Collection of Interesting Data Published in Various Documents

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This report is merely a collection of interesting data that Imanaka noticed during the course of the collaborative work. When readers are interested in more details, please look into original materials or have a contact to Imanaka.



Fig. 1. Contamination map of ¹³⁷Cs within the 30 km zone around the Chernobyl NPS [1].

- Redrawn by Imanaka from the original map, 137 Cs levels of which are divided into 12 classes. *note:* Imanaka visited near village Kryuki in the summer of 1993, and measured an exposure dose rate of 44 µSv/h above the ground with a scintillation spectro-surveymeter. This value is evaluated to correspond to the initial 137 Cs deposition density of about 1,200 Ci/km², based on the relation between the deposition density and exposure rates obtained from other measurements.

Level of ¹³⁷ Cs contamination (Ci/km ²)	Area (km ²)
over 1,000	21
200 - 500	59 112
100 - 200	187 364
20 - 50	892
10 - 20 5 - 10	114 41
2 - 5	172
1 - 2 0.5 - 1.0	63 19
Total	2,044

Table 1. Level of ¹³⁷Cs contamination in the alienation zone belonging to Ukraine [2].

remarks:

- Alienation zone is defined as the area around the Chernobyl NPS from where inhabitants evacuated in the first weeks or months after the accident. This zone does not necessarily coincidence with the 30 km circle around the site, and is somewhat larger than the circle.

- Total activities of ¹³⁷Cs, ⁹⁰Sr and ^{239,240}Pu in soil within the alienation zone in Ukraine are reported to be 110,000, 100,000 and 800 Ci, respectively. Besides, Activities in storage/disposal sites within the alienation zone reportedly amount to 410,000, 56,000 and 1,400 Ci of ¹³⁷Cs, ⁹⁰Sr and ^{239,240}Pu, respectively [2].

- The area of the alienation zone belonging to Belarus is reported to be $1,700 \text{ km}^2$ [3].

Table 2. Excerpts of description about the health state of inhabitants from the secret protocols of the Operative Group of the Politic Bureau of the Central Committee of the Communist Party of the Soviet Union [4].

