The construction of cause-of-death statistics database of modern Japan — part (2): regional variations of mortality*

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Abstract

The temporal transitional pattern of Japanese mortality shows that the epidemiologic transition had begun during the interwar period. As Taueber (1958) suggested, the continuous decline of Japanese mortality in the interwar period was accounted mainly by the decline of infant mortality. On the other hand, the mortality of adult did not decline so much during the same period, and rather the mortality rates rose in some diseases.

In the background of these phenomena, the regional variations of mortality transition between urbanized regions and rural regions were observed. These regional variations were caused by various epidemiologic factors, such as climatic conditions, geographical conditions, sanitary conditions, medical services, and other socio-economic conditions. Thus, if we inspect the regional differences on mortality rate, we will be able to grasp the characteristics of socio-economic development of regional society in modern Japan. While the close relationship between the mortality and the economic development has been discussed occasionally in the field of economic history, the transition of regional mortality mostly has not been considered yet in the perspective of economic development in modern Japan.

In this paper, we examine the temporal transitional patterns of mortality of major causes-of-death sorted by forty seven prefectures, and discuss the regional characteristics of transitional patterns. There are obviously some different transitional patterns which seem to reflect epidemiologic factors of each region. Based on these observations, we estimate the conceptual model that expresses the transition of mortality rate in modern Japan. As the result of consideration, we propose the assumption about the relationship between the mortality transition and the socio-economic development of regional society.

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* We would like to dedicate this paper to his proud spirit of a distinguished scholar in Japan, Professor Minoru Sawai, with our strong expectation of following him.

This research was financially supported by the Grant-in-Aid for Scientific research "Living environments, infant mortality and disease structure in historical perspective: the experience of modern Japan" (2012-2015, Osaka University, Kenichi Tomobe, #24530397)

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JEL Classification: I15, J11, N35
Keywords: Disease, Health, Mortality, Regional, Urban Rural

I. Introduction

In our previous paper, "The construction of cause-of-death statistics database of modern Japan - part (1): issues and approaches", we introduced the Cause-Specified Death Statistics Database (CSDS-DB) which is the main data source of our studies. Also, we demonstrated the temporal transition of mortality sorted by causes-of-death in modern Japan.

According to the Omran's categorization of epidemiologic transition, Japan is sorted as the "Accelerated Model"[1]. His categorization is based on the fact that the decreasing of Japanese mortality had progressed after WWII dramatically as follows; "the period taken for mortality to reach the 10 per 1,000 level was much shorter than that for the classical model"[2].

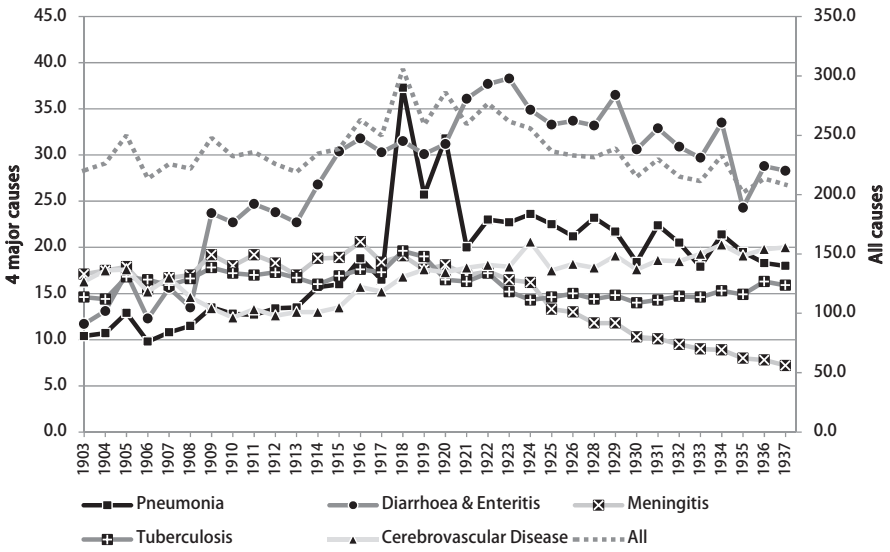

Chart 1: The mortality transitions of 8 major diseases, 1903-1937

Chart 1 shows the time series of mortality rates of eight diseases (diarrhoea & enteritis, pneumonia, meningitis, tuberculosis, bronchitis, cerebrovascular disease, beriberi and typhoid) from 1903 to 1937 (omitted 1927) based on the CSDS-DB; the mortality rate is calculated as a crude death rate per 10,000 people. The chart indicates two distinct peaks in 1918 and 1920. Needless to say, these peaks were caused by the pandemic influenza. Except the influenza anomaly, more than forty percent of Japanese mortality in the interwar period was accounted by such diseases as pneumonia, bronchitis,

[1] Omran (1971)
[2] Omran Id.

meningitis, cerebrovascular disease, and diarrhoea (or enteritis). While those major diseases had indicated almost the same mortality rate in 1903, after that they showed different trends each other.

Both Mortality rates of bronchitis and meningitis descended continuously. On the other hand, those of pneumonia, diarrhoea and enteritis rose until early the 1920's in contrast. Also, meningitis and tuberculosis indicated the same level of mortality rate in 1903. The Meningitis mortality descended continuously; on the other hand, that of tuberculosis rose until 1918, and descended until 1924, then rose again during World War II.

According to the above statistical observations, we assume that the first epidemiological transition of Japan began in the inter-war period. This assumption does not reject Omran's thesis, but rather expands it. While the transition was not so drastic like the decline in the post-war period, we can reasonably suggest the remarkable changes of nation's health have occurred in this period.

Consequently, the issue discussed in the next phase is to decipher the changes in mortality rates. Regarding the decline of Japanese mortality rate during the interwar period, Taeuber suggested that the decline of infant mortality rate contributed to it; her assertion was able to ensure by statistics. In the period, the most part of infant death was accounted by such diseases as meningitis, bronchitis, diarrhoea and pneumonia; thus the above facts are fitting to the Taeuber's assertion.

On the other hand, it is reasonable to ask "Was the temporal trend of mortality synchronous phenomenon everywhere across Japan?", because the factors surrounding life environment of Japan were various in those days. Actually, if we inspect the declining trend of mortality by each prefecture, we can recognize obvious regional variation between the trends; the temporal trends of mortality were not synchronous in the prefectural level. The important point in here is that the mortality might be reflecting not only the nation's medical and hygienic status, but also socio-economic status. Therefore, to examine the temporal trend of regional mortality is useful and important in the scope of socio-economic history. In this paper, we shall begin with demonstrating the regional variation of mortality rate during the interwar period of Japan.

