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

Short title: **Sightseeing tourists and COVID-19 outbreak**

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ICMJE Statement

Contributors JK were 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

Long-distance travel for sightseeing was believed to spread the COVID-19 outbreak. It was banned until 2022. However, details of travel effects on infectivity had never been examined. This study was conducted to assess long-distance travel effects on infectivity at a resort island, including a period when mutated strains were dominant. Unique daily data of Yakushima Airport users and visitors at a major hotel in Yakushima were used to evaluate sightseeing tourism effects on newly confirmed COVID-19 patients. During the study period of August 19, 2020 – August 10, 2022, the Omicron variant strain was dominant. Sightseeing tourists as represented by airport users were found to have no significant effect on infectivity. Hotel visitors might have had a significant positive effect, but the expected magnitude of the effect was one patient, at most. Results suggest that sightseeing tourists did not heavily affect the COVID-19 outbreak.

Introduction

In addition to ex ante evaluation, policy conducted by government should be evaluated ex post facto. However, in Japan, these official evaluations are rarely done because the government is held to a public posture of never making mistakes. Particularly, countermeasures against the COVID-19 outbreak have never been subjected to ex post evaluation. Because of the pandemic's scale and the lack of knowledge and experience about COVID-19, ex ante evaluation might be difficult and imprecise. However, ex post evaluation is also lacking. For example, long-distance travel for sightseeing was believed to spread the outbreak. It was been banned until 2022. A report of one study [1] advocated this public stance, but it included many mistakes. Its value as evidence was eventually discounted.

The study indicated that travel-associated COVID-19 incidence during July 22–26, when the so-called "Go To Travel Campaign" GTTC had started, was much higher than during the earlier periods of June 22 – July 21 or July 15–19. That study also compared the period of August 8–31. Patient data of two types were used: onset date and the date of positive testing.

Some odd points can be identified in the report of that study. The first is that the proportion of people with a travel history during the GTTC period was almost comparable to that 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 period than for 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 greater 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 between the two periods would be valid if the underlying outbreak situation other than the examining point was 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 for the potential differences in outbreak situations is expected to be necessary. The underlying outbreak situation, unrelated to GTTC, was reflected in the number of patients who had no travel history or any sightseeing. To control for 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 starting period. This finding indicates that the authors' results and conclusion 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 history or tourism was much smaller than in the GTTC period or the prior period. Although the authors did not compare incidence during the period with that of either the prior period or the GTTC period, the rate of incidence during the period in August was probably lower than in other periods. In fact, some patients using GTTC might have been included in the period, as described above. Their inclusion might be inconsistent with the authors' conclusions.

A third point is that the whole of Japan showed the peak of newly infected persons as July 23: the GTTC starting date. Therefore, we infer that GTTC might have reduced infectiousness. We also consider climate conditions. At around the end of July, the rainy season in Japan ceased; summer began, bringing higher temperatures. At least, GTTC was insufficient to raise the number of patients and cancel out benefits from the improved climate conditions. Taken together, these points suggest that GTTC might not be the main factor determining the course of the outbreak.

Moreover, GTTC must also have increased the number of patients without travel history if GTTC had a strong effect on the outbreak. For example, one can consider a patient who traveled using GTTC on July 22 and 23, with subsequent onset on July 24.

This patient had a travel history with GTTC, but was not included in a group of patients with a travel history whose onset date was included in the GTTC started period: July 27–31. Nevertheless, presymptomatic patients are well known to be infectious during their symptomatic period [2]. This patient might infect hotel staff or persons in visited areas. Such patients also had no travel history. Their onset dates were July 27 and 28. They included a group of patients without travel history in the GTTC start period of July 27–31. Therefore, GTTC certainly increased the number of patients without a travel history, but it did not increase patients with a travel history in such cases. When considering the effects of GTTC, it is therefore necessary to check the number of patients irrespective of their travel history.

Finally, 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 found the same results as those obtained from this study. In fact, this study was conducted in 2022, but similar research without the valuable data in this study was posted in January 4, 2021, and obtained the same results as those found for GTTC [3]. In general, ex ante policy evaluation is necessary, but estimating its effects precisely was very difficult. However, ex post evaluation can be done as soon as possible if preparation for it had been planned before policy activation. If so, a policy banning long-distance travel without any legitimate rationale could have been prevented in 2021 and thereafter.

Another study [4] found contrary evidence, indicating that the effective reproduction number was significantly lower during the period when long-distance travel was promoted. A study [5] of airport users at a local airport showed reduced infectivity. These findings might be strong evidence casting doubt on the legitimacy and rationale of the policy banning long-distance travel. However, these studies specifically examined large areas: the former examined the entirety of Japan; latter was a prefecture, for which only the original strain was examined. In general, for a larger study area, it is expected to be more difficult to identify who traveled for long distance for sightseeing. For that reason, the analysis might be more indirect. Moreover, the mutated strain was well known to have higher infectivity than the original strain [6,7]. Therefore, some probability exists that long-distance travel might affect the infectivity of the mutated strain differently than the original strain. It must be analyzed in a much smaller area, with inclusion of the period during which the mutated strain was dominant.

