Association of sightseeing tourists and COVID-19 outbreak: A case study of a hot spring resort

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ICMJE Statement

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

Abstract

Background: Long-distance travel for sightseeing, which was believed to have spread the COVID-19 outbreak, was banned until 2022. Nevertheless, no report has described a detailed examination of that belief and policy.

Object: This study was conducted to confirm the effects of long distance travel on infectivity at a hot spring resort.

Method: We used a unique dataset including the daily numbers of visitors at three major hotels in Ibusuki city to evaluate how sightseeing tourism affected the COVID-19 effective reproduction number and newly confirmed patients. Study periods were January 25 through August 31, 2022 for the effective reproduction number and from August 19, 2020 through September 20, 2022 for newly confirmed patients.

Results: Neither measure of infectivity was found to be significantly associated with tourism, as represented by hotel visitors.

Discussion and Conclusion: Estimation results demonstrated that sightseeing tourists might not have affected the COVID-19 outbreak.

Introduction

Policies administered by governments should be evaluated ex post facto as well as ex ante. However, such official evaluations are rare in Japan because governments are postured as never making mistakes. Moreover, countermeasures against the COVID-19 outbreak have never been evaluated ex post because, during the pandemic, little knowledge and experience about COVID-19 were available. Ex ante evaluation was too difficult and imprecise. That lack of ex ante evaluation notwithstanding, ex post evaluation has also been rare. For example, long-distance travel for sightseeing was believed to spread outbreaks. In fact, such travel was banned until 2022. At least one study [1] advocated this public stance, but it included numerous mistakes and was discounted as evidence and as a basis for policy. It was refuted and contradicted completely [2].

Another study [3] found contrasting evidence that the effective reproduction number was significantly lower during the period when long distance travel was promoted. Moreover, another study [4] showed that airport users at a local airport reduced infectivity. These findings might be strong evidence casting doubt on the legitimacy and rationality of policies banning long-distance travel. However, these studies examined large areas specifically. The former study examined the entirety of Japan. The latter assessed a prefecture, and the original strain. In general, the study areas were larger, suggesting greater difficulty in identifying people engaged in long-distance tourism. The eventual analyses might be more indirect. Moreover, the mutated strain was well known to have had higher infectivity than the original strain [5,6]. Indeed, some probability exists that long distance travel affects the infectivity of the mutated strain differently than it affects the infectivity of the original strain. Studies must analyze tourism in much smaller areas and include a period during which the mutated strain was dominant.

Therefore, this study was conducted to confirm long-distance travel effects on infectivity at a hot spring resort. Specifically, we examined Ibusuki city in Kagoshima prefecture, as shown in Figure 1. That city of about 37.7 thousand residents has a famous hot spring and sightseeing spots. Collaboration among epidemiologists and major hotels in Ibusuki city facilitates deeper analyses to examine the object of this study. Especially, the daily number of hotel visitors at three major hotels in Ibusuki city can be used. Official published data have been monthly or annual data. Consequently, the association between sightseeing tourism and infectivity have not been analyzed using readily available, published data. The unique collaboration made for this study enabled us to approach this study objective precisely.

As a countermeasure against the COVID-19 outbreak in Japan, school closure and voluntary event cancellation were required from February 27 through the end of March. Large commercial events were also cancelled. Subsequently, a state of emergency was declared on April 7 through 25 May, entailing voluntary restrictions against going out the shutting down of businesses that personally served customers. During this period, the first peak of infection was reached on April 3. The next peak occurred on July 29, as shown in Figure 1. However, even though the so-called "Go To Travel Campaign" (GTTC) might have expanded the outbreak, it was started on July 22. The GTTC program, which was aimed at supporting tourism businesses, subsidized 50% of travel expenses with coupons issued for shopping at tourist destinations. The GTTC continued through December, by which time the third wave had been reached. The third wave was larger than either of the prior two waves in December. Therefore, GTTC was inferred as the main reason for the third wave [7].

However, although results were mixed, results of some earlier studies have suggested that COVID-19 might be associated with climate conditions, at least in China [8–10]. Another study using cross-sectional international comparison among Europe countries found no association among climate conditions and COVID-19 outbreak surge dates [11]. If the association were confirmed for Japan, then GTTC might not be inferred as the main reason for the third wave in winter.