II. Regional variation of mortality rate

As a start of inspection, let us define the eleven regions of Japan as follows (See also Chart 2):

1) Hokkaido: Hokkaido prefecture
2) Tohoku: Aomori, Iwate, Miyagi, Akita, Yamagata and Fukushima prefecture
3) Kanto: Ibaraki, Tochigi, Gunma, Saitama, Chiba, Tokyo and Kanagawa prefecture
4) Hokuriku: Niigata, Toyama, Ishikawa and Fukui prefecture
5) Chubu: Yamanashi, Nagano and Gifu prefecture
6) Tokai: Shizuoka, Aichi and Mie prefecture
7) Kinki: Shiga, Kyoto, Osaka, Hyogo, Wakayama and Nara prefecture
8) Chugoku: Hiroshima, Okayama, Tottori, Shimane and Yamaguchi prefecture
9) Shikoku: Tokushima, Kagawa, Ehime and Kochi prefecture
10) Kyushu: Fukuoka, Saga, Nagasaki, Oita, Kumamoto, Miyazaki and Kagoshima prefecture

11) Okinawa: Okinawa prefecture

The definition of region is based on the geographical partition used commonly, aside from a couple of exceptional region. Since the Hokkaido, Shikoku, Kyushu and Okinawa region are geographically separated from Honshu Island, they are defined as the independent regions. The Tohoku, Kanto and Kinki region are based on the common definition.

Chart 2: The eleven regions of Japan

While the Chubu region usually includes Shizuoka, Aichi, Nagano, Gifu and Yamanashi prefectures, here we divide these prefectures into the inland area (the Chubu region) and the seaside area (the Tokai region). Also, Mie prefecture sometimes belonged to the Kinki region, but we put it on the Tokai region because it closely related to Aichi at the case of the process of industrialization.

Next, we calculate the mortality rate (crude death rate)[3] of each region based on the cause-specified death of prefecture from 1902 to 1937 (1927 is omitted because of lacking data). Targeted diseases are related to the five major causes which selected from the cause-specified death statistics, as follows: diarrhoea & enteritis, pneumonia, meningitis, tuberculosis and cerebrovascular disease. The population of each prefecture is based on census, and the non-census years are linear-interpolated.

According to the above procedure, the time series of mortality rates are reconstructed for every region. Chart 3 to 7 show the time series transition of mortality of five major diseases sorted by regions. The overviews of features of each disease are as follows:

1) Pneumonia

The pneumonia (See Chart 3) case shows the common transitional pattern in all regions. Both high two peaks correspond to the timing of pandemic influenza. While there is few statistical evidence regarding the relationship between pneumonia and influenza, it is highly suggested the high mortality of pneumonia was strongly related to the excess death caused by the pandemic influenza. The regional difference of pneumonia mortality was not large in comparison with that of other major diseases; thus, the transitions of regional mortality rates of pneumonia were almost parallel each other.

[3] We use “mortality rate” in meaning of “crude death rate” in this paper.

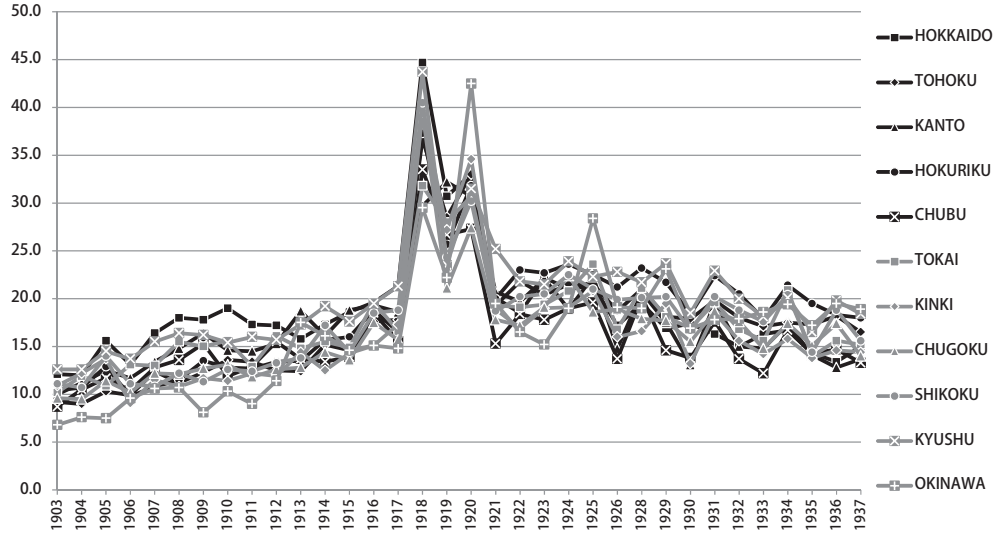

Chart 3: The pneumonia mortality rates in 11 regions, 1903-1937

2) Diarrhoea & Enteritis

The regional difference of diarrhoea & enteritis mortality (See Chart 4) was small in early 1900's, and then it continued to spread during the interwar period. While no extreme peak was observed, the mortality rate of diarrhoea & enteritis continued to rise from 1903 to 1923 in all regions. During this phase, the increase rate of mortality was especially high in the Tohoku and Hokuriku region while low in the Chugoku, Shikoku and Kyushu region. And also the mortality rate descended during the interwar period in other regions except the Tohoku region. Generally speaking, both diarrhoea &

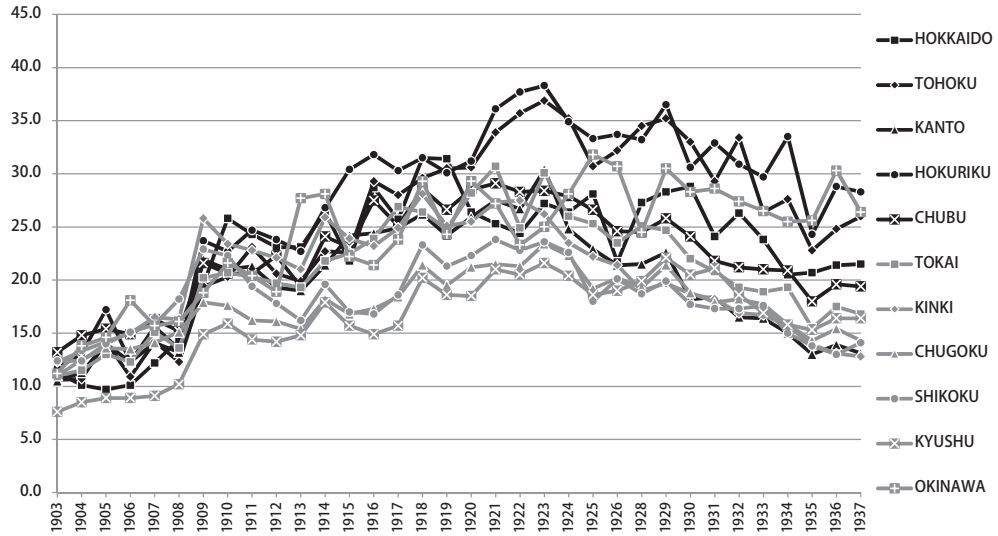

Chart 4:The diarrhoea & Enteritis mortality rates in 11 regions, 1903-1937

enteritis are major causes of infant mortality; hence this observation can be interpreted as the sign of higher infant mortality. To clarify this issue, we have to inspect the age-specific mortality rate. Additionally, the Kanto region showed the sharp peak in 1923. The coming of peak mortality was brought by the breakdown of the sanitary systems damaged from the gigantic earthquake, "Kanto Dai-Shinsai", which attacked the Kanto region in 1923. The mortality in the Kanto region continued to decline after 1923. These observations show the regional difference of diarrhoea & enteritis mortality was becoming wide during the 1920's and the 1930's.