Therefore, the object of this study was confirmation of long-distance travel effects on infectivity at a resort island during the period when the mutated strain was dominant.

We specifically examined Yakushima Island of Kagoshima prefecture, shown in Fig 1. It is a world Natural Heritage area, and therefore a famous tourist destination with about 13,000 residents. Collaboration among epidemiologists and a leading company in Yakushima operating the airport and hotels enhanced analyses conducted for this study. Especially, we can use the daily numbers of Yakushima Airport users and visitors to a major hotel in Yakushima. Official published data were monthly or annual data. Therefore, we are unable to analyze the association among sightseeing tourists and infectivity using data published to date.

As countermeasures against the COVID-19 outbreak in Japan, school closure and voluntary event cancellation were required from February 27 to the end of March. Large commercial events were cancelled. Subsequently, a state of emergency was declared on April 7 extending through 25 May, requiring voluntary restriction against going out. Businesses serving customers were shut down. During this period, the first peak was reached on April 3. It then reemerged until July 29, as shown in Fig 1. However, the GTTC started on July 22, with 50% government-subsidized travel and coupons issued for shopping at tourist destinations. The program was aimed at reinforcing sightseeing businesses, even though it presented some risk of expanding the outbreak. Thereafter, GTTC continued to the end of December, by which time the third wave had emerged.

The third wave was larger than either of the prior two waves in December. Therefore, GTTC was inferred as the main reason underlying the third wave [8].

However, although results were mixed, some research suggests that COVID-19 might be associated with climate conditions, at least in China [9–11]. Some studies using cross-sectional international comparisons in Europe countries indicated no association between climate conditions and COVID-19 outbreak surge dates [12]. If the association was true for Japan as well, then GTTC might not have been the main reason for the third wave in winter.

Moreover, mobility was inferred as the main cause of the outbreak dynamics, at least for the first wave in Japan [13] as well as in the world [14]. However, one study [15] showed that non-pharmaceutical interventions including lockdowns had a strong effect on reducing transmission, at least in 11 European countries, until April. Another study [16] of 131 countries found that the introduction and relaxation of lockdowns or movement restrictions had limited effects on infectiousness, except for public event bans, although their data were limited to the end of July 2021. Another report [17] described that strict movement restrictions in Argentina from March were effective at reducing mobility, but not in slowing the outbreak. These mixed results suggest that those countermeasures might not affect mobility considerably.

How the numbers of visitors for sightseeing or those who traveled long distances themselves affected the outbreak situation in rural areas had not been analyzed. Certainly such information was likely to be less available for epidemiological analysis. Of course, some annual or monthly data related to travel or sightseeing might be available in general, but such data would be too aggregated, leaving too few data to conduct statistical analyses for a short period of less than one year. Fortunately, we can collaborate among epidemiologists, statisticians, and a company managing resort hotels and buses to an airport in a rural area. Consequently, daily data of bus users from the airport and visitors at these hotels are available. Therefore, we can test directly the hypothesis that visitors for sightseeing and/or travelling long distance spread outbreak in rural areas. This hypothesis was the rationale for banning long distance travel during the first and second states of emergency and served as the rationale for ceasing GTTC, although it has not been analyzed and confirmed to date.

Materials and methods

Unique data for the daily number of Yakushima Airport users and visitors to a major hotel in Yakushima were provided by Iwasaki Industrial Corporation of Kagoshima prefecture, Japan. However, this information was not complete. Some sightseeing tourists might have taken a jetfoil or ferry to Yakushima rather than using the airline connecting Kagoshima, Osaka, and Tokyo. Moreover, some visitors stayed at hotels in Yakushima other than the corporate hotel. The allowances for this incompleteness of this information are discussed later.

The COVID-19 outbreak activity was measured by the daily number of newly confirmed patients, including asymptomatic patients, among Yakushima residents. In general, the outbreak situation was measured by the effective reproduction number [5,18]. However, if a population is small, the effective reproduction number cannot be estimated or cannot be estimated steadily because its denominator, the number of patients who can infect others weighted by their infectivity, was too small or sometimes zero. Even in the case of Yakushima, it was too volatile before January 2022 [19]. In other words, no analysis using the effective reproduction number can be performed for GTTC or the original, or Alpha or Delta variant strains. However, analyses using newly confirmed patients were available even for the study period which included no patients. Moreover, by emphasizing patients among residents, we can exclude some probability of increasing the number of patients at Yakushima by tourists who probably were infected outside Yakushima.

