth date of each of the children. (Unfortunately the 1958 roentgenograms of the wrist and knee, intended for assessment of osseous maturation, were lost at sea.)

Longitudinal studies of incremental growth data and bone maturation studies over the period since exposure will be undertaken when ages of the children are more firmly established.

3. Ophthalmological Findings

Ophthalmological examinations including slit-lamp studies at yearly intervals have not revealed any opacities of the lens that might be associated with irradiation effects. No differences in visual acuity between exposed and unexposed people have been noted. The 3- and 4-year examinations revealed an increase in incidence of pterygium in the exposed population. Arcus senilis and senile cataracts are of slightly higher incidence in the exposed group but have not shown an increase since exposure. In general most of the Marshallese people examined have superior vision and accommodation compared to our standards. The incidence of glaucoma, myopia, retinal arteriosclerosis, and squint are low. Many of the people have large corneas which will be further studied.

4. Fertility

It has not been possible to show even a temporary sterility on the basis of comparison of frequency of pregnancies in the exposed with the unexposed people. There have been 18 healthy babies born in each of the exposed and unexposed groups since the accident. The pregnancies were distributed fairly evenly over the 4-year period.

5. In Utero Effects and Effects on Pregnancy

Four fetuses were irradiated *in utero*. One was in the first, two in the second, and one in the third trimester. Full-term deliveries resulted in apparently normal babies. There were five miscarriages or babies born dead or dying shortly after birth. Lack of vital statistics in this regard makes it impossible to evaluate these findings with certainty. From comparison with small numbers of unexposed people, however, it does not appear that this number is excessively high.

6. Other Findings Common to Both Exposed and Unexposed Marshallese

a. Nutrition. The diet of the Rongelap people is extremely limited in variety, although the caloric intake appears to be adequate. They appear to maintain satisfactory nutritional status without gross vitamin deficiency, except that at the time of the 4-year examinations about 12 children were found to have mild night blindness. This defect was corrected with vitamin A therapy.

b. Diseases. The paucity of findings associated with degenerative diseases in the Marshallese people is striking. Although the population examined is too small to permit any valid statistical analysis, the clinical impression is that diseases such as atherosclerosis and hypertension are considerably less common and of less severity than in a comparable group of our population. Electrocardiographic tracings revealed a low incidence of positive findings, and the general age appearance of the tracings is younger than would be expected. This is in contrast to the general impression that these people age more quickly and possibly have a shorter life span. No cases of malignancy have been seen in the populations under discussion. There has been a general feeling that conditions such as peptic ulcer, hernia, varicose veins, hemorrhoids, and vaginal prolapse are much less common than one might anticipate in examining a random group of people of similar age in our society. One interesting finding has been the high incidence of kyphoscoliosis. The cause is not apparent. Skin infections, particularly with tenia versicolor and impetigenous lesions in children, have been quite prevalent, though dermatophytosis of the feet has been of low incidence. Extensive dental caries was commonly found.

c. Congenital anomalies. The incidence of congenital anomalies is believed to be higher than found in Americans. The increase may be due to the fact that these people have been living in a relatively isolated area for some 2000 years with prevalent consanguineous matings.

d. Laboratory findings of interest. Eosinophilia is prevalent. As pointed out, about half of the people have greater than 5% eosinophils in their differential counts. An *intestinal parasite survey* at the 4-year study revealed stools positive for various parasites in about 80 to 85% of the people. Hookworm was the only parasite noted, however, which is generally associated with eosinophilia; but the incidence was too low (about 2% of the people) to account for the generally high eosinophil counts. The prevalence of skin diseases may be partly responsible. Another possibility is that the incidence of trichinosis infestation may be high. (Pigs are used for meat, and rats are numerous on the island.) This will be a subject of further study. The low incidence of hookworm would not account for the low *hematocrit* readings. In fact, there was no correlation in individuals between hematocrit, parasite infestation, and eosinophilia. The tendency toward low hematocrits may be related to nutritional deficiency of iron or proteins, but there is no good evidence that these factors are involved.