3) Meningitis

The case of meningitis shows the different transitional pattern compared to the previous two diseases. The overall trend of meningitis mortality looks like a long and continuous descending pattern (See Chart 5).

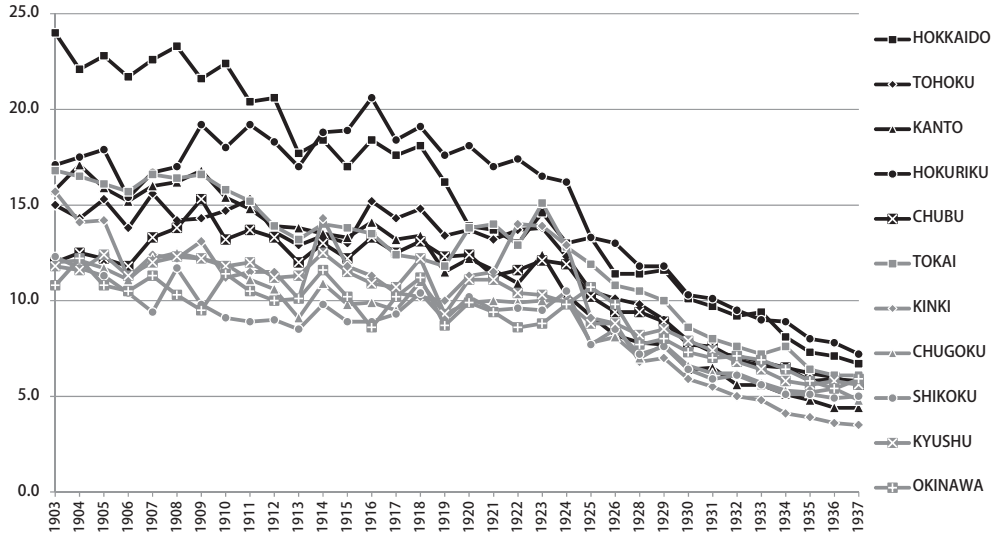

Chart 5: The diarrhoea & Enteritis mortality rates in 11 regions, 1903-1937

Especially, in early 1900's, the meningitis mortality was extremely high in the Hokkaido and Tohoku region. Since there are few descriptions about the high level of meningitis mortality rate in the Hokkaido and Tohoku region, what we can do now is just speculation. One possibility is the bad sanitary condition of people, especially surrounding infants and mother. In this period, most of the victims of meningitis were infants or young children[4]. Since there was no antibiotic in Japan yet, the way to prevent meningitis was to avoid infection from pathogens, and to empower the immunity of infant. At that time, because there were many non-doctor villages in both the Hokkaido and Tohoku region, infants who might be saved if they were treated appropriately had been dead by meningitis.

[4] Kiple ed. (1993)

As one assumption, the continuously declining rate of meningitis mortality shows the improvement of sanitary conditions and medical services. Verifying the assumption is at our next stage of research. The mortality rates of two regions decreased continuously, and then reached almost the same level in comparison with that of other regions. These observations obviously show the temporal transition of meningitis mortality was descending and the difference among regional mortality rates was steadily diminished.

4) Tuberculosis

The tuberculosis mortality shows the complicated transitional pattern (See Chart 6) compared with other diseases.

The Kinki region indicated higher tuberculosis mortality rate throughout the observational period. The Tuberculosis mortality rate of the Kinki region showed the higher level before the Spanish Flu, and it declined rapidly during 1920's; but it increased again in 1930's and finally it exceeded the mortality rates of other causes-of-deaths. The rapid decrease of tuberculosis mortality of 1920's can be explained by the excess death caused by the pandemic influenza[5]. The high tuberculosis mortality of the Kinki region was associated with industrialization, especially the prosperity of cotton-spinning industry.

Chart 6: The tuberculosis mortality rates in 11 regions, 1903-1937

The tuberculosis mortality of the Kanto region was also high in the early 1900's, and then it decreased rapidly after 1918. While the high level of tuberculosis mortality of the Tokyo city in early 1900's can be explained by the degradation of living environment caused by rapid

[5] Hanashima & Tomobe (2012). Also, Noymer & Garenne (2000) verified same phenomenon in United State.

urbanization, the decline from 1920 to 1922 cannot be explained by the same logic. The decrease of tuberculosis mortality in 1920's can be explained by the excess death caused by the pandemic influenza as same as the case of the Kinki region.

Also, in the Chubu region, large and rapid decline of tuberculosis mortality rate was observed from 1919 till 1921. While this phenomenon also can be partly explained by the excess death of influenza, it cannot be resolved completely. Probably, the great decline of tuberculosis mortality in the Chubu region was closely related to the change of working environment of factory workers[6].

The Tohoku region clearly showed the low mortality throughout the observation period; it was less than the half of the Kinki region's mortality. Due to our thinking, it was related to the infection risk to tuberculosis pathogen. But, the specific mechanism of low tuberculosis mortality in this region is not specified and the persuasive theory has not been showed yet.

Generally speaking, the regional difference of tuberculosis mortality did not converge and the temporal transitional patterns were varied with regions.

5) Cerebrovascular disease

The case of cerebrovascular disease showed the wide regional difference (See Chart 7).