The period from infection to reporting was presumed to be several days. It includes the incubation period, the period from onset to visiting a doctor, testing, and reporting. In general, reporting was delayed for several days after infection. Therefore, we regressed the number of newly confirmed patients with some delay on the number of sightseeing tourists as well as other potential explanatory variables. Then, we sought the best-fitting lag as measured by the adjusted determinant coefficient over a 0–30 day delay.

The study period was defined as August 19, 2020 – April 10, 2022. Before this period, no COVID-19 patient had been confirmed

We use some variables as explanatory variables. First, the sightseeing tourists to Yakushima were counted through the number of Yakushima Airport users or number of visitors in a corporate hotel. Because these two variables were presumed to be mutually correlated, we used only one of them for regression analyses.

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

Additionally, we identified several remarkable countermeasures in Japan: four state-of-emergency declarations, a travel campaign, and school closure and voluntary event cancellation (SCVEC). The latter, SCVEC, extended from February 27 through March in 2020: this countermeasure required school closure and cancellation of voluntary events, and even cancellation of private meetings. The first state of emergency was declared on April 7, 2020. It ceased at the end of May. It required school closure, shutting down of some businesses, and voluntary restriction against going out. To subsidize travel and shopping at tourist destinations, GTTC started on July 22, 2020. It was halted at the end of December 2020.

The second state of emergency was declared on January 7, 2021 for the 11 most-affected prefectures. These countermeasures required restaurant closure at 8:00 p.m., with voluntary restrictions against going out, but did not require school closure. They continued through March 21, 2021.

To clarify associations among R(*t*) and GTTC or valuable data in addition to climate, mobility, and countermeasures except for GTTC, we used ordinary least squares regression to regress the daily R(*t*) on daily dummy variables for GTTC, and daily data of airport limousine bus users and visitors at the resort hotels, as well as dummy variables for daily climate, mobility, and dummy variables for countermeasures. We used Google-provided mobility data showing stays at venues of six types, such as restaurants, shopping malls or amusement centers; grocery stores or pharmacies; parks;

transition areas; workplaces; and homes (https://www.google.com/covid19/mobility/). The data show a mobility comparison to a base day. It defined 100 if number of persons staying at a type of place was the same as the base day.

We expected the sign of the explanatory variables to be the following: airport limousine bus users and visitors at the resort hotels or GTTC increased infectivity if the policy of banning long-distance travel was rational. Countermeasures such as the emergency status or SCVEC were presumed to decrease infectivity. We adopted 5% as the significance level.

Results and discussion

Figure 2 shows the newly confirmed cases of COVID-19 including asymptomatic cases through August 10, 2021 in Yakushima. The initial case was detected on August 19, 2020. However, cases were sporadic until 2022. From January 2022, the cases were reported continuously. They showed the largest peak in August when the Omicron BA.5 variant strain was dominant.

This figure shows cases confirmed at Yakushima among visitors to Yakushima. They caused no outbreak among Yakushima residents until 2021. In 2022, the confirmed cases in Yakushima residents and visitors were parallel, but visitors might not have caused outbreaks among residents. These findings suggest negation of the legitimacy and rationality of the policy banning long-distance travel.

Figure 3 presents the number of Yakushima Airport users and visitors to a corporate hotel. In April and May, 2020, when the first state of emergency was declared, the values of the two variables decreased drastically. Subsequently, these values recovered during the GTTC activated period until December 27, 2020 and fluctuated in an almost identical range during GTTC.

Figure 4 shows the adjusted determinant coefficients with several delays, using airport users or hotel visitors as a proxy for sightseeing tourists. As one might expect, a 15-day delay best fitted both variables we used. Therefore, hereinafter, the dependent variable was the number of newly confirmed patients with a 15-day delay.

Table 1 presents the significant association of sightseeing tourists with the newly confirmed 15-day delay, both for airport users and hotel visitors. The proxy of sightseeing tourists was significant and positive. However, the estimated coefficients of these variables were small: 0.0030141 and 0.0042166. Figure 2 shows that the maximum number of airport users was less than 470 per day. The maximum number of hotel visitors was less than 210 per day. Results show that 1.416627 and 0.885486 were the estimated increases when airport users to hotel visitors changed from the minimum number, 0, to the maximum: fewer than two persons. Therefore, the effect of sightseeing tourists was quite small in terms of public health, although the results are significant. Atmospheric temperatures, coverage of second and third vaccinations, the proportion of BA.5 lineage of the Omicron variant strain, the fourth state of emergency, and the Olympic games expanded the outbreak. By contrast, GTTC, coverage of the fourth vaccination, proportions of Alpha, Delta, BA.1 orBA.2 lineage, and the Omicron variant strain curbed the outbreak. The fourth vaccine coverage results were as expected, although those of the second and third vaccination coverage were opposite. During the period when the outbreak was large, 2022, when the Omicron variant strain was dominant, the vaccine coverage of the second and third doses had almost reached their maximum. Therefore, the outbreak was greater during higher vaccine coverage of the second or third dose. By contrast, the fourth vaccination was high in 2022, when the number of newly confirmed patients was larger. If a waning effect of vaccination were incorporated for analysis, then the estimation results might have differed.

