Original Article

Verification of the Overestimation of the “Deaths Associated with Influenza Pandemic of 1918–1919, Japan” Claimed in a Demographic Study

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SUMMARY: Official records show that the Japanese influenza death toll in 1918–1920 was 385 thousand. However, a recently published study claims that the records are skeptical, claiming the figure to be “an anomaly by Asian standard,” and re-estimated the number to be about 2 million by its unique demographical calculation. However, it is not sound from the following socio-historical and statistical perspectives: i) Japan had developed accurate registration and surveillance systems which might not have existed in other developing countries; ii) there were unique socio-economic situations that claim that the relatively low mortality rate in Japan was not a “myth”; iii) the proposed re-estimation was an overestimation, because if it was a fact, about 1.6 million influenza deaths should have not been detected nationwide, i.e., about 3% of the population. Also, the influenza death toll was unrealistically large compared to the all-causes mortality of that period; iv) Japan started census in 1920 and it should have significantly affected the demographic data analysis. However, the effect by this artifact was not taken into account. Consequently, it caused the severe overestimation of the death; v) we recalculated the mortality using the same method and dataset but we could not reach an estimated figure similar to that claimed in the paper.

INTRODUCTION

The worst influenza pandemic in the history hit almost all over the world in 1918, 1919, and 1920; and high mortality numbers were recorded in many countries and regions (1,2). However, some researchers claimed that there were significant underestimations in the mortality records of the pandemic (3), for example, in those of India, Pakistan, and Indonesia (4,5), because they only had insufficient infrastructures and mechanisms for registration of birth and death, and they did not have adequate systems for surveillance, reporting and recording of infectious diseases (6). In this context, an article was published in 2013 by S. Chandra (7), which attempted to re-estimate the mortality during the influenza pandemic of 9 decades ago in Japan. According to the paper, the investigation was initiated by a personal notion of the author, which stated as follows: “... the curiously low death rate attributed to Japan compared with other countries in Asia is one of the strangest aspects about the pandemic” and that the official records of the pandemic deaths by Japanese authority had a “severe problem of underreporting.”

The author conducted unique, demographical calcu-

lations trying to prove those statements and to “bring the Japan’s pandemic experience in line with that of other parts of Asia.” The author concluded that the mortality due to the “1918–1919” influenza epidemic in Japan was about 2 million. This new estimate is 8 times greater than that of the official records based on the surveillance during that time, which had been accepted broadly: 257 thousand deaths from August 1918 to July 1919, which included the first wave that started in the October 1918 and peaked in the November 1918, and 128 thousand deaths from August 1919 to July 1920, which included the second wave that started from December 1919 and peaked in January 1920 (8). It is much greater than the figure of 453 thousand deaths estimated by Hayami (9), and 4 times greater than the latest estimate suggested by Richard et al., which had been the largest estimate until Chandra’s report: 481 thousand deaths as a total of the first and second waves (10). We think that Chandra’s preconception was not sound from the socio-historical and epidemiological viewpoints, and that the calculation and its interpretation were misleading.

In this paper, we critically discuss the real situation of Japan during that time as well as the shortcomings of the claimed results stated in the report. The critical discussion was made utilizing the information from historical records and literatures from different perspectives, which are useful and important to understand the Japanese situation at that time. In addition, we show the result of our verification of the mortality by applying the same dataset and estimation procedures which were used in that study.

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MATERIALS AND METHODS

Critical reviewing of the paper in question, in the light of knowledge from related historical documents: We reviewed a number of historical documents and articles published on the influenza pandemic in Japan in 1918–1920. From published literatures, we also figured out the socio-historical situations of Japan during that period. Based on the obtained information above, we critically read the report published by Chandra (7) from many different viewpoints.

Examining the calculation on the reproducibility of the results: The reproducibility of the discussed paper's estimation was examined by a calculation using the same dataset and estimation procedure described in the study. We re-examined the result applying the same equation used in the paper (7) for calculation and for drawing conclusion. The equation is as follow:

$$LPOP_{it} = \pi_0^i + \pi_1^i T_t + \pi_2^i FLU_t + \pi_3^i T_t FLU_t + \varepsilon_{it}$$

$$LPOP_{it}$$
 means the natural logarithm of a population in the prefecture i at time t ; T_t is the linear time trend; FLU_t is the dummy variable representing the post-pandemic years, and ε_{it} is a random error term in the standard random coefficients model, which estimated 8 specifications of the above equation.

