



Circulatory diseases in the cohort of Mayak PA workers occupationally exposed to radiation

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Introduction

- **This presentation reports on results of studies of incidence and mortality from circulatory diseases (CDs) including ischaemic heart disease (IHD), cerebrovascular diseases (CeVD) and lower extremity arterial disease (LEAD) in the cohort of Mayak PA workers occupationally exposed to radiation at low dose rates over a prolonged period.**



Mayak PA - the first Russian nuclear facility – started operation in June 1948. Mayak PA is located 10 km from Ozyorsk city in the Southern Urals.

Mayak PA:

Main facilities

- *Reactors*
- *Radiochemical plant*
- *Plutonium plant*

Auxiliary plants



The study cohort

The study cohort included all workers first employed at one of the main facilities (reactors, radiochemical, plutonium) in 1948 – 1982 followed up to 31.12.2008

Characteristics of the study cohort

Characteristics of the study cohort as of December 31, 2008	
Cohort size	22,377
Females	25%
Migrants from Ozyorsk	41%
Vital status known	95%
Deceased	54%
 with known cause of death	96%
Alive	46%
Incidence data available	97%
Information on non-radiation factors available	93%
Biological samples	25%

Occupational radiation exposure of Mayak PA workers

- **Reactors**
 - *Chronic external gamma-ray exposure*
- **Radiochemical plant**
 - *Chronic external gamma-ray exposure*
 - *Intake of alpha-particles through inhalation*
- **Plutonium production plant**
 - *Chronic external gamma-ray exposure*
 - *Intake of alpha-particles through inhalation*

Radiation exposure monitoring

- **Individual monitoring of external exposure has been performed since the start-up of the Mayak PA**
 - *Individual measured annual doses from gamma-rays are available for all workers included in the study cohort*

- **Regular monitoring of internal radiation dose started later – since 1960**
 - *Alpha-activity of plutonium in bioassay was measured for only 39% of workers who could be potentially exposed to radionuclides*