Actually, mobility was inferred as the main cause of the outbreak dynamics, at least in the first wave in Japan [12] and worldwide [13]. One study [14] found that non-pharmaceutical interventions including lockdowns strongly affected transmission reduction, at least in 11 European countries through April. Another study [15] of 131 countries found that the introduction and relaxation of lockdowns or movement restrictions had limited effects on infectiousness, except for public events bans, although their data were limited to the end of July, 2021. One study [16] of Argentina showed that strict movement restrictions imposed from March were effective at reducing mobility but not at mitigating the outbreak. These mixed results suggest that those countermeasures might not strongly affect mobility.

However, how the numbers of sightseeing visitors or long-distance travelers themselves affect outbreak situations in rural areas has not been described in reports of the relevant literature. The reason for the apparent lack of such studies is that such information might be less available for epidemiological analysis. Little if any annual or monthly data related to travelling and sightseeing might be available. Such data would be too aggregated, thus leaving too few data points to apply statistical analysis for a short period for less than one year. To support the present study, collaboration has been achieved among epidemiologists, statisticians, and companies managing resort hotels and buses to airports in a rural area, with daily data of bus users from airport and visitors at these hotels. Therefore, the hypothesis that sightseeing visitors and long-distance travelers spread the COVID-19 outbreak in rural areas can be tested directly. This hypothesis was the rationale for policies banning long-distance travel during the first and second states of emergency or during cessation of the GTTC, although they have not been analyzed or confirmed to date.

Methods

Unique data including the daily numbers of hotel visitors to three major hotels in Ibusuki city were provided for analysis, but the information was insufficient to cover all hot spring visitors comprehensively. Some tourists might have stayed at other hotels. Moreover, because Ibusuki city is located 50 km south of Kagoshima city, which is at that center of Kagoshima prefecture, some visitors to the hot springs in Ibusuki city might not have stayed at hotels. The influence of this information is discussed later.

The COVID-19 outbreak activity was measured by the daily number of newly confirmed patients, including asymptomatic patients, in Ibusuki city [17]. In general, the outbreak situation was expressed by R(*t*). Therefore, the procedure for calculating R(*t*) was the same as that used for earlier studies [2–4].

However, if the population is small, then the effective reproduction number cannot be estimated or cannot be estimated steadily because its denominator, and then the number of patients who can infect others, weighted by their infectivity, was very small or sometimes zero. Even in the case of Ibusuki city, it was too volatile before January 25, 2022. In other words, analyses using the effective reproduction number cannot be performed for GTTC or the original, or Alpha or Delta variant strains. However, analyses using newly confirmed patients were feasible, even for study periods including no patients. Moreover, because of data unavailability in the future period, the effective reproduction number during the last 20 days of the study period was incomplete and unstable. For that reason, we also omitted results obtained for September 2022

The period from infection to reporting was presumed to be several days. It includes the incubation period, period from onset to visiting a doctor, testing, and reporting. In general, reporting would lag several days after infection. In light of that fact, we regressed the number of newly confirmed patients with some lag on the number of tourists as well as other potentially explanatory variables. Then, we sought the best-fitted lag measured by the adjusted determinant coefficient over 0 to 30 days delay. The value of R(t) was adjusted for these lags. Therefore, these lags need not be considered for analyses in which R(t) was the dependent variable.

The study period for analysis conducted with newly confirmed patients was defined as August 19, 2020 through September 20, 2022, when the report from Ibusuki city listed the last detected initial case in Ibusuki city. After this period, information about COVID-19 patients in Ibusuki city has not been available.

We use some variables as explanatory variables. First, the number of tourists to Ibusuki city was inferred as the number of visitors at three major hotels in Ibusuki city.

Average temperature and relative humidity data for Kagoshima prefecture were used as climate conditions. Temperatures were measured in degrees Celsius. We obtained Japan Meteorological Agency data (https://www.data.jma.go.jp/gmd/risk/obsdl/index.php).

Additionally, we identified several remarkable countermeasures in Japan taken during the study period: three of four state-of-emergency declarations and the GTTC. The second state of emergency was declared on January 7, 2021 for the 11 most-affected prefectures. This countermeasure mandated restaurant closure at 8:00 p.m., with voluntary restrictions against going out, but school closure was not required. That declared state continued through March 21, 2021. The third and fourth state-of-emergency declarations were put into effect from April 24 through June 20, 2021 (third) and from July 12 through September, 2021. During the fourth declared state of emergency, the Olympic Games were held in Tokyo from July 22 through August 8, 2021. We also consider the Olympic Games as a potentially infectivity-affecting event.

