Did travel truly spread infectious disease? The case of influenza during New Year vacation in Japan

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ICMJE Statement

Contributors YO was responsible for the coordination of the study and set the data. TS and JK analyzed the data. All authors contributed to the writing of the final manuscript.

Abstract

Background: In Japan, long-distance domestic travel was banned while the SARS-Cov-2 original strain was dominant under the first declared state of emergency from April 7, 2020 until the end of May, 2020. Subsequently, the “Go To Travel Campaign” (GTTC) travel subsidy policy was activated until the second state of emergency was declared, with long-distance domestic travel banned from January 7, 2021.

Object: We consider how travelling affects the infectivity of infectious diseases by examining influenza activity before and after the New Year vacation period.

Method: We examined the slope of the cumulative number of influenza cases in January 4–7 or after to ascertain whether it was steeper than in the 10 seasons preceding the COVID-19 pandemic, which emerged in 2020.

Results: The estimated slope during January 4‑7 and after was not significantly higher than the slope in December.

Discussion and Conclusion: We can find no evidence of higher infectivity attributable to intensive and extensive travel activities during the New Year vacation.

Introduction

Policies conducted by government should be subjected to rigorous ex post as well as ex ante evaluation. However, in Japan, official evaluations are rare because government officials, serving in their public roles, are implicitly believed never to make mistakes. Particularly, countermeasures against the COVID-19 outbreak have never been evaluated ex ante. Because less knowledge and experience were available for the COVID-19 pandemic, ex ante evaluation was understandably difficult and imprecise. Nevertheless, ex post evaluation is also rarely conducted.

In Japan, long-distance domestic travel was banned while the SARS-Cov-2 original strain was dominant under the first declared state of emergency on April 7, 2020 until the end of May, 2020. Subsequently, the “Go To Travel Campaign” (GTTC) travel subsidy policy was activated until the second state of emergency, with long-distance domestic travel banned from January 7, 2021. At that time and to the present day, the long-distance domestic travel ban effects or “Go To Travel Campaign” effects on infectivity have aroused national debate. Nevertheless, the controversy related to effectiveness has not been resolved to date because little scientific evidence has been forthcoming.

One exceptional study [1] advocated the public policy stance which was taken, but it included many mistakes and was regarded as inadequate for use as evidence. It insisted that the travel-associated COVID-19 incidence during July 22–26, when GTTC had started (hereinafter, we designate this period as the GTTC started period), was much higher than during either earlier period of June 22 – July 21 or July 15–19. That study also specifically examines the period of August 8–31. Patient data of two types were used: the onset date and the date of testing positive.

We have identified some odd points in the report of that study. The first is that the proportion of people with a travel history during the GTTC period was comparable to similar proportions of people during the two prior periods. Especially, when the earlier period was defined as July 15–19, the proportions of people with a travel history among patients with an available onset date were smaller for the GTTC started period than during the prior period. However, the authors found significantly higher incidence during the GTTC started period. Their findings might merely reflect the fact that the total number of patients in the GTTC period was higher than during the prior period. In other words, they did not control the underlying outbreak situation and therefore found incorrect association. Comparison of incidence rates among two periods would be valid if the underlying outbreak situation were the same in the two considered periods.

Therefore, comparison of incidence rates between the two periods might be inappropriate for this issue. At least, controlling the potential differences in the outbreak situations is expected to be necessary. The underlying outbreak situation, unrelated to GTTC, was reflected in the number of patients without a travel history or any sightseeing. To control the underlying outbreak situation, analysis of the share of patients with a travel history or sightseeing might be one procedure. However, that share did not increase markedly during the GTTC started period. This fact indicates that the authors' results and conclusions are misleading.

A second point is that the authors of that report referred to the period of August 8–31, when GTTC was continuing. The proportion of patients with a travel or tourism history was much smaller than in the GTTC started period or the prior period. Although the authors did not compare incidence in the period with that of either the prior period or the GTTC started period, the rate of incidence during the period in August was probably lower than in other periods. In fact, some patients using GTTC perhaps might have been included in the period, as described above. That fact during August 8–31 might be inconsistent with the authors' conclusion.

A third point is that GTTC must also have increased the number of patients without a travel history if GTTC had a strong effect on the outbreak. For example, one can consider a patient travelling using GTTC on July 22 and 23, then showing disease onset on July 24. This patient had a travel history with GTTC but was not included a group of patients with a travel history, whose onset dates were included in the GTTC started period of July 27–31. Nevertheless, presymptomatic patients are well known to have infectiousness during the symptomatic period [2]. This patient might therefore have infected hotel staff or persons visiting tourist areas. They did not have a travel history: their onset dates were July 27 and 28. Therefore, they were included a group of patients without any travel history in the GTTC started period July 27–31. Therefore, GTTC certainly increased the number of patients without any travel history, but did not increase patients with a travel history in this case. Consequently, when considering the GTTC effects, one must check the number of patients irrespective of their travel history.

