



# Surgical volume reduction and the announcement of triage during the 1st wave of the COVID-19 pandemic in Japan: a cohort study using an interrupted time series analysis

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## Abstract

**Purpose** The coronavirus disease (COVID-19) pandemic has caused unprecedented challenges for surgical staffs to minimize exposure to COVID-19 or save medical resources without harmful patient outcomes, in accordance with the statement of each surgical society. No research has empirically validated declines in surgical volume in Japan, based on the usage of surgical triage. We aimed to identify whether the announcement of surgical priorities by each Japanese surgical society may have affected the surgical volume decline during the 1st wave of this pandemic.

**Methods** We extracted 490,719 available cases of patients aged > 15 years who underwent elective major surgeries between July 1, 2018, and June 30, 2020. After the categorization of surgical specialities, we calculated descriptive statistics to compare the year-over-year trend and conducted an interrupted time series analysis to validate the decline of each surgical procedure.

**Results** Monthly surgical cases of eight surgical specialities, especially ophthalmology and ear/nose/throat surgeries, decreased from April 2020 and reached a minimum in May 2020. An interrupted time series analysis showed no significant trends in oncological and critical surgeries.

**Conclusion** Non-critical surgeries showed obvious and statistically significant declines in case volume during the 1st wave of the COVID-19 pandemic according to the statement of each surgical society in Japan.

**Keywords** Coronavirus disease · COVID-19 · Surgery · Surgical volume · Reduction · Japan

## Introduction

The rapid spread of the coronavirus disease (COVID-19), which first appeared in Wuhan, China, has been increasing and disrupting healthcare systems worldwide [1]. During the COVID-19 pandemic, surgical staffs have experienced unprecedented challenges [2–4]. To minimize exposure to COVID-19 and save medical resources to prevent harmful outcomes for the patients, cancellation or triage of surgeries are recommended [3–5]. Patients with critical diseases and

cancers should still receive surgery as usual; whereas, cases with benign diseases can be postponed [6–8].

Previous studies suggest that there are wide variations in the trends of the affected number of surgical procedures depending on the country and time period [3, 4, 9]. The Japanese Surgical Society (JSS, which consists of ten major surgical societies in Japan) announced the importance of triage by case severity and surgical recovery planning for the backlog of surgeries [10]. A comprehensive surgical and medical care strategy is also recommended to prevent potential adverse health implications caused by surgical delays [11].

However, there are no studies validating the trends of surgeries based on the announcement of surgical triage during the 1st wave of this pandemic in Japan, one of the regions most affected by COVID-19 at the earliest stage throughout the world. In this report, we performed a retrospective cohort study discussing the impact of the 1st wave of the

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COVID-19 pandemic on major elective surgical procedures in Japan, referring to the priorities announced by each surgical society in Japan.

## Methods

### Data source

We used the Diagnosis Procedure Combination (DPC) data from the Quality Indicator/Improvement Project (QIP) database, the program administered by the Department of Healthcare Economics and Quality Management, Kyoto University.

The DPC/per-diem payment system (PDPS) is a Japanese prospective payment system applied to acute care hospitals that is comparable to diagnosis-related databases in the United States [12, 13]. A total of 1730 hospitals adopted the DPC/PDPS in 2018, accounting for 54% of all general beds in Japanese hospitals [14, 15]. DPC data do not include information on laboratory findings and reasons for surgery; instead, they provide information included in the discharge summary, such as the primary diagnosis, comorbidities [identified by using the International Classification of Diseases, 10th Revision (ICD-10) codes], type of surgery, and codes corresponding to the medical procedures performed.

### Study population

Among the QIP hospitals, the eligibility criteria for inclusion in this study were as follows: age > 15 years and having had selective surgical procedures during hospitalization between July 1, 2018, and June 30, 2020. We did not exclude any patients.