To clarify associations and R(*t*) or newly confirmed patients and sightseeing tourists, in addition to climate, mobility, and countermeasures, we used ordinary least squares regression to regress the daily R(*t*) or newly confirmed patients on data for the number of daily hotel visitors at three hotels, as well as daily climate, mobility, vaccine coverage, the proportions of the mutated strains, and dummy variables assigned to countermeasures. For mobility, we used Google-provided mobility data showing the presence of people at six venues: restaurants, shopping malls and amusement areas; grocery stores and pharmacies; parks; transition areas; workplaces; and homes (https://www.google.com/covid19/mobility/). Those data reflect mobility compared to some base day. A number of 100 is assigned if the number of persons staying at a type of venue was the same as the base day.

We expected the sign of the explanatory variables to be the following: hotel visitors at three major hotels or GTTC increased infectivity if the policy of banning long distance travel was rational. State of emergency countermeasures were presumed to decrease infectivity if they were applied conscientiously. Moreover, the vaccine coverage was expected to reduce infectivity. By contrast, mutated strains such as the Omicron variant strain, particularly its B.5 its sublineage, had higher infectivity than the original or earlier mutated strains [5, 6, 18–21]. We adopted 5% as the significance level.

Ethical considerations

Information about patients used for this study was collected under the Law of Infection Control, Japan and published by newspaper [17]. Three hotels provided business recorded data voluntarily. Data about visitors at three hotels included no personal or private information. Therefore, no ethical issue is posed by this study.

Results

Figure 2 presents newly confirmed cases of COVID-19, including asymptomatic cases, through September 20, 2022 in Ibusuki city. The initial case was detected on July 1, 2020. However, cases were sporadic until 2022. From January 2022, the cases were reported continuously, exhibiting the largest peak in August when Omicron BA.5 variant strain was dominant. Therefore, we limited these analyses to the association of

R(t) and tourism after January 25, 2022.

Figure 3 shows numbers of visitors at three corporate hotels. In April and May, 2020, when the first state of emergency was declared, two variables decreased greatly. Subsequently, these recovered during the GTTC activated period to December 27, 2020. Then these fluctuated in almost identical ranges to those of the GTTC.

Figure 4 presents the estimated R(t) from January 25 through August 2021.

The highest peak was recorded in March when dominate lineage switched from BA.1 to BA.2. The second and third peaks occurred respectively in June and July when the BA.2 and BA.5 lineages dominated.

Figure 5 shows the adjusted determinant coefficients with several delays using newly confirmed patients as dependent variables. The findings indicate a 25-day delay as the best fitted. Therefore, hereinafter, the dependent variable was the number of newly confirmed patients with a 25-day delay.

Table 1 shows that tourism was not associated with R(t) and newly confirmed with a 25-day delay. Therefore no evidence can be found to support some rationale for a long-distance travel ban policy.

Temperatures, humidity, and going to restaurants increased R(t). However, coverage of the fourth vaccination decreased it. Regarding the newly confirmed patients, going to groceries and pharmacies, coverage of the second to fourth vaccination, the proportion of BA.5 sublineage of the Omicron variant strain, the fourth state of emergency, and the Olympic games extended the outbreak. By contrast, the proportion of the Delta variant strain and BA.1 and BA.2 sublineages of the Omicron variant strain suppressed the outbreak. Results related to vaccine coverage and newly confirmed patients were unexpected. Results related to the proportion of the Delta variant strain and BA.1 and BA.2 sublineages of the Omicron variant strain coverage and newly confirmed patients suggest that these mutated strains were less infective than the original Wuhan strain, which might be inconsistent with earlier research [5,6,18–21].

Discussion

Estimation results indicated that sightseeing tourists might not increase infectivity and expand the outbreak at all. The legitimacy and rationale for banning sightseeing and long-distance travel might not be supportable. In an accompanying study [20], the effective reproduction number in 2022 found for Yakushima, a resort island in Kagoshima prefecture, Japan, was not associated with the number of sightseeing tourists. This study found results consistent with those of that accompanying study.