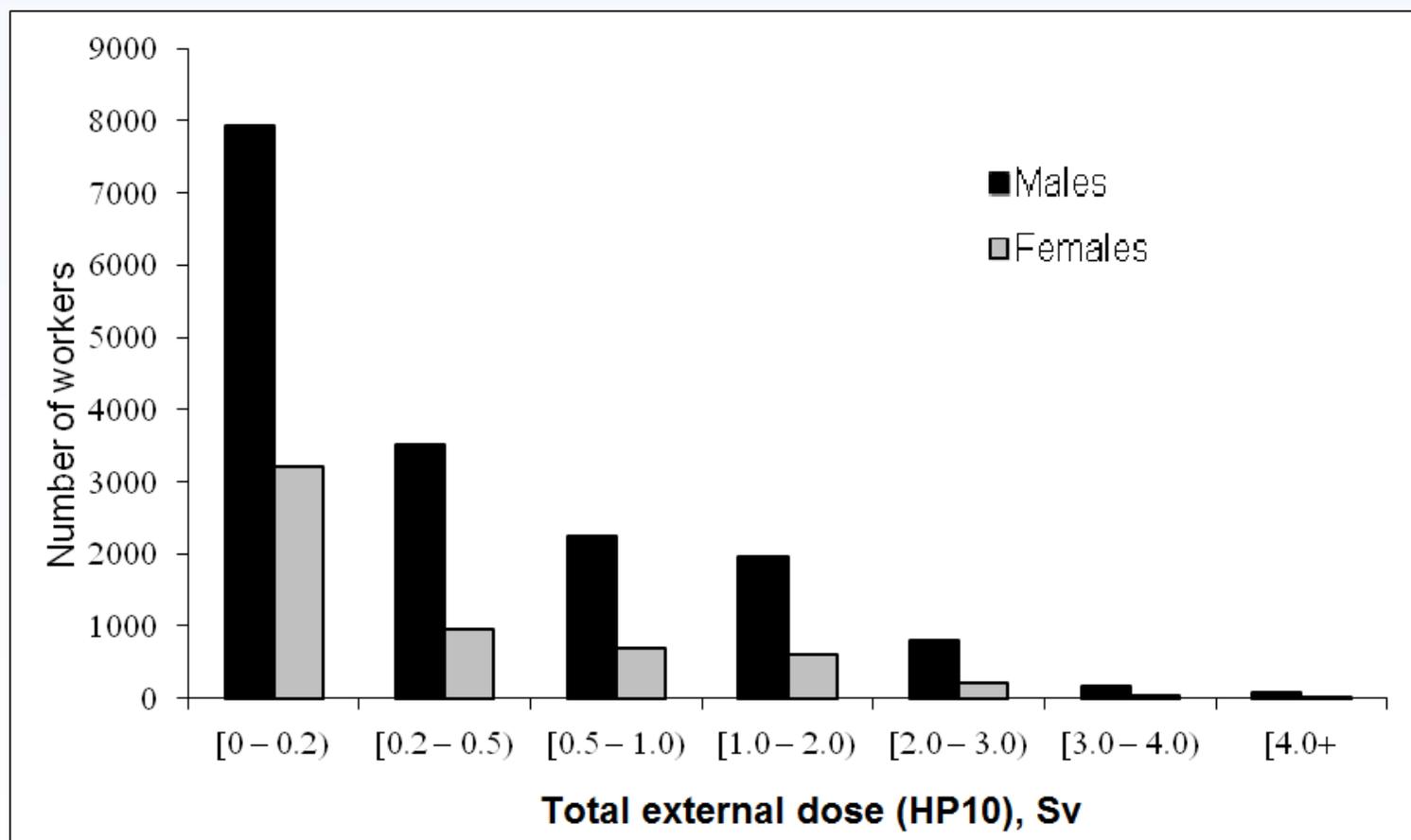
Dosimetry

This study was based on dose estimates for external and internal exposures provided by the Mayak Workers Dosimetry System – 2008 (MWDS – 2008) developed under Russian-American collaboration.