These people generally show *high total serum protein levels* (mean of 8 gm) with

increased γ-globulin (mean of 2.4 gm). The explanation for these findings is not immediately apparent.

An unexpected finding is a generally *high protein-bound iodine* value (mean value for the population, 9.4 μg per 100 ml). The explanation for this is not apparent, particularly in view of the fact that the people do not clinically appear to be hyperthyroid. *Serum cholesterols* and *creatinine* levels were found to be within normal limits.

C. Beta Lesions of the Skin, Epilation

Multiple β-ray lesions of the skin, mainly on the areas of the body not covered by clothing, and spotty epilation associated with β-ray lesions of the scalp appeared in many of the people beginning 12 to 14 days after exposure and continuing over the following few weeks. Most of the lesions were superficial and were characterized by thickening and pigmentation of the skin accompanied by mild itching and burning. Desquamation followed, with healing and repigmentation over the next few weeks. Regrowth of hair began about 3 months after exposure, with complete return of normal hair by 6 months. About 20% of the cases exhibited more severe lesions which ulcerated, but, in all except one severe ear lesion, complete healing occurred within a few weeks. Microscopic changes were characteristic of radiation effects, with the epidermis showing the greatest damage. About 14 cases continue to show residual changes at this time characterized by mild scarring and atrophy and varying degrees of decreased and, in some cases, increased pigmentation. In no case, either grossly or microscopically, has any malignant or premalignant change been observed.

D. Internal Absorption of Radioactive Isotopes

At present the accumulated evidence supports an assumption made initially that after contamination by fallout the radiation dose from external sources would be higher than that from internally deposited sources. Because, however, so relatively little is known about the mechanisms and consequences of internal deposition of fission products, study of this phase of the problem was among the first of the studies undertaken in 1954 and has continued to be a part of subsequent re-examinations of the exposed population.

A few short-lived radioisotopes, I^{131}, Sr^{89}, and Ba^{140}, accounted for most of the activity found in urine specimens obtained during the first 24 days after the contaminating event. Analysis of the 24-day urines performed 2 years later showed that the samples also contained some Sr^{90} and Cs^{137}. The Sr^{90} activity in the urine decreased from 12 d/m/l in the 24-day specimens to 0.34 to 1.41 d/m/l in the 1957 specimens. The Sr^{90} analyses on urine samples taken in the 4-year survey have not been completed. The Cs^{137} urinary activity fluctuated, decreasing from 174

d/m/l on the twenty-fourth day to 33 d/m/l in 1956, and then increasing to 137 to 370 d/m/l in 1957.[7] Preliminary analysis of the 1958 data indicates that the Cs^{137} activity in urine increased by a factor of 100 over the 1957 levels. (Two residents of Utirik Atoll who had been living on their island since several months after its accidental contamination in the 1954 fallout had urinary Cs^{137} activities of 11,653 and 3735 d/m/l in 1957.)

As part of the 3-year postexposure survey, 4 of the Rongelap people were brought back to Argonne National Laboratory where a more direct measurement of the internally deposited γ-ray-emitting radioisotopes was obtained (*7*). The most prominent γ-ray emitter was identified as Cs^{137}, and the presence of the neutron-induced radionuclide Zn^{65} was discovered. Analysis of the spectra indicated an average body burden of 0.02 μc of Cs^{137} and 0.03 to 0.07 μc of Zn^{65} in the Rongelap residents. Two Utirik residents similarly measured had 0.22 and 0.41 μc of Cs^{137} and 0.482 and 0.229 μc of Zn^{65} (*16*).

Comparison of spectra in various groups of people at Rongelap Atoll in 1958 shows that there is little difference between those exposed in the 1954 fallout and those not exposed. A small group of people who moved from a noncontaminated island to Rongelap island only 2½ months previous to the present survey had less than one-half the Cs^{137} level and less than one-third the Zn^{65} level of the Rongelap residents. A group of 56 people who had been living until a month before the survey on a slightly more contaminated island about ten miles to the north showed slightly higher Cs^{137} peaks than the inhabitants of Rongelap Island.