Some unexpected results were obtained for all vaccine effects on the number of newly confirmed patients, although the result of vaccine effect of the fourth shot to R(t) was negative and significant as expected. The estimated coefficients of vaccine effects on the newly confirmed patients were 0.18–0.92 because vaccine coverage was measured by percentage, as 0–100. Therefore, these estimated coefficients suggest that patients would increase by 18–92 people if vaccine coverage were increased from no vaccination at all to full coverage. These numbers would be too large for Ibusuki city: in fact, the peak of epidemic curve in Figure 2 was less than 120.

Major differences existed among two dependent variables of the denominator. The effective reproduction number was controlled by the denominator. However, newly confirmed patients were not controlled. In this sense, to measure outbreak activity, the effective reproduction number might be more appropriate than the newly confirmed patients. However, controlling the denominator prohibits analysis of data before January 25, 2022 because the denominators were too small or zero: the effective reproduction number is either incalculable or unstable. Therefore, the study period for the effective reproduction number must exclude the period when the original, Alpha and Delta strain were dominant. Only during the period when Omicron was dominant in 2022 was the number of patients large, even in Ibusuki city. The effective reproduction number is calculable and stable. In other words, for analyses before 2022, the effective reproduction number might be inappropriate. The newly confirmed patients were more appropriate for use in considering the effects of sightseeing tourism on the outbreak.

The weakest point of this study might be the representativeness of using these unique data: daily hotel visitors at three corporate hotels. Unfortunately, no comparable daily data were available. However, comparable monthly data for all hotels in Ibusuki city were available. Figure 6 depicts monthly data of visitors at all hotels in Ibusuki city. The correlation coefficient among them from January 2020 through August 2022 was 0.9817; the p-value was 0.000. Therefore, the three corporate hotels providing daily data presumably reflect the data of other hotels and therefore all hotel visitors to Ibusuki city.

The present study has some limitations. First, this study specifically examines only Ibusuki city, Kagoshima prefecture. Therefore, it is not certain that the same results are applicable to other places in Japan or to the whole of Japan.

Second, regression analysis such as that used for this study does not mean causality. Although we inferred that the number of hotel visitors would expand the outbreak, a wider outbreak might increase hotel visitation. One must bear such points in mind when interpreting the results.

Conclusion

We demonstrated that an increased number of sightseeing tourists might not have expanded the COVID-19 outbreak. Therefore, we conclude that the rationality and fairness of the policy banning long distance travel were weak.

The present study is based on the authors' opinions: it does not reflect any stance or policy of their affiliations.

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Ethical considerations

All information about patients used for this study was collected under the Law of Infection Control, Japan and published by newspaper [17]. Information related to hotel visitors at corporate hotels was provided voluntarily for analyses. Hotel visitors had no personal or private information. Therefore, no ethical issue is posed by this study.

Competing interest

No author has any conflict of interest, financial or otherwise, to declare in relation to this study.

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Table 1: Estimation results of association among the estimated reproduction number / newly confirmed with 25 days delay with hotel visitors at three major hotels in Ibusuki city from August 19, 2020/ January 25, 2022 through August 31, 2022/ September 20, 2022

	Effective reproduction number		Newly confirmed patients with 25-day delay	
Explanatory variable	Estimated coefficient	*p* value	Estimated doefficient	*p* value
Visitors at three hotels	0.000466	0.068	-8.8E-05	0.943
Temperature	0.039137	0.044	0.021047	0.715
Humidity	0.009696	0.048	-0.00813	0.767
Place: Restaurant, shopping mall or amusement	0.031125	0.028	-0.10975	0.05
Place: Grocery store or pharmacy	-0.01403	0.375	0.140052	0.023
Place: Park	-0.00408	0.415	-0.00054	0.982
Place: Transition	0.007483	0.47	0.009137	0.851
Place: Workplace	0.021809	0.1	-0.0201	0.73
Place: Home	0.041157	0.352	0.090826	0.696

2nd state of emergency			-0.15892	0.875
3rd state of emergency			-0.42121	0.731
GTTC			0.155073	0.871
4th state of emergency			4.496548	0.006
Olympic			4.713315	0.004
Vaccine coverage of the second dose with lag (%)	0.132773	0.63	0.316527	0
Vaccine coverage of the third dose with lag (%)	-0.02557	0.137	0.175827	0.047
Vaccine coverage of the fourth dose with lag (%)	-0.07184	0.001	0.915219	0.004
Share of Alpha variant strain (%)			-0.00489	0.745