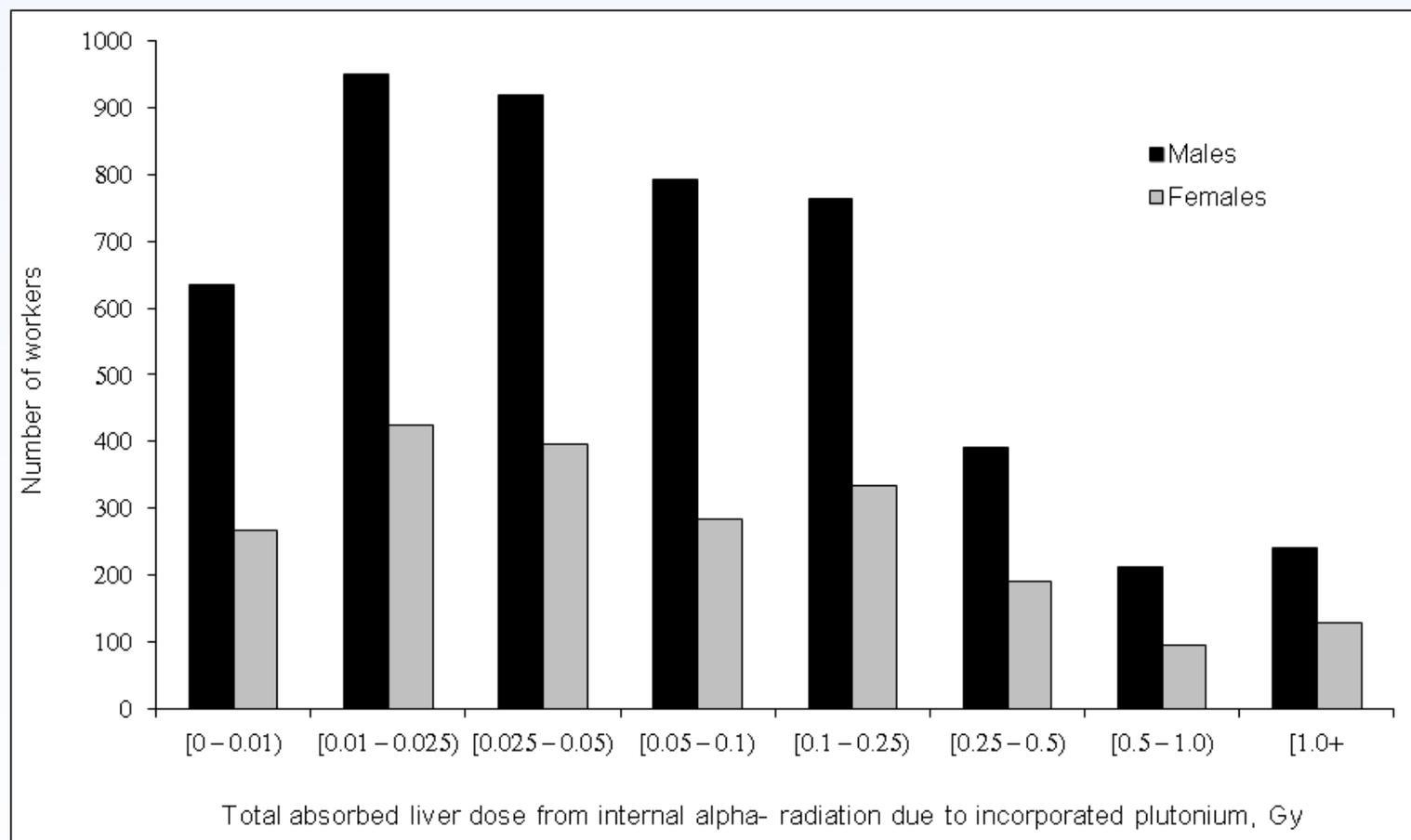
Radiation dose estimates

- The mean total dose from external gamma-rays was 0.54 (SD 0.76) Gy for males and 0.44 (SD 0.65) Gy for females.
- The mean total absorbed alpha-particle dose to the liver from incorporated plutonium was 0.44 (SD 2.11) Gy in males and 0.23 (SD 0.77) Gy in females.

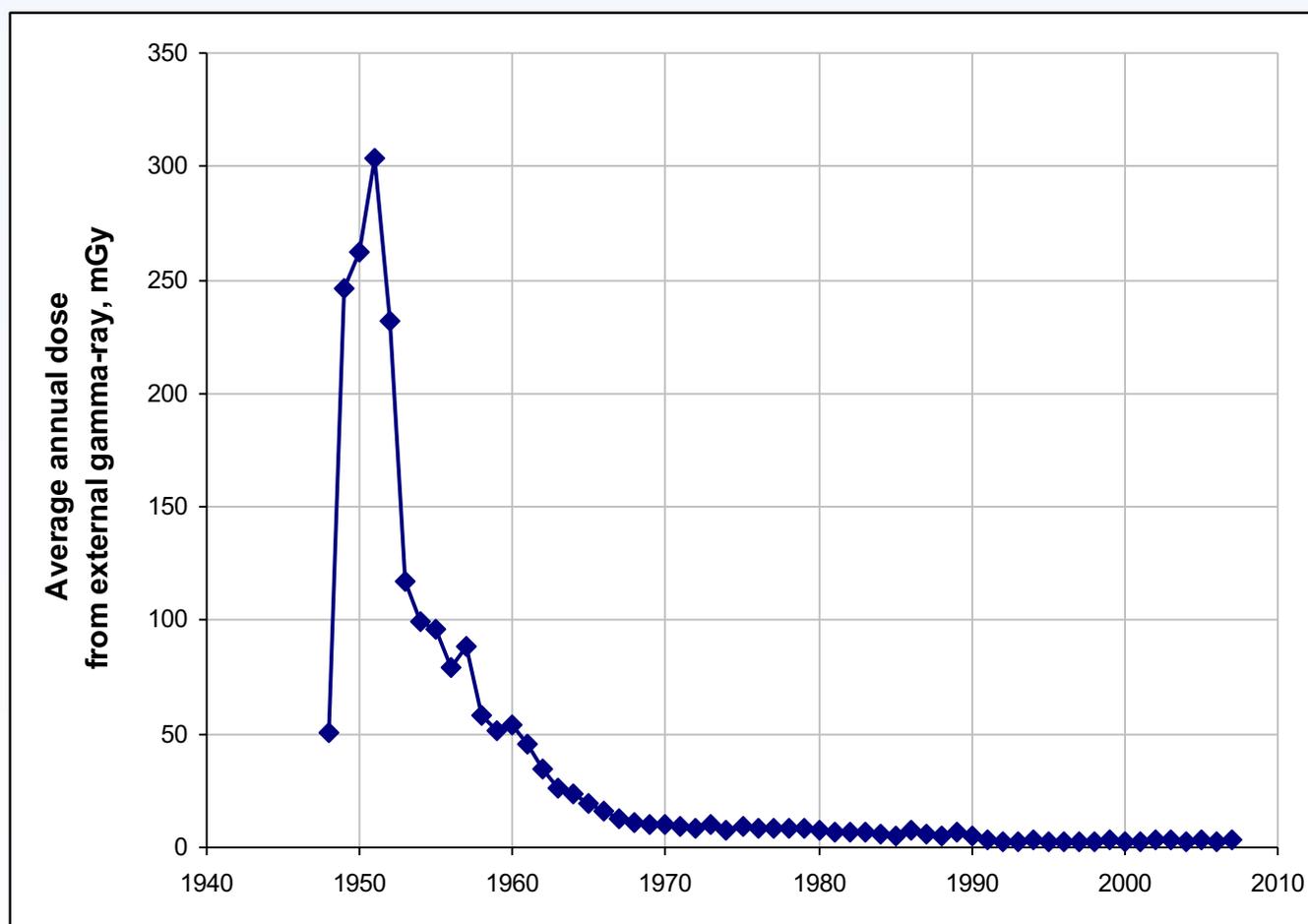
Distribution of workers by the total dose from external gamma-rays



