RADIATION RESEARCH 137, S68–S97 (1994)

Cancer Incidence in Atomic Bomb Survivors. Part III: Leukemia, Lymphoma and Multiple Myeloma, 1950–1987

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Preston, D. L., Kusumi, S., Tomonaga, M., Izumi, S., Ron, E., Kuramoto, A., Kamada, N., Dohy, H., Matsuo, T., Nonaka, H., Thompson, D. E., Soda, M. and Mabuchi, K. Cancer Incidence in Atomic Bomb Survivors. Part III: Leukemia, Lymphoma and Multiple Myeloma, 1950–1987. *Radiat. Res.* 137, S68-S97 (1994).

This paper presents an analysis of data on the incidence of leukemia, lymphoma and myeloma in the Life Span Study cohort of atomic bomb survivors during the period from late 1950 through the end of 1987 (93,696 survivors accounting for 2,778,000 person-years). These analyses add 9 additional years of follow-up for leukemia and 12 for myeloma to that in the last comprehensive reports on these diseases. This is the first analysis of the lymphoma incidence data in the cohort. Using both the Leukemia Registry and the Hiroshima and Nagasaki tumor registries, a total of 290 leukemia, 229 lymphoma and 73 myeloma cases were identified. The primary analyses were restricted to first primary tumors diagnosed among residents of the cities or surrounding areas with Dosimetry System 1986 dose estimates between 0 and 4 Gy kerma (231 leukemias, 208 lymphomas and 62 myelomas). Analyses focused on time-dependent models for the excess absolute risk. Separate analyses were carried out for acute lymphocytic leukemia (ALL), acute myelogenous leukemia (AML), chronic myelocytic leukemia (CML) and adult T-cell leukemia (ATL). There were few cases of chronic lymphocytic leukemia in this population. There was strong evidence of radiation-induced risks for all subtypes except ATL, and there were significant subtype differences with respect to the effects of age at exposure and sex and in the temporal pattern of risk. The AML dose–response function was nonlinear, whereas there was no evidence against linearity for the other subtypes. When averaged over the follow-up period, the excess absolute risk (EAR) estimates (in cases per 10^4 PY Sv) for the leukemia subtypes were 0.6, 1.1 and 0.9 for ALL, AML and CML, respectively. The corresponding estimated average excess relative risks at 1 Sv are 9.1, 3.3 and 6.2, respectively. There was some evidence of an increased risk of lymphoma in males (EAR = 0.6 cases per 10^4 PY Sv) but no evidence of any excess in females. There was no evidence of an excess risk for multiple myeloma in our standard analyses.

INTRODUCTION

By the late 1940s there were suggestions of an increased risk of leukemia among the survivors of the atomic bombings of Hiroshima and Nagasaki. These early observations led to the establishment of a registry of cases of leukemia and related disorders, including lymphomas, among atomic bomb survivors (*1*). In 1952 Folley *et al.* (*2*) reported clear evidence of an excess risk of leukemia, making this disease one of the first long-term health effects to be noted in this population. The Leukemia Registry data have been the basis of a series of reports (*3–5*) that have helped to clarify our understanding of the risks of radiation-induced leukemia. Since their establishment in 1958, the Hiroshima and Nagasaki tumor registries have also collected information on hematopoietic and lymphatic malignancies in these cities.

The most recent comprehensive reports on leukemia risks in the atomic bomb survivor population appeared more than 10 years ago. These reports considered the nature of the dose response (*6*), general patterns of leukemia incidence in the Life Span Study (LSS[1]) cohort from 1950 through 1978 (*7*), the distribution of onset times for leukemia cases reported to the Leukemia Registry between 1946 and 1975 (*8*), and

[1]Abbreviations used: AHS, Adult Health Study; ALL, acute lymphocytic leukemia; AMFIT, Additive Multiplicative Fitting Program for analysis of data for cohort survival from *Epicure User's Guide* (see ref. *26*); AML, acute myelogenous leukemia; ATB, at time of bombings; ATL, adult T-cell leukemia; DATAB, computer program from *Epicure User's Guide* (see ref. *26*); DS86, Dosimetry System 86; CLL, chronic lymphocytic leukemia; CML, chronic myelocytic leukemia; EAR, excess absolute risk; ERR, excess relative risk; HTLV, virus known to cause adult T-cell leukemia; FAB, French–American–British classification; ICD-O, International Classification of Diseases—Oncology; LSS, Life Span Study; NHL, non-Hodgkin's leukemia; NIC, not in city; RERF, Radiation Effects Research Foundation; T65D, tentative 1965 dosimetry; T65DR, tentative 1965 dosimetry revised.

0033-7587/94 $5.00