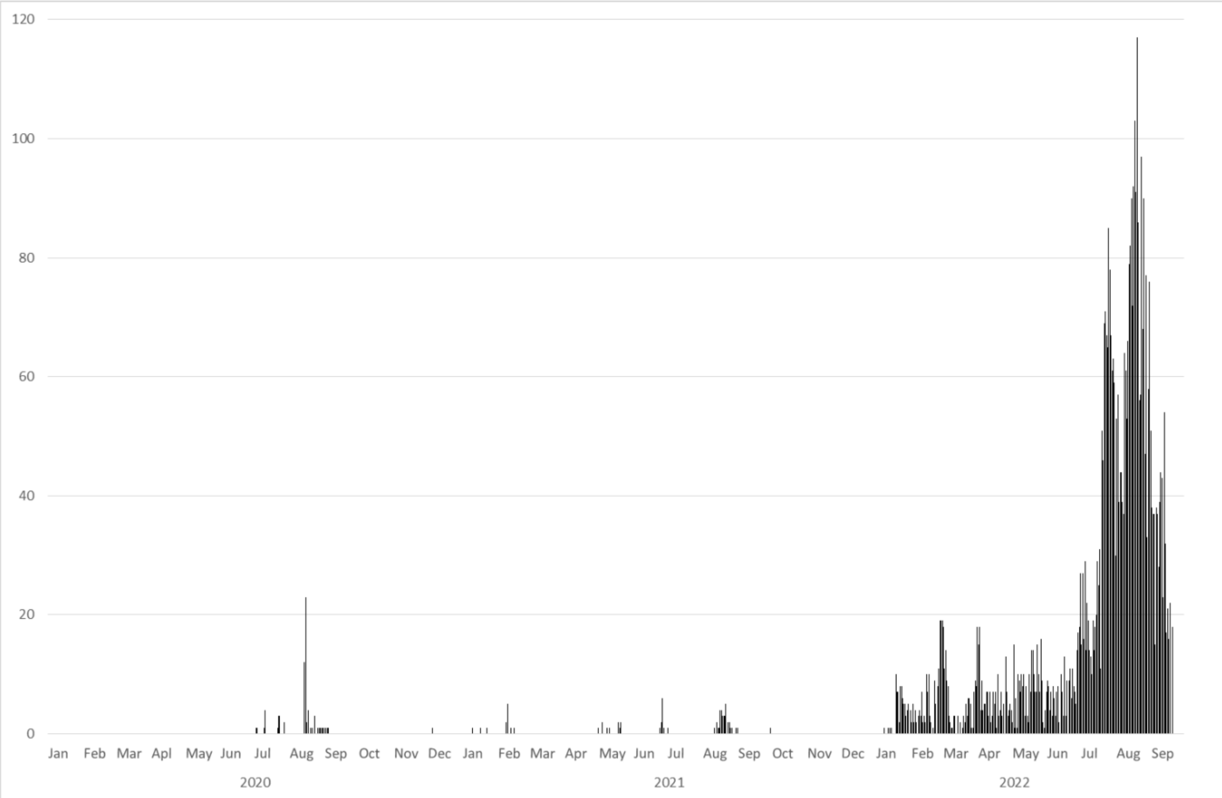
Share of Delta variant strain (%)			-0.24736	0
Share of Omicron BA.1 variant strain (%)	-0.01907	0.363	-0.22704	0
Share of Omicron BA.2 variant strain (%)	-0.01978	0.321	-0.30101	0
Share of Omicron BA.5 variant strain (%)	-0.01456	0.478	0.372003	0
constant	-8.19481	0.72	-0.62761	0.744
Adjusted R^2		0.2186		0.8856

Note: Yellow marking denotes significance except for constant terms. The estimation period for the effective reproduction number was from January 25 through August, 2022. The period before January 9, 2022 was omitted because the effective reproduction number was higher than six and too volatile. Because of anticipated future data limitations, the effective reproduction number in the last 20 days was incomplete and unstable. Therefore, we also omitted this period from estimation. The estimation period for the newly confirmed patients was March 1 through September 20, 2022.

Figure 1: Map of Kagoshima prefecture and Ibusuki city.

Figure 2: Newly confirmed patients in Ibusuki city through September 20, 2022.

