RADON AND THE LUNG CANCER
– A REAL EFFECT OR JUST AN ASSUMPTION?

Radon in the Environment 2015 Conference

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Radon risk

Recent study from Sweden:

"Residential exposure to radon is considered to be the second cause of lung cancer after smoking"

"Lung cancer risk was assumed to increase by 16 % per 100 becquerels per cubic meter (Bq/m³) indoor air radon"

SOURCE: Axelsson G, Andersson EM, Barregard L. Lung cancer risk from radon exposure in dwellings in Sweden: how many cases can be prevented if radon levels are lowered? Cancer Causes Control (Springer), 2015, DOI 10.1007/s10552-015-0531-6
13 European studies

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Statistical methods
We assessed the association between radon and lung cancer in two ways. Firstly, a model was fitted in which the risk of lung cancer was proportional to \((1 + \beta x)\) where \(x\) is measured radon concentration and \(\beta\) the proportionate increase in risk per unit increase in measured radon. Secondly, we subdivided cases and controls by categories of measured radon concentration and plotted relative risks across different categories against estimated mean exposure levels in those categories. In both types of analy-

\[
\text{ERR [\%/mSv/year]} = 0.47 + 0.42 - 0.31
\]
13 European studies

**Results:**

Risk of lung cancer versus measured radon concentration
After we stratified for study, age, sex, region of residence, and smoking the risk of lung cancer increased by 8.4% (95% confidence interval 3.0% to 15.8%; $P = 0.0007$) per 100 Bq/m$^3$ increase in measured radon concentration. We stratified for

**Initial assumption:**

Statistical methods
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The authors selected a linear model to process the data, which are very uncertain, and then showed that the data fit the linear model that they assumed.

There are also other models that would fit the widely scattered data. But they were not tested.
Other studies with the linear assumption

Other studies with the linear assumption


![Graph showing the risk of lung cancer against radon concentration (Bq/m3)]
Other studies with the linear assumption

- UNSCEAR 2000
- and many others

![Graphs showing risk estimates of lung cancer from exposure to radon](image)

**Figure II. Risk estimates of lung cancer from exposure to radon (based on [L21]).**

Shown are the summary relative risks from meta-analysis of eight indoor radon studies and from the pooled analysis of underground miner studies, restricted to exposures under 50 WLM [L22] and the estimated linear relative risk from the correlation study of Cohen [C18].
Assumption of the linearity

According to the linear no-threshold (LNT) hypothesis, the excess risk increases linearly vs. Bq/m$^3$ (or vs. mSv effective dose) from zero to the maximum. However, there are no data that support the validity of this hypothesis over the whole range of doses.
The „zero radon environment”

Many authors widely use the value “0 Bq/m$^3$”, as a background for linear extrapolation of their results.

However, there is no place on earth without the concentration of radon, and epidemiological data with “zero” dose from radon does not exist.

There is no empirical confirmation of any extrapolation from high doses or concentrations down to zero radon level.

All assumptions based on 0 Bq/m$^3$ make no sense.
Non-linear studies

Many studies show no correlation or even a negative correlation between lung cancer and low radon concentration

Thompson et al. 2008

German study


![Graph showing the risk of lung cancer vs. radon concentration in Bq/m^3 for control group no. 1 and no. 2 (ICRP).]
Cohen study

Joint re-analysis of 28 studies

- 28 independent radon studies taken into account in one meta-analysis
- Bayesian robust statistical method was used
- 7 models were fitted to the data

Joint re-analysis of 28 studies

- Model 1 – $RR = 1$
- Model 2 – $RR = a$, where $a$ denotes a constant to be fitted,
- Model 3 – $RR = a + bD$, where $a$ and $b$ are fitting parameters, and $D$ denotes the annual dose,
- Model 4 – $RR = 1 + bD$, differs from Model 3 by setting the parameter $a$ to 1,
- Model 5 – same as Model 4 but with the parameter $b$ constrained to the positive values (LNT model),
- Model 6 – $RR = a + bD + cD^2$ with $a$, $b$ and $c$ being fitting parameters,
- Model 7 - $RR = 1 + bD + cD^2$, i.e. same as Model 6 but with the parameter $a$ set to 1.
Joint re-analysis of 28 studies


![Graph showing the relationship between average annual dose and risk of lung cancer](image.png)
Joint re-analysis of 28 studies

Two analysed low dose ranges:

- up to 70 mSv/year (391 Bq/m$^3$)
- up to 150 mSv/year (838 Bq/m$^3$)
  - $1 \text{ Bq/m}^3 \rightarrow 0.179 \text{ mSv/year to lungs}$
  - source: (UNSCEAR 2006, Annex E, Table 25)

Full analysis with 28 studies

Narrowed analysis with 26 studies

- Cohen’s and miners’ data excluded
Results

Assuming linear (LNT) dependence:

- 28 studies, <150 mSv/y: ERR = (0.11 ± 0.03) %/mSv/y
- 26 studies, <150 mSv/y: ERR = (0.19 ± 0.03) %/mSv/y
- 28 studies, <70 mSv/y: ERR = (0.13 ± 0.03) %/mSv/y
- 26 studies, <70 mSv/y: ERR = (0.43 ± 0.16) %/mSv/y

This one similar to Darby et al.: ERR = 0.47 %/mSv/year

However, using robust statistics, the most probable model is constant one (Model 1) ➔ no risk in analysed range
Results

No risk is a final result irrespective of the data used

- range up to 70 or 150 mSv/year
- 26 or 28 studies

Model 1 can correspond to the threshold dose-response curve
Conclusions

- The pooled Bayesian analysis of 28 radon studies shows that there is no evidence for lung cancer risk increase in low dose range.

- To accept the linear no-threshold (LNT) model, one should *a priori* have higher degree-of-belief in such relationship than in a dose-independent model.

- The widely presented increase in lung cancer due to low concentrations of radon is not a real effect; it is an assumption only.
Thank you!

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