Cardiovascular and Cerebrovascular Diseases in the Extended Cohort of Mayak Nuclear Workers

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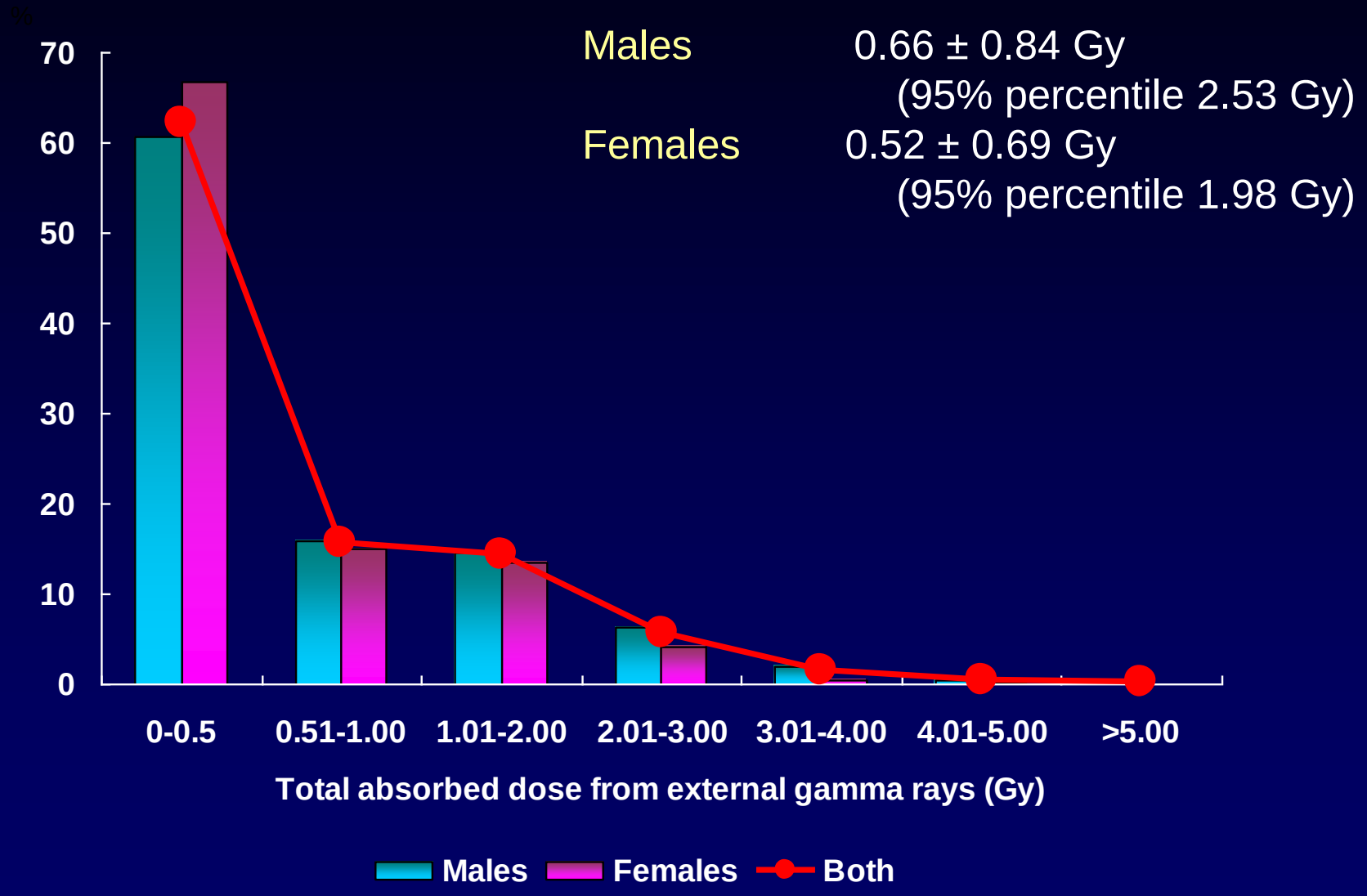
Objective

to estimate risk of incidence and mortality from ischemic heart disease (IHD) and cerebrovascular diseases (CVD) in the workers first employed at one of the main Mayak PA plants during 1948-1972 and followed up to the end of 2005 in relation to the dose from protracted external or internal exposures whilst allowing for non-radiation risk factors.