Another study proved that the effective reproduction number was lower during the GTTC activated period [3]. It is noteworthy that this study could have been done in mid-March or at the end of March, 2021, if those valuable data had been prepared. At that time, we had found the same results as those presented for this study. In fact, that study was performed in 2022, although similar research was posted on January 4, 2021, with the same results obtained for GTTC.

In general, ex ante policy evaluation is necessary. However, it is often very difficult to estimate policy effects precisely. By contrast, ex post evaluation can be done as soon as possible if preparations for it are planned before policy activation. If such evaluations of policies banning long-distance travel without any legitimate rationale had been done, then their deleterious effects could have been prevented in 2021 and thereafter.

Another study [4] found reverse evidence that the effective reproduction number was significantly lower during the period when long-distance travel was promoted. Moreover, another study [5] of airport users at a local airport showed reduced infectivity. These findings might be strong evidence casting doubt on the legitimacy and rationality of policies banning long-distance travel.

The present study was conducted to examine some evidence for association among travelling and infectious diseases outbreak, in general, even before the Covid-19 pandemic emerged, particularly seasonal influenza activity during the New Year vacation from December 31 to January 3 of the following year. During this period, 29.6 in 2017/2018, 29.9 in 2018/2019 [6], and 29.3 in 2019/2020 [7] million Japanese people (approximately 25% of the total population) travelled to their hometown or went sightseeing. How did this mass travel affect influenza activity during several seasons? Because influenza was a widely known infectious disease and because travelling during the New Year vacation was a national event, influenza activity during and after the New Year vacation can be expected to be widespread phenomena, at least, among specialist of infectious diseases. Therefore, the object of this study using data available before the pandemic era is to ascertain how intensive and extensive travel activities affect the infectivity of infectious diseases.

Methods

We use data for daily influenza activity in Japan obtained from Prescription Surveillance (PS), which is known as the most timely, precise, and nation-wide surveillance system for influenza not only in Japan, but also in the world [8–10]. Data for the day prior are published in the morning on the following web site (http://prescription.orca.med.or.jp/syndromic/kanjyasuikei/index.php).

Especially, we examine dynamics during one month before and after the New Year vacation: December 1 to January 31 of the following year each season. To exclude A/H1N1/pdm in the 2009/2010 season and the COVID-19 pandemic, we investigated the 10 seasons of 2010/2011 – 2019/2020.

We apply the modified Gompertz function, which is an asymmetric sigmoid curve, to the cumulative number of patients since December first in each season as

$$\log N_t = \beta_0 \text{-exp}(-\beta_1 - \beta_2 \times D_t - \beta_3 \times Y_t - \beta_4 \times \mathrm{V}_t - \beta_5 \times G_t - \beta_6 \times E_t),$$

where t stands for the number of days, D_t denotes the number of days since December 1, Y_t is a dummy variable for data in January, V_t expresses the number of days since January 3 during January 4–7 and is otherwise zero, G_t is a dummy variable after January 8, and E_t signifies the number of days since January 8 and is otherwise zero. If travelling during the New Year vacation raises infectivity, then the slope of the cumulative number of patients during January 4–8 would be higher than the baseline slope of the sigmoid curve. Subsequently, infectivity declined to normal level. However the effect of more newly infected people in January 4–8 can be expected to continue for some time. Therefore, the estimated β_4 and β_6 values are expected to be positive; also, $\beta_4 > \beta_6$.

We exclude estimation of the epidemic curve for Sundays, national holidays, and the New Year vacation because almost all hospitals and clinics are closed. Because PS reports the number of prescription with antiviral drugs for influenza, it underreports the number of patients on these days. By contrast, on Monday or the day after a holiday, the reported number of patients might include patients who had onset on or before a Sunday or holiday. They might visit a doctor on Sunday or on a holiday if hospital or clinic is open on a Sunday or holiday. Therefore, the cumulative number of patients on a

Monday following a holiday might be naturally connected with that of Saturday or the day before the holiday.

However, because the New Year vacation is long, four days, some patients had onset and recovery without visiting a doctor during the vacation. They were not recognized by PS as patients. Therefore, underestimation can be expected to occur during long holidays. This gap has continued. It is manifested as a shift to the right-hand-side of the curve of the cumulative number of patients. The estimated coefficients of β_3 imply this shift.

