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Indoor Radon and Lung Cancer in the Radium Dial Workers

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INTRODUCTION

Internally deposited radium has long been known to have tumorigenic effects in the form of sarcomas of the bone and carcinomas of the paranasal sinuses and mastoid air cells.[1-3] However, the radium dial workers were also exposed to radiation hazards other than that occurring from ingestion of the radium paint, viz., external gamma radiation and elevated concentrations of airborne radon.[4] The uranium miners were also exposed to high concentrations of radon in the 1950s and later,[5,6] and numerous cases of lung cancer have occurred in that population. However, unlike the atmosphere in the uranium mines, the air in the dial painting plants was probably rather clean and perhaps not much different from the air in many houses. In view of the current concern over the possibility of lung cancer in the general population being caused by radon (progeny) in houses, it is important to examine the mortality due to this usually fatal disease in the dial workers and to attempt to relate it to their exposure to radon, to the extent that that is possible.[7]

METHODS

A cohort of 749 white female dial painters was established. This cohort was first employed prior to 1930 and was followed from 1957 to either the worker's date of death, the date

lost to follow-up, or the closing date of the study (1985). For these women, the body content of radium was determined while they were alive by means of either whole body radioactivity (gamma), radon in expired air, or both. Based on a number of surveys [8,9] these women were exposed to an average level of radon of 1850 Bq m^{-3}. An estimate of systemic radium intake was made using the Norris retention function [10] coupled with knowledge of the duration of employment from company records. Cigarette smoking information was obtained from questionnaires of the individual worker and/or reports from colleagues. Death certificates were obtained for members of the cohort and searched for lung cancer (category 162.1 ICDA).[11]

Mortality analysis was performed with a computer program developed by Monson,[12] updated to version 88. Person-years of follow-up were accumulated for each study subject beginning with 1957 and were calculated in five-year intervals of time and age. They were multiplied by age and cause specific annual death rates for U.S. white females. The expected numbers were summed and divided into the observed number to obtain a standardized mortality ratio (SMR). A 95% confidence interval (95% CI) for the SMR was computed by the method of Rothman and Boice.[13]

RESULTS

There were 12 lung cancer deaths observed, compared to eight expected (Table I). Although the SMR is greater than unity, the 95% confidence interval includes the value of 1.0; thus the result is not statistically significant. For duration of employment, the only result that was statistically significant was observed for the group employed 100 weeks or more. A dose-

response trend is evident. For estimated radium intake, the SMR increases steadily as radium intake increases, but in no case is it significantly different from unity.

Additionally, the analysis takes into consideration the effects of cigarette smoking. Marinberg et al. [14] reported that 32 percent of the dial painters were smoking at the time of their medical examination or interview. This compares to a smoking prevalence rate of 8 percent for U.S. women of the same age. Among smokers the observed number of lung cancer deaths was 6; the expected number was 2.48 (SMR= 2.42, 95% CI= 0.88-5.27). Among non-smokers, the SMR was 0.78 (observed = 3, expected = 3.87).

In conclusion, the data suggest an increased risk for lung cancer with increasing indoor radon levels. This risk seems largely or entirely confined to smokers. It should be remembered that the statistical power of this study is limited and there is potential for misclassification of smoking status.

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TABLE I

Observed and expected lung cancer mortality in

749 white female radium dial painters

	No. of Subjects	Lung Cancer Mortality Observed	Expected	SMR	95% CI
Employment (weeks)					
< 20	280	2	3.21	0.62	0.07-2.25
20-99	213	3	2.23	1.35	0.27-3.94
100+	256	7	2.74	2.55	1.02-5.26
Ra_{226} intake (K Bq)					
< 20	266	3	3.11	0.96	0.19-2.82
20-199	287	4	3.21	1.24	0.33-3.19
200+	196	5	1.85	2.71	0.87-6.32
Total	749	12	8.17	1.47	0.76-2.56