## Variables and surgical procedure

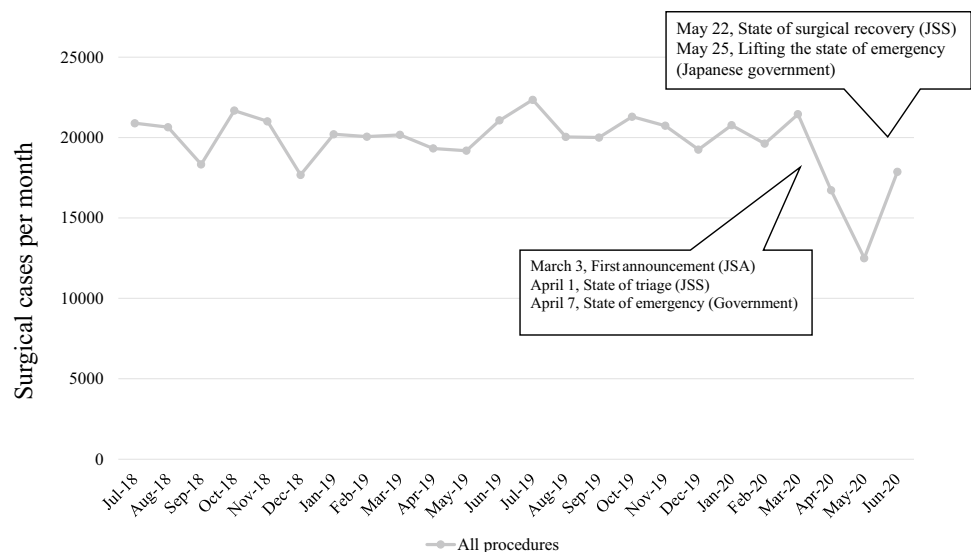
Regarding the patients' background characteristics, we referred to their sex, age, and length of stay (LOS), as well as the Charlson and Elixhauser comorbidity indices [16]. We also identified and categorized the surgical speciality from the main surgery during admission based on previous reports [5, 9]: oncological, abdominal, genitourinary, cardiovascular, neurosurgery, orthopedic, ophthalmology, and ear/nose/throat (ENT). Except for oncological surgeries, owing to the wide variety of surgical procedures, we included the top three most common surgeries in Japan based on the National Database of Health Insurance Claims and Specific Health Checkups of Japan (NDB), which covers the medical claim information of the entire Japanese population of 127 million [17]. Details on the surgical classification are shown by K codes, which are the claims codes for surgery, in Supplemental Table 1.

### Statistics

The monthly case volumes of our total eligible surgeries are presented in Fig. 1, using line graphs. The monthly cases by surgical speciality between July 2018 and June 2020 are also shown in Table 1 to compare the reduction.

We used ITS, including segmented regressions, to ascertain any volume changes due to the COVID-19 pandemic on population-level admissions. We statistically evaluated the changes in the volume of surgeries based on the date of admission adjusted for seasonality through a Fourier term [18]. We hypothesize that COVID-19 would have affected the number of scheduled admissions especially after April 2020 as an implemented point, in which the Japanese Society of Anesthesiologists and the JSS requested surgeons

**Fig. 1** Trend of the selected monthly surgical procedures between July 1, 2018 and June 30, 2020, with major statements by the JSA, JSS, and the Japanese government. *JSA* Japanese Society of Anesthesiologists, *JSS* Japan Surgical Society, *PCR* polymerase chain reaction



**Table 1** Monthly cases according to surgical type between July 2018 and June 2020 for the interrupted time series analysis

