THE ICRP’S LUNG CANCER RISK FROM PROTRACTED EXPOSURE TO RADON AND ITS PROGENY

On the basis of the results of the recent combined analyses of epidemiological studies, the International Commission on Radiological Protection (ICRP) revised the lifetime excess absolute risk of radon-induced lung cancer to $5 \times 10^{-4}$ per working level month (WLM)\(^1\). When applying this new coefficient in risk assessment, it should first be understood that the coefficient is associated with a chronic exposure scenario, i.e. a constant low-level exposure per year for many years. Secondly, the coefficient expresses the excess risk from radon exposure to the natural baseline risk by an increment dependent on radon progeny exposure in the unit of (WLM) and the coefficient represents an absolute risk in addition to the baseline risk that is independent of the baseline risk. Thirdly, it is the nominal risk coefficient for radon-induced lung cancer. A nominal risk coefficient means, according to the ICRP\(^2\), the sex- and age-averaged lifetime risk estimated for a representative population.

For residential radon exposure (7000 h $y^{-1}$ indoors and an equilibrium factor of 0.4), one WLM equals a 1-y exposure to a radon gas concentration of 227 Bq $m^{-3}$. Since the results of national radon surveys are reported exclusively in radon gas concentration in the units of Bq $m^{-3}$, the lung cancer absolute risk of $5 \times 10^{-4}$ per WLM can be converted to $2.2 \times 10^{-4}$ per 100 Bq $m^{-3}$ for indoor radon exposure.

Data for the populations of Canada, the USA and the UK along with the global data are shown in Table 1. This table gives population statistics, population-weighted average radon concentrations and estimated lung cancer deaths due to radon exposure available in the literature\(^3-7\). The worldwide population statistics, average radon concentration as well as estimated lung cancer deaths related to radon are also included in Table 1\(^3, 8, 9\).

A nominal risk coefficient can be applied to a population. The ICRP-predicted number of lung cancer deaths due to indoor radon exposure, $N_{LC,Rn}$, for a given population will be

$$N_{LC,Rn} = N_{pop} C_{AM} \frac{2.2 \times 10^{-4}}{100}.$$

where $N_{pop}$ is the size of a population and $C_{AM}$ is the population-weighted arithmetic mean radon concentration expressed in Bq $m^{-3}$.

Normally, one would consider the entire population including children, youths and adults. When $N_{pop}$ represents an entire population, the ICRP-predicted numbers of lung cancer deaths per year resulting from radon exposure are given in the third column of Table 2 for Canada, the USA, the UK and the World. By dividing those numbers by the total lung cancer deaths in a year\(^10-13\) given in the second column of Table 2, the percentages of lung cancer deaths from radon exposure for each of the representative populations are obtained. The predicted percentages are significantly higher than previously estimated\(^4, 6, 7\).

Statistics of lung cancer incidence and mortality by age\(^10, 12\) have shown that almost all lung cancers are diagnosed among adults aged 25 y and older. Even though childhood exposure to radon will contribute to an increased risk of developing lung cancer later in life, lung cancer cases are very rare for people under the age of 25 y primarily because of the long latency period for radon-induced lung cancer. Since lung cancer occurs only among people aged 25 and older, the ICRP-predicted number of lung cancer deaths due to radon for a given population should be adjusted to:

$$N_{LC,Rn} = N_{pop} A C_{AM} \frac{2.2 \times 10^{-4}}{100},$$

where $A$ is the proportion of adults in a population, as given in the third column of Table 1. Applying the nominal risk coefficient to adult populations, the ICRP-predicted lung cancer deaths per year are
given in the fourth column of Table 2 together with the associated percentage estimates. For Canada and the USA, the ICRP-predicted percentages of deaths from radon-related lung cancer in homes are in fairly good agreement with the estimates made by Health Canada(4) and the USEPA(6). However, after the adjustment to the adult population, the ICRP estimate for the UK is still higher than the estimate by Gray and Darby(7) by a factor of 3–9% vs 3%.

This may be due to the fact that different risk models and different adjustments for the smoking effect were used. In Health Canada’s estimate, the BEIR VI risk model(14) modified by the USEPA was used and the smoking adjustment outlined in the BEIR VI Report(14) was followed.

The World Health Organization has estimated that the proportion of all lung cancers linked to radon lies between 3 and 14% depending on the average radon concentration in the country and also on the method of calculation(9). If 40 Bq m\(^{-3}\) is a reasonable estimate for the worldwide average indoor radon concentration(8), the current ICRP absolute risk coefficient predicts more than 345 000 lung cancer deaths per year due to radon. In 2011, there were a total of 1 370 000 lung cancer deaths in the world(13). Therefore, the new estimate would predict that 25 % of lung cancers worldwide could be attributable to indoor radon exposure when the new risk coefficient is applied to the adult population. This estimate is much higher than WHO’s estimate of 3–14 %.

REFERENCES


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