Regarding variant strains, a major variant strain other than the BA.5 lineage of the Omicron variant strain reduced the outbreak compared with the original strain. Those results might be inconsistent with those of earlier studies [20–23].

The estimated coefficients of the BA.5 lineage were highest, followed by those of the BA.2, BA.1, and Delta variant strains. The latter emergent variant strain expanded the outbreak.

Conversely, GTTC was significant and negative in both specifications. That finding might be strong evidence against the notion that GTTC expanded the outbreak. It is consistent with results of an earlier study of GTTC [18]; it contradicts results of another study [24].

Estimation results indicate that sightseeing tourists might not have expanded the outbreak to any considerable degree. Although the findings were not strong evidence, they might not support the legitimacy and rationale of banning sightseeing and long-distance travel.

An accompanying study [19] found that the effective reproduction number in 2022 in Yakushima was not associated with sightseeing tourists. For this study, newly confirmed patients among residents of Yakushima with a 15-day delay were positively associated with the number of sightseeing tourists. Major differences between the two studies were the denominators of the dependent variables. The dependent variable used for the earlier study, the effective reproduction number, was dominated by its denominator. By contrast, the dependent variable in this study, newly confirmed patients, was not controlled. In this sense, to measure outbreak activity, the effective reproduction number might be more appropriate than newly confirmed patients.

However, controlling the denominator in the earlier study prohibited analysis before 2022 because the denominators were too small or zero. For that reason, the effective reproduction number was not calculable, or showed unstable fluctuation. Therefore, the study period used for the earlier study excluded the period when original, Alpha and Delta strains were dominant. Only during the period when Omicron was dominant in 2022 was the number of patients large, even in Yakushima. Therefore, the effective reproduction number became calculable and stable. In other words, the effective reproduction number might have been inappropriate for analyses before 2022. The newly confirmed patients were more appropriate for consideration of the effects of sightseeing to outbreak.

The weakest point in the analyses used for this study might be the representation of unique data: the daily Yakushima Airport users and visitors in the corporate hotel. Unfortunately, no comparable daily data were available, but monthly comparable data were available. One is the monthly number of visitors to Yakushima using transport, airlines, jet foils, and ferries [25]. Regarding airline and jet foil users, the numbers of Yakushima residents and visitors were also reported. Unfortunately, we are unable to identify residents and visitors among the ferry users. Consequently, even though the data covered all visitors to Yakushima including Yakushima residents, the presence of residents among all three transportation users cannot be disregarded completely.

Figure 5 shows all airline users, airline users who were not Yakushima residents, all jetfoil users, jetfoil users who were not residents, and ferry users. Almost no airline users were residents, but about half of jetfoil users were residents. The correlation coefficient among all airline users and total three transportation users during the period from January 2019 through December 2021 was 0.8858; its *p* value was 0.000. The correlation coefficient among airport users including Yakushima residents and the sum of visitors using an airline or jetfoil excluding Yakushima residents during January 2019 through September 2022 was 0.9236; its *p* value was 0.000. Therefore, we conclude that all airline users represent all three transportation users or nonresident visitors.

Other data used to confirm the unique data we used were monthly data of visitors at another two major hotels in Yakushima, as shown in Fig 6. The correlation coefficient among them from January 2020 through October 2022 was 0.7365; its *p* value was 0.000. Therefore, a corporate hotel providing daily data can represent other major hotel and thus all hotel visitors in Yakushima.

The present study has some limitations. First, this study examines only Yakushima, Kagoshima prefecture. One cannot be assured that the same results hold for other places, even for other locations in Japan or the entirety of Japan.

Second, regression analysis such as that used for this study does not indicate causality. Although we inferred that the number of hotel visitors would expand the outbreak, a larger outbreak might reinforce hotel visits. One must bear that possible relation in mind when interpreting the results.

Conclusions

We demonstrated that increased numbers of sightseeing tourists might not have expanded the COVID-19 pandemic to any great degree. We conclude that the rationale and fairness of the policy banning long distance travel were questionable.

The present study and its results are based on the authors' opinions: they do 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 Yakushima town office [26]. Iwasaki Industrial Company provided business recorded data about airport and jetfoil users and hotel visitors. Information about two other hotels were provided voluntarily. Data about airport or jetfoil users and hotel visitors included no personal or private information. Therefore, there is no ethical issue related to this study.