That is, it was especially high in the Tohoku region and low in both the Okinawa and the Hokkaido region. Additionally, it rose gradually in all regions from 1915 until the war time; the regional differences did not converge, rather widened. Since the high mortality rate of cerebrovascular disease in the Tohoku region continued to the post-war period, it was caught by several epidemiologic researches. Momiyama inspected the cerebrovascular disease mortality in the Tohoku

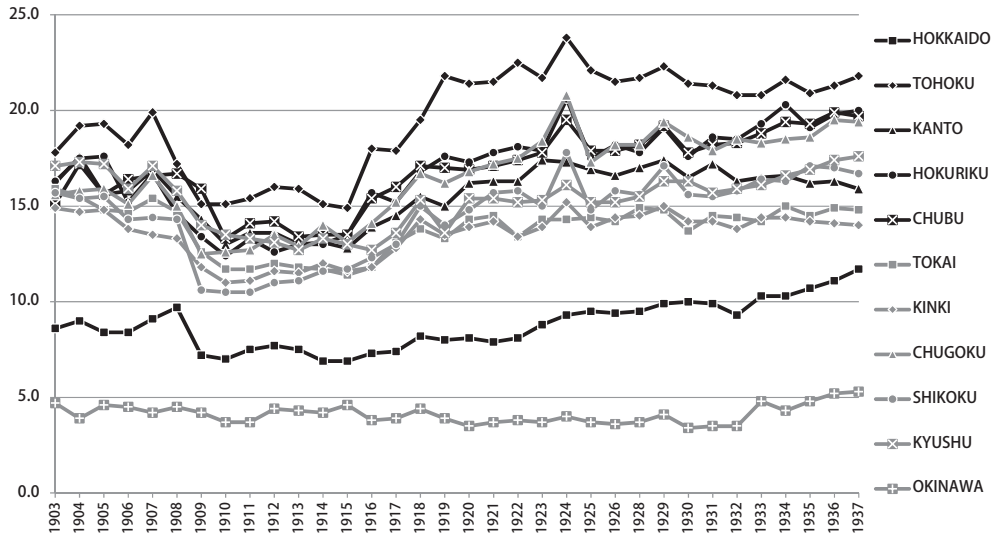

Chart 7: The cerebrovascular disease mortality rates in 11 regions, 1903-1937

[6] Hanashima & Tomobe Id.

region from the perspective of disease geography, and concluded it related to the life style of having salty food much in this region[7].

III. Regional variations of mortality transitional pattern

As we have shown above, each disease had the peculiar mortality transitional pattern. If we look over the mortality transitional patterns of five major diseases by every eleven regions, we can clarify the relationship between the mortality of each disease. Let us present the temporal transitional patterns in each region.

1) The Hokkaido Region (See Chart 8)

In the Hokkaido region, the extremely high mortality rate of meningitis was observed in the early 1900's. That was obviously higher than those of other regions, and the regional difference was larger than almost 10/10,000. The characteristics of mortality transition of the Hokkaido region as follows:

(1) The higher mortality rate of meningitis in the early 1900's.
(2) The higher mortality rate of diarrhoea & enteritis during the interwar period.
(3) The Five major mortality rates did not converge toward the end of observation period.

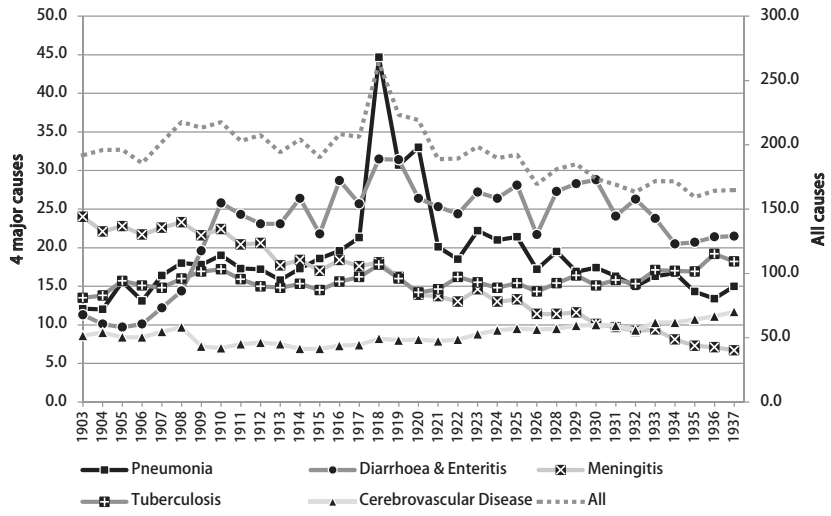

Chart 8: The mortality transition in the Hokkaido region, 1903-1937

2) The Tohoku Region (See Chart 9)

The notable feature of the Tohoku region is the extremely high rates of diarrhoea & enteritis mortality from 1920's to 1930's. The diarrhoea & enteritis mortality began to rise from 1908, and then in 1923 it reached the peak. While this temporal trend was basically similar to that of other

[7] Momiyama (1971), Momiyama inspected cerebrovascular disease mortality in the postwar Japan.

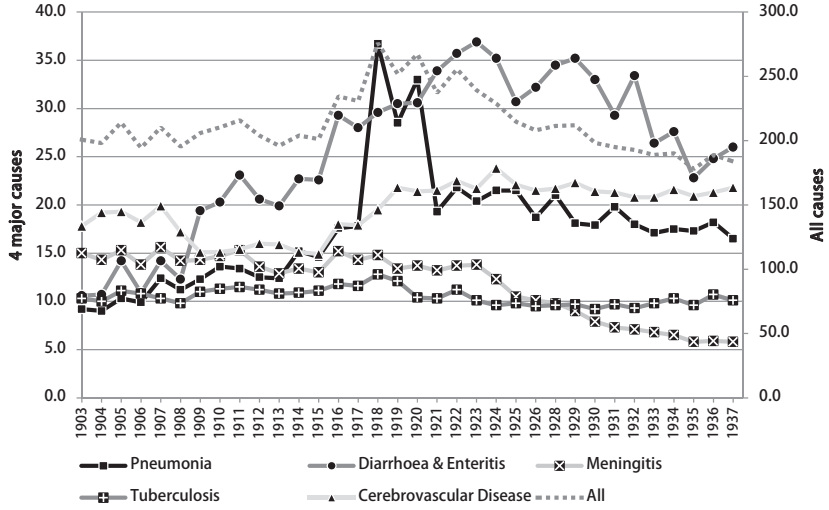

Chart 9: The mortality transition in the Tohoku region, 1903-1937

regions, the mortality of diarrhoea & enteritis in the Tohoku, Hokuriku and Okinawa region was particularly high.

As the overview of the Tohoku region, the whole of mortality rate at that time was pulled up by diarrhoea & enteritis mortality, and it did not converge during the interwar period. The characteristics of mortality transition of the Tohoku region as follows:

(1) The extremely high mortality rate of meningitis in the early 1900's.

(2) The high mortality rate of diarrhea & enteritis during the interwar period.

(3) The five major mortalities did not converge at the end of observation period.