Because the 1958 data have not been subjected as yet to thorough analysis, quantitative statements regarding the body burdens are preliminary. On the basis of counts made with appropriate standards corrected for absorption and geometry, however, it is estimated that the body burden is 0.3 to 1.7 μc of Cs^{137} and 0.1 to 0.8 μc of Zn^{65}. (The body burden of the Rongelap people of Cs^{137} at 1 day after exposure in 1954 is estimated as having been about 0.01 to 0.02 μc.)

The spectra of whole-body γ-ray activity seen in 1957 and in 1958 in one of the Rongelap residents exposed in 1954 are compared in Fig. 4. In both spectra Cs^{137} and Zn^{65} are responsible for most of the γ-ray activity, but the 1958 levels of both are much higher than those seen in 1957. An additional peak is seen at 1.6 Mev in the 1958 spectrum. This peak was a prominent feature of the background spectrum and has tentatively been ascribed to La^{140}. It is probable that the Ba^{140}-La^{140} isotopic pair resulted from fallout contamination from the 1958 Pacific test series. The ship containing the steel room was slightly contaminated before proceeding

[7] We are grateful to Col. James Hartgering (MC) USA, Maj. Kent T. Woodward (MC) USA, Lt. Ariel Schrodt of the Walter Reed Army Medical Center, Dr. John Harley, and Mr. Edward Hardy of the New York Operations Office of the U. S. Atomic Energy Commission, and Dr. Stanton Cohn of the Brookhaven National Laboratory for assistance in radiochemical analyses.

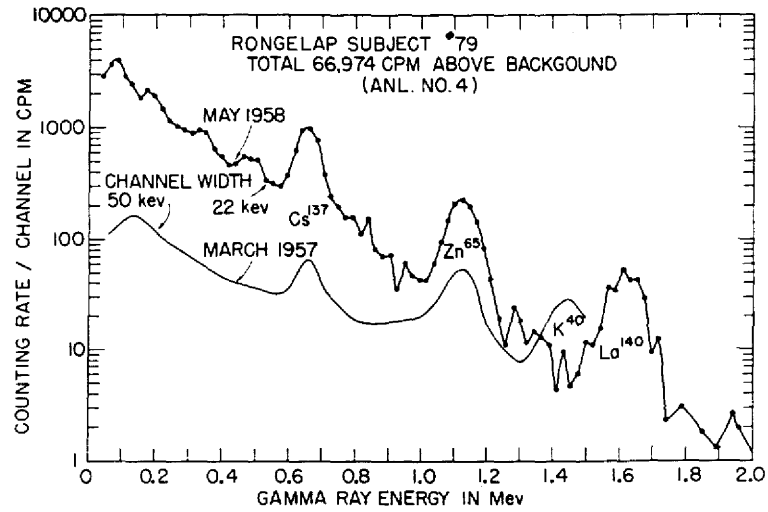

FIG. 4. Gamma-ray spectrographic data on Rongelap male (No. 79, exposed in 1954), comparing 3-year body burden of γ-ray isotopes (measured at Argonne National Laboratory) after he had been living on an uncontaminated island with body burden at 4 years after he had been living on Rongelap nearly 1 year. 6-468-58

from Eniwetok to Rongelap.[8] Low levels of Ba^{140}-La^{140} were also present on Rongelap, as indicated by the low levels of this isotope in the spectra of some of the people measured on Rongelap. It should be noted that not all the subjects showed a distinct peak at 1.6 Mev. For example, the spectrum shown in Fig. 5 has very little net activity above 1.2 Mev. The presence of the large 1.6-Mev peak in the background, however, makes it difficult accurately to evaluate the K^{40} peak at 1.46 Mev, which shows up clearly in the 1957 spectrum.