Competing Interests

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 newly confirmed with 15 day delay and Yakushima Airport users or hotel visitors from August 19, 2020 through August 10, 2022

	Yakushima Airport users		Hotel visitors	
Explanatory variable	Estimated coefficient	*p* value	Estimated coefficient	*p* value
Yakushima Airport users/ Hotel visitors	0.0030141	0.000	0.0042166	0.000
Temperature	0.0278003	0.003	0.0350133	0.000
Humidity	-0.004591	0.277	-0.003881	0.366
Place: Restaurant, shopping mall or amusement	-0.0015924	0.854	0.0002047	0.982
Place: Grocery store or pharmacy	-0.0043603	0.644	-0.0024424	0.799
Place: Park	0.0001898	0.960	0.0019607	0.608
Place: Transition	-0.0073791	0.333	-0.0036488	0.650
Place: Workplace	-0.0000363	0.997	0.0005131	0.957
Place: Home	-0.0070095	0.847	-0.0021283	0.955
2^{nd} state of emergency	-0.4253346	0.053	-0.4051802	0.070
3rd state of emergency	0.0446091	0.814	-0.0277672	0.885
GTTC	-0.9382708	0.000	-0.9651931	0.000
Vaccine coverage of the second dose with lag (%)	0.1529007	0.000	0.1479414	0.000
Vaccine coverage of the third dose with lag (%)	0.0656881	0.000	0.0698412	0.000

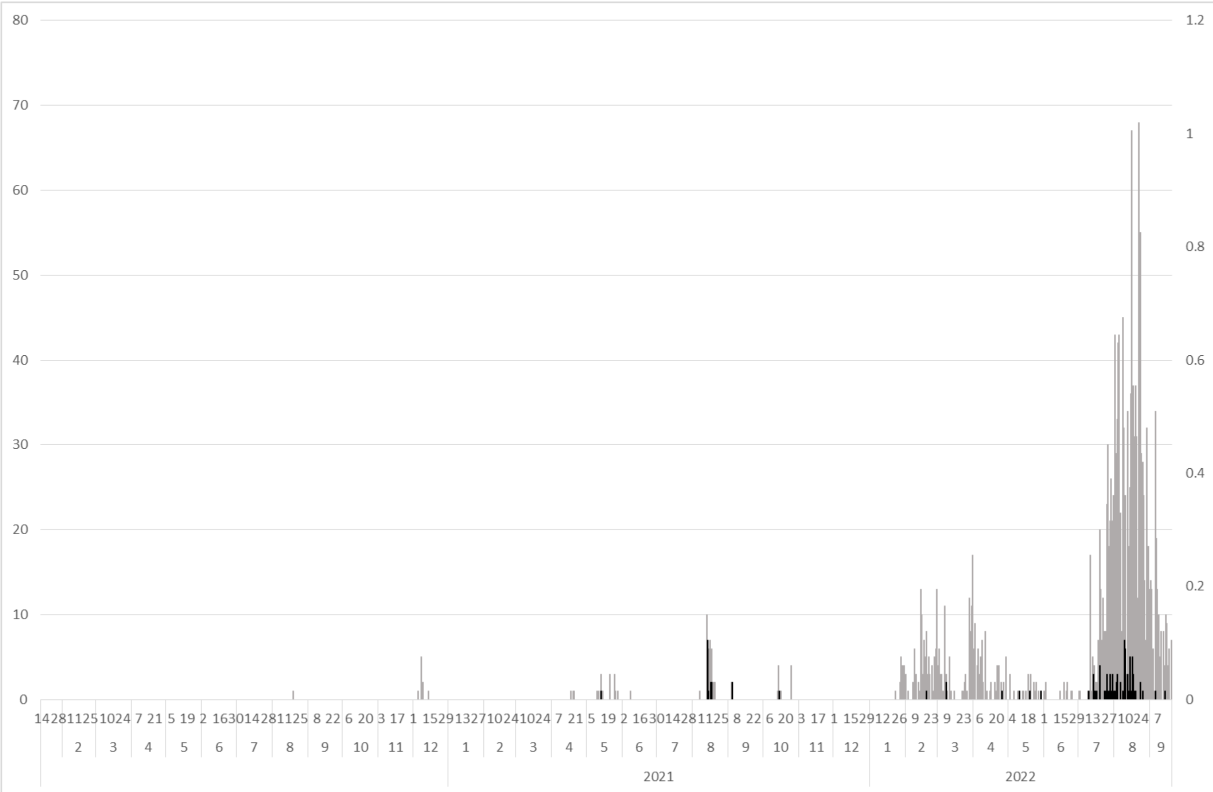
Vaccine coverage of the fourth dose with lag (%)	-0.6860188	0.000	-0.6539192	0.000
Share of Alpha variant strain (%)	-0.0086424	0.019	-0.0086599	0.021
Share of Delta variant strain (%)	-0.1295698	0.000	-0.1244489	0.000
Share of Omicron BA.1 variant strain (%)	-0.1036224	0.000	-0.0988985	0.000
Share of Omicron BA.2 variant strain (%)	-0.177287	0.000	-0.173618	0.000
Share of Omicron BA.5 variant strain (%)	0.1004268	0.000	0.1023614	0.000
4th state of emergency	3.045889	0.000	2.920672	0.000
Olympic	1.088278	0.000	1.13071	0.000
constant	-0.0113576	0.973	0.2163709	0.520
Adjusted R^2	0.9718		0.9709	

Note: Yellow highlights show significance, except for constant terms. The number of observations was 732.