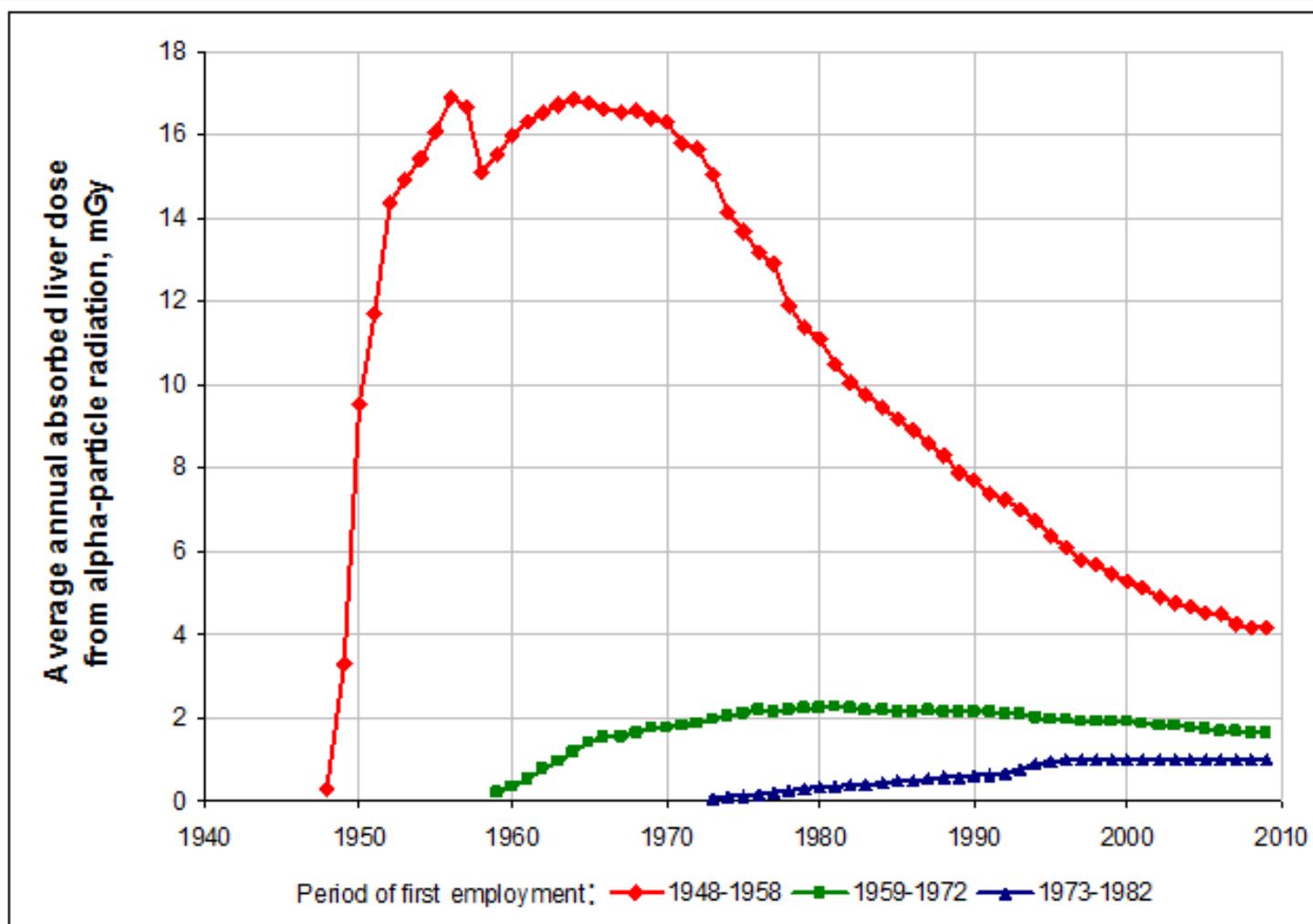
Distribution of workers by the total dose from internal alpha-radiation to liver



