Smallpox Mortality in a Mountainous District in Japan where neither Variolation nor Vaccination had been performed

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Extremely high smallpox mortality was reported at the time when neither variolation nor vaccination had been performed. C.D. Dixon[1] noted that whole tribes were exterminated when smallpox was introduced in the West Indies in 1507, and that whole races were exterminated when it first appeared in Brazil in 1563.

However, few documents from that time which prove such high smallpox mortalities are extant.

In *Sokei Gūki*[2] the numbers of patients and deaths in an epidemic of smallpox, which was introduced from the Izu peninsula to Hachijo Island in 1795, were noted. The data can be arranged as follows.

Name of Village	Population	Smallpox Patients	Smallpox Deaths	Infectivity (%)	Mortality (%)	Case-Fatality (%)
Miné	1,400	1,200	460	85.71	32.86	38.33
Kashidaté	900	103	29	11.44	3.22	28.16
Suyeyoshi	800	55	15	6.88	1.88	27.27
Aogashima	150	19	13	12.67	8.67	68.42

However, in Kashidaté village, there had been a smallpox epidemic in the past; in Sueyoshi village, many inhabitants fearing smallpox took refuge in the mountains, and in Aogashima, only people who had been variolated had immigrated from Hachijo Island. Therefore, only the data from Miné village are for virgin land, and the mortality and case-fatality were 32.86% and 38.3% respectively.

(1)

In 1795, smallpox raged in the Yonezawa clan (Yamagata prefecture), at a time when even variolation was not practiced. Two thousand and sixty four deaths were recorded out of 8,389 patients and the case-fatality reached 24.60%.[3]

Because there are extant only few documents concerning smallpox mortality in ancient times, the authors would like to report the data covering 80 years from 1771 to 1851 from a mountainous district in Gifu prefecture, Japan where neither variolation nor vaccination had been performed.

I. Materials for Investigation

(1) Kakochos of Ōgenji Temple

For the investigation the data in a monograph *Studies on Kakochos* (death registers) *of Ō-Temple in Hida*[4] was used.

Ō-Temple (Ōgenji) is situated in Miya-mura (village) near Takayama-shi (city), Ōno-gun (county), Gifu-ken (prefecture). Ōgenji belongs to the Ōtani school of the Jōdo-Shinshū sect of Buddhism, and was founded about five hundred years ago. (Fig. 1)

The chief priests of Ōgenji, especially those who were in charge in the Edo Period (1600~1867), were respected scholars, and they noted about one hundred names of diseases in their Kakochos or death registers. In Ōgenji immense volumes of Kakochos from 1528 are still in existence.

Fig. 1 Ōgenji Temple

The Kakocho is a register in which the popular name, posthumous Buddhist name, the date of death and the age of death of dead parishioners were usually recorded. In the Kakochos of Ōgenji not only these items but also the date of birth, the sex, the cause of death, and sometimes various family matters were recorded. Even social events and human interest stories were sometimes recorded in diary style.

From 1688 to 1730, only uncommon deaths such as hanging, drowning etc. were recorded, but since then many names of diseases such as Rōgai (pulmonary tuberculosis), Shōkan (typhoid fever), Ribyo (dysentry), etc. were recorded as the cause of death. Therefore, the record of smallpox in the Kakocho seems to be highly credible.

Though variolation was introduced in 1744 to Nagasaki, the sole trade port at that time situated at the western part of Japan, but it had not been carried out in the district under investigation. On the other hand, vaccination was carried out since 1849 in Japan, but in Gifu prefecture it was carried out in 1870 for the first time[5], and it was in 1875 in Hida district[6]. Therefore, the data reported here are that of in the district where neither variolation nor vaccination had been carried out.

Parishoners of Ōgenji were the inhabitants of Miya-village (52km² in area) in Ōno county, and those of Adakasu, Nagisa, Nagatoro, Tokusabora, Hikisagé, Gobō, Utō, Musugo, Kuguno, and Yamanashi villages (107km² in area) in the same county.

Meterological data of the villages are as follows. Atomospheric temperature (yearly mean): 8.7°C (Miya village); 10.5°C (other villages), Amount of rainfall: 200mm (Miya village); 168mm (other villages), Period of snow fall: From the last part of December to the last part of March, Height above sea level: ca. 600 m.