We declared 5% as significance level and performed all statistical analyses using software (Stata SE 17.0; Stata Corp.).

Results

Figure 1 shows the cumulative number of influenza patients excluding periods when hospitals and clinics are closed. The wider mid-curve gap represents the New Year vacation. At first glance, the New Year vacation shifts the curve to the right-hand-side. Moreover, the slopes of the curves were not steeper than either before or after a vacation.

Table 1 presents estimation results obtained using the Gompertz function. All $\beta_{0\text{-}3}$

values were found to be significant, but no $\beta_{4\text{-}6}$ value was significant, though β_5 and β_6 were not identified in the 2014/2015 season. Therefore, the null hypothesis, that no difference exists between slopes of the curve of January 4–8 and after compared with the slope in December, cannot be rejected.

Discussion

We cannot find any evidence of a remarkable increase in infectivity associated with the New Year vacation. That finding casts doubt on higher infectivity attributable to widespread travel during the New Year vacation.

This fact should be very well known, at least among specialists for infectious diseases. If this readily demonstrated fact is not considered in discussions of GTTC by specialists, they might be intending to disregard it. If so, legitimacy of the policy banning long-distance travel, including ceasing of GTTC, was not fair or rational.

This study requires the use of precise daily data of influenza activity nationwide. Fortunately, we can use data provided by PS. Since 2007, PS has been developed through cooperation among research groups and EM Systems Co. It has been operated by the Japan Medical Association, Japan Pharmaceutical Association, and EM Systems Co. Ltd. It reports the estimated number of patients based on information of prescriptions filled at external pharmacies. By the end of March 2024, approximately 15,211 pharmacies were participating, collectively accounting for about 30% of all pharmacies in Japan. Actually, PS monitors the number of prescriptions with anti-influenza virus drugs, anti-herpes virus drugs, antibiotic drugs, antipyretic analgesics, multi-ingredient cold medications, and antidiarrheal and intestinal drugs. Moreover, antibiotics are classified into five types: penicillin, cephem, macrolide, new quinolone, and others.

The present study has some limitations. First, this study specifically emphasizes influenza and not COVID-19. One cannot ignore the possibility that, in the case of COVID-19, travelling had a stronger effect than that of influenza, although some studies have denied it.

Second, although we examined infectivity nationwide, in some resort or remote hometowns, infectivity rose during the New Year vacation because of greater than usual temporary congestion. By contrast, in urban areas such as Tokyo or Osaka, congestion disappeared during the period. Therefore, infectivity might have declined. This study might show that increases in resort areas or remote places and decreases in urban areas were cancelled nationwide. If we particularly examine resort areas or urban areas, great differences in infectivity during the period might be observed.

Conclusion

We demonstrated that travelling during the New Year vacation did not raise the infectivity of influenza. The policy banning long-distance travel, including the cessation of GTTC, was not fair and rational.

Acknowledgments

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Ethical considerations

All information was presented and available for the general public on the internet. Therefore, no ethical issues are associated with this study.

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Table 1: Estimation results of Gompertz function to the cumulative number of influenza patients in ten seasons of 2010/2011 – 2019/2020