The differences between the 1957 and 1958 body burdens of Cs^{137} and Zn^{65} reflect the different levels of these isotopes in the diet. It is not known whether they have reached equilibrium with the increased amounts of these isotopes in their present environment. Because of the relatively short biological half-lives of Cs^{137} and Zn^{65}, little of the present levels can be attributed to the original activity which was absorbed in 1954. Therefore most of the activity represents Cs^{137} and Zn^{65} ingested relatively recently.

E. Late Effects

The acute effects of exposure of this population to fallout radiation have subsided. That the dose of whole-body γ-radiation had been in the sublethal range was

[8] The absence of peaks except at 1.6 Mev and the fact that external procedures such as washing down the decks and removing contaminated deck paint definitely lowered the background inside the room (from about 70,000 counts/min to about 25,000 counts/min total counts) indicated that the contamination was outside the steel room.

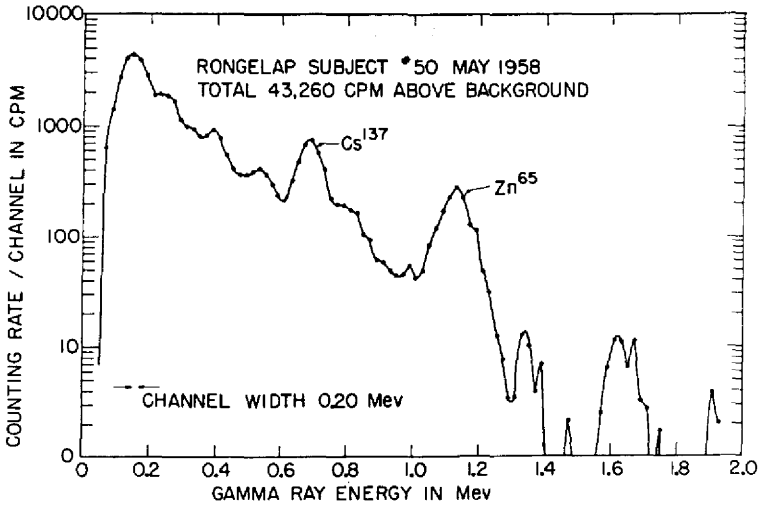

FIG. 5. Body burden of γ-ray isotopes in Rongelap man (No. 50, exposed in 1954) after he had been living on Rongelap island for nearly 1 year. 6-467-58

substantiated by the following findings: the early symptoms of nausea and vomiting were mild, transitory, and did not recur; the hematopoietic depression was insufficient to result in clinical evidence of increased susceptibility to infection or in gross bleeding; no obvious effects on fertility, or on children who were irradiated *in utero*, or on the course of pregnancies were noted; and, lastly, no deaths have occurred that appeared to resemble acute or late radiation deaths that have been described. At 4 years postexposure, the only remaining evidences of the initial radiation exposure to be found are (1) the lag in complete recovery of certain peripheral blood elements to the levels of the comparison population; (2) remaining residua of the β-ray lesions of the skin; and (3) low levels of remaining radioisotopes absorbed internally.

Late effects of radiation exposure have not been seen, but certain of the more fundamental of these effects that have been observed in animals and to a lesser extent in man will be mentioned in relation to the Marshallese.

1. *Shortening of life span* (*2*, *3*, *6*) has not been evident. The 3 deaths that have occurred in the exposed population do not appear to indicate a higher mortality rate than seen in the comparison populations. From these observations it would appear that some of the higher estimates of life shortening per roentgen may be too high.

2. *Premature aging* (*1*, *4*, *7*, *14*) is difficult to assess. From observations over the past 4 years the impression is that the exposed people have neither aged faster nor appear older than similarly aged unexposed Marshallese. No doubt the subtle

changes that occur with aging would be difficult to detect over this period of time. During the 4-year survey, data have been collected in an attempt to obtain semiquantitative estimates of biological age by scoring the degree of certain criteria such as greying of the hair, skin looseness, skin retractility, arcus senilis, retinal arteriosclerosis, accommodation, and blood pressure. These data have not been completely analyzed yet.