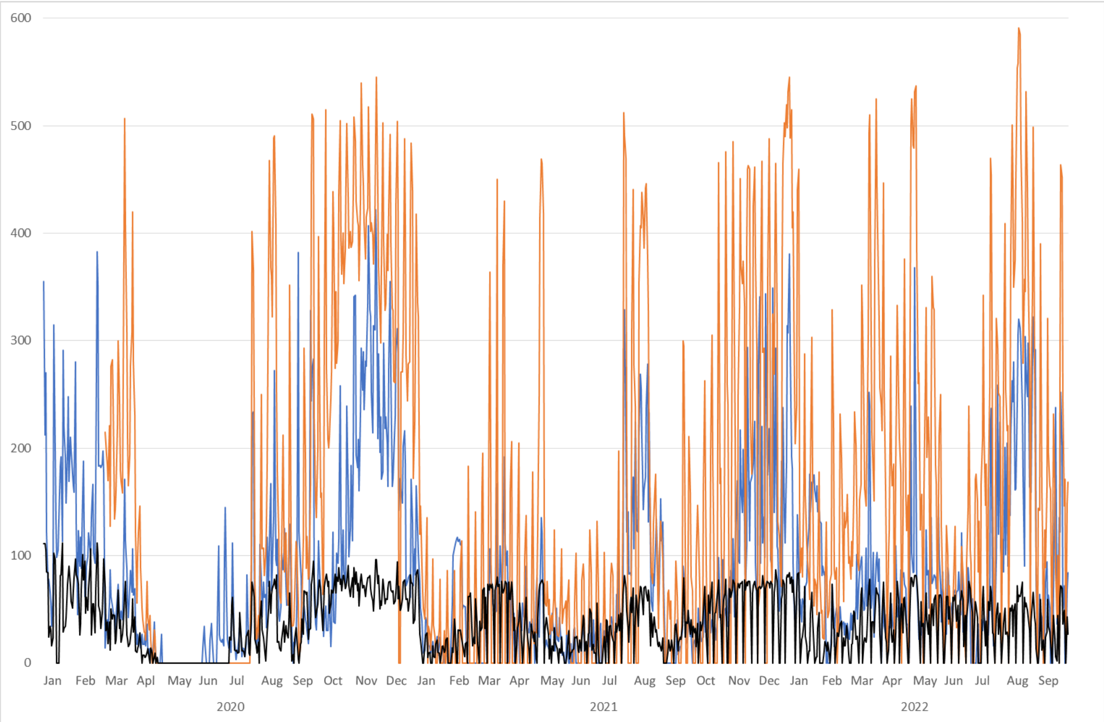
(persons)



Note: Bars represent newly confirmed patients in Ibusuki city.

