Risks of non-cancer diseases at low and intermediate dose levels in the French cohort of nuclear workers: updated follow-up 1968-2014

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INTRODUCTION

Context

- Radiation-associated risks of non-cancer diseases remain poorly understood in the low dose/low dose-rate range.
- Populations of nuclear workers are particularly relevant to study health effects of protracted exposures to low doses at low dose-rates of ionizing radiation (IR).

Objective

- To report on risk of death from non-cancer diseases of nuclear workers badge-monitored for external IR exposure and followed-up through several decades
- To strengthen the basis for radiation protection.

MATERIALS AND METHODS

- The SELTINE cohort of nuclear workers employed by CEA, Orano, or EDF companies in France was followed-up for mortality from 1968 to 2014.
- Cumulative doses due to occupational external IR (mostly photons) were reconstructed individually and expressed either in $H_p(10)$ dose equivalents in Sievert (Sv) or absorbed doses to organs of interest in Gray (Gy).
- Estimates of excess relative rate (ERR) per Sv or Gy have been calculated using Poisson regression methods and a linear ERR model:
  - ERR were estimated only for males who represent 87% of the cohort;
  - the background mortality rate was modeled as a function of age, calendar year, company, duration of employment, and socioeconomic status;
  - cumulative doses were lagged by 10 years to allow for a latent period in radiation effect.

RESULTS

Characteristics of the SELTINE cohort of nuclear workers in France (males only)

Number of male workers	69,487	
Number of accrued person-years	2,202,492	
Follow-up (1968-2014), in years (SD)		
Mean duration	31.7	(11.4)
Mean age at end of follow-up	62.8	(13.6)
Vital status on 12/31/2014, n (%)		
Alive	55,134	(79.3)
Deceased	14,131	(20.4)
Lost to follow-up	222	(0.3)
Employment		
Mean age at hiring, in years (SD)	26.4	6.3
Mean duration, in years (SD)	26.5	(9.0)
Socioeconomic status, n (%)		
Managers and engineers	13,466	(19.4)
Administrative employees	2,909	(4.2)
Skilled workers	40,537	(58.3)
Unskilled workers	11,787	(17.0)
Unknown	788	(1.1)
Cumulative Hp(10) dose, in mSv		
Number of exposed* workers (%)	49,995	(71.9)
Mean (SD), whole cohort	17.7	(39.7)
Mean (SD), exposed* workers only	24.7	(44.9)

SD: standard deviation; * with at least one positive recorded dose

Excess relative rate (ERR) of death from non-cancer diseases per unit of 10-year lagged cumulative dose in males only, SELTINE cohort, 1968-2014

Cause of death	Target tissue	Observed deaths	ERR/Gy	95% CI	p-value
Non-cancer diseases	$H_p(10)$	8,577	0.02	-0.49; 0.57	0.952
Diabetes mellitus	$H_p(10)$	169	-0.91	ne; 2.62	0.536
Mental and behavioral disorders	Brain	235	2.74	-1.95; 10.33	0.316
Diseases of the nervous system	Brain	531	3.47	-0.48; 8.56	0.091
Dementia, Alzheimer's disease	Brain	269	9.62	3.05; 18.68	**0.002**
Parkinson's disease	Brain	124	-1.30	ne; 7.44	0.711
Circulatory diseases	$H_p(10)$	3261	0.09	-0.72; 1.03	0.834
Ischemic diseases	$H_p(10)$	1,258	-0.23	ne; 1.38	0.763
Cerebrovascular diseases	$H_p(10)$	684	1.41	ne; 4.05	0.194
Hypertensives diseases	$H_p(10)$	120	2.31	ne; 9.98	0.374
Respiratory diseases	Lung	558	0.22	ne; 3.71	0.884
Chronic obstructive pulmonary diseases	Lung	164	0.15	ne; 7.52	0.958
Digestive diseases	Colon	583	0.96	-1.72; 4.58	0.531
Cirrhosis	Liver	166	3.72	ne; 13.64	0.288

* estimated from a linear model, adjusted on calendar year, age, sex, company, duration of employment, and socioeconomic status; CI: likelihood-based confidence interval; NC: convergence not achieved; *ne*: not estimated.

Summary of results

- No association was observed for most of outcomes
- Only mortality from dementia and Alzheimer's disease showed a statistically significant dose-risk association

CONCLUSION

- The long follow-up makes this cohort informative with respect to the long-term risks following protracted exposure to low-dose ionizing radiation.
- The observed association between dementia mortality risk and ionizing radiation was not observed in previous analyses and should be viewed with caution
- The association between dementia mortality risk and IR should be further investigated by other studies

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