<date of<="" th=""><th>otocol> <description about="" health="" of="" people="" state="" the=""></description></th><th></th></date>	otocol> <description about="" health="" of="" people="" state="" the=""></description>	
/1986/ A	1 29, April 30: No description.	
May 1:	p impose him (remark: Mr Shchepin, the first Deputy Minister of Health of the USSR) a task to report to	o the
•	perative Group the data on the numbers of hospitalized, including children, and of patients with radiation disea	ase.
May 3:	o description.	
May 4:	y the situation on May 4, 1,882 people are hospitalized in total. Total number of examined people reached 38	3,000
-	ersons. Radiation disease of various seriousness appeared with 204 persons, including 64 infants.	
May 5:	otal number of hospitalized people reached 2,757 persons, including 569 children. Among them, 914 persons	have
-	mptoms of radiation disease. 18 persons are in very serious state and 32 persons are in serious state.	
May 6:	y the situation at 9:00 on May 6, the total number of hospitalized reached 3,454 persons. Among them, 2	2,609
-	ersons are in hospital for treatment, including 471 infants. According to confirmed data, the number of radia	ation
	sease are 367 cases, including 19 children. Among them, 34 persons are in serious state. In the 6th Hospit	tal in
	oscow, 179 persons are in hospital, including two infants.	
May 7:	uring the last day, 1,821 persons were additionally hospitalized. At 10:00 May 7, the number of persons in hos	spital
	r treatment is 4,301, including 1,351 infants. Among them, diagnosis of radiation disease was established with	ı 520
	ersons, including staffs of Ministry of Internal Affairs of the USSR. 34 persons are in serious state.	
May 8:	uring the last day, the number of hospitalized persons increased by 2,245, including 730 children. 1,131 per	rsons
	ft hospital. By the situation at 10:00 May 8, the total of 5,415 persons are in hospital for treatment, including 1	,928
	ildren. Diagnosis of radiation disease was confirmed with 315 persons.	
May 10:	uring the last two days, 4,019 persons were hospitalized, including 2,630 children. 739 persons left hospitalized	al. In
	tal 8,695 persons are in hospital, including 238 cases with diagnosis of radiation disease, among which 26	5 are
	ildren.	
May 11:	uring the last day, 495 persons were hospitalized and 1,017 persons left hospital. In total, 8,137 persons a	re in
	ospital for treatment and examination, among which 264 persons with diagnosis of radiation disease. 37 person	s are
	serious state. During the last day 2 person died. Total number of death by the accident amounted to 7 persons.	
May 12:	uring the last day, 2,703 persons were hospitalized, most of which were in Belarus. 678 persons left hosp	pital.
),198 persons are in hospital for treatment and examination, among which 345 persons have symptom of radi	ation
	sease, including 35 children. Since the time of the accident, 2 persons perished and 6 persons died of disease	s. 35
	ersons in serious state.	
May 13:	uring the last day 443 persons were hospitalized and 908 persons left hospital. 9,733 persons are in hospital	d for
	eatment and examination, including 4,200 children. Diagnosis of radiation disease was established with	299
	ersons, including 57 children. During the last day, one person died. In total two persons perished and one dis	ed in
 Mov 14.	uspital.	or of
May 14:	uting the last day 1,059 persons were additionary hospitalized and 1,200 persons left hospital. The humo-	died
	iring the last day	uicu
May 16.	ne number of persons in hospital is 7.858 including 3.410 children. Diagnosis of radiation disease is establi	ished
101uy 10.	ith 201 cases. The total number of deaths is 15, including 2 deaths on May 15.	bilea
May 20:	uring the last 4 days the number of hospitalized persons increased by 716. Radiation disease was confirmed	with
11 11 1 2 01	1 cases, including 7 children. The number of death is 17, and 28 are in serious state. Symptoms of radi	ation
	sease were established only with persons who were directly at the zone of the scene and development of	f the
	cident.	
May 22,	ay 26: No description.	
May 28:	172 persons are in hospital for examination and treatment, including 183 persons with established diagnos	is of
•	diation disease (among them one infant). During the last week, one person died. The total number of death on	May
	B is 22 (plus 2 victims at the beginning of the accident).	-
June 2:	669 persons are in hospital for examination and treatment, including 171 persons with established diagnos	is of
	diation disease. The number of deaths amounted to 24 (besides, two persons perished at the beginning or	f the
	cident). 23 persons are in serious state.	
June 4, J	e 9: No description.	
June 12:	494 persons are in hospital for examination and treatment, including 189 persons with established diagnos	is of
	diation disease. The number of death until June 12 is 24 persons (plus 2 victims at the beginning of the accide	nt).
June 20,	me 25, July 2, July 7, July 10, July 23, July 31, August 13, August 22, September 5,	
Septemb	19, October 17, November 15, /1987/ January 4, March 16, July 13, /1988/ January 6: No description	

remark: The total number of 40 protocols are included in the secret document, all dates of which are shown above. The above numbers of deaths and serious states almost correspond to the numbers of cases with firemen and plant staffs.

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		Ι	Ι	I	III
	Patient of acute radiation		Follow-up study of 500		Japanese adult
	syndrome [5]		liquidators [6]		(male, 35-45 years
	Group A	Group B	Belarus	Russia	old)
Sample size	106 persons	103 persons	494 persons	474 persons	-
Number of death	9 cases	5 cases	5 cases	17 cases	-
Cumulative death rate after	85%	40%	10%	36%	2.04
the accident*	0.5 %	4.7 %	1.0 %	5.0 %	~2 %

Table 3. Number of death after the accident among persons who survived the initial period of acute radiation syndrome and among 500 liquidators specially followed-up in a EC/CIS study.