In the discussed paper (7), a regression formula was employed using the population statistics from 1917 to 1930 and entered the “Flu dummy” variable into the formula to measure the impact of the pandemic as the estimated coefficients of the dummy: “1” before 1920 and “0” after 1920. The author used “the full dataset consist of observations for each of 47 prefectures for the population count for the years 1898, 1903, 1908, 1913, and 1918, and the census data for 1920, 1925, 1930, and 1935, for a total of 423 observations of the official statistics pertaining to the quinquennial population count (1918 and before) and census years (1920 and after).” He also used the limited data without those in 1898 and 1935 (in Table 1 in Reference 7), as well as “the full dataset” (in Table 2 in Reference 7). Re-calculation was performed, with the same dataset and estimation method mentioned above, except with a difference in the statistical analysis software used; we used STAT10 while the author used SAS.

RESULTS

The reliability of the surveillance records provided by the authority: looking back to the social structure of Japan around 1918–1920: In the discussed paper (7), severely underestimated records by Japanese authority at that time were stated as the reason for the low death number. Therefore, we reviewed the important historical documents and the articles on the influenza pandemic in Japan in 1918–1920 as well as those on the socio-historical situation of Japan during that period. On the basis of our review, we rebut the claim of underestimated death numbers.

If his estimated number of influenza deaths, 2 million from 1918–1919, was true, Japanese authority, which counted the deaths at about 0.39 thousand, missed to detect the deaths of about 1.6 million people. The total population of Japan at that time was about 55–57 million people (11). This means that about 3% of the

community members' deaths nationwide had not been detected by the authority. It is quite an unrealistic estimation and judging by the result of our literature reviewing, it is clear that the detailed fatality data collection was possible during that time. It was already passed about 40 years since the collapse of the oppressive feudal system, which lasted more than 300 years. The groundwork for the social structure, which consisted of urban industrialized cities and rural farming villages in relatively narrow inhabitable land, had already been laid in the 1910s in Japan. There was also a strong bondage among the people living in the community (12). Community members acted in strong compliance with laws and regulations. In addition, there was a tradition of registration and a precise recording system for the departed souls maintained by Buddhist temples. The temple authority usually covered every community member and also gave each of them a posthumous name as a part of important religious funeral rituals (13,14). Under those special situations, Japanese local authorities had a solid system of birth and death registrations. The data obtained by the system could be used for many kinds of demographic analyses by researchers today (14). Moreover, during the pandemic, the authorities closely monitored the influenza-infected people with a unique disaster monitoring system. The surveillance was performed as a task of the Naimu-Shou, the Home Ministry, which supervised both the police and public health systems in Japan (8) by using the on-site police network system that had already been deployed nationwide in every community. Each on-site policeman took care of his territory community, which did not have a chaotic slum that was seen in many other Asian countries. For example, one policeman covered about 500 residents of a few hundred families on average in metropolitan Tokyo (15) and probably far less in rural areas. Those policemen checked the daily morbidity and mortality of his territory and reported to the local headquarters by wire (8,9,16). Altogether, the aforementioned findings suggest that the mortality data reporting system during that time is trustable.

Overestimation of the death toll in the paper judging from statistical viewpoints: By logical analyses, we found the following 4 points that prove the influenza-death number concluded in that paper, 2 million, to be irrational and unreliable.

First, at least the all-causes mortality data does not support his conclusion. The all-causes death tolls of years 1917, 1918, 1919, 1920, and 1921 in Japan were about 1.20, 1.49, 1.28, 1.42, and 1.29 million, respectively (11). On the other hand, the author claimed that the influenza death toll was 2 million in the “1918–1919” pandemic. The basic concept that he used in figuring out the influenza-associated death toll was the difference between the population of 1920, extrapolated from by data of the quinquennial investigation until 1918, and the observed population after 1920 (by census), which started in the year, *de facto* about 2 years from the beginning of 1919 to about the end of 1920. We could understand from the statistical data (11) that the all-causes mortality, during this approximately 2 years period, was less than 2.7 million total. A calculation based on these figures told us that the death toll other than influenza was only 0.7 million, 0.35 million

per year, on average, which is pragmatically too small compared to the non-pandemic year death tolls of 1917 or 1921.

