Evidence of cardiovascular disease risk in the workplace

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Cardiovascular Disease (CVD) Risk

- High acute doses of ionizing radiation increase the risk of blood circulatory system disease (e.g. heart attack and stroke).
- There is growing evidence that low/moderate acute doses or low/moderate dose-rates also increase the risk of CVD, but this is not presently included in the ICRP scheme of radiological protection.
- Some of this evidence is from epidemiological studies of exposure in the workplace.

Summary of estimates of the excess relative risk (ERR, the proportional increase in risk compared to the background risk) of various circulatory diseases per gray of cumulative whole-body external gamma-ray dose, and associated 95% confidence intervals, obtained from studies of radiation workers. Results for all circulatory diseases combined are given, where available, or where not, major cardiovascular disease categories. Doses are lagged by 10 years, except where stated otherwise. Adaptation and update of tables presented by Little et al. (2012) and Little (2013).

Workforce	Cohort size	Mean cumulative external dose (Gy)	Circulatory disease[a]	ERR/Gy (95% CI)
Mayak, Russia	18 856	0.593	IHD incidence IHD mortality CeVD incidence CeVD mortality	0.16 (0.09, 0.23) 0.04 (-0.03, 0.11) 0.53 (0.42, 0.64) 0.06 (-0.04, 0.17)
15 countries	275 312	0.021	CVD mortality	0.09 (-0.43, 0.70)
NRRW-3, UK[b]	174 541	0.025	CVD mortality	0.25 (-0.01, 0.54)
BNFL, UK[b,c]	38 779[d]	0.057	CVD mortality[e]	0.65 (0.36, 0.98)[f]
France[b]	59 021	0.023	CVD mortality	0.31 (-0.90, 1.74)[f]
ORNL, USA[b,g]	14 095	NA	IHD mortality	-2.86 (-6.90, 1.18)
Russian Chernobyl liquidators	61 017	0.109	CVD incidence	0.18 (-0.03, 0.39)
Eldorado uranium miners, Canada	16 236[d]	0.052	IHD mortality[h] CeVD mortality[h]	0.15 (-0.14, 0.58) -0.29 (<-0.29, 0.27)
German uranium miners	58 982	0.041	CVD mortality	-0.13 (-0.38, 0.12)

CVD = cardiovascular disease; CeVD = cerebrovascular disease; IHD = ischemic heart disease; NA = not available; CI = confidence interval
[a] Mortality data are based on underlying cause of death; [b] some overlap with 15-country study; [c] some overlap with NRRW-3 study; [d] men only included in analysis; [e] 15-year dose lag; [f] 90% CI; [g] analysis conducted in terms of the cumulative dose received after the age of 45 years; [h] 2-year dose lag

BNFL Workforce

(McGeoghegan *et al.*, *Int J Epidemiol* 2008; **37**: 506-518)

- Standardized mortality ratios (SMRs) for circulatory disease compared to the general population of NW England.
- All male workers:

  SMR = 0.84 (95% CI: 0.82, 0.86)

  ➔ pronounced "healthy worker effect".
- Male "blue collar" workers:

  SMR = 0.89 (95% CI: 0.87, 0.91)
- Male "white collar" workers:

  SMR = 0.70 (95% CI: 0.67, 0.73)

BNFL Workforce

(McGeoghegan *et al.*, *Int J Epidemiol* 2008; **37**: 506-518)