* Durations of observation are 10 years, about 7 years and 10 years for I, II and III, respectively *Remarks:*

- 1. According to the first detailed report about the accident by the USSR government [7], the number of deaths by the accident was reported to be 31 cases. The number of persons who suffered acute radiation syndrome (ARS) was reported to be 203 persons, all of whom were firemen and staffs of the station. Among them, 28 persons died in three months related with ARS. Two persons died on the day of the accident: one staff was missing within the destroyed reactor and the other died of severe burns. One death was from other reason.
- In November 1986, the number of ARS was revised to be 237 cases [8]. That is, 209 (= 237 28) persons were alive at that time.
- Later on, 103 cases out of 237 were excluded from the category of ARS [5].
- Group A in the above Table consists of 106 patients with whom diagnosis of ARS was confirmed. Group B consists of 103 patients with whom diagnosis of ARS was given in 1986, but later canceled. The period for observation is for 10 years (1986-1995).
- Death causes of Group A: 3 coronary heart diseases, 2 myelodysplastic syndrome, 1 lung gangrene, 1 lung tuberculosis, 1 liver cirrhosis, and 1 fat embolism.
- Death causes of Group B: one cases of car accident, hypoplasia of haematopoiesis, encephalitis/encephalomylitis, sarcoma (thigh), and coronary heart disease.
- 2. This study was carried out within the frame of the EC/CIS collaborative project [6], in order to check the traceability of contingents in the Chernobyl registries. 500 liquidators were randomly selected from the Registries in Belarus and in Russia. As a result of special efforts to ascertain their states, 4 persons remain unknown and 2 persons emigrated abroad in the Belarussian group. These numbers in the Russian group were 4 and 22 persons, respectively. The time of state ascertainmemt was not exactly mentioned, but the time of address ascertainment was described to be 01.10.1993 and 31.12.1992 for Belarussian and Russian groups, respectively.
- Death cause of 5 Belarussian liquidators: 1 acute mycardial infarction, 1 cerebrovascular disease, 1 fracture of the skull, 1 fracture of the back bone and 1 Hpdgkin's disease.
- Death cause of 17 Russian liquidators: 4 hangings, 2 cancers (one pharynx, one stomach), 2 haemorrhages (one internal, one pancreas), 2 internal brain trauma, 1 gangrene of the intestine, 1 carbon monooxide poisoning whilst intoxicated, 1 car crash, 1 ischemic heart disease, 1 heart insufficiency and 2 unknown causes.
- 3. Death rate of Japanese male are taken from the Vital Statistics in Japan in 1986.

*			
Group	Ukraine [2] (State Registry of Ukraine)	Russia [9] (Russian National Medical-dosimetric Registry)	Belarus [10] (Chernobyl Registry)
Total number of registered person	474,095	435,276	204,982
(date)	(96.1.1)	(95.9.1)	(95.1.1)
including:			
A. Liquidators	184,672	152,325	53,192
B. Evacuees and resettlers	62,711	12,889	~10,000*
C. Inhabitants in contaminated areas	189,518	251,246	~90,000*
D. Children of A-C groups	37,194	18,816	?

Table 4. Population size of the Chernobyl registries carried out in each affected country.

* These numbers were obtained by a private communication with Matsko in Minsk.

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	Ukraine [2]	Russia [9]	Belarus [11]
Population size of primary cohort	174,812 persons	143,032 persons	45,674 persons
Fraction of persons with dose record	59 %	80 %	26 %
Average recorded dose	160 mSv	107 mSv	57 mSv

Table 5. Characteristics of liquidator population in the Registry of each country.

- Primary cohorts consist of liquidators who are subjects of following-up study; principal information about places and period of their working at Chernobyl are known.

	Number of		Recorded external irradiation (mSv)					
	persons	no record	<50	50-99	100-249	250-500	>500	
Workers in	135,800	65,300	8,000	20,900	34,100	7,300	270	
1986-87	100 %	48.1 %	5.9 %	15.4 %	25.1 %	5.4 %	0.20 %	
Workers in	39,000	6,600	26,200	5,500	510	90	0	
1988-90	100 %	17.0 %	67.2 %	14.2 %	1.3 %	0.23 %	0 %	

 Table 7. Distribution of observed and expected numbers of cancers in 1993-1994 among male



Fig 2. Dynamics of disabled rate among liquidators registered in Russia [13] and Ukraine [12].

liquidators registered in	a Belarus by dura	ation of work in th	e 30 km zone [11].
1			