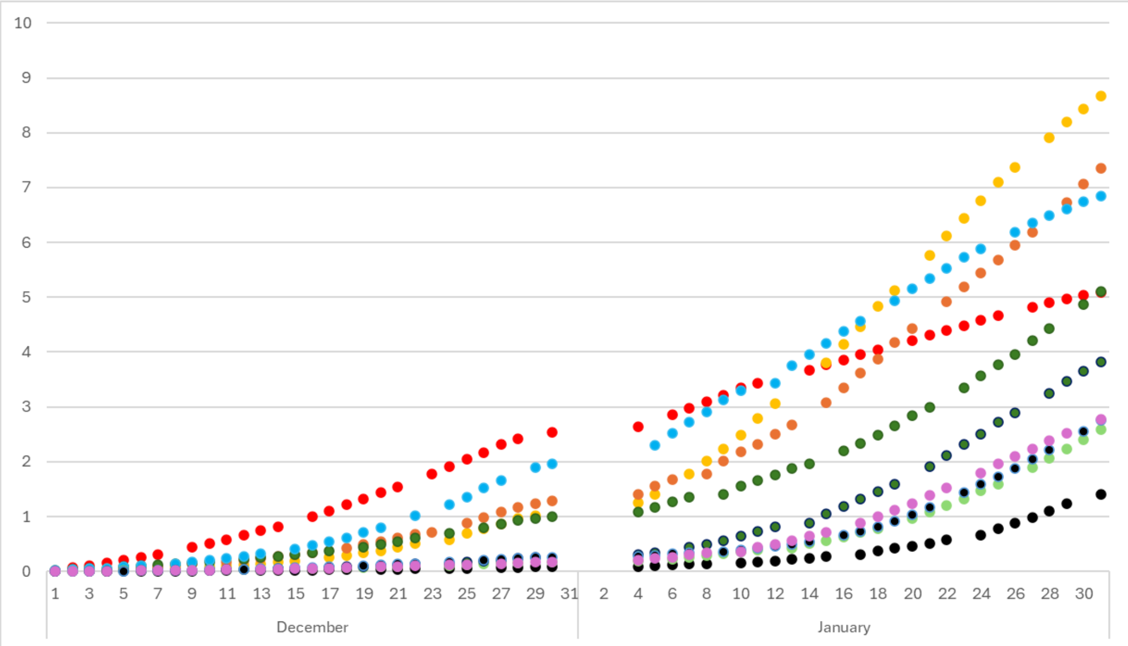
	Estimated coefficient	*p* value	Estimated coefficient	*p* value	Estimated coefficient	*p* value
Season	2010/2011		2011/2012		2012/2013	
Constant	15.43606	0.000	15.26553	0.000	15.63613	0.000
Constant term in exponential	-1.94862	0.000	-1.97416	0.000	-2.03539	0.000
Days since December 1	0.026972	0.000	0.034895	0.000	0.032023	0.000
Dummy for January	-0.76761	0.444	0.0249	0.983	-0.51554	0.668
Days during January 4–7	0.017269	0.530	-0.00785	0.806	0.009446	0.776
Dummy after January 8	-0.84364	0.461	-1.62439	0.236	-0.94958	0.485
Days after January 8	0.036698	0.043	0.029765	0.093	0.032981	0.091
Adjusted R^2	0.9901		0.989		0.9902	
Season	2013/2014		2014/2015		2015/2016	
Constant	16.38883	0.000	15.39936	0.000	15.35053	0.000
Constant term in exponential	-2.03058	0.000	-1.71955	0.000	-2.02653	0.000
Days since December 1	0.020507	0.000	0.057274	0.000	0.023471	0.000
Dummy for January	-0.2571	0.650	-2.60798	0.736	-0.30377	0.709
Days during January 4–7	0.003585	0.816	0.070814	0.736	0.004507	0.840
Dummy after January 8	-0.50212	0.432	NA	NA	-0.67698	0.464
Days after January 8	0.015845	0.095	NA	NA	0.019856	0.145
Adjusted R^2	0.9935		0.9857		0.9892	
Season	2016/2017		2017/2018		2018/2019	
Constant	15.52369	0.000	15.9389	0.000	16.19647	0.000
Constant term in exponential	-1.69065	0.000	-1.83582	0.000	-1.97019	0.000
Days since December 1	0.041697	0.000	0.042463	0.000	0.038961	0.000
Dummy for January	-0.46566	0.777	-0.59792	0.754	-0.91234	0.444
Days during January 4–7	0.006145	0.892	0.010667	0.841	0.021375	0.517
Dummy after January 8	-1.39395	0.464	-1.21016	0.549	-0.77863	0.566
Days after January 8	0.037803	0.164	0.038638	0.048	0.04092	0.053

Adjusted R^2	0.9887		0.994	0.9951
Season	2019/2020			
Constant	15.42627	0.000		
Constant term in exponential	-1.52406	0.000		
Days since December 1	0.066646	0.000		
Dummy for January	-0.45882	0.793		
Days during January 4–7	0.002755	0.954		
Dummy after 8 January	-1.32112	0.511		
Days after January 8	0.035431	0.217		
Adjusted R^2	0.9971			

Note: Sample sizes were 50 in the 2017/2018 season, 48 in 2013/2014, 2018/2019, and 2019/2020 season, and 49 otherwise. NA denotes not available or unidentified.

Figure 1: Cumulative number of influenza patients in seasons from December 1 for ten seasons: 2010/2011 – 2019/2020.

(million patients)



Day/Month

Note: Sunday, national holidays, and New Year vacation (December 31 – January 3), when hospitals and clinics were closed, are not shown. The greatest cumulative number of patients on January 31 was during the 2011/2012 season, followed by 2012/2013, 2015/2016, 2013/2014, 2010/2011, 2017/2018, 2019/2020, 2018/2019, and 2016/2017 seasons. The smallest number was during the 2014/2015 season. The difference in the number of cases was attributable to the number of Sundays during the study period. Also, Emperor Hirohito's birthday was commemorated on December 23 until 2015, but was not commemorated thereafter.