

Cancer and non-cancer mortality among  
Inhabitants in the **H**igh **B**ackground  
**R**adiation **A**rea of Yangjiang (HBRA), China  
(1979-1998)



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# Background Information and Objective

## Background Information

- The study was conducted since 1972
- The study period included  
1979-1981, 1982-1986, 1987-1990, 1991-1995, 1996-1998
- The average annual effective doses

HBRA: 6.4 mSv	(external: 2.10 mSv, internal: 4.27 mSv)
CA: 2.4mSv	(external: 0.77 mSv, internal: 1.65 mSv)

# Background Information and Objective

## Background Information

- On the basis of hamlet-specific average external doses , cohort members were classified into four groups

Table 1 Classification of dose group for cohort members

Group	average annual effective doses ( $10^{-5} \text{ Sv} \cdot \text{a}^{-1}$ )
High	246.07 (224.10-308.04)
Intermediate	210.19 (198.07-224.09)
Low	183.31 (125.29-198.06)
Control	67.92 (50.43-95.67)



# Background Information and Objective



## Objective

The major purpose is to examine if any excess cancer mortality rate in the HBRA with considering the comparative analyses and the possible effects by other potential confounding factors.



# Material and Method

## Subjects and their collected

- The mortality data for the period **1979-1986** were collected by a prospective follow-up survey of dynamic populations, consisting of around 80 000 inhabitants in the HBRA and as many in the CA.
- The mortality data for **1987-1998** were obtained from a prospective follow-up survey of a fixed cohort consisting of 106 517 individuals alive as of the January 1, 1987.



# Material and Method

## Mortality follow-up survey

- trained local census takers surveyed the hamlets of the study areas to collect information on deaths and migrations among inhabitants in each hamlet.
- The collected information was recorded in the demographic survey sheet prepared for each household in the hamlet.
- The task group on mortality follow-up survey, then, visited the studied areas and reviewed the survey sheets.





# Material and Method

## Mortality follow-up survey

- In order to ascertain the cause of death, they visited all the major hospitals in the study area, and reviewed medical records of the deceased studied subjects and extracted relevant information.
- If necessary, they revisited the local village doctors and the family members or next of kin to collect further information on cause of death.
- The underlying cause of death thus ascertained was coded according to the 9<sup>th</sup> revision of the International Classification of Diseases (ICD-9)



# Material and Method

## **Statistical methods**

- Risk analysis was based on the tabulated person-years data, cross-classified by the variables having the following categories: sex, attained age (0, 1, 2, 3, 4, ... 89,  $\geq 90$  years old), and the follow-up period (1979-1981, 1982-1986, 1987-1990, 1991-1995 and 1996-1998)



# Material and Method

## Statistical methods

- Relative risk (RR) was calculated to compare the mortality in the HBRA and the CA using the following model:

$$R = \alpha e^{\beta x}$$

$\alpha$ - represents the stratum background mortality rates specific for sex, attained age group and follow-up period categories;

$x$ - is an indicator variable of living in the HBRA ( $x=1$  for HBRA inhabitants, and  $x=0$  for CA).

$\beta$ - is the log relative risk for the comparison between the HBRA and the CA. All the p-values presented are two-sided.

# Material and Method

## Statistical methods

- The excess relative risk (ERR) per sievert dose (Sv) was estimated using the following model:

$$r = r_0[1 + ERR(dose)]$$

**$r$ - is the mortality rate for given age, sex, and calendar period**

**$r_0$ -is the background or baseline of the mortality rate specified for period of follow-up, sex, and age in the population**

- **RRs and ERRs, and their 95% confidence interval (CI) were obtained from Poisson regression analysis using the AMFIT in Epicure**

# Results (No. of all deaths, cancer deaths and PYs)

Numbers of all deaths, cancer deaths and person-years by dose-rate group in Yangjiang study (1979-1998)

