

The entire population of 1,235 women was examined by comparing the observed and expected deaths per calendar year, starting with the year of first exposure to radium and ending in 1976. Observed deaths numbered 529, while only 461.2 were expected, yielding an observed-to-expected ratio of 1.15 ( $p < 0.005$ ). However, removal of the deaths from radium-induced malignancies (bone sarcomas and head carcinomas) reduced the observed-to-expected ratio to 0.99 (455 deaths versus 460.3 expected). When the cumulative net survival was plotted against the cumulative net expected survival, the two curves were almost identical.

Stehney et al. (1978) summarized their findings as follows:

This study has demonstrated that when the radium tumor deaths are removed, the average survival of the dial worker population is indistinguishable from estimates of the survival of contemporary white females of the same age. This is a remarkable result, for it implies that, to the precision obtainable with a population of some 1000 persons, the life expectancy of the remaining population was unaffected by radium burden.

Some of the earliest dial painters did die of causes other than bone sarcoma or head carcinoma shortly after leaving their work. Without doubt, these women had very large radium burdens. None of them survived long enough to be in the population studied by Stehney et al. (1978). Their radium intakes were thought to be much higher (and in cases measured after death, intakes were found to be higher) than those of any of the women in the above study. People with very large radium burdens will certainly experience radiation damage and probably will not survive long enough for a malignancy to develop.

After the radium program at Argonne had ended, Stehney (in press) presented a second paper on life shortening at an international seminar on radium and thorium (in Heidelberg, April 1994). In this publication, which extended the study to the end of 1989, Stehney used the revised estimates of systemic radium intake and enlarged the study population to include 1,301 women first employed before 1930 (the early group) and 1,242 first employed in 1930-1949 (the late group). In the early group, 85 deaths from radium-induced malignancies were observed, but only 724 deaths occurred from all other causes versus 755 expected. Life shortening ( $\pm$  standard error) of  $1.8 \pm 0.5$  years was calculated for the entire group before the cases with radium-induced malignancies were removed. The late group experienced no radium-induced malignancies, and 350 deaths were observed versus 343 expected. This work, therefore, validated the conclusion from the original