International Collaborative Study of Cancer Risk among Radiation Workers in the Nuclear Industry – Study of Errors in Dosimetry


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A large-scale multinational epidemiological study of cancer risk among nuclear industry workers has been conducted in 17 countries, coordinated by the International Agency for Research on Cancer (IARC) in Lyon. The objective is to derive precise, direct estimates of cancer risk following low-dose protracted exposure to ionising radiation. Although radiation exposure in the nuclear industry has been assessed more precisely than exposure to other occupational carcinogens, thanks to routine personal monitoring, the accuracy of recorded individual dose estimates varies with time and place. A study was therefore conducted to identify the main sources of errors in doses, to quantify them and to take them into account in the estimation of radiation-induced cancer risk. Predominant dose to workers included in most of the study cohorts was from penetrating, higher energy (100 keV to 3000 keV) photon radiation. For these, the various dosimetry systems used over time in the study facilities provide reasonably accurate measurement of exposure. The IARC study was restricted to workers whose doses were predominantly from photons in this energy range.

One important source of errors identified in the study was the response of dosemeters in actual workplace exposure conditions. A method for quantifying errors related to dosimetry technology and radiation fields was developed, combining information on energy and geometry response of dosemeters with information on workplace radiation fields, in order to derive period- and facility-specific estimates of errors in recorded doses.

Predominant energy of exposure was evaluated by experts from nuclear power plants, research centres and fuel production facilities. The estimates were confirmed by an independent method, based on analyses of detailed dosimetric data. The predominant geometry of exposure in working environments was also evaluated, based on expert estimates and a limited number of measurement studies. On average, workers were predominantly exposed to photon radiation in the 300-3000 keV range, an estimated 50% of doses were received in isotropic exposure conditions and 50% in anterior-posterior (AP) geometry. For individual workers, however, the isotropic component varies from 20 to 90% in nuclear power plants and from 40 to 100% in mixed-activity facilities.

In total 124 different types of dosemeters were used over time in study facilities. Experiments have been conducted on ten representative dosemeters which were exposed, on phantom, to three energies of photon radiations in three simulated geometries. Results were extrapolated to all dosemeter types. At 662 keV the responses of all dosimeters were generally similar. However, old film dosemeters either over or underestimated doses, depending on filters used, especially when irradiated to low energy photon radiation.

Based on this work, a parametric, log-normal error structure was developed (taking into account errors related to dosemeter response, radiation fields and recording practices), as well as a method to take these errors into account in the risk estimation process within the International Study. Analyses to evaluate the impact of these errors on the risk estimates are underway.