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Commentary

Mortality patterns in British and US radiologists: what can we really conclude?

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There have been several studies of age-specific and cause-specific mortality among radiologists, with the goal of quantifying the effects of their radiation exposure. The most recent report, published by Doll and colleagues [1], assessed 100 years of observations in terms of mortality from cancer and other causes. Relative to all male physicians, male British radiologists who entered the field between 1897 and 1979 showed a small but significant overall increase in cancer mortality (standardized mortality ratio (SMR)=1.16) and a small but significant decrease in non-cancer mortality (SMR=0.86). The increased cancer risk is not surprising in that estimated annual doses to early radiologists were typically in the range of 1 Gy year^{-1} [2].

When British radiologists are stratified by time-of-entry into the profession, the most recent cohort (1955–70) showed a decrease in cancer mortality compared with the physicians, control group (32 observed, 45 expected; SMR=0.71), though this difference in cancer mortality was not statistically significant [1]. In addition, there was a significant decrease in non-cancer mortality (SMR=0.64) in the British radiologists compared with all physicians. These decreases in risk relative to all physicians have attracted much interest [3–5], leading to speculation that low doses of radiation could increase longevity.

The corresponding, but much larger, study of male US radiologists [6, 7] has, surprisingly, received much less attention. Some comparisons between the two studies, both of which are retrospective cohort studies, are given in Table 1, in which we only consider radiologists who entered the profession after 1920, when at least minimal radiation protection practices were in place. There are advantages and disadvantages to both studies; the British study has a longer follow-up and included radiologists who entered the field more recently, and the US study has the advantage of considerably larger numbers and a more direct analysis of the "all physicians" control groups (in the British studies the control mortality rates for "all male medical practitioners" were estimated indirectly from census data).

If only radiologists who entered the field after 1920 are analysed, the US study shows good evidence of significantly increased standardized mortality ratios, relative to all physicians, both for cancer and non-cancer mortality. The British study shows no evidence for a different SMR between the radiologists and all physicians for cancer mortality, and a significant decrease in SMR for non-cancer mortality.

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If we stratify each study by its most recent cohort only (1955–79 in the British study, 1940–69 in the US study), neither shows a significant SMR for cancer mortality compared with all physicians, though the SMRs are again lower for the radiologists in the British study.

How are we to interpret these somewhat smaller radiation risks estimated from the British radiologists compared with the US radiologists? The British study included radiologists who entered the field up to 1970, compared with 1960 in the US study; clearly radiation risks do decrease for radiologists who entered the profession later [1], due to lower doses and shorter follow-up. However, if we directly compare risks in British and US radiologists who entered the field during the same time period, the SMRs are still somewhat lower in the British study than the US study. For example, among radiologists entering the field in the 1920s and 1930s, cancer SMRs were 1.24 for the British cohort and 1.38 for the US cohort. Year for year, however, the doses to the two cohorts were probably quite similar; estimated mean annual doses to British radiologists decreased from 5 mGy in 1964 [8] to 0.5 mGy in 1984 [9] compared with estimated mean annual doses to US radiologists from 1972 to 1978, respectively, of 1.2 mGy, 0.7 mGy, 1.1 mGy, 3.6 mGy, 3.2 mGy, 1.3 mGy and 1.7 mGy [10].

Although it is beyond the scope of this communication to undertake a formal meta-analysis, an appraisal of the SMR data in Table 1 would suggest that, if the US and British studies were appropriately combined: (a) the SMR for all radiologists entering the field after 1920 compared with all physicians would probably be significantly greater than unity for cancer mortality, but would be close to unity for non-cancer mortality; (b) for the more recent lower-dose cohorts, the estimated SMR for cancer mortality, compared to all physicians, would not be significantly different from unity.

Support for this last point comes from a more detailed analysis of causes of death in a cohort of 20 000 British consultants employed in the National Health Service between 1962 and 1979 [11], *i.e.* when mean annual occupational doses to radiologists and radiotherapists would have been at most a few mGy [8, 9]. For the 1600 radiologists and radiotherapists in this cohort, their risk of dying from any cause (from 1962 to 1992) was 1.03 (95% confidence interval: 0.92–1.15) compared with all consultants; the corresponding relative risk for cancer mortality in the radiologists and radiotherapists was 0.99 [95% confidence interval: 0.80–1.23].

In short, in the early "pre-shielding" era, radiation risks to radiologists were large and easily demonstrable. In the

Table 1. Comparison between two retrospective cohort studies of mortality amongst radiologists

	British study [1][a]	US study [6, 7]
No. of radiologists in study	2629	6510
Control physicians	Rates estimated from census data	23215
Year of entry into profession	1920–1979	1920–1969
Last year of follow up	1996	1974
No. of radiologists deceased	837 (35%)	1871 (29%)
SMR for all cancer mortality[b]	1.04 (n.s.)	1.31 (s.s)
SMR for non-cancer mortality[b]	0.86 (s.s.)	1.18 (s.s.)
SMR for all cancer mortality for most recent entry cohort[b]	0.71 (n.s.) (profession entry 1955–79)	1.15 (n.s.) (profession entry 1940–69)

SMR, standardized mortality ratio; n.s., not statistically significant ($p>0.05$); s.s., statistically significant ($p<0.05$).
[a]Restricted to radiologists who entered the profession after 1920.
[b]SMRs relative to all physicians (this is the most appropriate comparison group as death rates in 25–74-year-old British physicians are about half those of the general public [11]).

current era, where annual doses are more than a thousand-fold lower, the radiation effects may be below the limit of detectability for a retrospective cohort study, and arguably for any current epidemiological method. Thus it is entirely to be expected that some studies will produce null results, some will produce slightly positive results and others will produce slightly negative results, which is the case for the studies discussed here [1, 6, 7, 11].

Estimating the risks to a human population from low doses of radiation is difficult. Usefully estimating risks to a population receiving annual occupational doses of less than 1 mGy is extraordinarily difficult, because the SMRs are close to unity. The fact that a low-dose epidemiological study yields results indistinguishable from the controls provides no evidence one way or the other as to whether there are, in fact, health consequences, although it does rule out large risks or large benefits.

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