Second, as mentioned above, in the discussed paper, estimation of the influenza death toll of the pandemic in Japan in “1918–1919” was based on the difference between the expected population of 1920, using pre-pandemic trajectory until 1918 that was obtained by quinquennial investigations and the observed population in 1920 by the census started in that year. However, it was found by our bibliographic investigation, that the population of 1918, used for the extrapolation, was that of December 31, 1918, the date of the quinquennial investigation, and the population of 1920 was that of October 1, 1920, the date of the census. Accordingly, it was found that the majority of the influenza-death toll in the first wave, which claimed as the largest mortality in the pandemic and peaked in November 1918 (8,9,17), was not included in his calculation. This means that the author did not include a considerably large part of the mortality from the start of the epidemic, October 1, 1918, to December 31, 1918 in his estimation, and measured the fatality of only a part of the first wave after its peak had passed and that of the second wave. The mortality of the first wave was greater than the second wave in Japan(8). Thus, the author’s estimation should still be an underestimation.

Third, it is noteworthy to mention that the population census was started in Japan in 1920, as the author also correctly referred, and that the statistical method for the population counting was drastically changed from before. It should be theoretically and practically impossible to separate the effects of the pandemic in 1918–1920 and the change of the statistical method in 1920, in the data from 1917 to 1930. These potentially merged 2 consecutive events changed the size of the Japanese population record, which might have led to the overestimation of mortality due to the first wave of 1918–1919.

Fourth, a birth cohort study using the census retrospectively, revealed that the number of births per couple was drastically decreased after 1920 in comparison to before 1920 (ca. 37% decrease). This phenomenon was along with economic growth toward the modern industrialization of the country, and associated with a decrease in the total fertility rate (18). This might also, at least partly, work for lowering census data on the population after 1920 and, thus, work for the overestimation of the influenza death toll of “the pandemic 1918–1919.”

Re-examination for reproducibility of the calculation: We could not reproduce the results of that discussed paper even though we used the same dataset and estimation procedure as shown in Tables 1 and 2. Each table contains 8 specifications, which were performed in that paper, specifications 1–4 included Kanto earthquake prefectures, but 5–8 do not. Specifications 1, 2, 5, and 6 included Hokkaido outlier, but others do not. Specifications 1, 3, 5, and 7 included 1918 population count data, but others do not, and we have shown the estimated coefficient of FLU_t , the dummy variable representing the post-pandemic years. All coefficients were statistically insignificant: the estimated coefficients of FLU_t , the dummy variable representing the post-pandemic years, was distributed in each specification from

Table 1. Estimation for the “Flu dummy” by our re-calculation of the results shown in the table 1 of the discussed paper (7)

Specification	Estimated coefficient	S.E.	P-value
1	−.049449	.0470126	0.293
2	−.040577	.0523818	0.439
3	−.0654416	.0401401	0.103
4	−.056894	.0447053	0.203
5	−.042589	.0454223	0.348
6	−.0329914	.0505304	0.514
7	−.0599414	.0358768	0.095
8	−.0506818	.0398226	0.203

The 8 specifications are same as those defined in that discussed paper (7). The re-calculation was performed using the STATA 10.

Table 2. Estimation for the “Flu dummy” by our re-calculation of the results shown in the table 2 of the discussed paper (7)

Specification	Estimated coefficient	S.E.	P-value
1	−.0414386	.0410326	0.313
2	−.038016	.0439017	0.387
3	−.0574794	.0351465	0.102
4	−.0542264	.0376323	0.150
5	−.0352233	.0392868	0.370
6	−.0318342	.0419876	0.448
7	−.0526439	.030965	0.089
8	−.0494413	.0330943	0.135

The 8 specifications are same as those defined in that discussed paper (7). The re-calculation was performed using the STATA 10.

−0.0654 in specification 3 to −0.03299 in specification 6. However, the lowest P -value of FLU_t was achieved in specification 7, which included the 1918 population count data, but excluded Kanto earthquake prefectures and Hokkaido outlier using the 1898–1935 data. However, it was 0.089. Therefore, in all 8 specifications, the estimated coefficients of FLU_t were insignificant at the 5% level.

DISCUSSION

We figured out the socio-economic reasons to speculate that the relatively low mortality rate in Japan, during that pandemic stated in Japanese official records, has not been at a level of a so called “myth,” as written in the preceding paper. We do not necessarily deny the possibility that the mortality number recorded by the authority at that time might be underestimation to some extent, but it is important to know the extent of such underestimation, if any. Based on the findings in reviewing the articles, it was found that the surveillance was conducted appreciably at a high level of accuracy, which might at least be comparable enough with the western countries at that time, and even with Japan today.