3. *Degenerative diseases* have not been found to be increased in the exposed people. No *malignancies* have been detected. In the irradiated Japanese an increased incidence of leukemia has been noted (*17*, *18*). There have been no cases of *leukemia* or *leukemic tendency* noted in the Marshallese. (No cases have shown decrease in alkaline phosphatase of neutrophils, nor have increased levels of basophils been noted.) Since the incidence of malignancy or leukemia would be expected to be relatively low with the dose of irradiation received and since such a small population is involved, the probabilities are good that such effects will not be observed in the Marshallese.

4. *Ophthalmological changes* related to late effects of radiation (*8*, *20*) have not been seen. Slit-lamp observations over the past 4 years have revealed no polychromatic plaques or cataracts. No differences were found in visual acuity in the exposed and unexposed children.

5. *Genetic effects*. No specific studies for genetic effects have been conducted; however, no abnormalities have been noted in the 18 babies born of irradiated parents. In view of the generally negative findings in the studies of the first-generation offspring of the irradiated Japanese (*19*), it is unlikely that genetic studies in this group will be fruitful.

6. *Beta-irradiation*. No late effects of β-irradiation of the skin such as chronic radiation dermatitis or premalignant or malignant changes have been found in the Marshallese.

7. *Body burdens of radioactive isotopes*. The present body burdens of radioactive isotopes absorbed from both the initial contaminating event and the present habitation on Rongelap are far below the accepted tolerance levels, and the hazard from this exposure is unlikely to result in any late effects.

Even though, as pointed out, the radioactive contamination of Rongelap island is considered perfectly safe for human habitation, the levels of activity are higher than found in other inhabited locations in the world. The habitation of these people on the island, therefore, affords a most valuable ecological radiation study on human beings. Since only small amounts of isotopes are necessary for tracer studies, the various radioisotopes present can be traced from the soil, through the food chain, and into the human being, where the tissue and organ distribution, biological half-lives, and excretion rates can be studied. Such investigations will be done by the use of whole-body γ-ray spectroscopy of the people and of sample materials, and by radiochemical analysis of soil, food, and human excreta.

ACKNOWLEDGMENTS

The success of a mission of this type depends on the assistance of many individuals and organizations. The authors wish to express their sincere appreciation to those who participated and others too numerous to mention whose efforts contributed to the successful completion of the survey.

We are particularly grateful to Dr. C. L. Dunham and his staff of the Division of Biology and Medicine of the Atomic Energy Commission and Dr. L. E. Farr and many others at the Brookhaven National Laboratory for their enthusiastic support.

The support of the Department of the Navy in furnishing an LST and transportation of the team as well as the assistance of the staff of the Naval Medical Research Institute, the Naval Radiological Defense Laboratory, the Commander-in-Chief of the Pacific Fleet, Naval Station Kwajalein, and the officers and men of the LST, Plumas County, was vital to the success of the mission.

In the Marshall Islands we greatly appreciate the splendid assistance of the Trust Territory officials, particularly Mr. Maynard Neas, Drs. John Iaman, Dr. A. Hicking, Trigar Ishoda, Nelson, and many other Marshallese who assisted us.

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DISCUSSION

M. TSUZUKI: I should like to make some remarks on the radiation injuries of twenty-three Japanese fisherman, which occurred 4 years ago. The fishermen lived together for 2 weeks on a small contaminated boat. After 4 weeks they showed leukopenia and myelophthisis; after 6 weeks, disturbance of liver function and jaundice; after 3 months hypo- or aspermia, etc. We have lost one case, as a result of severe hepatitis. Now, after 4 years, all surviving fisherman are feeling well and looking healthy. I cannot say now anything about the late effects of their radiation injury.