Figure 1: Map of Kagoshima prefecture and Yakushima.

Figure 2: Newly confirmed patients in Yakushima through August 10, 2022.

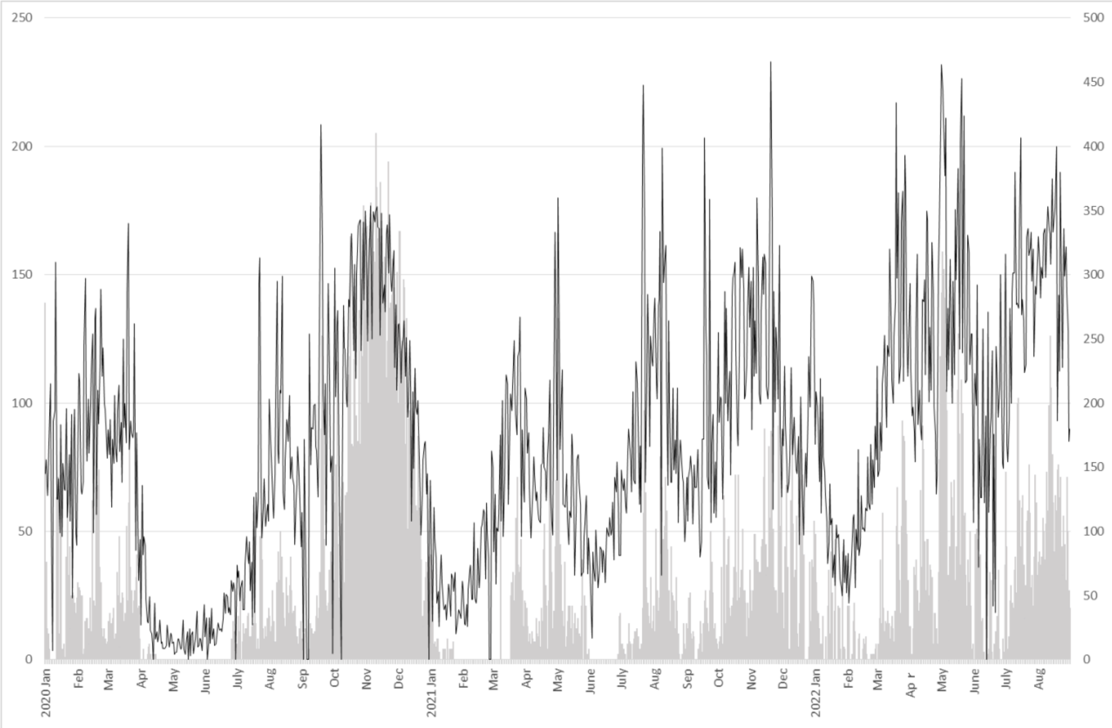
(persons)



Note: Black bars show newly confirmed patients who did not live at Yakushima; gray bars show newly confirmed patients among Yakushima residents. The source of newly confirmed patients was http://www.town.yakushima.kagoshima.jp/info-living/31331/