3) The Kanto Region (See Chart 10)

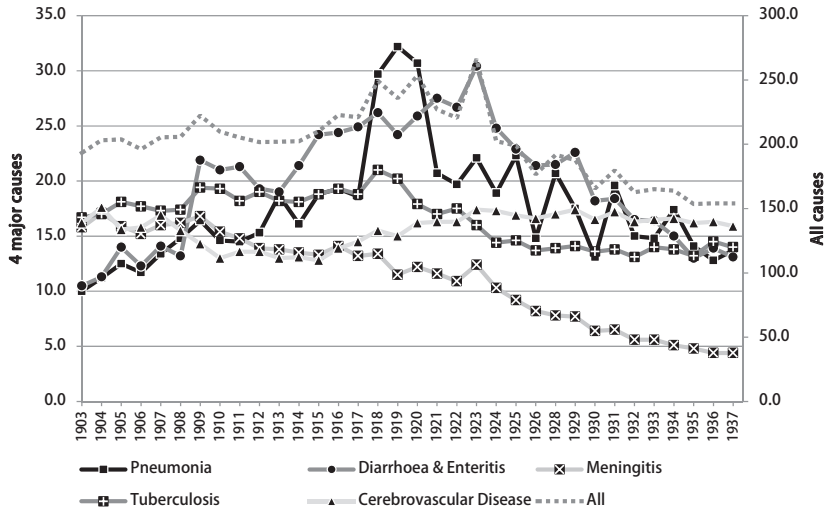

Chart 10: The mortality transition in the Kanto region, 1903-1937

The Kanto region includes two metropolitan cities, Tokyo and Yokohama; but such prefectures as Ibaraki, Tochigi, Gunma, Saitama, and Chiba were almost rural area in the prewar period. The mortality in these rural prefectures showed relatively high rate at the case of diarrhoea and enteritis, and looked similar to that of Tohoku region. In contrast, both Tokyo and Kanagawa showed evidently the different pattern to that of other prefectures in this region.

The temporal transitional pattern of mortality in the Kanto region basically reflected that of Tokyo and Yokohama, and the mortality converged toward 1937.

The characteristics of mortality transition of the Kanto region as follows:

(1) The high mortality rate of tuberculosis early 1900's and 1930's

(2) The rapid decrease of meningitis mortality rate after 1923.

(3) The major mortalities except meningitis converged at the end of observation period.

4) The Hokuriku Region (See Chart 11)

The notable feature of the mortality transition of the Hokuriku region is that the pace of decline of overall mortality during 1930's was slower than that of other region. Particularly, the diarrhoea & enteritis mortality rate continued to keep the higher rate. The mortality rate of cerebrovascular disease continued to rise during the interwar period, and it exceeded the mortality of pneumonia. Moreover, the tuberculosis mortality rate in Ishikawa prefecture was considerably high, and had been rising until World War II period.

The characteristics of mortality transition of the Hokuriku region as follows:

(1) The extremely high mortality rate of diarrhoea & enteritis.

(2) The high mortality rate of cerebrovascular disease.

(3) The five major mortalities did not converge at the end of observation period.

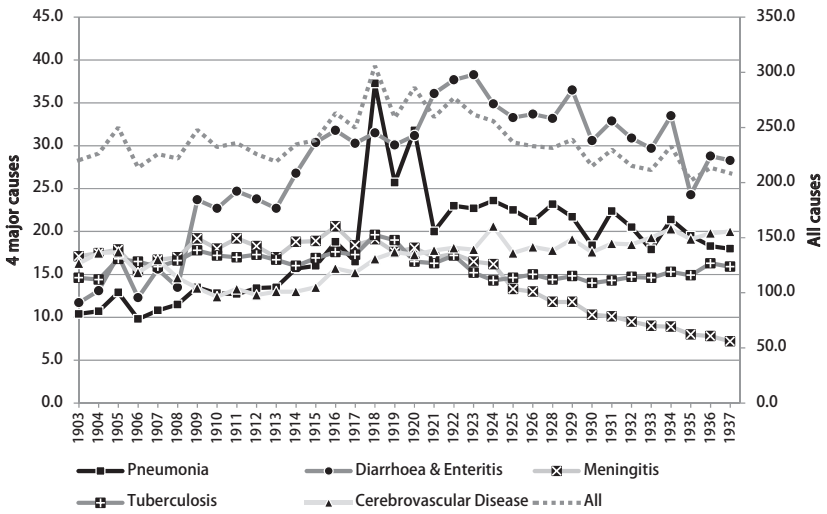

Chart 11: The mortality transition in the Hokuriku region, 1903-1937

5) The Chubu region (See Chart 12)

The Chubu region includes Nagano, Yamanashi and Gifu prefecture which were closely related to the development of textile industries.

The Mortality rate of diarrhoea & enteritis was very high until 1930, and then it was declined.

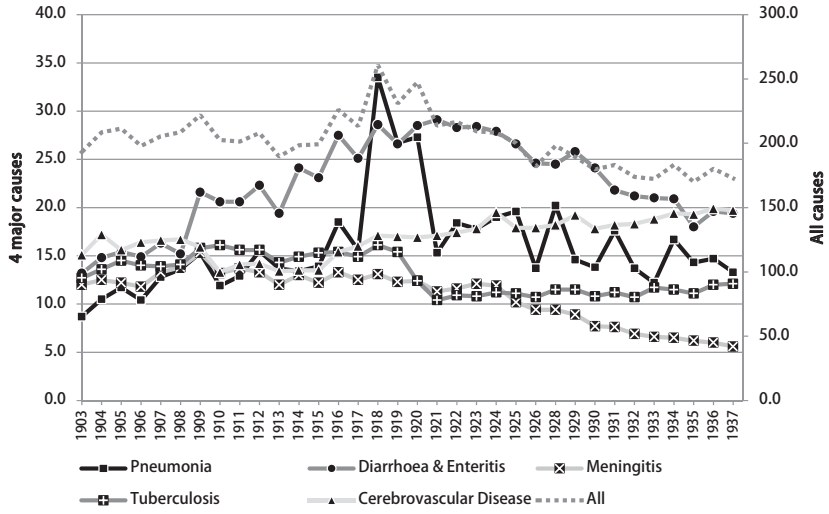

Chart 12: The mortality transition in the Chubu region, 1903-1937

The tuberculosis mortality rate was high until the peak of pandemic influenza, but it descended very rapidly by 1921. While this rapid decrease of tuberculosis mortality was distinguished in this period, any rational explanations have been never given to us.

The cerebrovascular disease mortality rate continued to rise during the observation period, and it recorded the highest mortality rate among five diseases in 1937.

The characteristics of mortality transition of the Chubu region as follows:

(1) The high mortality rate of diarrhoea & enteritis and cerebrovascular disease.

(2) The rapid decrease of tuberculosis mortality rate from 1919 to 1921.

(3) The five major mortalities did not converge at the end of observation period.

6) The Tokai Region (See Chart 13)

The Tokai region includes the Nagoya metropolitan area, and the industrial nexus area was formed along the seaside. In the interwar period, the main industry of the Nagoya metropolitan area was textile industry, especially cotton-mill and weaving.

While the diarrhea & enteritis mortality rate was high in 1921, it continuously decreased.

In the overview, the mortality transition of the Tokai region was obviously decreased during the interwar period, and mortality rates of major diseases (except meningitis) did not converge.

