Correcting for measurement errors when estimating lung cancer risk associated with radon exposure among uranium miners

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Context

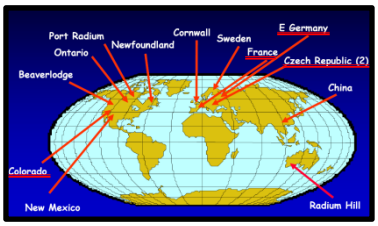
In epidemiological studies, Measurement errors (ME) can substantially bias the estimation of the parameters. A broad variety of methods for ME correction has been developed, but they have been rarely applied. The present work 1/ characterizes ME associated with radon exposure (^{222}Rn and its decay products) in the French cohort of uranium miners, 2/ evaluates its impact on the estimated excess relative risk of lung cancer death associated with radon exposure and 3/ assesses the behavior of different methods for correcting ME effects

Materials & methods

French Cohort of Uranium Miners

- Includes more than 5000 miners chronically exposed to radon with a follow-up duration of 30 years
- ME associated to radon exposure have been characterized for each individual, taking into account the evolution of uranium extraction methods and that of radiological monitoring over time

Photo PC Guiollard



Stram et al., 1999; Allodji et al., 2012; Heidenreich et al., 2012

Simulation study

- Simulation study (1,000 replications) based upon the baseline data of the French Uranium Miners Cohort Study

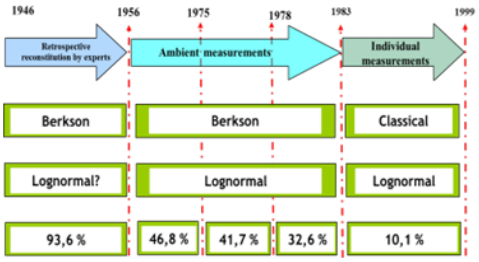
Methods for correcting ME

- Substitution Method (also called Regression Calibration) denoted RC-SM
- Estimate Calibration Method (Regression Calibration variant) denoted RC-ECM
- Simulation Extrapolation Method denoted SIMEX

Results

Characteristics of ME associated with radon exposure

Allodji et al., J Radiol Prot 2012



Impact of ME on the Excess Relative Risk

Allodji et al., Radiat Environ Biophys 2012

- ME lead to an attenuation of the estimated ERR per 100 WLM, with substantial bias in the order of 60%

Performance of ME correction methods

Allodji et al., Stat Med accepted

In case of perfect knowledge of ME characteristics

- About 50-60% of the bias was corrected
- SIMEX seems to offer better performance for the correction of ME than the two other methods implemented

In case of imperfect knowledge of ME characteristics

- Serious overestimation (overcorrection) with the SIMEX method
- None of the three error-correction methods was able to provide any meaningful bias correction

Correction of ME in the French uranium miners cohort

Allodji et al., Stat Med accepted

	Without correction of ME	After correction of ME		
		RC-SM	RC-ECM	SIMEX
ERR per 100 WLM	0.776	1.098	0.909	1.700
Standard Error of ERR	0.280	0.398	0.330	0.570
95% confidence interval	0.226- 1.325	0.317 - 1.879	0.262 – 1.556	0.759 - 2.581

WLM: Working Level Month; ‡based on most plausible characteristics as determined from the French Uranium Miners' Cohort.

- Corrected ERR was increased (ranging from 0.909 to 1.700 per 100 WLM)

Discussion & conclusion

This work illustrates the importance of ME correction in order to obtain more reliable ERR estimates of lung cancer risk associated with radon exposure among French uranium miners. Such corrected risk estimates should prove of great interest in support to the determination of protection policies against radon

References

- Stram DO, Langholz B, Huberman M and Thomas D C. Correcting for exposure measurement error in a reanalysis of lung cancer mortality for the Colorado plateau uranium miners cohort. Health Physics 1999; 77:265–275.
- Allodji RS, Leuraud K, Bernhard S, Henry S, Bénichou J, Laurier D. Assessment of uncertainty associated with measuring exposure to radon and decay products in the French uranium miners cohort. J Radiol Prot. 2012; 32(1): 85-100.
- Allodji RS, Leuraud K, Thiébaut AC, Henry S, Laurier D, Bénichou J. Impact of measurement error in radon exposure on the estimated excess relative risk of lung cancer death in a simulated study based on the French Uranium Miners' Cohort. Radiat Environ Biophys. 2012; 51(2): 151-163.
- Heidenreich WF, Tomasek L, Grosche B, Leuraud K and Laurier D, Lung cancer mortality in the European uranium miners cohorts analyzed with a biologically based model taking into account radon measurement error, Radiat Environ Biophys. 2012; 51(3): 263-275.
- Allodji RS, Thiébaut AC, Leuraud K, Rage E, Henry S, Laurier D, and Bénichou J, The Performance of Functional Methods for Correcting non-Gaussian Measurement Error within Poisson Regression: Corrected Excess Risk of Lung Cancer Mortality in Relation to Radon Exposure among French Uranium Miners. Statistics in Medicine; accepted for publication,