Description of the Study Cohort

Workers included in the cohort	18 763
Females (%)	25.3
Migrants from Ozyorsk (%)	46.0
Vital status known (%)	94.4
Deceased (%)	56.6
Cause of death known (%)	95.7
Alive (%)	43.4
Morbidity data (%)	95.0

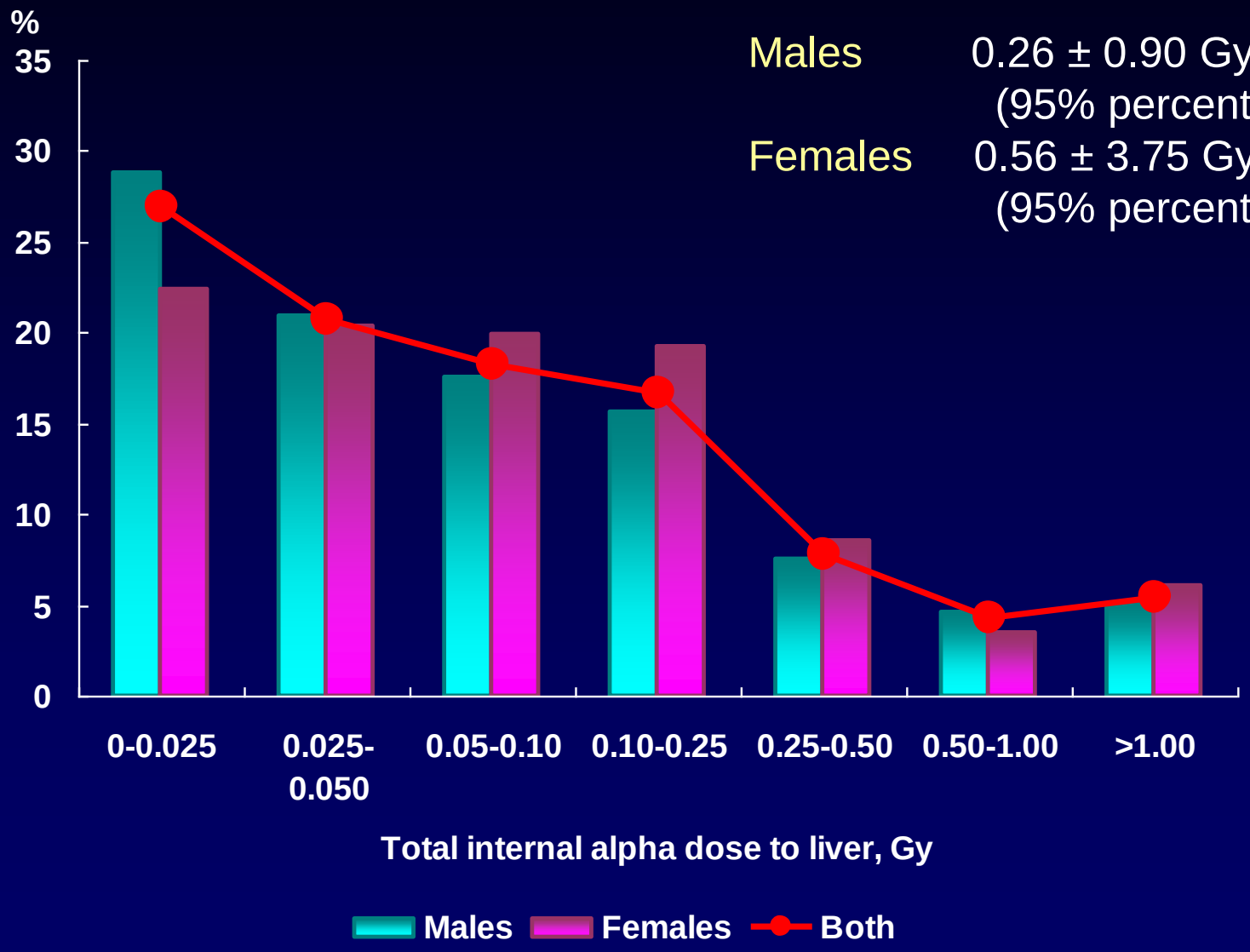
External Gamma Rays (*Mayak Dose-2005*)



Males 0.66 ± 0.84 Gy
(95% percentile 2.53 Gy)

Females 0.52 ± 0.69 Gy
(95% percentile 1.98 Gy)

Internal Alpha-radiation (*Mayak Dose-2005*)



