RADON AS A RISK FACTOR FOR EXTRA-PULMONARY TUMOURS

OLAV AXELSON\textsuperscript{1,*} and FRANCESCO FORASTIERE\textsuperscript{2}

\textsuperscript{1} Department of Occupational Medicine, University Hospital, 581 85 Linköping, Sweden
\textsuperscript{2} Epidemiologic Unit, Latium Health Authority, Rome, Italy

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Exposure to radon in uranium and other mines is a well recognised risk factor for lung cancer. There is also increasing evidence of a risk of lung cancer from indoor radon. An excess of stomach cancer has been observed in some mining populations but the role of radon is unclear. A few correlation studies and a case-control study have indicated that exposure to indoor radon could be of some importance as a cause of other tumours, especially acute myeloid leukaemia, melanoma and kidney cancer. Also prostate cancer and some other cancer types have correlated with estimated radon exposure but the relatively few studies are not quite consistent with each other. Nevertheless, the various observations of extra-pulmonary tumours associated with radon exposure may warrant further studies, especially with regard to childhood exposure and cancers.

Key words: Kidney cancer, leukaemia, lung cancer, melanoma, stomach cancer, radiation, radon.

INTRODUCTION

In the early 1920s 'radium emanation', or radon, was suggested to be responsible for the excess of lung cancer in miners, that had been first reported in 1879 from Schneeberg in Germany\textsuperscript{1} and somewhat later from Joachimsthal in the Czech Republic.\textsuperscript{2} It was not until the 1950s and 1960s, however, that the role of radon and its decay products became more clear and finally agreed upon as the cause of pulmonary cancer in uranium, iron and other metal miners.

In the late 1970s, it was observed that rather high levels of radon could occur in dwellings as emanating from the ground and from stony building materials. Since then, several studies have indicated a lung cancer risk from indoor radon, but there are also some observations suggesting a possible risk of other cancers. The intention is here to review the various observations reported in this latter respect. However, a brief introductory note on radon and its decay products may be useful, along with a few remarks on the lung cancer risk from occupational and environmental exposure in this respect.

ORIGIN AND DECAY OF RADON

The radioactive decay of trace amounts of uranium in the Earth's crust through radium is the source of radon, or more precisely the isotope radon-222, which is a noble gas. The further decay of radon results in a series of radioactive isotopes of polonium, bismuth and lead. The first four of these isotopes, with half-lives from less than a millisecond up to almost 27 minutes, are referred to as short-lived radon progeny (or radon daughters). Further down the decay chain there are more long-lived isotopes, such as lead-210, which like lead in general tends to accumulate in bone. There is also another decay chain from thorium through radon-220, or thoron, but the elements in this series are usually of less concern.

Like radon-222 itself, also its decay products polonium-218 and polonium-214 emit alpha-
particles. These particles travel less than 100 micrometers into the tissue, but their high energy causes an intense local ionization, damaging the tissue with a subsequent risk for cancer development. There is also beta- and gamma-radiation from some of the decay products of radon, but these types of radiation have a much lower energy content than the alpha-radiation, and the effect has usually been considered marginal.

Some radon and decay products are absorbed and transported to various other organs, so that there is a possibility for effects also elsewhere than in the lung; some deposition also takes place on the skin. Recent dosimetric calculations have indicated that the exposure to alpha particles for sites other than lung could be of some biological importance, especially the irradiation of red bone marrow, kidney, and skin.

INDOOR RADON

Indoor radon was measured in Swedish dwellings already in the 1950s, and levels were found in the range of 20–69 Bq m⁻³. Recent measurements of indoor radon in Swedish homes have revealed higher levels, i.e. 122 Bq m⁻³ as an average in detached houses and 85 Bq m⁻³ in apartments, suggesting a general increase in the levels over time, but there are great variations as from 11 to 3,500 Bq m⁻³.

Concentrations in the range of 40–100 Bq m⁻³ have been reported as an average for dwellings in many countries, e.g. USA, Norway, Finland, Germany, etc. Considerably higher levels such as two or three thousand Bq m⁻³, may occur in many houses, and this would correspond to about double the occupational standard for mines in most countries.

Radon in homes depends to some extent on building material but more important is the leakage from the ground. There is a considerable local variation in radon emanation from the ground, however, even within a few meters as due to cracks and porosity of the ground. Air pressure, temperature and wind conditions, but also various behavioural factors which influence ventilation play a major role for the concentrations that may build up indoors. The introduction of central heating during this century is likely to have reduced the thermal ventilation in comparison to older houses with fireplaces and increased indoor radon levels. The more recent efforts to improve insulation and preserve energy, may have further impaired the situation.

The assessment of exposure to indoor radon for epidemiologic purposes is problematic and has to be based on the type of house, on the geological features underneath the house, and on measurements of current concentrations for extrapolations to the past. However, only the exposure of an individual, which relates to the home environment can be estimated in this way, but there are considerable uncertainties involved and the costs get high since most individuals have lived in several houses, which have to be measured and evaluated. Furthermore, urban people tend to spend as much time in other constructions as in their homes, which cannot be accounted for.

In some correlation studies, the geological features of a region have been considered as a proxy for indoor radon exposure. For example, volcanic versus sedimentary structures differing in radioactivity, the occurrence of granite with an increased radioactivity, and even worked phosphate deposits with an increased radioactivity, have been utilized for dividing populations so as to create a contrast in exposure.

Estimated averages of background gamma radiation levels per county have also been used as a surrogate for potential indoor radon since there tends to be a rather strong correlation between gamma radiation and emanation of radon from the ground. Examples of some other indicators of radon exposure in correlation studies are data on Ra-226 in water or investigated levels of radon in water and indoor air.

RADON AS AN OCCUPATIONAL AND ENVIRONMENTAL LUNG CANCER RISK

Since the early 1960s, many mining populations with exposure to radon and its decay products have been studied both by the cohort and the case-control techniques as summarised elsewhere. There are at least some 15 more or less independent studies reported in this respect, which all show a consistently increased risk of lung cancer for underground miners, even if the overall risk ratios vary from about 1.5 to 15. As could be expected, miners with a low exposure to radon and progeny have had little or no excess of lung cancer, i.e. in coal and potash mining and also in iron mining.

Until now, in early 1993, about a dozen case-control studies on indoor radon and lung cancer have been published since 1979 along with two studies of cohort character. Most of these studies have been rather small in size and of a pilot type, but almost all of them have shown some effect of indoor radon, usually with odds ratios up to about 2, and with higher estimates for certain subgroups. Recently the first results from a larger case-control study on indoor radon and lung cancer also have appeared, and the overall risk, taken as the odds