(2) Calculation of the Population

As a basis for computation of the population in the past, names and ages of the total inhabitants in 1970 were inquired and listed separately according to age. Dead persons from 1969 to 1771 were determined according to age (Recorded Group) (Table 1). The number of dead persons was added according to age to the 1970 po-

Table 1 Basis for Computation of the Population

A.D. \ Age	1	2	3	4	5	......
Number of Inhabitants	1970	A^*	B	C	D	E	......
Number of Deceased	1969	a_1^{**}	b_1	c_1	d_1	e_1	......
Inhabitants	1968	a_2	b_2	c_2	d_2	e_2	......
	1967	a_3	b_3	c_3	d_3	e_3	......

* A, B, C, D, E···Number of inhabitants by age in the year 1970.
** a, b, c, d, e···Number of deceased inhabitants by age.

Table 2 Calcuation of the Population

A.D. \ Age	1	2	3	4	5
1970	A	B	C	D	E
1969	B a_1+ (a_1+B)	C b_1+ (b_1+C)	D c_1+ (c_1+D)	E d_1+ (d_1+E)	F e_1+ (e_1+F)
1968	b_1+C a_2+ (a_2+b_1+C)	c_1+D b_2+ (d_2+c_1+D)	d_1+E c_2+ (c_2+d_1+E)	e_1+F d_2+ (d_2+e_1+F)	......

pulation (refer to Table 2), and the population in 1969 was calculated (*Calculated Population*). By repeating the same procedure, the population each year in the past was computed.

If there were dead persons whose ages were not recorded in the Kakocho (Non-recorded Group), the average age of the Calculated Group in that year was applied to them, and a *Revised Population* was obtained. During 1771 to 1851, recorded persons were 7818 and the non-recorded were 285 (3.68%).

Year after birth	Japanese counting
<one	1 year old
<two	2 years old
<three	3 years old
<four	4 years old
<five	5 years old

(4)

In this report the age according to the Japanese way of counting years of age was used as above.

(3) Smallpox Mortality

The smallpox mortality each year was calculated by dividing the total number of smallpox deaths by the Revised Population of that year. In the calculation, the third decimal point was rounded off to the nearest whole number.

The smallpox mortality among total deceased inhabitants was calculated by dividing the total number of smallpox deaths by the total number of deceased inhabitants.

The smallpox mortality of children under five years old was calculated by dividing the total number of smallpox deaths of children under five years old by the total number of deaths of the same age.

II. Results

(1) The smallpox mortality in the Hida district during the 80 years from 1771 to 1851 was calculated. The highest mortality was 3.28% in 1804. The highest mortality of smallpox among the total deceased inhabitants was 64.79% in the same year. (Table 3)

(2) The smallpox mortality of children under five years old among the total deceased children of the same age was calculated, and highest mortality was 67.50% in 1772. (Table 3)

(3) The smallpox mortality of the total inhabitants ran parallel to the smallpox mortality of children under five years old among the total deceased children of the same age. (Chart 1)

(4) Two types of smallpox mortality curves were observed. One type had a high peak followed by flat or horizontal curves at almost the zero level for some years such as seen in 1790, 1797, 1804, 1811, 1823, and 1846. The other type had a low peak with a wide base as seen in 1783~85, 1827~32 and 1835~43. (Chart 1)

(5) Seasonal fluctuation of smallpox deaths numbers (smallpox outbreak) seems not distinct. (Table 4)