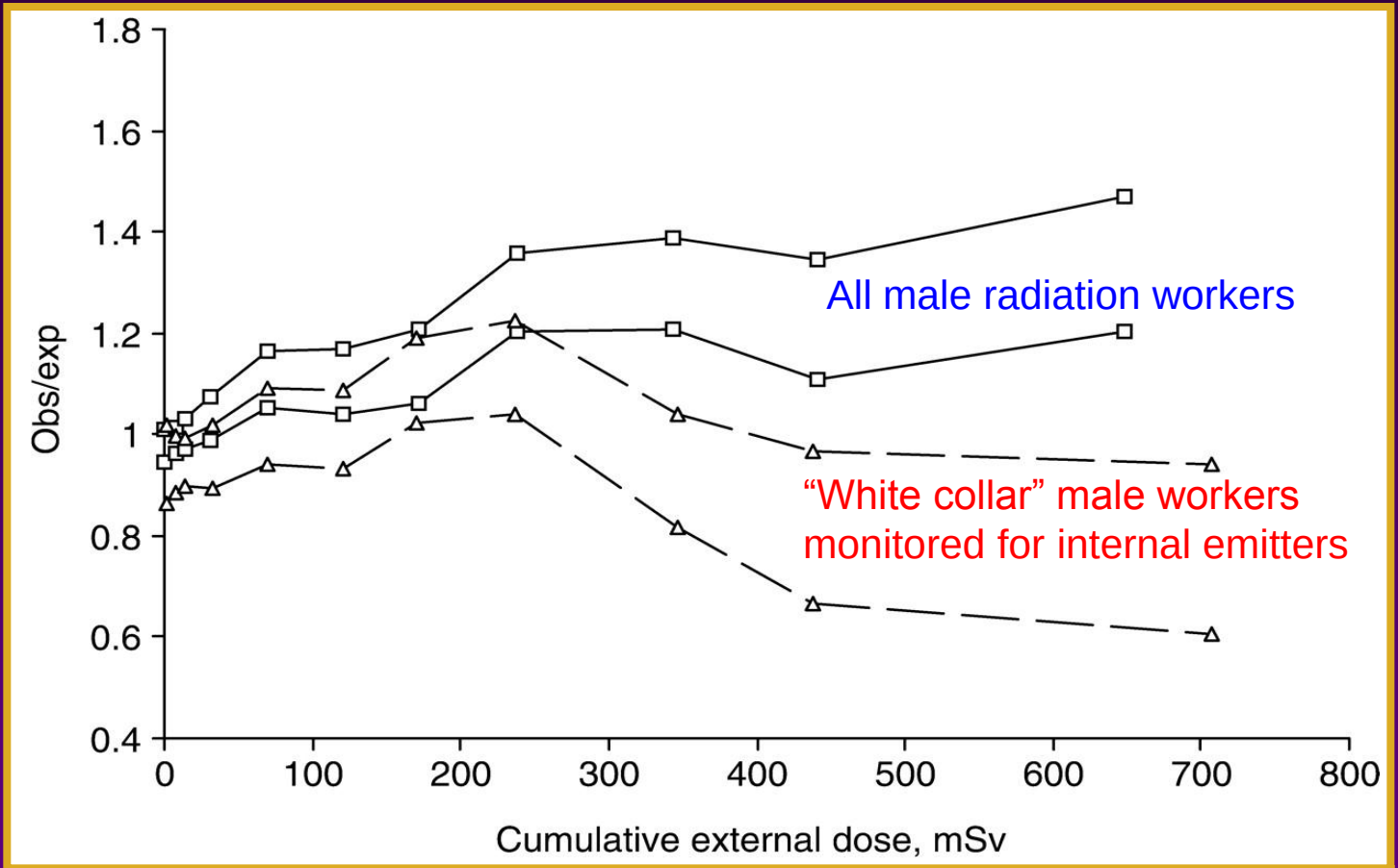
Estimates of **ERR/Gy for cardiovascular disease mortality**, and associated 90% confidence intervals, in groups of male workers categorized by radiation monitoring status (external exposure only *vs* external and internal exposure) and by occupational socioeconomic status ("white collar" *vs* "blue collar"). Doses lagged by 10 years.

Radiation monitoring status	Occupational socioeconomic status	
	"white collar"	"blue collar"
External only	1.38 (-0.05, 3.27)	1.25 (0.56, 2.08)
External plus internal	-0.29 (-0.66, 0.21)	0.76 (0.37, 1.23)

Statistically significant heterogeneity (p = 0.016)

Circulatory System Disease Deaths

(McGeoghegan *et al., Int J Epidemiol* 2008; **37**: 506-518)



Loess smoothers (±1 SE) on point estimates of the ratio of observed to expected mortality from circulatory system disease, for non-industrial internal radiation workers compared to all radiation workers

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Mayak Workforce

(Moseeva *et al.*, *Radiat Environ Biophys* 2014; **53**: 469-477)

- Ischemic heart disease (IHD) and cerebrovascular disease (CeVD) incidence and mortality in Mayak workers first employed during 1948-72 and followed up to end 2005.
- Incidence data for Ozyorsk residents *only*.
- Mortality data for Ozyorsk residents, but also for emigrants to remainder of Russia (46% of cohort by end 2005), using additional source of national death registration data.

