ANALYSIS OF MEDICAL OCCUPATIONAL EXPOSURE TO IONIZING RADIATION ON TAIWAN DURING PAST TWO DECADES

Pao-Shan Weng and Shu-Ying Li

Health Physics Division, National Tsing Hua Univeristy, Hsinchu, Taiwan 300, Republic of China

Analysis of the data was obtained from the very inception of the centralized laboratory for personnel dosimetry service operated by the National Tsing Hua University on Taiwan of Republic of China from 1960 to 1979 for the yearly occupational exposure to ionizing radiation. During the 20 yr monitoring period, analysis was performed with reference to (1) medical occupational exposure, (2) maximum and average yearly dose-equivalent, (3) range of dose-equivalent, (4) percentage of maxmium permissible dose-equivalent, (5) number of workers including sex and age, (6) detailed quarterly analysis for the years 1977 ∿ 1979, (7) types of radiation sources, (8) estimation of genetically significant dose-equivalent, and (9) estimation of marrow and leukemia significant dose-equivalents.

ESTIMATION OF GENETICALLY SIGNIFICANT DOSE-EQUIVALENT

The genetically significant dose-equivalent (GSD) can be calculated with the following formula:

$$D = \frac{\sum_j \sum_k (N_{jk}^{(F)} W_{jk}^{(F)} d_{jk}^{(F)} + N_{jk}^{(M)} W_{jk}^{(M)} d_{jk}^{(M)})}{\sum_k (N_k^{(F)} W_k^{(F)} + N_k^{(M)} W_k^{(M)})} \quad (1)$$

where

D = annual genetically significant dose.
N_{jk} = number of individuals of age-class k, subjected to class j exposure, i.e., either radiographic or fluorographic X exposure or other sources.
N_k = total number of individuals of age-class k.
W_{jk} = future number of children expected by an exposed individual of age-class k subsequent to a class j exposure.
W_k = future number of children expected by an average individual of age-class k.
d_{jk} = gonad dose per class j exposure of an individual of age-class k.
(F) = female.
(M) = male.

ESTIMATION OF MARROW DOSE AND LEUKEMIA SIGNIFICANT DOSE-EQUIVALENT

The leukemia significant dose-equivalent (LSD) estimated here was calculated according to a weighting factor. This factor takes into account the shape of the time-incidence curve of radiation-induced leukemia, and the survival statistics for the various age groups in the population. The data for this factor were obtained from the leukemia incidence among the Hiroshima A-bomb survivors located within 3000 m from the hypocenter at the time of the bomb (1).

The population mean marrow dose equivalent and the leukemia dose-equivalent are calculated by the following formulas;

$$D_p = \frac{\sum_j \sum_k N_{jk} d_{jk}}{\sum_k N_k} , \qquad D_\ell = \frac{\sum_j \sum_k N_{jk} d_{jk} L_{jk}}{\sum_k N_k} \tag{2}$$

where

D_p = population mean marrow dose-equivalent (MMD).
D_ℓ = leukemia signigicant dose-equivalent.
L_{jk} = significant factor of leukemia incidence for an average individual of age-class k, subjected to a class j exposure.
d_{jk} = mean bone-marrow dose-equivalent per class j exposure of an individual of age-class k.

Jones (2) has made measurements with a phantom of the dose received by critical body organs relative to the exposure at the conventional position of a personal dosimeter. His experimental results were used to calculate the GSD and LSD.

The average expected children census data released by our National Health Administration are that for age 18∿45 yr, the average expected children are 2.30 for both sexes, and for age above 45 yr, the average expected children are 0.015 for both sexes.

RESULTS AND DISCUSSION

The distribution of Tsing Hua film badge users in each county or city is shown in Fig.1 where the numeric numbers indicate the number of hospitals or clinics being monitored. The results of film badge monitoring expressed in terms of the ranges of dose-equivalents in μSv's *vs*. number of personnel monitored during the past two decades (1960∿1979) are shown in Fig.2; the majority is in the undetectable range whether they are in diagnostic radiology (DR), radiotherapy (RT), or nuclear medicine (NM). Taking into account the average expected children for an average individual of age-class k subjected to a class j exposure and the critical body organ dose-equivalent relative to the exposure of film badge, we obtain the GSD by Eq.(1) and the results of calculation are shown in Fig.3. The LSD is shown in Fig.4 by Eq.(2) where the MMD is not shown but it differs from LSD by a weighting factor. The average annual dose-equivalents of all personnel being monitored are shown in Fig.5 and the maximum dose-equivalents for an individual ever detected are shown in Fig.6. Some of the results are not shown in the figures such as sex of workers, detailed quarterly analysis for the years 1977∿1979, and the percentage of maximum permissible dose-equivalent due to space limit and next in importance. The types of radiation source are mainly 602 diagnostic X-rays (75∿250 kVp), 13 ^{60}Co units, a few LINAC's, and ^{131}I and ^{99m}Tc as the main radioisotopes.

