Original article

Scand J Work Environ Health. 2015;41(1):407–412. doi:10.5271/sjweh.3496

Eligibility for low-dose computerized tomography screening among asbestos-exposed individuals [1]

by Natalie R Fitzgerald, William M Flanagan, William K Evans, Anthony B Miller,[2] for the Canadian Partnership against Cancer (CPAC) Cancer Risk Management (CRM) Lung Cancer Working Group.

[1] Appendix: Details of CRMM-LC

[2] Correspondence to: Anthony B Miller, MD, Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada. [E-mail: ab.miller@sympatico.ca]

Calculation of lung cancer risk in CRMM-LC

The risk of developing lung cancer is given by the following equation, taken from the literature (21) and calibrated to Canadian cancer registry (CCR) data by age, sex and province:

$$p = (1+0.0031\times R) \times (1+0.00051\times S) \times \text{BackgroundRate} \quad \text{(eq 1)}$$

where R is the cumulative radon exposure in the population lagged 10 years, and S is the cumulative packs smoked lagged 10 years. The BackgroundRate is the incidence of lung cancer in a population unexposed to radon and smoking. The BackgroundRate was obtained through calibration (alignment) to Canadian data for the year 2005, by age, sex and province, and is assumed constant across time (within those dimensions).

The BackgroundRate represents the reference group (non-smokers and not exposed to radon) to which the RR of smoking (and radon) is applied in individuals exposed. By simulating the entire (sample) population across years which has a representative distribution of smokers (and non-smokers) and their smoking histories across years (by age, sex and province), there is only one unknown in the risk equation, the BackgroundRate (by age, sex and province). The BackgroundRates (by age, sex and province) are solved for numerically by iteratively running the simulation model with “guesses” for the BackgroundRates until the target rates from CCR are reproduced (for year 2005 by age, sex and province). The condition that must be satisfied is:

CCR rates (age, sex, province) = (radon RR applied to those exposed to radon) × (smoking RR × distribution of smoking history in population) × BackgroundRates (age, sex, province)

Once the BackgroundRates are determined from this iterative process, they become the input parameter to the simulation as part of the base model. Subsequently all simulations start from the base model and use these BackgroundRates in the calculation of risk. During the simulation of a single person, the RR from smoking is calculated based on their personal (simulated) smoking history and is set to 1 if they are non-smokers (same for radon). In non-smokers, their risk is equal to the BackgroundRates. The only qualification is that smokers with less than 10 years smoking history at the time of calibration (2005) in the model do not contribute risk (the equation uses 10 years lagged exposure), so they too are part of the reference group and described by the background rates.

The 3-year risk of developing lung cancer is calculated as

$$q = 1 - (1 - p)^3$$

The calculation to include asbestos follows (performed in Excel):

We assumed a RR of 2.0 as increased risk of lung cancer for persons exposed to asbestos (exposure not defined).

We choose two provinces, Ontario and Quebec, and did the calculation for age 50, 55, 60, 65 and 70, separately for males and females. We looked up the background incidence rate for each and used it in the calculation. The purpose of choosing different provinces, age groups and sex was to assess the robustness of our approach across of range of at risk populations.

We assumed 0 radon exposure.

Calculations were done for a set of smoking exposures in 5 pack-year increments from 0 to 45.

Pack-years were converted to cumulative packs smoked (S) for equation 1. Example, 5 pack-years = 5* 365 packs smoked. The result was substituted into equation 1 along with background rate to calculate probability.

When we wished to assume asbestos exposure we multiplied equation 1 by 2.0 (assumed RR of asbestos exposure).

Example: a male aged 50 in Ontario has a background risk of developing lung cancer 19.3 per 100,000. If this male had a smoking history of 30 pack-years, no radon exposure and no exposure to asbestos, their risk of developing lung cancer would be

$$p = (1+0.0031\times0) \times (1+0.00051\times(30\times365) \times (19.3/100000) = 0.00127$$

His 3-year risk would be

$$q = 1 – (1- 0.0013)^3 = 0.0038$$

Now if this same individual had been exposed to asbestos, we assume the relative risk of 2 associated with asbestos so effectively the results for p and q would be

$p = 0.00127 \times 2.0 = 0.0025$ (one year risk)

$q = 1 – (1- 0.0025)^3 = 0.0076$ (3 year risk)

We matched the risk of developing lung cancer for persons exposed and unexposed to asbestos to compare the levels of smoking in the two groups. In this example, a male with between 10-15 pack-years smoking consumption and exposed to asbestos would have the same risk as person with 30 pack-years and unexposed to asbestos.

Simulating exposure to asbestos in CRMM-LC:

We did not model asbestos explicitly. We used the 3-year risks as calculated above to determine who would be eligible for screening. That is, those with 30 pack-years smoking history or those with 12.5 pack-years and exposed to asbestos have the same 3-year risk of developing lung cancer equal to 0.0076.