Computed Tomography and Occupational Radiation Exposure of "Mayak" Workers: CT Register

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1. Background and terms

Mayak PA – Russian first nuclear cycle factory for Plutonium production
Mayak Worker Cohort (MWC)- workers exposed to external gamma- and incorporated plutonium (Pu-239)
Ozyorsk Population – people living in the surrounding area
Computed Tomography – an additional source of radiation exposure for both Ozyorsk population and Mayak workers
OCTC study – Ozyorsk Computed Tomography Cohort Study

2. Methods

Study Design: Retrospective cohort study (OCTC)
Source: CT Register – the database of Ozyorsk population including nuclear workers, exposed to diagnostic CT.
The data collected from 5 hospitals located in the Southern Urals of Russian Federation. Medical and dosimetric information has been derived from CT diagnostic protocols.
Cohort: Ozyorsk residents born between 1916-2018 and exposed to at least 1 CT during the lifetime.
Follow-up period started in 1993 when first CT scanners appeared in the Southern Urals, and ended in Dec, 31, 2018
Follow-up time (T) calculated from 1st CT to the date of exit: cancer diagnosis , death, end of 2018, or lost to follow-up
Mayak Workers were identified in the CT Register database
Cancer morbidity used for the analyses. The data from local Cancer Registry has been linked to the study. First malignancies were considered as cases.
Predisposed conditions accounted (e.g. pre-cancer conditions clinically stated before the 1st CT examination)
Vital status has been updated for **65.3%** of cohort (as of December, 31, 2018)
Cause of death: established for 86.1% of Ozyorsk residents

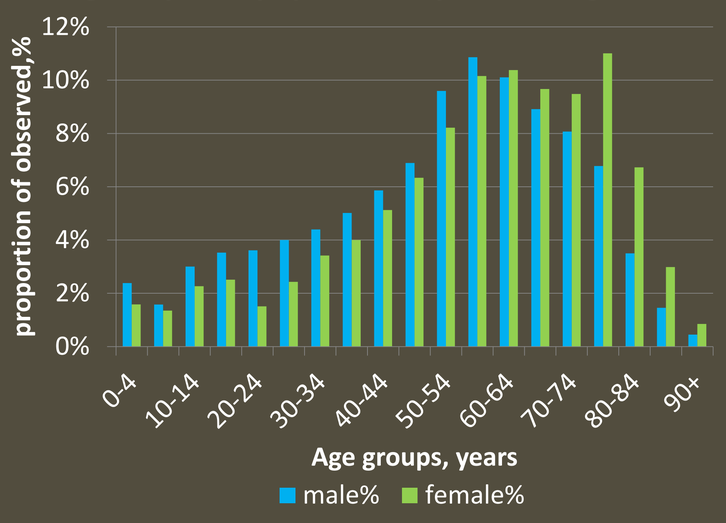
3. Results

Cohort of **16,624 persons** exposed to CT (**26,626** CT examinations), including 25% of Mayak workers (**29.8%** of those worked with **Pu-239** with measured internal doses**)**
Effective Dose for single CT 5**.6** mSv (min 0.1-max 50.2); for Mayak workers **4.0** mSv (min 0.2-max 50.2)
Total Cancer cases to the end of follow-up **2,842** (17.1%); among Mayak workers: 33.6%
Cancers diagnosed on or before CT examination – 67.6%
Pre-cancer cases – 24.7%. Second cancers – 2,8%.
% Deaths **30.2%** (cancer deaths 40.4%) % Alive **50.5%**
% Lost **19.4%** **Average T** for dead 1527 days (0-9866)

4. Discussion

Limitations: Possible lost of CT examinations outside Ural region. The retrospective recovery of handwritten information in part of the CT protocols.
Short follow-up period for severely ill persons.
Advantages: Study cohort with over than 16,600 exposed
Long-term follow-up up to 25 years with possibility to extend.
Detailed information on vital status, cancer morbidity and cause of death. The cohort includes younger ages (CT exposure before occupational history).
Both single and multiple CT exposure scenario. External and internal individual radiation doses for workers.
A possibility for reconstruction of CT absorbed doses.