Males 0.26 ± 0.90 Gy
(95% percentile 1.01 Gy)

Females 0.56 ± 3.75 Gy
(95% percentile 1.33 Gy)

Effects studied

		Number of deaths/cases	Person-years
IHD (410-414 ICD-9 codes)	mortality	2 629	717 459
	incidence	6 134	351 635
CVD (430-438 ICD-9 codes)	mortality	1 495	717 459
	incidence	7 326	336 738

Relative Risk and 95% CI for Analyses of External Gamma Exposure

IHD (vs. <0.2 Gy)

	0.2-0.5 Gy	0.5-1.0 Gy	> 1.0 Gy
Mortality	0.95 (0.83, 1.08)	0.94 (0.82, 1.09)	1.09 (0.95, 1.26)
Incidence	0.90 (0.82, 0.98)	0.95 (0.86, 1.04)	1.10 (0.99, 1.21)

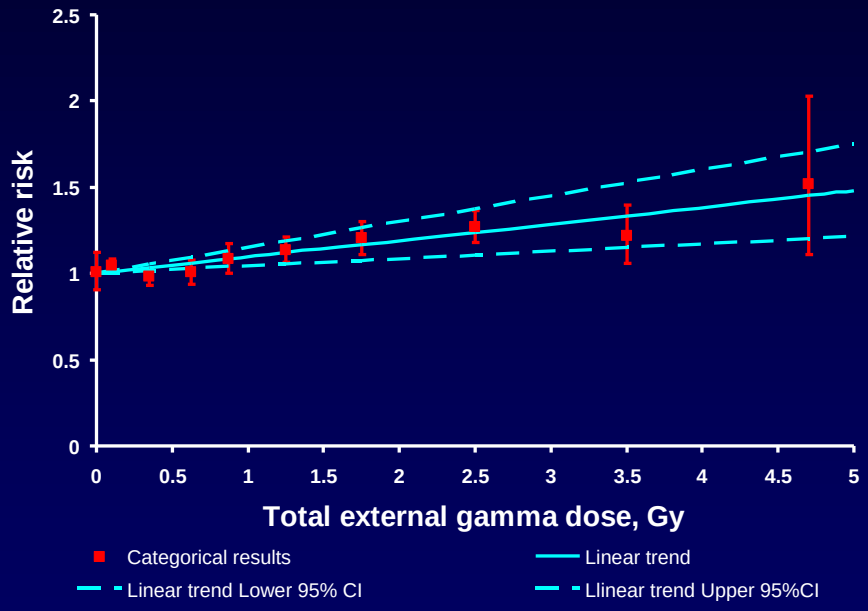
CVD (vs. <0.2 Gy)

	0.2-0.5 Gy	0.5-1.0 Gy	> 1.0 Gy
Mortality	0.91 (0.77, 1.08)	1.09 (0.91, 1.32)	0.97 (0.80, 1.18)
Incidence	1.12 (1.04, 1.22)	1.21 (1.10, 1.32)	1.61 (1.47, 1.76)

Analysis of External Gamma Exposure

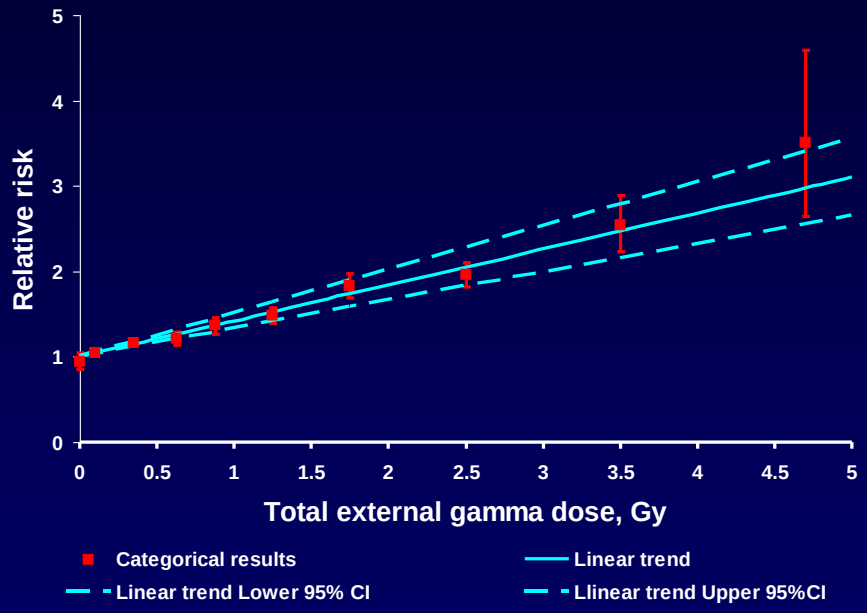
IHD Incidence

ERR/Gy = 0.10 (95% CI 0.05, 0.15)