Mean annual doses from external gamma-rays



Mean annual doses from internal alpha-radiation



Results



Mortality and incidence analyses in relation to non-radiation factors

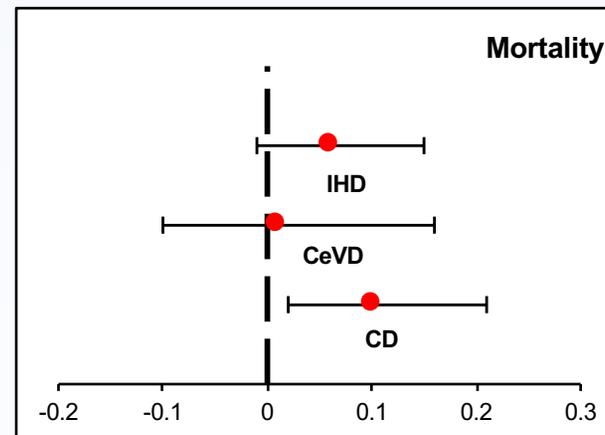
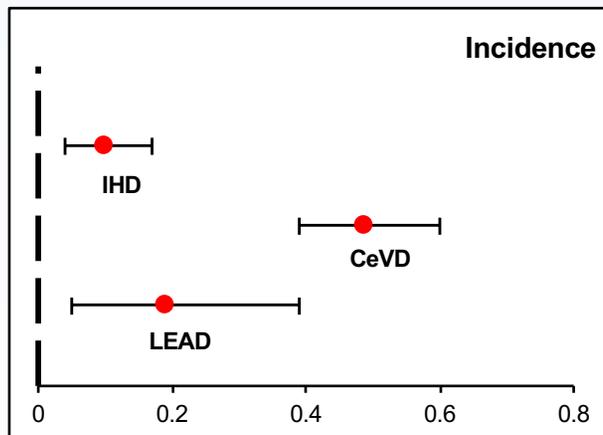
The study showed a significant association of CD incidence and mortality with non-radiation factors such as sex, attained age, smoking, alcohol consumption, hypertension, increased body weight, diabetes mellitus and others.

Results



Mortality and incidence analyses in relation to external exposure

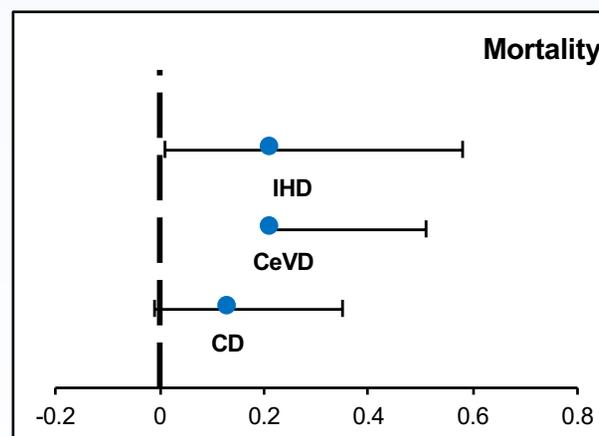
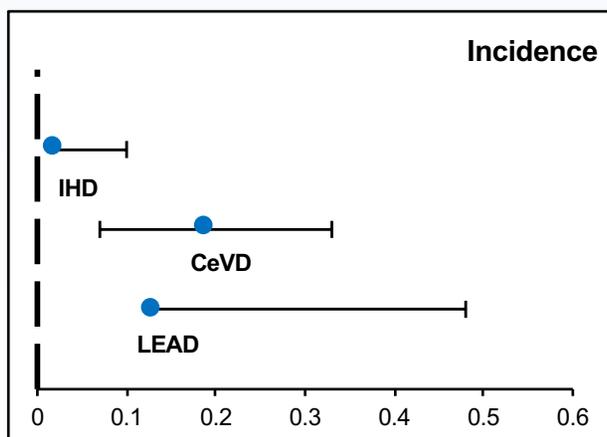
Significant linear associations of IHD, CeVD and LEAD incidence with dose from external gamma-rays were found after having adjusted for non-radiation factors and dose from internal alpha-radiation. Moreover a significant increasing linear trend in CD mortality with increasing dose from external gamma-rays was observed.