We only suggested that the figure of 2 million, as proposed in the paper’s conclusion (7), appears to be too inflated. Moreover, if the author meant the death figure of the “1918–1919 pandemic” to be the fatality by the pandemic in Japan from its starting to the end as a total, he should have included the additional number of deaths during October 1 to December 31, 1918. That

issue was somehow missed in the paper's calculation, as we point out in the second claim against the "overestimation" in the results section. The number is at least 0.2 million, according to the Japanese authority's data (8), or beyond that, as previously reported (9,10). Consequently, the author's estimate should become further inflated to at least 2.2 million or more than that, which would be also an unrealistic figure.

The mortality rates of Japan, suggested by many studies and have been accepted broadly, were modest. They were only close to those of western countries (2). The truth is that Japan experienced the severe damage but merely its extent was similar to those of the western world.

About the differences in conclusions: There were a striking contrast in methodology in estimating the epidemic deaths. We have relied on the information collected by actual surveillance, which was based on reality and certain accuracy. On the other hand, the author in that paper emphasized the demographic calculations as a novel way of analysis.

However, we could at least suggest the inappropriateness of the calculation, and its interpretation, including the possible great artifact. We criticized his conclusion by trusting the figure of all-causes mortality rather than that by demographical calculation. Reasons are as follows: i) In general, it has been well known that the flow data (for example, incomes at a moment, births or deaths) are more accurate than the stock data (for example, properties which change with time or counting a population of residence which often migrates). Thus, the mortality data is more reliable than the population data; ii) The collection of information on mortality, due to all-causes, could be thought to be easier and more accurate than that of the population census. Counting the deaths is easier than counting living persons, because the former does not move, is far smaller in number, and it does not need any definitions of specific cause-criteria (for example, kinds of diseases) or changes of social systems. It should not be affected by the effect of the change of the population census; iii) Furthermore, the collection of data of all-causes death was performed independently with the epidemic surveillance. Thus, it should overcome the bias that governments many countries in that time tended to use the optimistic data in reporting the pandemic deaths.

We showed that we could not reproduce the estimation done in the study even after using the same methodology and dataset, although, we could not identify the underlying reason. However, we can at least state that his estimation of the coefficient of FLU_t did not measure the pandemic alone. Fig. 1 shows graphs of type-A and type-B populations (19) until 1918, and their expected populations from 1918 to 1920, extrapolated using the trajectory from 1898 to 1918, with the graph of post pandemic populations after 1920 according to the data of census. Obviously, we can find a big gap between 1918 and 1920. There were the 2 major events related to population data in Japan during that period: the drastic change in the statistical method for the population counting, and the pandemic. There was a notable difference in the author's perspective and ours on which should be taken into account in between those 2 important events.

Fig. 1. Populations across the period 1918–1920. Open triangles and circles: type-A and type-B population until 1918 based on the older quinquennial population counting, respectively; open triangles and circles with broken lines: expected type-A and -B populations from 1918 to 1920, extrapolated from the trajectory of populations until 1918; Filled circles: population after 1920 based on the new census population counting. The data of 1918 and 1920 were provided from quinquennial population counting performed on December 31 and the population census on October 1, respectively. Type A population represented the people physically resided in different parts of Japan computed by adjusting the numbers with the hon-seki status downward to account for those who had the hon-seki status but lived in other locations, and type B population were further adjusted to account for the discrepancy between numbers of registered persons who immigrated into the various prefectures, which always exceeded the numbers of persons who migrated out, according to the discussed paper (7).

Hayami also doubted the population decrease based on the population datasets. He pointed out it as the severe effect of the change of the statistical methods, and concluded that the Japanese total population was not decreased by the pandemic influenza (9). It is quite impossible to separate the effects of the 2 events, even by applying any complex logics and mathematics. As a consequence, there was apparently a drastic population decrease resulting from the severe artifact by the change of the statistical system. The estimated coefficient of FLU_t with significance might represent the effect of the statistical event in 1920 alone. The gap in the graph should, at least, not be attributed only to the deaths by the pandemic influenza.