		Duration of work in the 30 km zone								
ICD-9	Site	Less than 30 days				1-6 months				
		0	Е	SIR	95%CI	0	Е	SIR	95%CI	
151	Stomach	7	12.1	58	23-119	5	7.3	69	22-160	
153	Colon	7	2.9	241	97-497	2	1.7	117	14-423	
162	Lung	14	22.1	63	35-106	9	12.0	75	34-143	
173	Skin	2	4.4	45	5-163	0	2.7	0	0-139	
188	Urinary bladder	5	3.0	167	54-390	4	1.6	245	67-628	
189	Kidney	3	3.4	88	18-257	4	2.1	189	52-485	
193	Thyroid grand	1	0.7	151	4-844	3	0.5	625	129-1826	
204-208	Leukemia	3	2.7	111	23-325	6	1.8	342	126-746	
140-208	All sites	61	85.2	72	55-92	41	50.4	81	58-110	

- Expected number (E) is obtained with age standardization based on the incidence data of the general population in Belarus.

Vear	Incidence rate (per 100.000 persons)				
I Cai	Workers in 1986	Workers in 1987			
1987	13.33 ± 4.71	-			
1988	6.42 ± 3.21	6.32 ± 4.47			
1989	14.06 ± 4.69	4.41 ± 3.12			
1990	14.50 ± 4.59	5.32 ± 3.07			
1991	18.13 ± 4.84	7.74 ± 3.46			
1992	12.59 ± 3.98	12.02 ± 4.25			
Total	13.35 ± 1.80	7.04 ± 1.57			

Table 8. Incidence of leukemia among Ukrainian liquidators [12].

- During 1987-1992, 141 cases of hemobalstoses disease were observed among registered liquidators, 86 cases among which were leukemia.

Table 9. Morbidi	ty of acute leukemi	a in children under	15 years old in Bel	arus in 1979-1992 [10].
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	Incidence per 1	million children	Total number of cases	Chemical contamination
Region	1979-1985 1986-1992		(1979-1992)	level in the environment, ton/km ²
Brest	42	44	208	2.80
Vitebsk	42	47	186	10.40
Gomel	34	43	210	4.60
Grodno	42	39	147	3.20
Minsk	37	41	195	2.20
Mogilev	50	42	184	7.60
Minsk citv	49	47	234	735.40
Total	42.0	43.3	1 364	_

Remarks: The Blood disease registry in Belarus was began in 1988 at the Research Institute of Heamatology and Blood Transfusion of the Health Ministry. So, the old data are supposed to be obtained by retrospective analysis.

Table 10. Average annual indices of hemoblastoses morbidity in the Bryansk region of Russia from1979 to 1993 [14].

	Annual indices per 100,000 persons, (number of cases during the period)		
	1979-85	1986-90	1991-93
Acute lymphoid leukemia:			
6 contaminated districts	$0.56 \pm 0.17(11)$	$1.55 \pm 0.34(21)$	$1.33 \pm 0.42(10)$
Bryansk city	$0.48 \pm 0.12(14)$	$1.59 \pm 0.26(37)$	$1.86 \pm 0.36(27)$
Other districts	$0.70 \pm 0.11(38)$	$1.14 \pm 0.18(42)$	$2.56 \pm 0.34(56)$
Hemoblastoses total:			
6 contaminated districts	$10.54 \pm 0.73(209)$	$12.79 \pm 0.97(173)$	$15.43 \pm 1.43(116)$
Bryansk city	$12.79 \pm 0.65(387)$	$18.73 \pm 0.90(437)$	$18.22 \pm 1.12(265)$
Other districts	$11.24 \pm 0.46(610)$	$13.17 \pm 0.60(485)$	$19.23 \pm 0.94(421)$

- 6 contaminated districts are districts of Gordeevsk, Zlynkovsk, Klimovsk, Klimovsk, Krasnogrsk and Novozybkovsk. *remarks:* The special registry of blood disease in the Bryansk region was established in 1987 at Haematological Research Center of RAMS. So, the old data are supposed to be obtained by retrospective analysis.

Table 11. Malignant cancer i	ncidence in the contaminated territories of Belarus: before and after the
Chernobyl accident and by	¹³⁷ Cs levels (Annual standardized incidence per 100,000 persons) [10].