CVD Incidence

ERR/Gy = 0.41 (95% CI 0.32, 0.50)



Sensitivity Analysis and Effect Modification for External Dose Analysis

- Findings for IHD and CVD incidence did not vary greatly when:
  - *adjusting for extra non-radiation factors;*
  - *adjusting for internal dose; and*
  - *using different lag periods*
- Raised risk of IHD incidence seen mostly in males.
- Raised risk of CVD incidence seen in both males and females.

Relative Risk and 95% CI for Analyses of Internal Alpha Exposure (liver dose)

IHD (vs. < 0.025 Gy)

	0.025-0.1 Gy	0.1-0.5 Gy	> 0.5 Gy
Mortality	1.31 (1.08, 1.59)	1.46 (1.17, 1.81)	1.87 (1.38, 2.53)
Incidence	0.99 (0.91, 1.08)	1.12 (1.01, 1.24)	1.21 (1.02, 1.42)

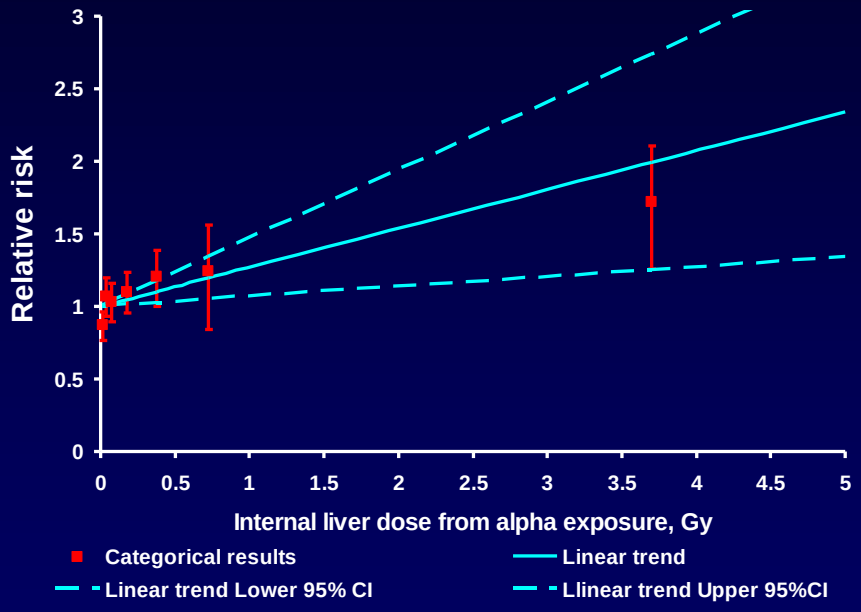
CVD (vs. <0.025 Gy)

	0.025-0.1 Gy	0.1-0.5 Gy	> 0.5 Gy
Mortality	0.85 (0.64, 1.11)	1.12 (0.83, 1.50)	1.02 (0.65, 1.61)
Incidence	1.09 (1.00, 1.17)	1.23 (1.12, 1.35)	1.57 (1.34, 1.84)