Table 3 Smallpox Mortality in the Hida District

Japanese Era Names	A. D.	Revised Population	Deaths (*)	Mortality	Total Inhabitants Smallpox		Smallpox Mortality for Total Deaths	Children under five years old				
					Deaths	Mortality		Population	Deaths (*)	Mortality	Smallpox	
											Deaths	Mortality
MEIWA 8	1771	2677	52 (1)	1.94	19	0.71	36.54	310	19	6.13	10	52.03
ANEI 1	72	2671	90 (1)	3.37	49	1.83	54.44	291	40	13.79	27	67.50
2	73	2632	55 (1)	2.09	1	0.04	1.82	272	12	4.41	1	8.33
3	74	2629	46	1.75	0	•	•	271	6	2.21	0	•
4	75	2663	57 (1)	2.14	0	•	•	292	18	6.16	0	•
5	76	2656	97	3.65	4	0.15	4.12	286	44	15.38	4	9.09
6	77	2628	57	2.17	1	0.04	1.75	269	10	3.72	0	•
7	78	2632	107 (1)	4.07	31	1.18	28.97	280	52	18.57	17	32.70
8	79	2625	82 (1)	3.12	6	0.23	7.32	297	38	12.79	3	7.90
9	80	2617	86	3.29	0	•	•	291	38	13.06	0	•
TENMEI 1	81	2597	78	3.00	0	•	•	301	29	13.06	0	•
2	82	2595	49	1.89	0	•	•	319	17	5.33	0	•
3	83	2627	94	3.58	10	0.38	10.64	338	51	15.09	5	9.80
4	84	2595	125 (5)	4.82	15	0.58	12.00	279	33	11.83	9	6.30
5	85	2545	81	3.18	3	0.12	3.70	276	32	11.59	2	6.25
6	86	2535	61	2.41	0	•	•	281	28	9.96	0	•
7	87	2562	87	3.40	0	•	•	295	33	11.19	0	•
8	88	2577	80	3.10	0	•	•	318	24	7.55	0	•
KANSEI 1	89	2585	69	2.67	6	0.23	8.70	344	35	10.17	4	11.43
2	90	2597	122	4.70	62	2.39	50.82	339	69	20.35	41	59.42
3	91	2600	67	2.58	2	0.08	2.99	354	36	10.17	2	5.56
4	92	2629	64	2.43	0	•	•	364	28	7.69	0	•
5	93	2667	72	2.70	0	•	•	377	39	10.34	0	•
6	94	2671	48	1.80	0	•	•	377	25	6.63	0	•
7	95	2734	71	2.59	0	•	•	415	43	10.36	0	•
8	96	2771	88	3.18	26	0.94	29.55	404	53	13.12	17	32.08
9	97	2784	153	5.50	71	2.55	46.41	397	94	23.68	49	52.13
10	98	2715	53	1.95	0	•	•	339	24	7.08	0	•
11	99	2765	79	2.86	0	•	•	377	38	10.08	0	•
12	1800	2778	83	2.99	0	•	•	375	43	11.47	0	•
KYOWA 1	01	2793	77	2.76	0	•	•	374	35	9.36	0	•
2	02	2813	76	2.70	0	•	•	368	44	11.96	0	•
3	03	2831	98	3.46	0	•	•	363	47	12.45	0	•
BUNKA 1	04	2807	142	5.06	92	3.28	64.79	337	79	23.44	35	44.30
2	05	2781	80	2.88	10	0.36	12.50	328	47	14.33	7	14.89
3	06	2808	56	1.99	0	•	•	332	25	7.53	0	•
4	07	2856	80	2.80	0	•	•	368	39	10.60	0	•
5	08	2861	75	2.62	0	•	•	371	31	8.36	0	•
6	09	2863	82	2.86	0	•	•	372	28	7.53	0	•