		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Oncology	July 2018–June 2019	4794	4710	4263	5057	4698	4080	4991	4500	4669	4508	4559	4911
	July 2019–June 2020	5033	4487	4718	4993	4652	4521	4952	4566	5118	4765	4037	4455
Abdominal	July 2018–June 2019	2671	2831	2442	2868	2772	2451	2517	2693	2632	2541	2398	2722
	July 2019–June 2020	2799	2794	2626	2816	2627	2523	2557	2541	2589	2016	1304	2350
Genitourinary	July 2018–June 2019	1890	1989	1680	1976	1788	1723	1739	1754	1759	1704	1557	1804
	July 2019–June 2020	1972	1991	1720	1952	1780	1894	1791	1738	1962	1556	1173	1626
Cardiovascular	July 2018–June 2019	1192	1094	996	1104	1182	950	1024	1034	1041	1059	1000	1136
	July 2019–June 2020	1260	1082	1070	1124	1149	1089	1074	967	976	883	638	1004
Neuro	July 2018–June 2019	1578	1501	1308	1569	1493	1278	1447	1448	1364	1370	1362	1572
	July 2019–June 2020	1658	1523	1377	1437	1413	1362	1413	1365	1463	1284	962	1441
Orthopedic	July 2018–June 2019	2967	3117	2755	3179	3144	2618	3212	3132	3324	2995	2874	3101
	July 2019–June 2020	3310	3049	2987	3309	3189	2817	3359	3189	3495	2385	1784	2703
Ophthalmologic	July 2018–June 2019	5169	4735	4333	5273	5276	4040	4691	4847	4780	4531	4893	5190
	July 2019–June 2020	5612	4443	4777	4954	5284	4408	4941	4622	5187	3533	2488	3891
ENT	July 2018–June 2019	634	672	557	654	655	543	587	649	603	617	542	632
	July 2019–June 2020	706	673	731	714	645	639	682	635	662	302	115	400

to triage some elective surgeries. We divided our datasets into two periods for ITS analysis: before the JSS surgical-triage-statement (July 2018–March 2020) and after that (April–June 2020). Monthly case volumes of scheduled admission with surgery are presented in Fig. 1 using line graphs. Baseline demographics for the population for ITS analysis are listed in Supplemental Tables 2–9. Age was expressed as the mean  $\pm$  SD and LOS as the median (interquartile range), which were compared using Mann–Whitney *U* tests. Categorical variables were expressed as percentages and compared using  $\chi^2$  tests. The level of statistical significance was set at  $p < 0.05$  (two-tailed) in Table 2. Statistical analyses were performed with R version 4.0.2 software program (R Foundation for Statistical Computing, Vienna, Austria).

The study protocol was approved by the Ethics Committee of Kyoto University Graduate School, Kyoto, Japan (R0135). This study was conducted in accordance with the ethical guidelines for medical and health research involving human participants issued by the Japanese National Government. The data were anonymized, and the requirement for informed consent was waived.

## Results

### Overview of all surgical specialities

We detected 258 hospitals and 490,719 cases of patients over 15-years-old with surgery between July 1, 2018, and June 30, 2020. Figure 1 displays the trend of total surgical cases per month. The case volume decreased from April

and reached a minimum in May ( $n = 12,501$ ). Compared to the previous year, every type of surgical volume, especially ophthalmologic and ENT surgeries, also indicated the smallest number of cases in May.

### Oncological surgery

Although prior year comparisons of all oncological surgeries showed a decline since April (Supplemental Fig. 1), the ITS analysis showed no significance in the surgical volume according to the *p* value of  $> 0.05$  (Fig. 2).

### Abdominal, genitourinary, and cardiovascular surgery

Prior year comparisons of all abdominal, genitourinary, and cardiovascular surgeries showed a decrease from April, especially for hernia and lower-limb varices surgeries (Supplemental Figs. 2–4). An ITS analysis showed  $p < 0.05$  in abdominal, stone, and lower-limb varices surgeries (Fig. 2: cholecystectomy  $p = 0.012$ ; hernia  $p = 0.002$ ; intestinal surgery  $p = 0.022$ ; stone surgery  $p < 0.001$ ; lower-limb varices surgery  $p < 0.001$ ).

### Neuro and orthopedic surgery

All surgeries except discectomy had low numbers compared to the previous year from April, particularly in May (Supplemental Figs. 5 and 6: spine fusion 68.5%; discectomy 63.3%; intracranial 49.7%; ORIF 49.3%; arthroplasty 70.1%; removal of nail 35.4%). ITS analysis of intracranial surgery and all orthopedic surgeries showed significant decline