	Control group			Low dose group			Intermediate dose group			High dose group		
	All causes of death	Cancer deaths	Person years	All causes of death	Cancer deaths	Person years	All causes of death	Cancer deaths	Person years	All causes of death	Cancer deaths	Person years
region												
Wudianmeihua	3539	347	528011	.	.	.	.	.	.	.	.	.
Dong-anling	.	.	.	2499	257	432499	2019	209	360494	1210	123	200806
Tongyou	.	.	.	550	57	82617	1155	92	157069	1472	117	231444
Follow-up period												
1979-86	1504	129	210710	1266	115	197605	1321	110	197318	1163	92	166454
1987-98	2035	218	317301	1783	199	317511	1853	191	320245	1519	148	265796
Sex												
Female	1623	122	256327	1417	117	245287	1420	89	244030	1128	78	197344
Male	1916	225	271684	1632	197	269829	1754	212	273533	1554	162	234906
AGE												
0- 39	486	59	363961	560	55	375102	553	60	374541	470	50	308753
40-49	190	65	53200	188	59	50061	117	47	48928	160	38	41353
50-59	317	76	44186	272	68	39663	285	73	40894	248	58	35592
60-69	681	82	39263	548	84	29220	570	70	31637	472	61	27708
70-	1865	65	27401	1481	48	21069	1589	51	21563	1332	33	18845
Total	3539	347	528011	3049	314	515116	3174	301	517564	2682	240	432250

- Through **1979 to 1998**, **1 992 940** PYs at risk were accumulated with the follow-up of **125 079** subjects, **12 444** deaths including **1 202** cancer deaths were identified.
- These included **294 628** PYs, **2029** total deaths and **199** cancer deaths from the last follow-up period of **1996-1998**.

# Results (Overall cancer mortality)

**Table 2** Relative risks of all-cancer deaths according to follow-up period, sex, age, method of diagnosis

Variable	Control		HBRA				
	area	Dong-anling+Tongyou		Dong-anling		Tongyou	
	Cases	Cases	RR (95% CI)	Cases	RR (95% CI)	Cases	RR (95% CI)
<b>All</b>	347	855	<b>1.00</b> (0.89- 1.14)	589	<b>1.08</b> (0.94-1.23)	266	<b>0.89</b> (0.75-1.04)
<b>Period</b>							
1979-86	129	317	<b>1.04</b> (0.84- 1.27)	223	1.13 (0.91-1.41)	94	0.86 (0.66-1.13)
1987-98	218	538	<b>0.98</b> (0.84-1.15)	366	1.04 (0.88-1.24)	172	0.90 (0.74-1.10)
<b>Sex</b>							
Female	122	284	0.96 (0.77-1.19)	189	0.95 (0.76-1.19)	95	0.99 (0.76-1.30)
Male	225	571	1.03 (0.88-1.20)	400	1.14 (0.97-1.35)	171	0.84 (0.69-1.03)
<b>Age</b>							
0-39	59	165	1.04 (0.77-1.41)	118	1.10 (0.80-1.50)	47	0.93 (0.63-1.37)
40-49	65	144	0.85 (0.63- 1.14)	99	0.87 (0.63-1.19)	45	0.81 (0.56-1.19)
50-59	76	199	1.01 (0.77-1.32)	135	1.10 (0.83-1.46)	64	0.89 (0.64-1.24)
60-69	82	215	1.17 (0.90- 1.51)	148	1.29 (0.99-1.70)	67	0.98 (0.71-1.36)
70+	65	132	0.92 (0.68- 1.23)	89	0.99 (0.72-1.36)	43	0.80 (0.54-1.17)
<b>Method of Diagnosis</b>							
Pathology only	95	234	<b>0.99</b> (0.78-1.25)	173	1.13 (0.88-1.46)	61	0.74 (0.54-1.03)
Others	252	621	1.02 (0.88-1.18)	416	1.06 (0.91-1.24)	205	0.94 (0.78-1.14)

# Results (site-specific cancer mortality)

Table 3 Estimates of relative risks for major cancer sites by dose-rate group (1979-1998)