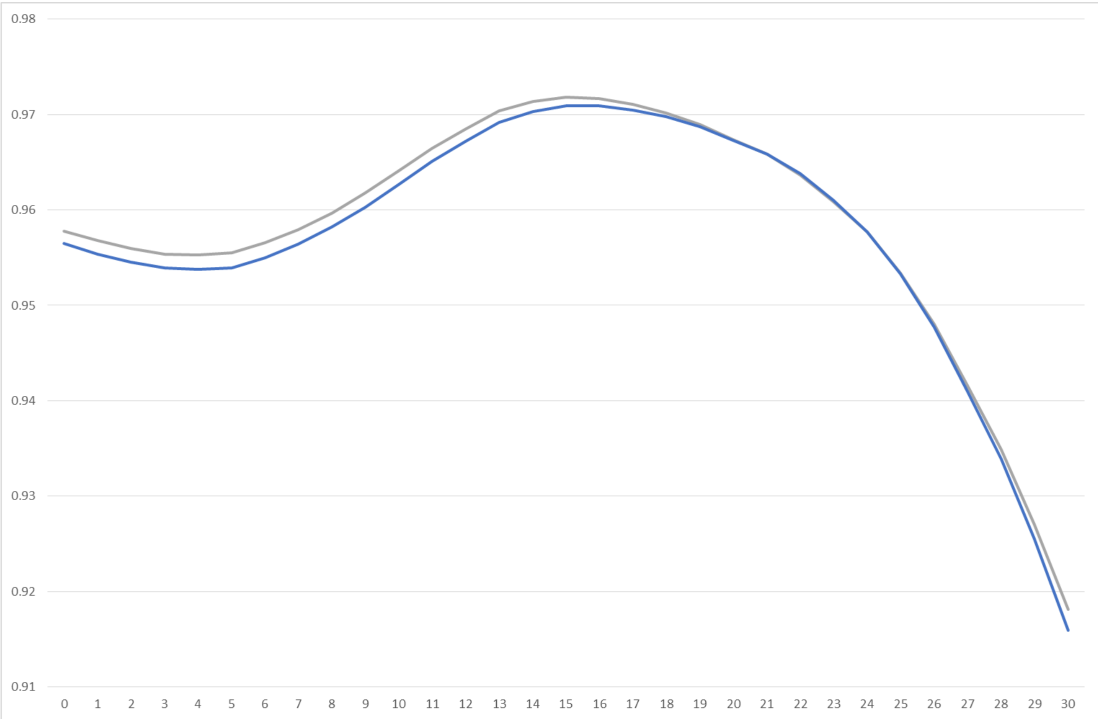
Figure 3: Yakushima Airport users and hotel visitors.

(hotel visitor) (Yakushima Airport users)



Note: Gray bars show the number of visitors to a corporate hotel (left scale). The black line shows the number of Yakushima Airport users (right scale).

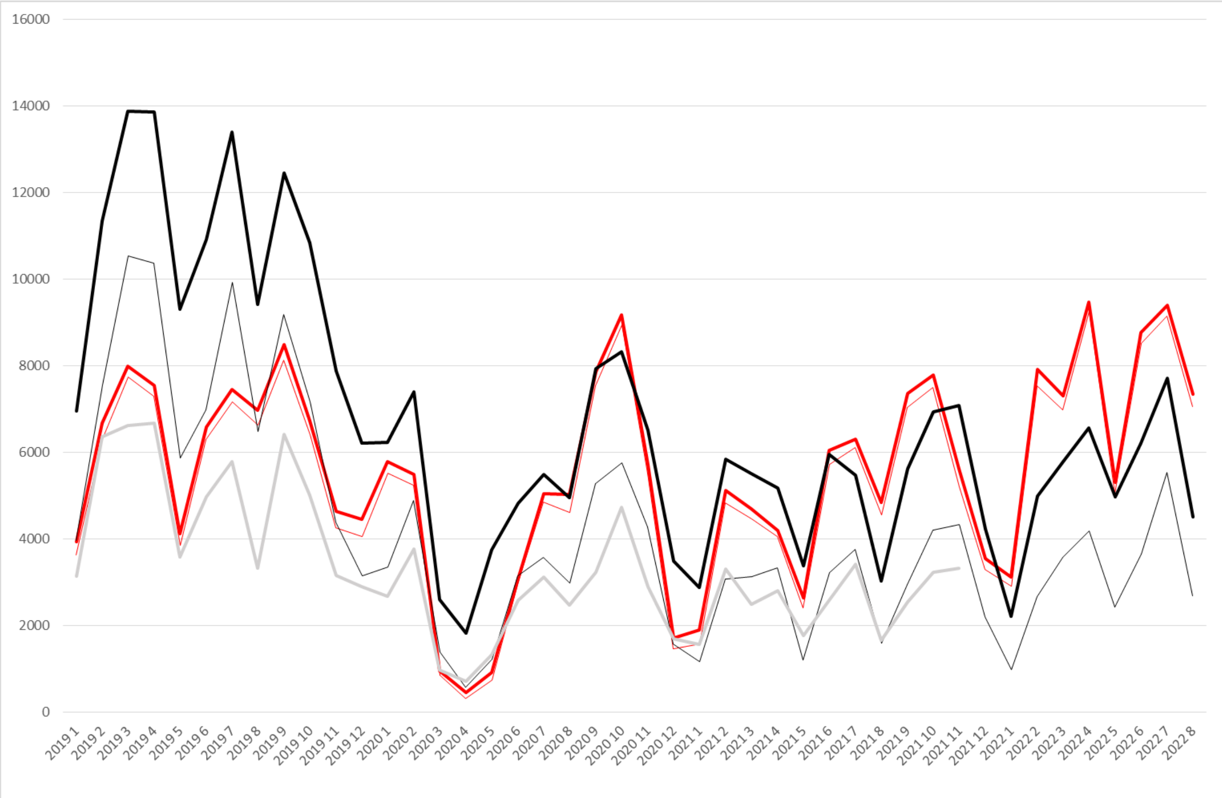
Figure 4: Adjusted determinant coefficients with several delays using airport users and hotel visitors.