Results

Mortality and incidence analyses in relation to internal exposure

Dose-response analysis for internal alpha-radiation due to incorporated plutonium showed significant linear associations of CeVD incidence and IHD mortality with total absorbed dose from internal alpha-radiation to the liver after having adjusted for non-radiation factors and dose from external gamma-rays.



IHD and CeVD incidence: analyses by total absorbed alpha-dose to liver for different values of the validity of dose estimates

Main analysis, 0 y lag	ERR/Gy (95% CI) (the whole cohort)	ERR/Gy (95% CI) (subcohort < 1 Gy)
IHD		
Validity [0;1]	0.07 (0.01, 0.14)	0.42 (0.13, 0.75)
Validity = 1	0.09 (0.01, 0.23)	1.06 (0.41, 1.98)
Validity > 0	0.06 (>0, 0.14)	0.38 (0.07, 0.74)
CeVD		
Validity [0;1]	0.28 (0.16, 0.42)	0.90 (0.56, 1.28)
Validity = 1	0.32 (0.14, 0.56)	0.98 (0.39, 1.77)
Validity > 0	0.18 (0.08, 0.30)	0.58 (0.26, 0.94)

Comparison with results of other studies

Ischemic heart disease

Incidence	
Mayak PA (Azizova, 2015)	0.10 (0.04, 0.17)
Mayak PA (Simonetto, 2014)	0.10 (0.04, 0.18)
AHS (Yamada, 2004)	0.05 (-0.05, 0.16)
Chernobyl recovery operations workers (Ivanov, 2006)	0.41 (0.05, 0.78)
Mortality	
Mayak PA (Azizova, 2015)	0.06 (<0, 0.15)
Mayak PA (Simonetto, 2014)	0.08 (0.02, 0.15)
LSS (Preston, 2012)	0.17 (0.08, 0.26)
LSS (Shimizu, 2010)	0.02 (-0.01, 0.15)
15-country study (Vrijheid, 2007)	-0.01 (-0.59, 0.69)
BNFL (McGeoghegan, 2008)	0.70 (0.33, 1.11)
UK (Radiation workers) (Muirhead, 2009)	0.26 (-0.05, 0.61)
French nuclear workers (Metz-Flamant, 2013)	0.71 (-1.20, 3.18)
Canadian Fluoroscopy Cohort (Zablotska, 2014)	0.01 (-0.04, 0.07)

Comparison with results of other studies

Cerebrovascular diseases

Incidence	
Mayak PA (Azizova, 2014)	0.49 (0.39, 0.60)
Mayak PA (Simonetto, 2015)	0.39 (0.31, 0.46)
AHS (Yamada, 2004)	0.07 (-0.08, 0.24)
Chernobyl recovery operations workers (Ivanov, 2006)	0.45 (0.11, 0.80)
Mortality	
Mayak PA (Azizova, 2014)	>0 (-0.10, 0.16)
Mayak PA (Simonetto, 2015)	0.03 (-0.04, 0.1)
LSS (Shimizu, 2010)	0.09 (0.01, 0.17)
BNFL (McGeoghegan, 2008)	0.43 (-0.10, 1.12)
UK (Radiation Workers) (Muirhead, 2009)	0.16 (-0.42, 0.99)
German uranium miners (Kreuzer, 2012)	0.44 (-0.14, 1.08)
15-country study (Vrijheid, 2007)	0.88 (-0.67, 3.16)

Comparison with results of other studies

Circulatory diseases

	Mortality
Mayak PA (Azizova, 2015)	0.10 (0.02, 0.21)
LSS (Shimizu, 2010)	0.11 (0.05, 0.17)
15-country study (Vrijheid, 2007)	0.09 (-0.43, 0.7)
BNFL (McGeoghegan, 2008)	0.54 (0.30, 0.82)
UK (Radiation Workers) (Muirhead, 2009)	0.25 (0.03, 0.49)
Techa river cohort (Krestinina, 2013)	0.036 (0.002, 0.075)/100 mGy



Conclusion

This study provides evidence for the increased risk of CD incidence and mortality following external gamma-ray exposure and a suggestive indication for the risk of CD following internal radiation exposure. Validity of dose from internal alpha-radiation strongly affects the dose-response for internal radiation exposure.



Acknowledgement

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THANK YOU!

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