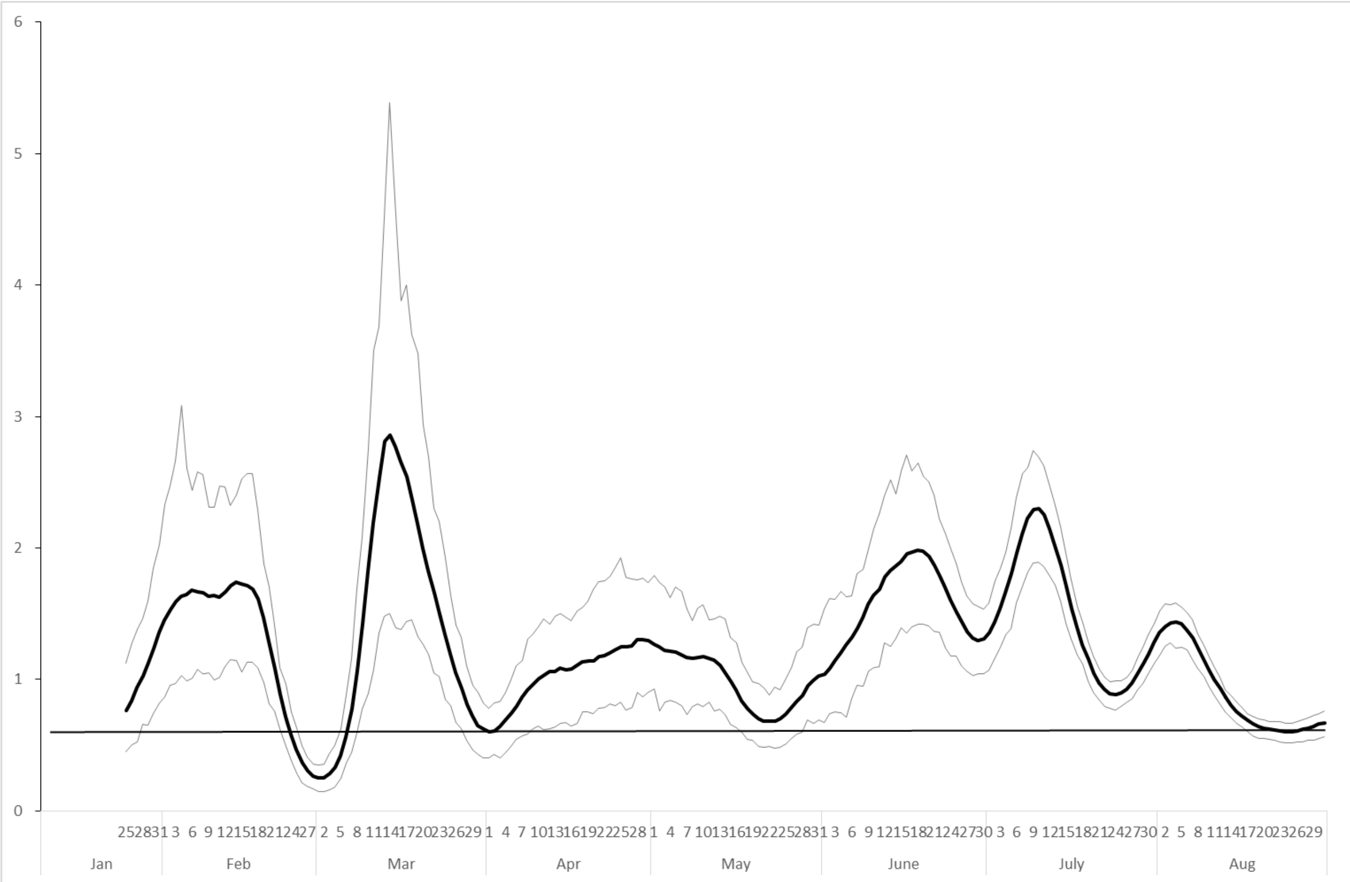
Figure 3: Hotel visitors at three hotels in Ibusuki city.

(persons)



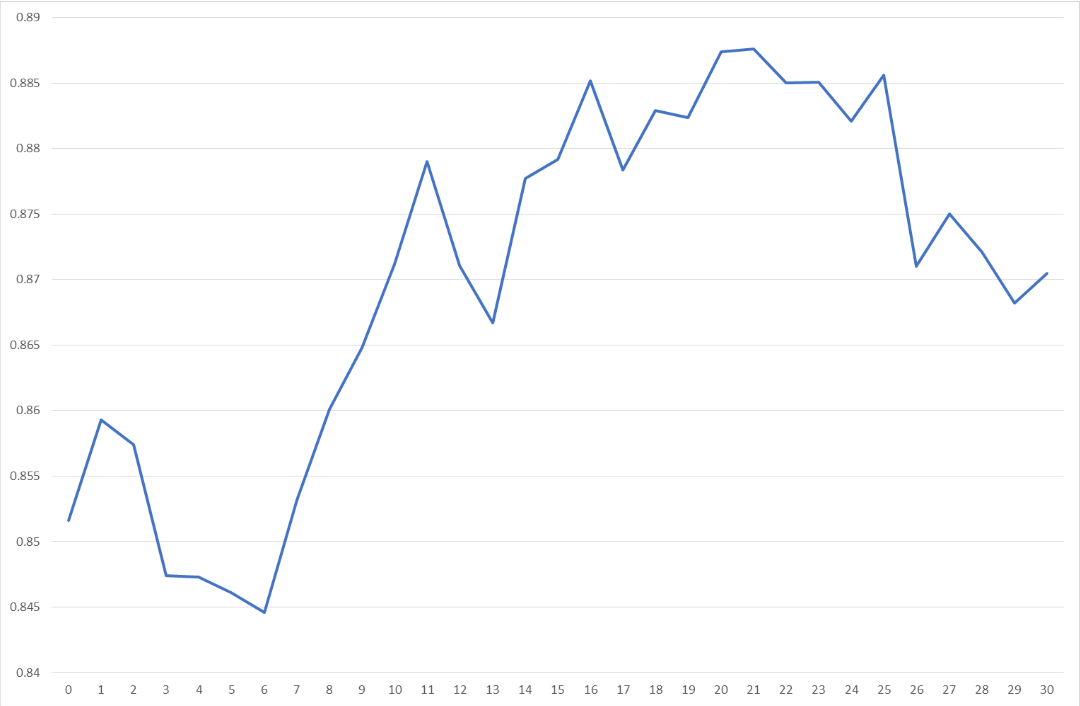
Note: Data for a hotel represented by the orange line had been shown since March 2020, but data of the other two hotels had started in January 2020 because of data availability at the hotel. The correlation coefficient of them from January 2020 through August 2022 was 0.9817; its *p* value was 0.000.