			-	
Contamination	Gomel region		Mogilev region	
level with ¹³⁷ Cs	before the accident	after the accident	before the accident	after the accident
Ci/km ²	1977-1985	1986-1994	1977-1985	1986-1994
>15	194.6±8.6	304.1±16.5**	221.0± 8.6	303.9± 5.1**
5-15	176.9 ± 9.0	248.4±12.5**	241.8 ± 15.4	334.6±12.2***
< 5	181.0 ± 6.7	238.0 ± 26.8	248.8 ± 14.5	306.2±18.0*

: Significant increase (; p<0.05, **; p<0.01, ***; p<0.001) as compared with the period before the accident.

- Cancer morbidity is based on the data of the Belarussian Cancer Registry during 1977 -1994.



Fig. 3. Distribution of children by health groups obtained by a special study in the WHO/IPHECA program [14].

Health indices: 1st class - healthy children from all indices of health, 2nd class -children with functional disturbances, risk for occurrence of chronic pathologies and high morbidity 3rd, 4th, 5th classes - ill children with chronic pathologies of different degrees

Table 12. Morbidity of Belarussian children included in the Chernobyl Registry [15].(1992, per 1,000 children)

- The number of children contained in the Chernobyl registry is 33,488. Among them, 6.9, 81.4 and 11.7 % are

Diseases	Children in the Register (A)	Whole Belarus (B)	Ratio (A/B)
Neoplasm	4.08	1.75	2.3
including: Malignant neoplasm	1.84	0.35	5.3
Thyroid cancer	0.82	0.05	16
Endocrine, metabolism and immune system disorders	133.78	33.66	4.0
Blood and hematopoetic tissue diseases	56.46	12.00	4.7
Blood circulation diseases	39.58	12.92	3.1
Otolaryngologic diseases	95.89	19.47	4.9
Digestive organ diseases	162.91	125.84	1.3
Psychic diseases	27.64	24.49	1.1

evacuees from the 30-km zone, residents or emigrants from the zone over 15 Ci/km² and children born with registered parents, respectively.



Fig. 4 Annual incidence of thyroid cancer in children and adolescents in Ukraine [16], 4 regions of Russia [17] and Belarus [18].

- 4 regions in Russia are the Bryansk, the Kaluga, the Tula and the Orel regions.

- Children's age of Ukraine and Russia is 0 - 18 years old at the time of the accident.

- Children's age of Belarus is 0 - 14 years old at the time of their cancer operation.



Fig. 5. Annual incidence of thyroid cancer in adults of Belarus [19].

Table 13. Estimates of economic loss due to the Chernobyl accident in Belarus for 198	6-2015 [10].
unit: Billion US Dollars (at the price in 1992)	

Item of loss	Period		
item of loss	1986-1995	1996-2015	1986-2015
Deterioration of people's health and	0.98	0.89	1.87
related countermeasures		•	
Manufacturing industry	0.19	0.44	0.63
Social circumstances: school etc.	7.77	6.47	14.23
Construction industry	1.40	1.28	2.68
Transport and communication	2.13	1.26	3.39
Houses and public facilities	0.52	2.94	3.46
Agricultural industry	38.31	33.70	72.00
Forest industry	1.26	2.85	4.11
Resettlement	4.36	0.72	5.08
Implementation of the Law to help the sufferers: compensation, privilege etc.	15.48	70.84	86.32
Contamination of mineral and water resources	2.12	0.55	2.67
Construction of monitoring	4.23	32.60	36.83
Monitoring works	0.26	1.46	1.72
Total	79.00	156.00	235.00

- Estimation was carried out at the Institute of Economy, Academy of Sciences of Belarus.

- All items consist of loss categories: direct and indirect loss, loss of profits, and additional expenditures.

- 235 billion USD corresponds to 32 times of the national budget of Belarus in 1985 or 21 times of it in 1991.

Year	Expenditure from the LCA Fund* (Billion Krb.)	Percentage to the national budget of Ukraine (%)	Percentage to general national production (%)
1991	6.2	-	2.1
1992	97.4	6.4	1.9
1993	1,966	6.3	1.3
1994	23,788	5.1	1.8
1995	94,199	5.8	1.8

*: LCA Fund: Fund for Liquidation of the Consequences of the Chernobyl Accident. Until September of 1991, works to liquidate the consequences of the Chernobyl accident and to help the sufferers were implemented directly by the budget of the former USSR. Thereafter, the finance has been given from the budget of Ukraine through the LCA Fund.

- Krb. is the currency unit used in Ukraine until 1996.

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