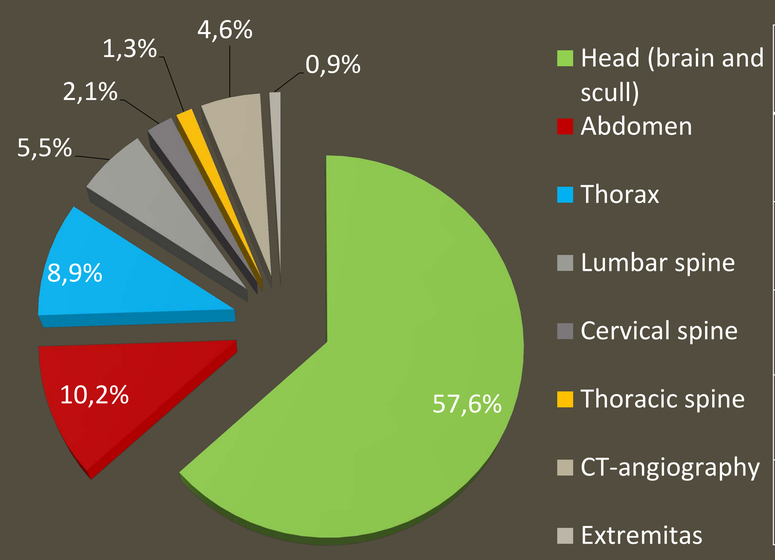
Fig.1 Exposed population by sex and age of 1st CT



Tab.1 Exposed population by sex and CT number

CT number	Both sex	%	Male	%	Female	%
1 CT	11,326	68.0	5,400	67.1	5,927	68.9
2-3 CT	4,303	25.8	2,138	26.5	2,165	25.2
4-5 CT	725	4.4	358	4.4	367	4.3
6-9 CT	329	2.0	130	1.6	109	1.3
10> CT	60	0.4	26	0.3	34	0.4
Total	16,653	100.0	8,051	48.3	8,602	51.7

Fig.2 Distribution by anatomic localization



Tab.2 Exposed population by area exposed and ED, mSv

Area	Observed	%	Persons	%	Mean ED
Head	15,784	59.3	11,222	67.4	1.8 (0.1-8.6)
Thorax	3,225	12.1	2,041	12.3	4.0 (0.4-28.0)
Abdomen	3,278	12.3	2,522	15.1	12.4 (0.4-50.2)
Other	3,778	14.2	873	5.2	5.7 (0.2-26.7)
Total	26,626	100.0	16,658	100.0	3.8 (0.1-50.2)

