5 Risk Estimates for Radium-Induced Malignancies

When the Argonne radium studies were initiated, the maximum permissible body burden, 0.1 μCi, was the reference value used to determine whether a radium-exposed individual might be at risk. This value had been adopted in 1941. Its adoption was reviewed by Evans (1980, 1981).

During the early years of the Argonne program, the emphasis was on enlarging the population under study and on improving the measurement techniques. Little attention was directed toward dose-response relationships. Hasterlik (1956) did call attention to the finding that radiographic changes increased in number and severity with increasing radium body content. Subsequently, Finkel et al. (1969) created dose-response curves for their data by plotting radium burden on a logarithmic scale versus incidence of radium-induced malignancies on a linear scale. The curves they drew suggested that a threshold existed. These workers examined the incidence of malignancies against both preterminal body content and estimated maximum radium burdens. No attempt was made to express the resulting curves algebraically; malignancies included both bone sarcomas and head carcinomas.

Meanwhile, at MIT, where more cases were available for study, Evans (1966) also examined dose-response functions. Using the available population of measured cases, he pointed out that at least 12 radiation dose parameters could be used with some 16 different response parameters. Graphic representations of 9 of these combinations were included in this 1966 publication. Evans pointed out that for residual ^{226}Ra burdens of 0.5-60 μCi, the fractional incidence of osteogenic sarcomas plus carcinomas of the paranasal sinuses or of the mastoids was about 40%; this value appeared to be independent of the residual body burden. Evans also suggested that time to tumor appearance increased substantially as the residual body burden decreased, so that for small residual body burdens the time to tumor appearance might exceed the human life span, providing a practical threshold below which these malignancies might not appear.

Other publications during this period used data from the radium programs to derive alternate dose-response functions for radium-induced malignancies (Hems 1967; Goss 1970; Gofman and Tamplin 1971). These analyses usually forced linear functions through the data without testing the resulting curves for goodness of fit.

Hems (1967) found that the data could be described by a linear nonthreshold function that predicted a tumor risk of 1 in 20 at an initial radium content of 100 μCi. Evans et al. (1968), in a letter to the editor of the journal that published Hems's paper, challenged the manner in which the data had been selected from the quoted sources. Hems, for example, selected only portions of