Figure 4: Estimated effective reproduction number and its 95% confidence interval. (R(*t*))



Note: Black line represents the estimated effective reproduction number. Gray lines represent its 95% confidence interval. Because the estimated effective reproduction numbers before January 25, 2022 were sometimes higher than six and unstable, the period before January 25, 2022 was omitted from this illustration. Because of future data limitations, the effective reproduction number in the last 20 days was incomplete and unstable. Therefore, we also omitted showing data for September 2022.

Figure 5: Adjusted determinant coefficients with several delays in newly confirmed patients from March 1, 2020 through April 20, 2022.

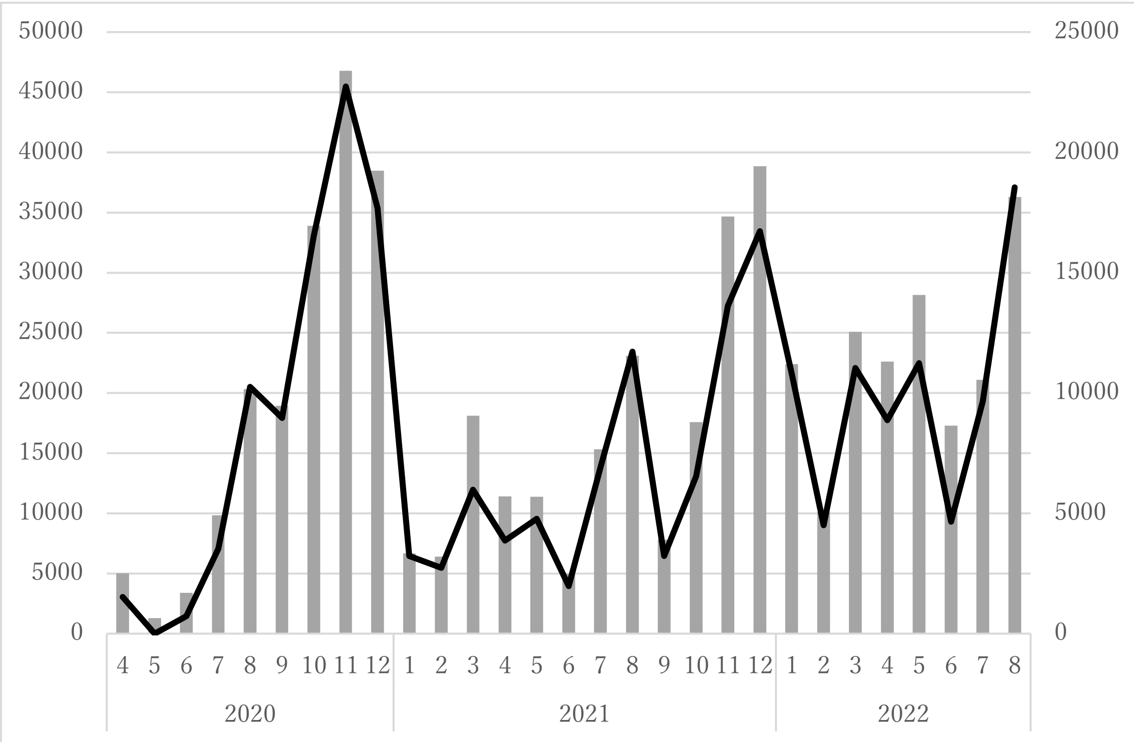


Delay in days

Note: Line represents the adjusted determinant coefficients of estimation with newly confirmed patients several days after on the explanatory variables today.

Figure 6: Monthly total numbers of hotel visitors in Ibusuki city and at three hotels.

(persons) (persons)



Note: Bars represent all hotel visitors in Ibusuki city measured by left scale. The line represents hotel visitors to three corporate hotels shown on the right scale.