**Table 2** Baseline demographics of the cases before and after the establishment of surgical triage protocols

	Oncological		Abdominal		Genitourinary		Cardiovascular	
	Before	After	Before	After	Before	After	Before	After
<i>N</i>	98,780	13,257	55,410	5670	38,163	4355	22,603	2525
Male, <i>n</i> (%)	52,485 (53.1)	7196 (54.3)	37,977 (68.5)	4080 (72.0)	9016 (23.6)	1105 (25.4)	13,727 (60.7)	1683 (66.7)
Age [mean (SD)]	69.32 (11.88)	69.56 (12.00)	64.89 (15.24)	65.25 (15.00)	53.03 (15.81)	53.80 (15.98)	70.33 (11.65)	70.70 (11.91)
Comorbidity index								
CCI > 2	12,795 (13.0)	1835 (13.8)	2607 (4.7)	309 (5.4)	647 (1.7)	87 (2.0)	2896 (12.8)	378 (15.0)
EI > 5	15,640 (15.8)	2173 (16.4)	5118 (9.2)	553 (9.8)	1409 (3.7)	190 (4.4)	4255 (18.8)	571 (22.6)
General anesthesia, <i>n</i> (%)	87,607 (88.7)	11,729 (88.5)	47,882 (86.4)	5000 (88.2)	32,865 (86.1)	3712 (85.2)	9891 (43.8)	1066 (42.2)
Postoperative ICU admission, <i>n</i> (%)	6064 (6.1)	1045 (7.9)	204 (0.4)	30 (0.5)	75 (0.2)	16 (0.4)	2097 (9.3)	378 (15.0)
Length of stay [median (IQR)]	11 (7, 15)	10 (7, 15)	5 (4, 7)	5 (4, 7)	6 (5, 8)	6 (5, 8)	5 (2, 14)	8 (3, 15)
	Neuro		Orthopedic		Ophthalmologic		Ear/nose/throat	
	Before	After	Before	After	Before	After	Before	After
<i>N</i>	30,301	3687	65,122	6872	101,986	9912	13,432	817
Male, <i>n</i> (%)	17,432 (57.5)	2180 (59.1)	22,970 (35.3)	2376 (34.6)	44,236 (43.4)	4731 (47.7)	7495 (55.8)	479 (58.6)
Age [mean (SD)]	66.91 (14.56)	66.07 (15.07)	63.36 (18.26)	65.32 (16.62)	74.57 (9.86)	73.93 (10.05)	47.24 (19.43)	49.33 (18.89)
Comorbidity index								
CCI > 2	1918 (6.3)	254 (6.9)	1886 (2.9)	223 (3.2)	3799 (3.7)	451 (4.6)	154 (1.1)	3 (0.4)
EI > 5	3780 (12.5)	483 (13.1)	4023 (6.2)	497 (7.2)	4007 (3.9)	482 (4.9)	367 (2.7)	27 (3.3)
General anesthesia, <i>n</i> (%)	29,891 (98.6)	3578 (97.0)	50,777 (78.0)	5309 (77.3)	1802 (1.8)	196 (2.0)	12,735 (94.8)	775 (94.9)
Postoperative ICU admission, <i>n</i> (%)	1017 (3.4)	179 (4.9)	108 (0.2)	21 (0.3)	3 (0.0)	0 (0.0)	8 (0.1)	2 (0.2)
Length of stay [median (IQR)]	16 (12, 23)	16 (11, 22)	12 (4, 23)	15 (4, 24)	3 (2, 4)	3 (2, 4)	7 (6, 8)	7 (6, 9)

with  $p < 0.05$  (Fig. 2; intracranial  $p = 0.002$ ; ORIF  $p = 0.03$ ; Arthroplasty  $p = 0.016$ ; removal of nail  $p = 0.016$ ).