Speculations about possible reasons for exceptionally low Japanese mortality in comparison with other Asian countries: Based on our literature review, we discuss the following 3 viewpoints or reasons for the relatively low mortality rate in Japan, compared to other Asian countries during the pandemic event. **(i) Economic situations:** Murray et al. analyzed the 1918–20 pandemic data of many countries globally, including Asian countries, and concluded that the economic situation using per-capita income explains a large fraction of variation in mortality among countries/areas in the pandemic (2). During that time, per-capita income in Japanese was not similar to the western countries (2). However, their living status was higher than in comparison to other Asian countries. Many visitors from western countries also impressed to see the traditional, simple, and hygienic lifestyle as well as the strong social bondage among the

Japanese people living in the same community (20). Japan had been working hard toward its industrial revolution and developing yearly as a rising country (12). The economic situation itself was not so bad. For example, even 7-storied modern concrete buildings were built on a coal miner island for miners and their families in 1917. At that time, Japan was industrializing and was also an independent, free country in which communities were relatively homogenous without destitute large slums and a caste system. The rank system had been abolished completely since the last Edo Shogun returned the political power to the emperor in 1868 (12). These social situations might differ greatly from many economically and socially deprived colonized countries/areas at that time. **(ii) Leaderships and social interventions:** In addition, social interventions against the pandemic were also blooming in Japan during that time. In a book, *America's Forgotten Pandemic*, AW Crosby, the author, stressed the importance of the efforts to fight against the epidemic, the tight community bond, and the leadership. After reviewing reports of mortalities of many actual community cases, he commented as follows: "Leadership, when effective, often proved a satisfactory substitute for physicians and hospitals"; "where it was lacking, killed as surely as the absence of any other essentials"; "effective leadership was vital to keeping death rates down"(1).

Notably, as we mentioned above, unlike other Asian countries, Japan had such a social structure system, strong community bondage, and the leadership to combat such a large scale epidemic.

Every local government had an administrative structure to fight against the influenza, including the funding to support private sectors and volunteer services for their activities. They also raised awareness by introducing mandatory wearing of respiratory masks to service providers, temporary closure of public spaces, and schools as well as advising the isolation of the infected patients and restricting them from going out, especially to crowded public spaces (8).

It should be also noted that systematic community interventions were possible in Japan, because not only was there strong community bondage, but there was also a high literacy rate among the adult population (96.6–98.8%, male >20 year-old, in 1920), which was achieved until that time (21). It was not so inferior compared to today. Notably, in Japan, the compulsory education started nationwide in 1900 with the slogan, "Let there be illiteracy in no village home, no illiterate in any village house" (22). Thus, social efforts to save the disadvantaged, including public communication activities and providing the poor with care, food and/or respiratory masks, were strongly promoted at the community level by the public, private sectors and volunteers (8). The public education regarding performance of public health activities and personal hygiene, including avoiding crowds and people coughing, wearing the respiratory masks, and the importance of nutrition, were also strongly promoted in schools, communities, public meeting places, and theaters. This was done through the use of posters, flyers, and advertising in movie films (8). General people of many under-developed countries/areas at that time might not have received benefits of those kinds of interventions because of the lack of

their own leadership. **(iii) Vaccine coverage against bacterial infections:** All the prefectural governments, as well as private sectors, provided a great number of influenza vaccines to their residents. The total dose of the vaccination was about 4.7 million, in the pandemic period, which covered about 8% of the population (8). Though it had not been focused on so far, this might have had an impact on the reduction of mortality. Unlike solely viral pneumonia, bacterial pneumonia was also reported as one of major causes of death during the influenza pandemic (23). The vaccine contained *staphylococcus*, *streptococcus* or *influenzae* bacteria, or a mixture of those as the antigen (8). The vaccine might have worked to some extent, against the exacerbation of bacterial pneumonia associated with viral infection as has been observed in these days in the efficacy of the pneumococcal conjugate vaccine for protecting elderly peoples from bacterial pneumonia (24).

Concluding remarks: Demographical analysis should be started without personal preconception and obtained results should be carefully judged. The finding could be validated in the light of country-specific socio-economic context, to avoid any misinterpretation due to analytical error or artifact. This rebuttal reflected that fact. In conclusion, based on our reinvestigation, we can comment that the official record of mortality in Japan, during the pandemic, is not so far from what actually occurred in the pandemic.

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Conflict of interest None to declare.

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