7	10	2865	73	2.55	5	0.17	6.85	363	30	8.26	4	13.33
8	11	2880	123	4.27	43	1.67	39.02	347	67	19.30	34	50.75
9	12	2851	76	2.67	10	0.35	13.16	316	34	10.76	8	23.53
10	13	2865	75	2.62	0	•	•	345	33	9.57	0	•
11	14	2903	76	2.62	0	•	•	362	35	9.67	0	•
12	15	2914	53	1.82	1	0.03	1.89	367	24	6.54	0	•
13	16	2948	80	2.71	0	•	•	382	34	8.90	0	•
14	17	2948	98	3.32	21	0.71	21.43	372	45	12.10	11	24.44
BUNSEI 1	18	2939	60	2.04	0	•	•	345	24	6.96	0	•
2	19	2967	81	2.73	0	•	•	355	37	10.42	0	•
3	20	2955	40	1.35	0	•	•	336	19	5.65	0	•
4	21	3005	65	2.16	0	•	•	356	27	7.58	0	•
5	22	3052	86	2.82	0	•	•	393	38	9.67	0	•
6	23	3078	166	5.39	80	2.60	48.19	411	100	24.33	57	57.00
7	24	3040	113	3.72	5	0.16	4.42	385	63	16.36	2	3.17
8	25	3037	87	2.86	0	•	•	388	40	10.31	0	•
9	26	3050	158	5.18	0	•	•	391	84	21.48	0	•
10	27	3005	87	2.90	2	0.07	2.30	371	45	12.13	2	4.44
11	28	3024	79	2.61	0	•	•	393	35	8.91	0	•
12	29	3050	111	3.64	16	0.52	14.41	414	61	14.73	12	17.67
TENPO 1	30	3075	97	3.15	0	•	•	413	38	9.20	0	•
2	31	3089	93	3.01	6	0.19	6.45	428	58	13.55	5	8.62
3	32	3104	102	3.29	9	0.29	8.82	413	47	11.38	6	12.77
4	33	3102	73	2.35	0	•	•	402	33	8.21	0	•
5	34	3132	145 (9)	4.63	0	•	•	408	60	14.71	0	•
6	35	3090	102	3.30	1	0.03	0.98	358	43	12.01	0	•
7	36	3075	104 (4)	3.38	21	0.68	20.19	334	32	9.58	10	31.25
8	37	3040	361 (76)	11.88	26	0.86	7.20	306	77(1)	25.16	16	20.78
9	38	2731	129 (7)	4.72	0	•	•	234	27		0	•
10	39	2693	63	2.34	2	0.07	3.17	244	28	11.48	1	3.57
11	40	2732	75	2.75	0	•	•	262	31	11.83	0	•
12	41	2786	82	2.94	2	0.07	2.44	326	43	13.19	1	2.33
13	42	2804	84 (1)	3.00	15	0.53	17.86	344	46		10	21.73
14	43	2849	73	2.56	5	0.18	6.85	391	33	8.44	2	6.06
KŌKA 1	44	2890	56	1.94	0	•	•	410	28	6.83	0	•
2	45	2942	68	2.31	0	•	•	433	48	11.09	0	•
3	46	2983	148	4.96	69	2.31	46.62	405	91	22.47	49	53.85
4	47	2963	48	1.62	3	0.10	6.25	381	24	6.30	3	12.50
KAEI 1	48	3017	49	1.62	0	•	•	382	28	7.33	0	•
2	49	3099	95	3.07	0	•	•	439	57	12.98	0	•
3	50	3110	75	2.41	0	•	•	444	38	8.56	0	•
4	51	3127	98	3.13	17	0.54	17.35	439	53	12.07	16	30.19
5	52	3142	120	3.82	30	0.95	25.00	404	66	16.34	16	24.24

*Numbers in parenthesis are those died from starvation, they are included in the death numbers.
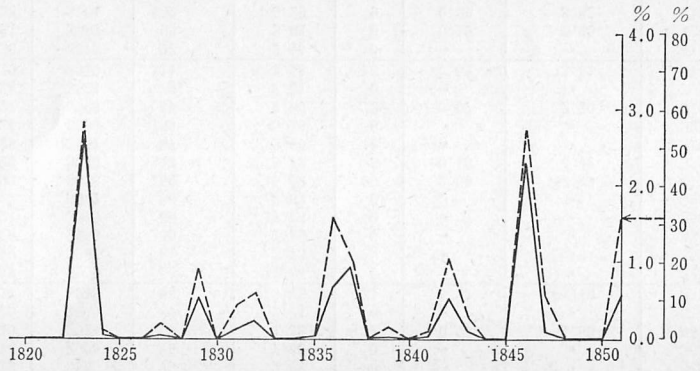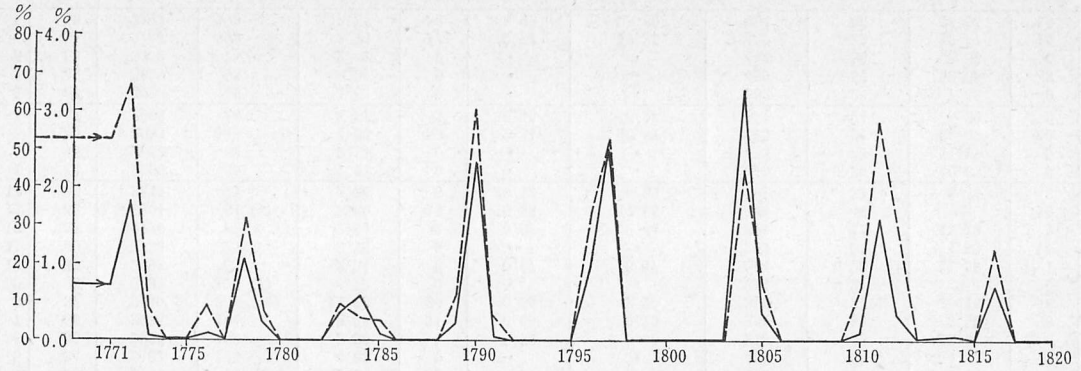
Chart 1 Smallpox Mortality among Total Inhabitants and Children under Five Years Old