Site of cancer, ICD-9 code	Control area*		Dose-rate group in HBRA				P for trend	HBRA (subtotal RR (95% CI)	
	Cases	Cases	Low	Intermediate		High			
			RR (95% CI)	Cases	RR (95% CI)	Cases			RR (95% CI)
All cancers	347	314	1.08 (0.93-1.26)	301	1.00 (0.86-1.17)	240	0.92 (0.78-1.08)	0.551	1.00 (0.89-1.14)
Leukemia, 204-208	13	10	0.82 (0.35-1.86)	15	1.20 (0.57-2.56)	11	1.07 (0.47-2.39)	0.836	1.03 (0.56-2.02)
Solid cancers	334	304	1.10 (0.94-1.28)	286	0.99 (0.85-1.16)	229	0.91 (0.77-1.08)	0.519	1.00 (0.88-1.14)
Nasopharynx, 147	66	53	0.96 (0.66-1.37)	56	0.98 (0.68-1.40)	44	0.88 (0.60-1.28)	0.557	0.94 (0.71-1.26)
Esophagus, 150	5	10	2.55 (0.91-8.21)	14	3.30 (1.26-10.24)	7	1.88 (0.60-6.37)	0.063	2.61(1.11-7.66)
Stomach, 151	37	28	0.91 (0.55-1.48)	31	0.98 (0.60-1.57)	22	0.79 (0.46-1.33)	0.531	0.90 (0.61-1.34)
Colon, 153	7	4	0.70 (0.18-2.33)	3	0.50 (0.11-1.80)	5	0.93 (0.28-2.92)	0.653	0.70 (0.28-1.89)
Rectum, 154	4	7	2.27 (0.68-8.70)	3	0.94 (0.18-4.25)	3	1.00 (0.20-4.56)	0.907	1.40 (0.49-4.97)
Liver, 155	100	89	1.07 (0.80-1.42)	73	0.84 (0.62-1.14)	56	0.74 (0.53-1.02)	0.098	0.89 (0.70-1.13)
Pancreas, 157	4	7	2.01 (0.61-7.70)	6	1.69 (0.48-6.62)	4	1.31 (0.31-5.57)	0.479	1.69 (0.62-5.87)
Lungs, 162	38	29	0.93 (0.57-1.50)	22	0.67 (0.39-1.12)	30	1.04 (0.64-1.68)	0.637	0.87 (0.60-1.30)
Bone, 170	5	5	1.22 (0.34-4.41)	3	0.69 (0.14-2.84)	4	1.07 (0.26-4.05)	0.889	0.99 (0.36-3.11)
Skin, 173	7	8	1.50 (0.54-4.30)	15	2.64 (1.11-6.93)	5	0.98 (0.29-3.07)	0.319	1.74 (0.80-4.33)
Female breast, 174	8	5	0.77 (0.23-2.33)	3	0.46 (0.10-1.59)	4	0.73 (0.20-2.33)	0.346	0.65 (0.27-1.66)
Cervix uterus, 180	1	5	6.34 (1.02-121)	2	2.53 (0.24-54.39)	2	3.02 (0.29-64.90)	0.309	4.01 (0.75-74.2)
CNS**, 191-192	7	7	1.11 (0.38-3.24)	10	1.56 (0.60-4.30)	7	1.29 (0.44-3.78)	0.504	1.32 (0.60-3.33)
Thyroid, 193	2	2	1.19 (0.14-9.97)	0	-	3	2.27 (0.38-17.30)	0.770	1.09 (0.23-7.60)
Lymphoma, 200-202	6	6	1.13 (0.35-3.62)	11	1.99 (0.76-5.80)	6	1.27 (0.40-4.06)	0.380	1.48 (0.64-4.01)

\* RR=1 in the control group

\*\* Brain and central nervous system





# Results(solid cancer)

## ERR estimated of solid cancers

- $-0.06/S_v$  (95% CI, -0.60-0.67) for entire HBRA and the CA
- $0.35/S_v$  (95% CI, -0.34-1.13) for Dong-anling and the CA
- $-0.052/S_v$  (95% CI, -1.03-0.2) for Tongyou and the CA



# Results(non-cancer diseases)

**Table 6 Relative risks of non-cancer deaths excluding external causes**

Factor s	Control			HBRA				
	Cases#	Dong-anling + Tongyou		Dong-anling		Tongyou		
		Cases	RR (95% CI)	Cases	RR (95% CI)	Cases	RR (95% CI)	
All	2847	7191	<b>1.06 (1.01-1.10)*</b>	4575	<b>1.05 (1.00-1.10)*</b>	2616	<b>1.07 (1.01-1.12)*</b>	
Period	1979-86	1233	3094	1.02 (0.95-1.09)	2006	1.03 (0.96-1.11)	1088	0.98 (0.91-1.21)
	1987-98	1614	4097	<b>1.09 (1.02-1.15)*</b>	2569	1.06 (0.99-1.13)	1528	<b>1.13 (1.05-1.21)*</b>
Sex	Female	1347	3353	1.05 (0.98-1.11)	2260	1.06 (0.99-1.13)	1093	1.02 (0.94-1.10)
	Male	1500	3838	<b>1.06 (1.03-1.13)*</b>	2315	1.03 (0.97-1.10)	1523	<b>1.11 (1.03-1.19)*</b>
Age	0-39	285	992	<b>1.31 (1.15-1.50)*</b>	682	<b>1.32 (1.15-1.51)*</b>	310	<b>1.29 (1.10-1.52)*</b>
	40-49	90	305	<b>1.28 (1.01-1.62)*</b>	190	<b>1.19 (0.92-1.53)</b>	115	<b>1.47 (1.11-1.93)*</b>
	50-59	208	525	1.00 (0.85-1.17)	311	0.94 (0.78-1.12)	214	1.09 (0.90-1.32)
	60-69	551	1288	1.06 (0.95-1.17)	812	1.05 (0.94-1.17)	476	1.06 (0.94-1.20)
	70+	1713	4081	1.01 (0.95-1.07)	2580	1.01 (0.95-1.07)	1501	1.01 (0.94-1.08)