The characteristics of mortality transition of the Tokai region as follows:

(1) The high mortality rate of diarrhoea & enteritis.

(2) The rapid decrease of meningitis mortality rate after 1923.

(3) The major mortalities except meningitis converged at the end of observation period.

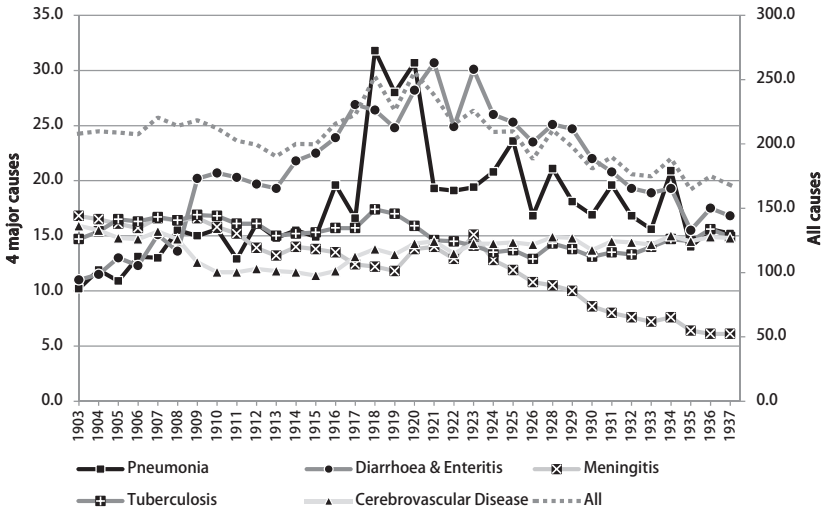

Chart 13: The mortality transition in the Tokai region, 1903-1937

7) The Kinki Region (See Chart 14)

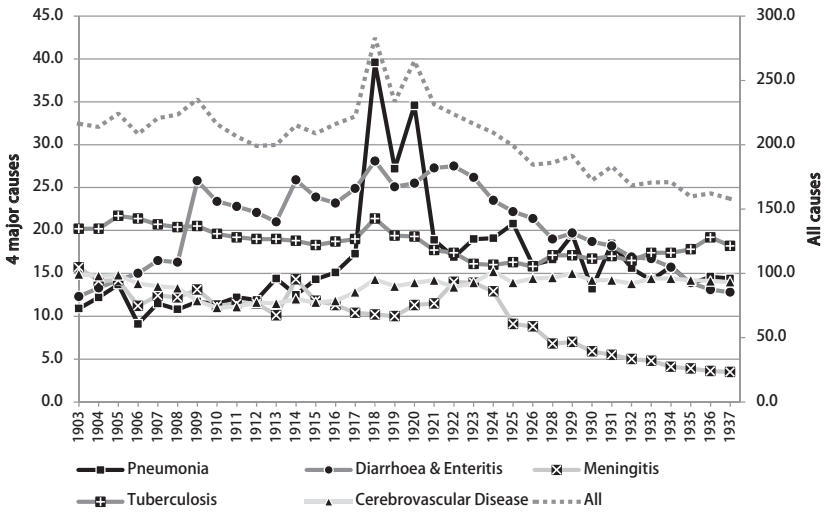

Chart 14: the mortality transition in the Kinki region, 1903-1937

The notable feature of the Kinki region was the high tuberculosis mortality rate compared to that of other regions. The tuberculosis mortality rate showed very high rate before the Spanish Flu descended on Japan, and it declined rapidly in 1920's; but it increased again in 1930's and finally it exceeded mortality rates of other causes-of-deaths. The characteristics of mortality transition of the Kinki region as follows:

(1) The high mortality rate of tuberculosis.

(2) The rapid decrease of meningitis mortality rate after 1923.

(3) The tuberculosis mortality exceeded other causes-of-deaths in 1930's.

8) The Chugoku Region (See Chart 15)

In the overview, the mortality transition of the Chugoku region had been almost flat except the time of pandemic influenza. The extreme peak of the pneumonia mortality rate in 1918 was caused by the pandemic influenza; the peak was particularly higher in such prefectures as Shimane, Hiroshima and Yamaguchi.

While the mortality rates of pneumonia, diarrhoea & enteritis and tuberculosis converged toward 1937, at last, the mortality rate of cerebrovascular disease exceeded mortality rates of these diseases. The tuberculosis mortality in the Chugoku region decreased in 1920's, and then continued to increase during 1930's.

The characteristics of mortality transition of the Chugoku region as follows:

(1) The extremely high mortality rate of pneumonia in 1918.

(2) The almost flat mortality rate.

(3) The cerebrovascular disease mortality exceeded other causes-of-deaths in 1930's.

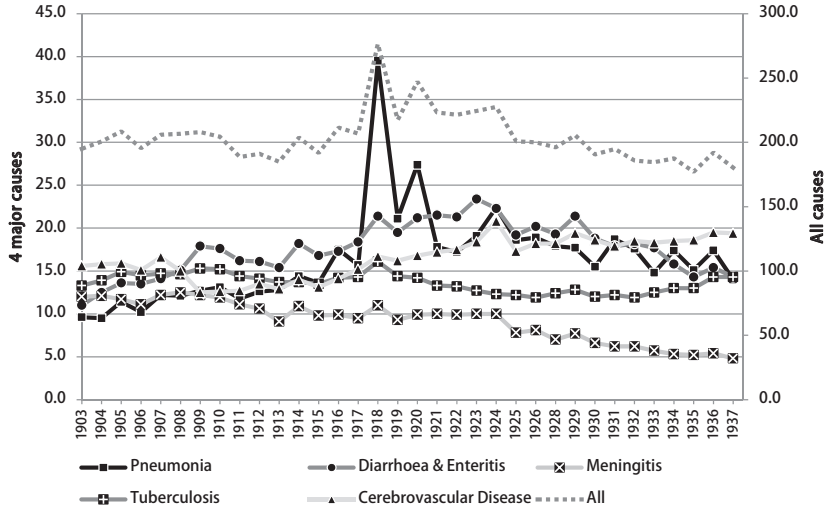

Chart 15: The mortality transition in the Chugoku region, 1903-1937

9) The Shikoku Region (See Chart 16)

In the Shikoku region, both Tokushima and Kagawa showed almost the same tendency of mortality while both Ehime and Kochi showed the same other one.

The pneumonia mortality at the time of pandemic influenza in 1918 was extremely high; especially, Tokushima and Kagawa marked the higher mortality rate of pneumonia.

In the overview, while the pneumonia mortality and diarrhoea & enteritis mortality showed excessive volatility in the early 1900's, mortality rates except meningitis converged toward the end

of the interwar period.

The characteristics of mortality transition of the Shikoku region as follows:

(1) The extremely high mortality rate of pneumonia in 1918.