Fig.3 Cancer morbidity in the cohort by age and sex

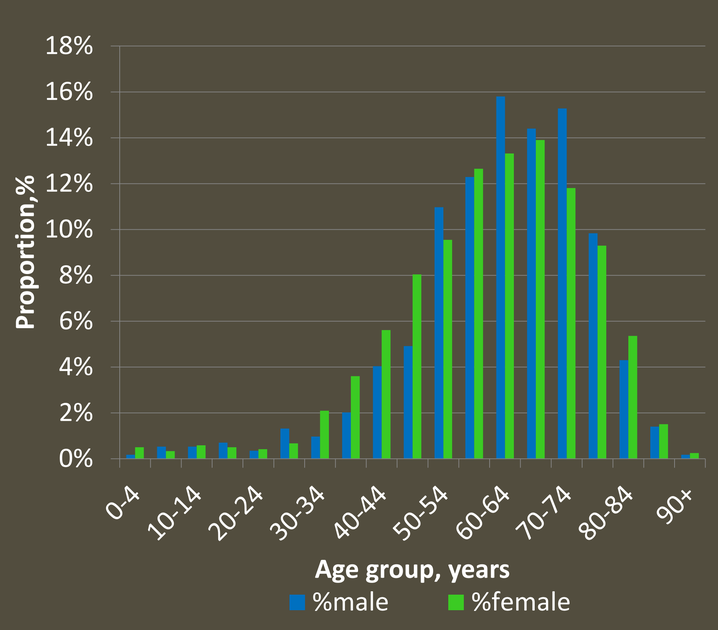
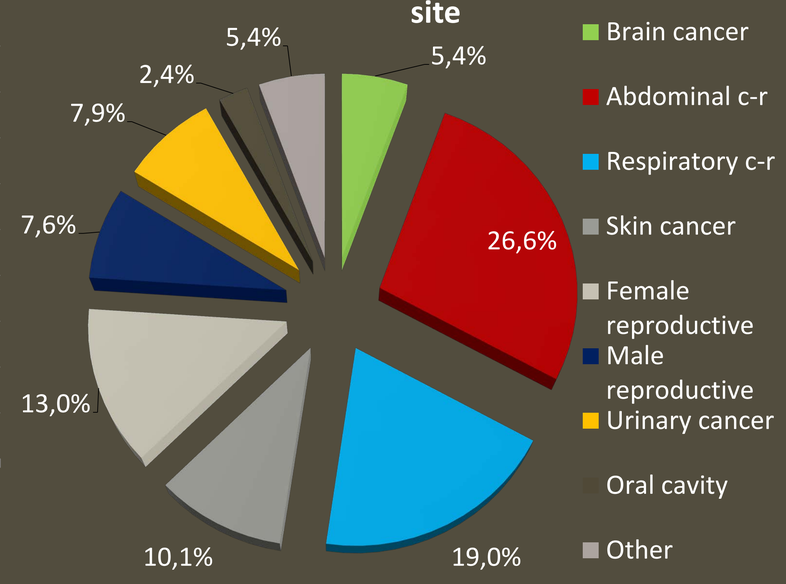


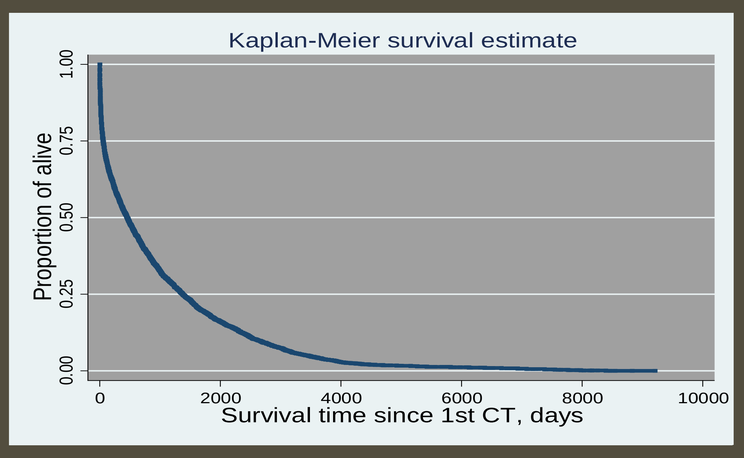
Fig.4 Cancer morbidity structure by cancer site



Tab. 3 Cancer cases diagnosed after CT, follow-up time and the percentage of pre-cancers and deaths

Time	Cases	Pre c-r%	%deaths	Total time
0 yr	673	24.7	73.4	478 671
1 yr	269	7.4	69.9	445 598
2 yr	195	5.6	64.6	405 785
5 yr	81	3.7	58.0	269 552
Total	**673**	**24.7**	**52.5%**	478 671

Fig.5 Survival function for exposed to CT (for those who had died before the end of follow-up)



5. Conclusions and Acknowledgements

The CT Register data is a valuable source of information for the retrospective epidemiological analyses of radiation risk in a cohort of individuals exposed to low dose of diagnostic radiation accounting background occupational exposure.
The OCTC data can contribute to the improvement the radiation safety standards for occupationally exposed workers.
We express our gratitude to CT departments teams for their assistance .