The dose-equivalents recorded by some of our film badges at the early period such as in the years of 1964 and 1968 in diagnostic radiology are questionable due to the uncertainty in dose evaluation at very high dose level. It happened that a few minor incidents occurred during those years. A good indication over the last decade was that the incidents of over-exposure were reduced though the number of radi-

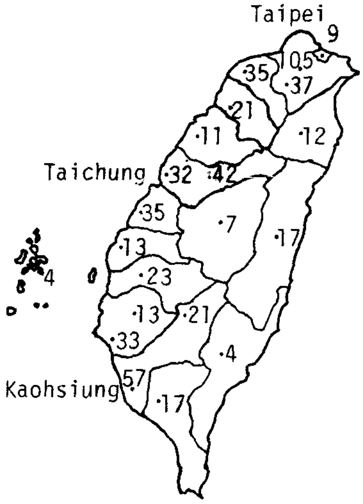

Figure 1

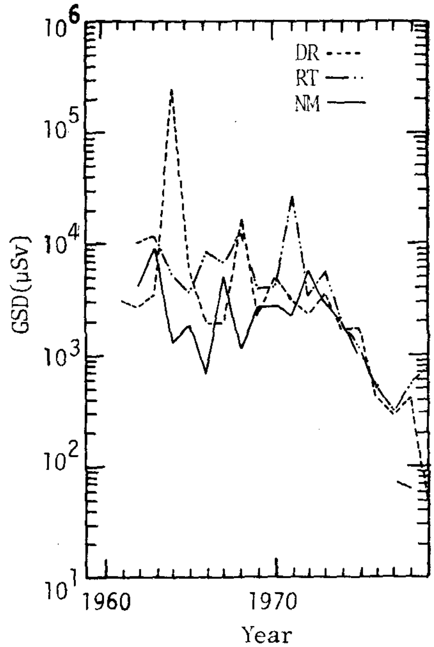

Figure 3

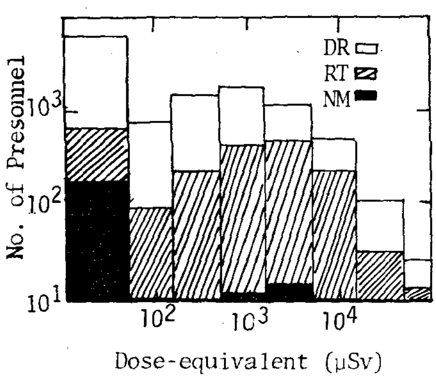

Figure 2

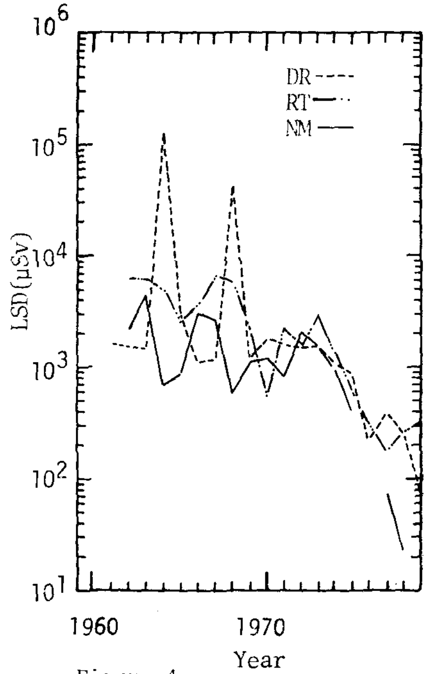

Figure 4

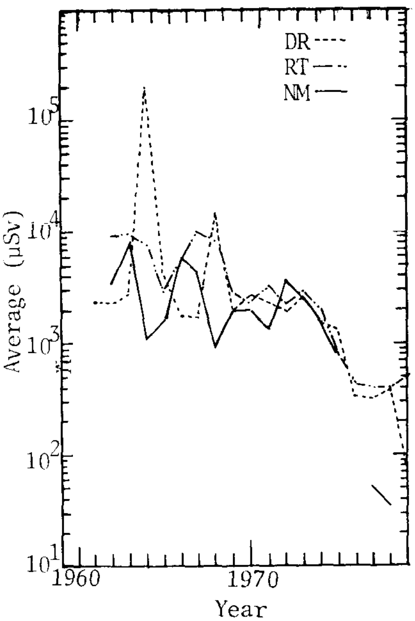

Figure 5

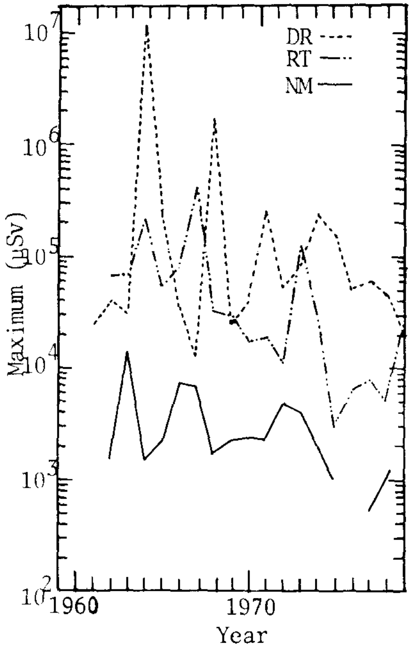

Figure 6

ation workers increased rapidly. Another good indication over the last 8 yr was that the average year dose-equivalent received by all medical radiation workers was decreasing and well below 1/10 of the maximum permissible dose-equivalent.

In contrast to other countries experience, females were less than 10% of the total number of radiation workers monitored. The majority of radiation workers is in the ages 18∿45. It is noted that significant high exposure were found among diagnostic radiology. Radiotherapeutic personnel were second.

The annual GSD and LSD were decreased though the number of radiation workers monitored increased every year. This may be attributable to the inplementation of a nationwide training program on radiation protection for all radiation workers in the Republic of China. Each session on the training course is formulated for one week and several courses are held by the joint efforts of the Atomic Energy Council and the National Health Administration every year. In addition, the promulgation of medical radiation control regulation in February 1973 and enacted thereafter may also be an important factor to reduce the exposure.

REFERENCES

1. Hashizume, Y., *et al.*, (1972) *Health Phys. 23*, 845-853.
2. Jones, A. R., (1974), AECL-2240, At. Energy of Canada Ltd.