(2) The cerebrovascular disease mortality exceeded other causes-of-deaths in 1937.

(3) The major mortalities except meningitis converged at the end of observation period.

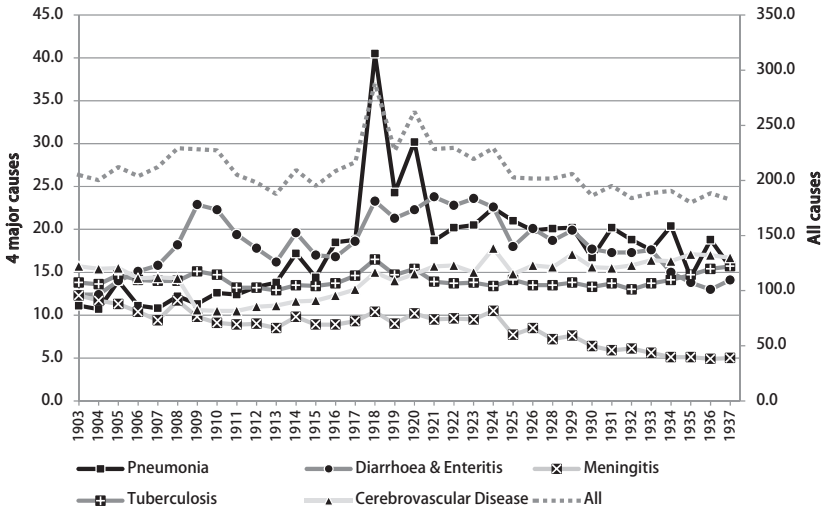

Chart 16: The mortality transition in the Shikoku region, 1903-1937

10) The Kyushu Region (See Chart 17)

While all prefectures in the Kyushu region indicated the higher pneumonia mortality at the time of Spanish Flu, the whole mortality did not fluctuate so much in comparison to other regions during

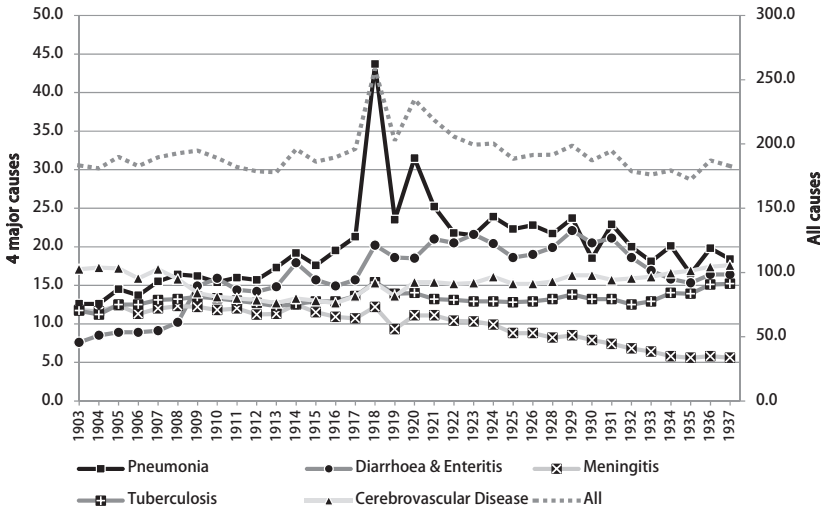

Chart 17: The mortality transition in the Kyushu region, 1903-1937

the observation period. The major diseases mortality rates except meningitis converged toward in the end of the interwar period. The tuberculosis mortality rate was relatively low in 1910's. But it continued to increase slowly during the interwar period.

The mortality rate of cerebrovascular disease decreased in 1910's, and then increased again. The temporal trends of mortality of both tuberculosis and cerebrovascular disease were similar to the Shikoku region's temporal trend.

Additionally, while the diarrhoea & enteritis mortality of Kagoshima prefecture increased obviously from 1902 to 1923, the cause of increase has not been clarified.

The characteristics of mortality transition of the Kyushu region as follows:

(1) The high mortality rate of pneumonia in 1918.

(2) The relatively low mortality rate of tuberculosis.

(3) The major mortalities except meningitis converged at the end of observation period.

11) The Okinawa Region (See Chart 18)

The whole mortality of the Okinawa region fluctuated so much. The mortality rate of each disease continued to increase except meningitis, and they did not converge like the Kyushu or Shikoku region.

The highest pneumonia mortality rate was observed in 1920; this is remarkable difference from other regions. The diarrhoea & enteritis mortality rate continued to increase during the interwar period. The tuberculosis mortality rate was also continued to rise, and then it marked the highest rate in 1935. The mortality rate of cerebrovascular disease remained low level.

While there are some criticisms regarding the accuracy of statistics in Okinawa region, in this paper we do not inspect this issue.

The characteristics of mortality transition of the Okinawa region as follows:

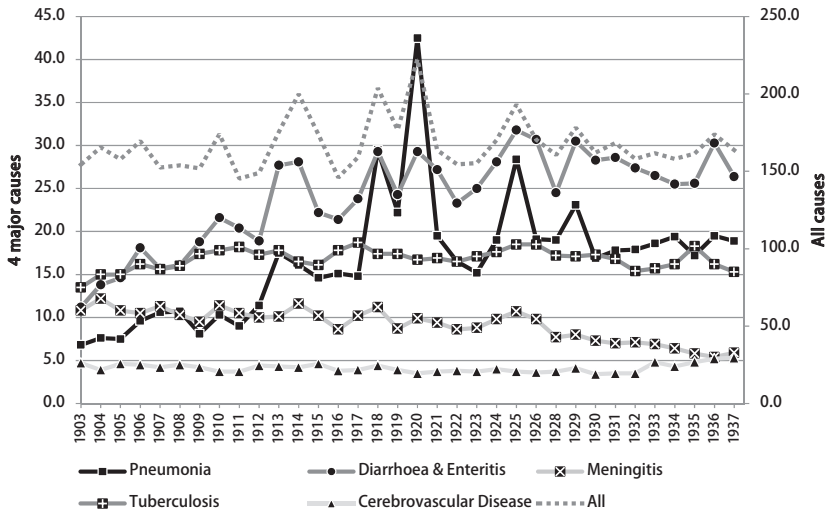

Chart 18: The mortality transition in the Okinawa region, 1903-1937

(1) The high mortality rate of diarrhoea & enteritis and tuberculosis[8].
(2) The lowest mortality rate of cerebrovascular disease.
(3) The five major mortalities did not converged at the end of observation period.

IV. Discussion and Conclusion

From the regional overview in the previous section, we can point out several characteristics of mortality transition in modern Japan.