Mayak Workforce

(Moseeva *et al.*, *Radiat Environ Biophys* 2014; **53**: 469-477)

Estimates of ERR/Gy, and associated 95% confidence intervals, for ischemic heart disease (IHD) and cerebrovascular disease (CeVD) incidence and mortality. Doses lagged 10 years. Incidence data available only for workers diagnosed while resident in Ozyorsk.

Ischemic heart disease (IHD)		
Incidence/Mortality	**Number of cases/deaths**	**ERR/Gy (95% CI)**
Incidence[a]	5422	0.16 (0.09, 0.23)
Mortality[b]	2515	0.04 (-0.03, 0.11)
Cerebrovascular disease (CeVD)		
Incidence[a]	6749	0.53 (0.42, 0.64)
Mortality[b]	1372	0.06 (-0.04, 0.17)

[a] Ozyorsk residents only (10 107 workers)

[b] Ozyorsk residents, plus emigrants (8749 workers) from Ozyorsk to the rest of Russia, a total of 18 856 workers.

Mayak Workforce

(Moseeva *et al.*, *Radiat Environ Biophys* 2014; **53**: 469-477)

Estimates of relative risk (RR), and associated 95% confidence intervals, of ischemic heart disease (IHD) and cerebrovascular disease (CeVD) mortality among workers who had emigrated from Ozyorsk when compared to mortality among workers who remained resident in Ozyorsk

Ozyorsk residential status	IHD mortality		CeVD mortality	
	Number of deaths	RR (95% CI)	Number of deaths	RR (95% CI)
Ozyorsk residents[a]	1480	1 (reference)	814	1 (reference)
Ozyorsk emigrants[b]	1077	0.87 (0.80, 0.94)	567	0.87 (0.78, 0.98)

[a] 54% of workers (10 107) who did not leave Ozyorsk by end 2005. Vital status known for ~100%, of whom 59% had died, of whom cause of death known for 99%.

[b] 46% of workers (8749) who had emigrated from Ozyorsk by end 2005. Vital status known for 88%, of whom 54% had died, of whom cause of death known for 90%.

Mayak Workforce

(Moseeva *et al.*, *Radiat Environ Biophys* 2014; **53**: 469-477)

Estimates of ERR/Gy, and associated 95% confidence intervals, for ischemic heart disease (IHD) and cerebrovascular disease (CeVD) mortality among all workers and workers remaining resident in Ozyorsk. 0-year lag used.

Ozyorsk residential status	IHD mortality[a]		CeVD mortality[a]	
	Number of deaths	ERR/Gy (95% CI)	Number of deaths	ERR/Gy (95% CI)
All workers (Ozyorsk residents and emigrants)[b]	2557	0.03 (-0.04, 0.10)	1382	0.06 (-0.05, 0.16)
Ozyorsk residents only[c]	1510	0.06 (-0.04, 0.16)	814	-0.04 (-0.15, 0.07)

[a] Results for 0-year lag
[b] 18 856 workers
[c] 10 107 workers who did not leave Ozyorsk by end 2005

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Cardiovascular Disease (CVD) Risk

- Studies of CVD risk following exposure to radiation in the workplace demonstrate the need to properly understand major influences that affect findings.
- These include not only potential data biases, but also the impact of the principal background risk factors for CVD risk, such as smoking and body mass index, and how these relate to levels of radiation exposure.

Circulatory Disease Risk

- At present, epidemiological studies, including occupational studies, indicate the existence of a raised risk of CVD following low-level exposure to radiation, but reliable inferences cannot yet be made because of unresolved interpretational issues.
- More research, both epidemiological and experimental, is required before firm conclusions can be drawn.

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