### Ophthalmologic and ear/nose/throat surgery

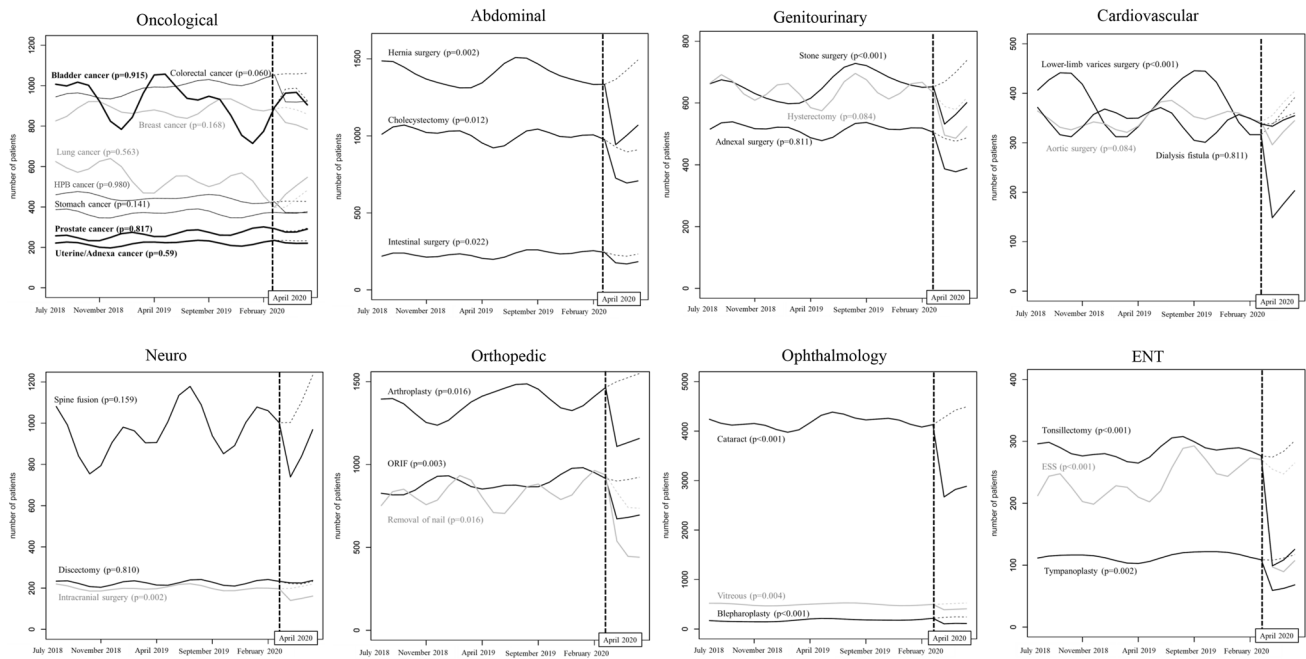
Supplemental Figs. 7 and 8 show a dramatic decrease in both types of surgical specialities in May (cataract 49.3%; vitreous 70.1%; blepharoplasty 35.4%; tonsillectomy 21.3%; ESS 14.4%; tympanoplasty 40.9%). The number of both types of surgeries declined because of COVID-19 (Fig. 2).

### Discussion

Our study showed the trends of scheduled admission with surgery and important changes in surgical volume during the COVID-19 pandemic based on the announcement of the surgical triage recommendation in Japan. We found that oncological surgeries and some critical surgeries had continued according to the ITS analysis during the 1st wave of

the COVID-19 pandemic, even though the year-over-year trend showed a decline.

The decline of oncological surgeries for gastrointestinal, hepato-pancreato-biliary, lung, breast, and genitourinary cancer was not significant in the ITS analysis, even though there were reductions in comparison to the same period of the previous year. For patients who had nonfatal diseases or did not require urgent medical intervention, JSS recommended postponement or performing surgery cautiously under appropriate infection control measures [5]. Owing to the risk of cancer-progression, prioritization of procedures should consider available evidence on time of surgery and oncologic outcomes [9, 19, 20]. The American College of Surgeons also recommended that surgery for low-risk cancer should be deferred but should not be postponed for most other cancers [21]. For example, our result for gastrointestinal cancer could reflect the recommendation because we did not include endoscopic procedures, which were usually performed for early-stage cancer outside the operating room. However, our result for prostate cancer showed no downward trend, which was opposite to urological triage



**Fig. 2** Monthly volume of each surgical procedure over time with interrupted time series analysis including segmented regressions. *HPB* hepatopancreato-biliary, *ORIF* open reduction internal fixation, *ENT* ear/nose/throat, *ESS* endoscopic sinus surgery

recommendations [22]. This was probably because of the relative affordability of hospital beds recruited in this study and the patients' wishes to perform the surgery as scheduled.