(1) In this period, the diarrhoea & enteritis was the dominant disease which brought death to people; the mortality rates were especially higher in the Tohoku, Hokuriku, Chubu, Tokai and Okinawa region during the interwar period.
(2) Another important disease contributed much to the mortality trend was pneumonia. Even if the higher mortality rate of pneumonia at the time of pandemic influenza was eliminated, it still dominated large share of mortality in every region.
(3) Moreover, the meningitis mortality rate clearly decreased in every region. Thus, the transitional pattern of meningitis mortality reflected to the descending trend of overall mortality during the interwar period of Japan[9].

While the characteristics shown above provide the perspective of epidemiologic transition in modern Japan, we need to identify the fundamental structure of mortality more clearly. Preston (1976) examined the cause-specified mortality of 165 populations (43 nations) to clarify the typical patterns of mortality change. In the study, he used a linear model "to identify and interpret regional and temporal differences in the cause structure of mortality"[10]. This method will be useful for our study too. Thus, let us examine the correlations between time-series data of the mortality rate of all causes and each mortality rate of major diseases to clarify the spatio-temporal patterns of mortality transition in modern Japan.

Table 1 shows the correlations of time-series matrix of overall mortality and five major diseases'

	All causes	Pneumonia	Diarrhoea & Enteritis	Meningitis	Tuberculosis	Cerebrovascular disease
All causes	1.00	**0.65**	0.48	**0.66**	0.59	-0.21
Pneumonia	0.65	1.00	0.71	-0.10	0.19	0.19
Diarrhoea & Enteritis	0.48	0.71	1.00	-0.09	-0.08	-0.01
Meningitis	0.66	-0.10	-0.09	1.00	0.59	-0.56
Tuberculosis	0.59	0.19	-0.08	0.59	1.00	-0.58
Cerebrovascular disease	-0.21	0.19	-0.01	-0.56	-0.58	1.00

Table 1: The correlation matrix of the 5 diseases and all causes

[8] Shimao (2008) discussed high tuberculosis mortality rate in Okinawa region that continued until the postwar period.
[9] Higami&Tomobe (2014) stresses the importance of meningitis as thinking about the rise and fall of infant mortality in Osaka city before World War II.
[10] Preston (1976), pp.9.

one. In the table, the case of pneumonia and meningitis indicates relatively higher correlation with overall mortality compared to other diseases. Based on the correlations, we applied multiple-regression model which defined the pneumonia mortality and meningitis mortality as explanatory variables.

Table 2 shows the result of multiple regression analysis; as the values of statistics shows, it is robustly significant. It means the overall mortality in this period is approximated by the mortality of pneumonia and meningitis. (Provisionally titled the "Pneumonia-Meningitis Model")

Explained variable : Overall Mortality Rate; (1903-1937)					
Variable*	Estimate	Std. error	t value	Pr (>|t|)	Significance
(Intercept)	97.76890	4.23382	23.09	<2e-16	< 0.001
Pneumonia	**0.28957**	0.0835	4.1160	0.00017	< 0.001
Meningitis	**0.50625**	0.1145	4.6590	0.00003	< 0.001
Multiple R-squared	**0.9552 (Adjusted 0.9523)**, 44 degrees of freedom				
F-statistic	330.5 on 2 and 31 degrees of freedom				
p-value	< 2.2e-16				

Table 2: The result of multiple regression analysis

Rank	Prefecture	R-squared	R	Rank	Prefecture	R-squared	R
1	NAGANO	0.96	0.98	25	NIIGATA	0.84	0.92
2	HOKKAIDO	0.95	0.97	26	GIFU	0.84	0.92
3	GUNMA	0.94	0.97	27	NAGASAKI	0.84	0.91
4	HYOGO	0.94	0.97	28	CHIBA	0.83	0.91
5	HIROSHIMA	0.94	0.97	29	SHIMANE	0.83	0.91
6	MIYAGI	0.93	0.96	30	FUKUI	0.82	0.91
7	FUKUSHIMA	0.92	0.96	31	MIYAZAKI	0.82	0.90
8	YAMAGATA	0.91	0.95	32	SHIZUOKA	0.81	0.90
9	IBARAKI	0.91	0.95	33	OSAKA	0.80	0.89
10	SAGA	0.90	0.95	34	KAGOSHIMA	0.80	0.89
11	YAMAGUCHI	0.89	0.95	35	TOKYO	0.78	0.88
12	AICHI	0.89	0.94	36	AOMORI	0.78	0.88
13	KYOTO	0.89	0.94	37	OKINAWA	0.73	0.86
14	FUKUOKA	0.88	0.94	38	OITA	0.73	0.85
15	TOKUSHIMA	0.88	0.94	39	AKITA	0.72	0.85
16	KUMAMOTO	0.88	0.94	40	NARA	0.69	0.83
17	TOYAMA	0.87	0.93	41	ISHIKAWA	0.68	0.82
18	IWATE	0.87	0.93	42	MIE	0.67	0.82
19	TOTTORI	0.87	0.93	43	YAMANASHI	0.59	0.77
20	SAITAMA	0.87	0.93	44	KOCHI	0.59	0.77
21	OKAYAMA	0.87	0.93	45	KANAGAWA	0.50	0.70
22	KAGAWA	0.86	0.93	46	EHIME	0.45	0.67
23	SHIGA	0.86	0.93	47	WAKAYAMA	0.22	0.47
24	TOCHIGI	0.85	0.92				
					ALL JAPAN	0.95	0.98

Table 3: The estimated regression coefficients of 47 prefectures;
the Pneumonia-Meningitis Model applied

Table 3 shows the coefficient of determination (R2) and the multiple correlation coefficients of every prefectures estimated by the "Pneumonia-Meningitis Model" shown above. The multiple-correlation coefficients in 42 prefectures are estimated higher than 0.8, and it is lower than 0.6 only in Wakayama prefecture.

This model simply indicates that overall mortality can be approximated by mortality of two diseases; additionally, the model shows the dominant cause-of-death in the process of epidemiologic transition in modern Japan.

Since pneumonia was the common disease for people of all ages, the temporal transitional pattern of mortality was almost similar to that of overall mortality; also the regional difference of transitional pattern was not so much varied that the pneumonia mortality represents the baseline mortality of Japan.

On the other hand, as we have discussed in the previous section, the meningitis mortality showed the continuous declining trend. In the early 20th century, meningitis was the severe disease especially for infants and young children, because antibiotics had not been introduced to Japan. Thus, the declining trend of meningitis mortality contributed much to the drastic decrease of infant mortality. To prevent the death from meningitis, the most secure way was to enforce the immunity of infant to avoid infection from pathogens. Additionally, the practical countermeasure was to improve the sanitary of living environment and to encourage the breast feeding. If this assertion is correct in our model, the decline of meningitis mortality represents not only the improvement of infant mortality but the rise of social intervention regarding sanitary condition surrounding infants and mothers.

Currently, while we don't have ample decisive evidence to support this assumption, some studies regarding infant mortality in modern Japan are suggesting the clues for ours[11]; so, we will consider this issue in the next stage of research.

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