——Total Inhabitants

······Children under Five Years Old

Table 4　Smallpox Deaths by Month

Year	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
1804					2		1	5	10	28	26	20	92
1811	6	9	6	4	2	3	1	2	3	5	5	2	48
1817		6	4	5	5		1						21
1823				4	12	16	8	12	12	10	6		80
1837	6	6	2	6			1		4	1			26
1846	7	7	13	14	19	4	2		3				69
Total	19	28	25	33	40	23	14	19	32	44	37	22	336

III. Discussion

Smallpox mortality may vary in accordance with the virulence of the prevailing variola virus. However, if such variations are disregarded, the smallpox mortality in a district where neither variolation nor vaccination had been performed will depend on the factors related to smallpox infectivity, such as the population density, traffic conditions and isolation of smallpox patients, etc. In the district under investigation, however, such factors did not seem to vary substantially during the observation period.

It is thinkable that the smallpox mortality will increase in case of starvation. However, the influence of starvation upon the smallpox mortality in the district was not cleary seen.

The low mortality curve which followed after a heavy outbreak of smallpox might be due to the sudden increase in the number of immune inhabitants and sudden decrease in the number of children under five years old. With the lapse of time, the immunity of inhabitants gradually decreased and, at the same time, the number of children who were highly susceptible to smallpox gradually increased. In this way, a basis for the next outbreak of smallpox was established.

Smallpox deaths before 1771 were as shown in Table 5. The first death was recorded on 22 nd January, in 1734 in Gobō village. At present, it is hard to clarify that why the first case of smallpox did not cause many smallpox cases and deaths.

Table 5 Smallpox Deaths before 1771

Village / Year	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	Shi.	Death Number
1734						1			1											2
38		1																		1
39			1	1											1					3
47	1																			1
50		2	4																	6
53	1																			1
55		2				2				1										5
58	2																			2
59	2										1					1				4
64																			1	1
65	15	1		5		2		3	1	1					1			1		30
66	1												3					1		5
69		10	2		2	2							1	2						19
Death Number	22	16	7	6	2	7	0	3	2	2	1	0	4	2	2	1	0	2	1	80
Frequency of Outbreaks	6	5	3	2	1	4	0	1	2	2	1	0	2	1	2	1	0	2	1	36

In order to know the route of smallpox invasion to Miya village the Kakochos of the following six neighboring temples were examined.

Name of Temple	Founded in	Situated at	Distance (km)
Ōgenji	1534	Miya Village	} 10
Unryūji	720	Takayama City	
Sōkenji	1632	Takayama City	} 10
Ankokuji	1340	Kokufu Town	
Seinenji	1531	Kokufu Town	} 12
Dōunji	1573-9	Kamioka Town	

As the death cause was not been recorded in the Kakochos except that of Ōgenji, the route of invasion was deduced from the increase of death numbers comparing with that of average ones.

When the death number increased over average death level, the invasion of smallpox was deduced, and the month of the first increase in one village was connected to that of another village. Considering the inclination of thus connected lines, the initiation and the route of invasion was presumed. Thus smallpox invasions were assumed as shown in Table 6.

Table 6 Route of Smallpox Invasion

Types of Invasion	Frequency
Miya ⟶ Takayama ⟶ Kokufu ⟶ Kamioka	7
Miya ⟵ Takayama ⟶ Kokufu ⟶ Kamioka	3
Miya ⟶ Takayama ⟵ Kokufu ⟵ Kamioka	2
Miya ⟵ Takayama ⟵ Kokufu ⟵ Kamioka	4

IV. Conclusion

The smallpox mortality in the district under investigation, where neither variolation nor vaccination had been performed, was not so high that all inhabitants were exterminated.

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