# RR=1 in the control area. \*P<0.05



# Conclusion

- The current study provided a similar result to previous one that the mortality of all cancers showed no significant difference between the HBRA and the CA, relative risk was estimated to be 1.00 (95%CI, 0.89 to 1.14).
- The non-cancer mortality was significantly elevated in the HBRA, and did not show much difference between Dong-anling region and Tongyou region . However, the excess was limited to the latter half of the observed period (1987-1998) and in the younger people (aged less than 50 years) .



# Other Lab Results

Table 8 Comparison of frequency of PBL IL-2SC between HBRA and CA

Age group (years)	HBRA		CA	
	No. of analyzed	Frequency (%)	No. of analyzed	Frequency (%)
<20*	9	20.11 ± 1.97	9	17.02 ± 3.90
20-50**	9	19.89 ± 1.75	9	17.17 ± 2.37
>50***	7	20.71 ± 0.86	9	15.78 ± 1.58
Total***	25	20.20 ± 1.61	28	16.63 ± 2.76

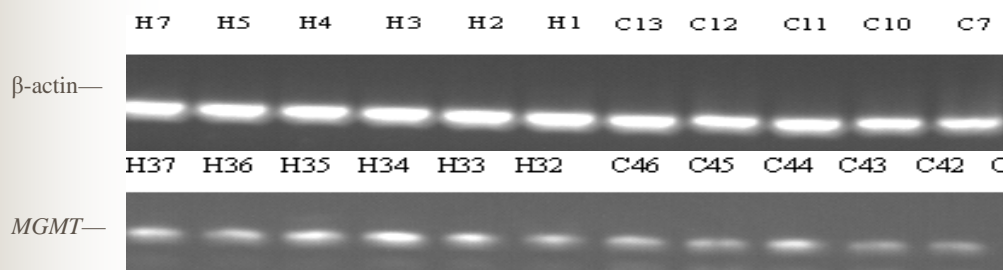
IL-2SC: interleukin-2-secreting cell. \* p>0.05, \*\*p<0.05, \*\*\*p<0.01

Based on “Immune competence and immune response to virus to high background radiation area, Yangjiang, China”. J.-M. Zou, J. Yao, N.-G. Chen et al. Luxin wei, Tsutomu Sugahara and Zufan Tao. Elsevier Science publishers B.V. Amsterdam 1997.

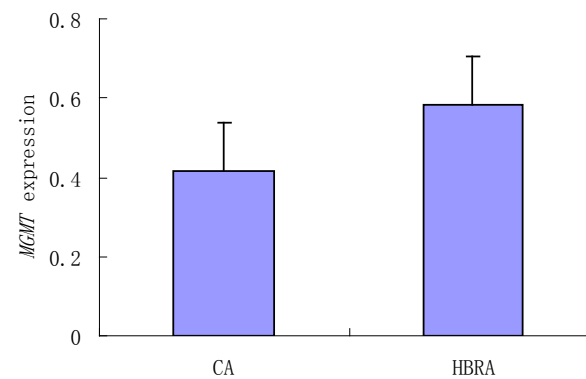
**Table 9 Comparison of anti-oxidative capacity (U/ml) in two populations**

Groups	n	SOD activity	GSH activity	CAT activity	T-AOC content
CA	53	50.23 ± 26.19	23.17 ± 4.33	2.20 ± 1.65	11.41 ± 3.78
HBRA	53	65.93 ± 38.50*	28.81 ± 6.36*	4.48 ± 2.19*	14.39 ± 3.06*

Significance: \* $P < 0.05$  compared with control group.



**Fig. 1** Gel electrophoresis image of DNA damage repair enzyme of MGMT mRNA (H: HBRA, C: CA)



**Fig. 2** Comparison of MGMT gene expression between the residents in HBRA and those in CA. Each value represents the mean  $\pm$  SEM. Significance:  $P < 0.05$  by ANOVA, the residents in HBRA vs. those in CA.





**Thank you!**