Analysis of Internal Alpha Exposure

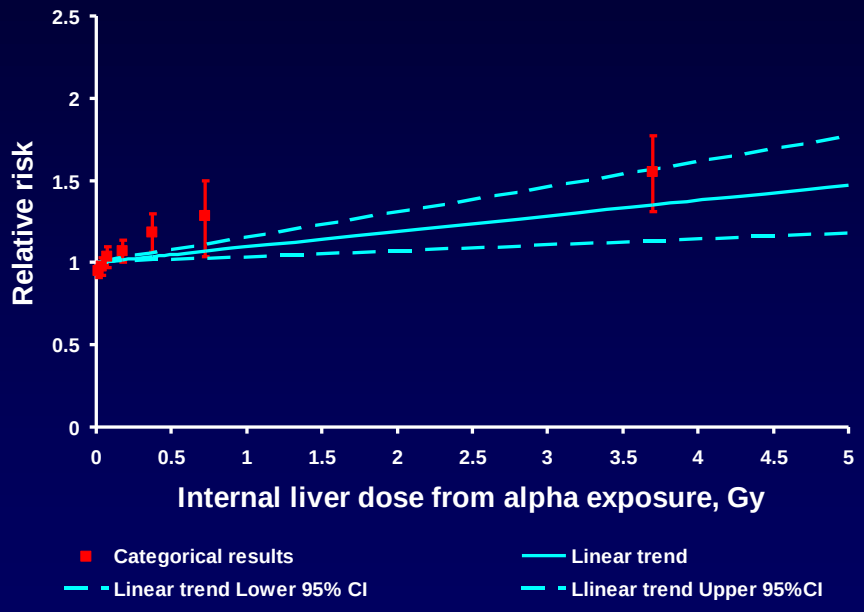
IHD Mortality

ERR/Gy = 0.26 (95% CI 0.07, 0.46)



CVD Incidence

ERR/Gy = 0.10 (95% CI 0.04, 0.15)



Sensitivity Analysis and Effect Modification for Internal Dose Analysis

- Findings for IHD mortality did not vary greatly when:
  - *adjusting for extra non-radiation factors; and*
  - *using different lag periods.*
- However, ERR/Gy for IHD mortality was lower and not statistically significant after restricting follow-up to Ozyorsk or adjusting for external dose.
- Findings for CVD incidence did not vary greatly when:
  - *adjusting for extra non-radiation factors;*
  - *adjusting for external dose; and*
  - *using different lag periods.*
- ERR/Gy for CVD incidence increased with increasing lag period.

Comparison of findings on IHD (External Exposure)

Cohort	Mean total dose (Gy)	Mortality or morbidity	Lag period (years)	Number of death or cases	ERR/Gy
A-bomb survivors: LSS	0.20	Mortality	23	4 477	0.17 (90% CI 0.08, 0.26)
A-bomb survivors : AHS	0.57	Incidence	13	1 546	0.05 (95% CI -0.05, 0.16)
Mayak workers (1948-1958)	0.84	Mortality	10	1 461	0.07 (95% CI -0.02, 0.15)
Mayak workers (1948-1972)	0.63	Mortality	10	2 590	0.06 (95% CI -0.02, 0.13)
Mayak workers (1948-1958)	0.84	Incidence	10	3 133	0.12 (95%CI 0.05, 0.19)
Mayak workers (1948-1972)	0.63	Incidence	10	5 274	0.10 (95% CI 0.04, 0.16)
Radiation workers (international study)	0.018	Mortality	10	5 821	-0.01 (95% CI -0.59, 0.69)
NRRW (UK)	0.025	Mortality	10	7 168	0.26 (90% CI 0.00, 0.55)
Chernobyl recovery operations workers	0.109	Incidence	-	10 942	0.41 (95% CI 0.05, 0.78)

Comparison of findings on CVD (External Exposure)

Cohort	Mean total dose (Gy)	Mortality or morbidity	Lag period (years)	Number of death or cases	ERR/Gy
A-bomb survivors: LSS	0.20	Mortality	23	3 954	0.12 (90% CI 0.02, 0.22)
A-bomb survivors : AHS	0.57	Incidence	13	729	0.07 (95% CI -0.08, 0.24)
Mayak workers (1948-1958)	0.84	Mortality	10	744	-0.02 (95% CI -0.12, 0.08)
Mayak workers (1948-1972)	0.63	Mortality	10	1 495	0.03 (95% CI -0.06, 0.13)
Myayak workers (1948-1958)	0.84	Incidence	10	3840	0.45 (95% CI 0.34, 0.56)
Mayak workers (1948-1972)	0.63	Incidence	10	7 264	0.40 (95% CI 0.31, 0.50)
Radiation workers (international study)	0.018	Mortality	10	1 224	0.88 (95% CI -0.67, 3.16)
NRRW: UK	0.025	Mortality	10	1 817	0.16 (90% CI -0.34, 0.77)
Chernobyl recovery operations workers	0.109	Incidence	-	12 832	0.45 (95% CI 0.11, 0.80)

Conclusions

- Raised risks of circulatory disease have been found in relation to:
  - *external radiation dose*, having adjusted for non-radiation factors and internal dose, and
  - *internal radiation dose*, having adjusted for non-radiation factors and (in the case of CVD morbidity) for external dose
- Risk estimates for external radiation are generally compatible with those from other large occupational studies and for the A-bomb survivors

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