Delay in days

Note: The gray line represents the adjusted determinant coefficients using airport users as sightseeing tourists of regression for newly confirmed patients with several days' delay. The blue line represents the adjusted determinant coefficients using hotel visitors as sightseeing tourists.

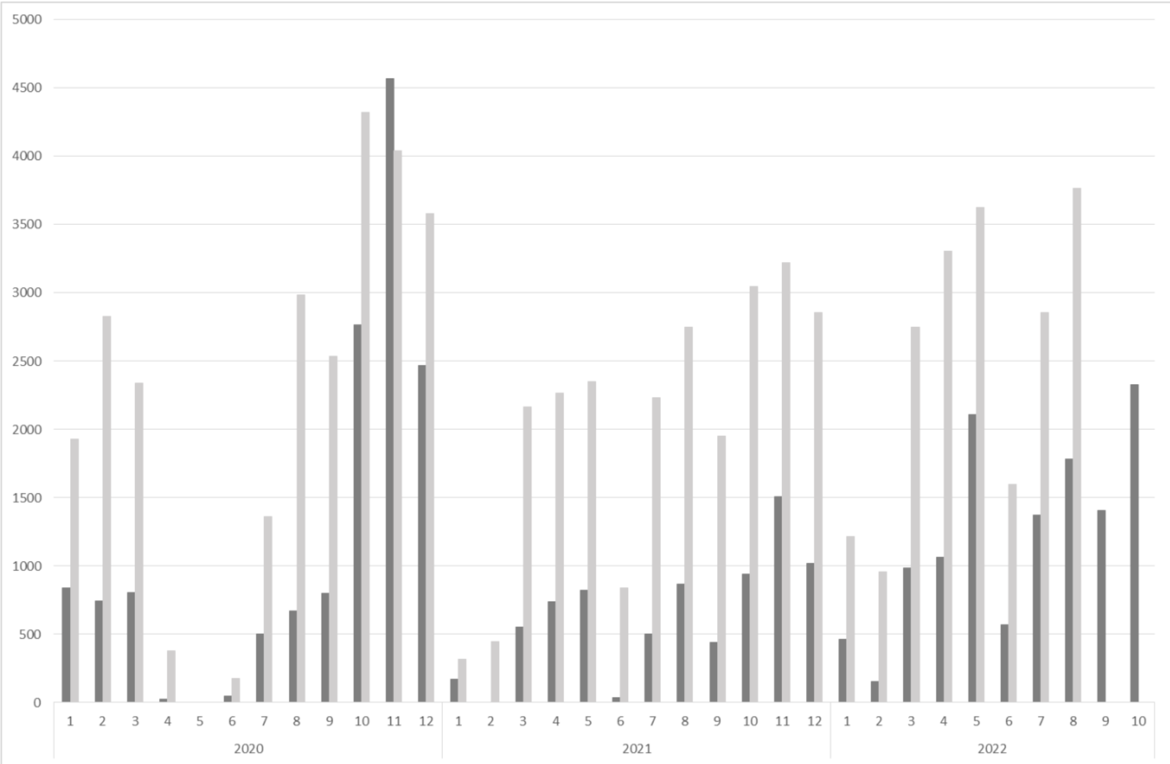
Figure 5: Monthly numbers of visitors using transport, airline, jet foil and ferry, by residence.



Note: The red line represents Yakushima Airport users including Yakushima residents. The red thin line represents Yakushima Airport users excluding Yakushima residents. Similarly, the black line represents jetfoil users including Yakushima residents and black thin line represents jetfoil users excluding Yakushima residents. The gray line represents ferry users who cannot be discerned as Yakushima residents, or not. The correlation coefficient among airport users including Yakushima residents and all visitors including Yakushima residents during January, 2019 through December, 2021, was 0.8858 and its p value was 0.000. The correlation coefficient among airport users including Yakushima residents and the sum of visitors using airline or jetfoil excluding Yakushima residents during January, 2019 through September, 2022, was 0.9236 and its *p* value was 0.000. Unfortunately, because ferry users excluding Yakushima residents were not identified, we are unable to define all visitors excluding Yakushima residents. Moreover, data about ferry users in 2022 were not available; not all visitors including ferry users were defined in 2022.

Figure 6: Guests at a corporate hotel and two other major hotels in Yakushima.

(persons)



Note: Black bars denote visitors at a corporate hotel. Gray bars show visitors at two other major hotels in Yakushima. Correlation coefficients among them from January 2020 through October 2022 were 0.7365; its *p* value was 0.000.