In terms of the abdominal, genitourinary, and cardiovascular surgeries, all but gynecological, aortic, and dialysis-fistula surgeries decreased with  $p < 0.05$  in ITS analysis. Selected abdominal and stone surgery have a low priority and are basically recommended to be delayed [5, 9, 22]. Regarding gynecological surgery, the Japan Society of Obstetrics and Gynecology did not established a system for surgical triage. The most common diseases for hysterectomy and adnexal surgery are uterine fibroids and ovarian cysts. Because these diseases could possibly lead to extreme anemia or torsion if left untreated, selected gynecological surgeries may have been performed with some priority [23]. During the COVID-19 pandemic, management of ICU beds and ventilators is important. There is also concern about a remarkable reduction in blood donation because many cardiovascular surgeries require perioperative transfusion [24, 25]. Considering the risk of COVID-19 infection and conservation of medical resources, certain surgical restrictions such as delaying of surgery for stable patients or transferring a patient to near-by hospitals are recommended for cardiac and aortic surgery by the Japanese Society for Cardiovascular Surgery, as in Western countries [26–28]. However, cardiovascular surgery is thought to be essential because of the risk of worsening or even death caused by surgical delay. For example, progression from asymptomatic to symptomatic (typically chest pain or shortness of breath) with an aortic

aneurysm can increase the risk of surgery, or even worse, make surgery impossible. Similarly, if the appropriate timing of surgery for dialysis fistula is missed, a patient's condition will become irreversible because of kidney failure. When medical resources, such as hospital beds, staff, and ventilators can be afforded to a certain extent, many cardiovascular surgeries should not be unnecessarily postponed, and such a trend was also observed in this study.

Within neurosurgery and orthopedic surgeries, every procedure declined compared to the same period in the previous year with  $p < 0.05$ , except for spinal surgeries including spine fusion and discectomy. According to a report by Johns Hopkins University, the decrease in cranial surgery cases was largest in the department of neurosurgery [29]. Triage of elective neurosurgery was basically judged based on the symptoms, such as any signs of life-, limb- or vision-threatening conditions [30]. The Japan Neurosurgical Society also announced similar statements with only an additional alert about endoscopic surgery [31]. In this research, we chose surgeries for brain tumor, intracranial hemorrhage, and intracranial vascular as cranial surgery based on their popularity in the NDB. Because patients who underwent these surgeries after scheduled admission might possibly have had trivial symptoms, our results could have been affected by such selection effects. Spine surgery also decreased, although the ITS analysis was not significant. The Japan Neurosurgical Society announced that spine surgery is intermediate or high priority according to the symptoms [31]. Patients with a spinal injury often experience paralysis,

which leads to a decline in activities of daily living (ADL) or quality of life, and the complaints of symptoms had possibly become more pronounced, which might have led to our results. Traumatic surgery is one that requires minimizing pre-operative delay and LOS despite a patient's COVID-19 status at each hospital [9], although whether surgery is performed with optimal timing or not should be decided in each hospital based on restrictions on elective resources and procedures [32]. Considering the necessity of traumatic surgery such as for fracture, surgical volume might have declined because of the state of emergency declared by the government that led to people voluntarily refraining from going out. Arthroplasty was sometimes performed for fracture patients, although most of them were for the treatment of osteoarthritis. This might be because we selected only scheduled admission patients. Osteoarthritis adversely impacts ADL regardless of there being a state of emergency, which could be related to our results.

Finally, surgeries associated with quality of life including ophthalmologic and ENT surgeries were focused on. The Japanese Ophthalmological Society and Oto-Rhino-Laryngological Society of Japan recommended cancellation or postponement of most elective surgeries because of the high probability of the COVID-19 virus being present in the nasal cavity, pharynx, and lacrimal fluid [33, 34]. Moreover, both ophthalmologists and otolaryngologists are a high-risk category of COVID-19 infection because their high daily outpatient and emergent patient volumes. In our study, the reason for the dramatic decrease in the surgical volume in otolaryngology and ophthalmology compared to other surgical categories might be that patients themselves were reluctant to be seen and that physicians in these two departments were strictly triaged by urgency.

This report focuses on the 1st wave of the COVID-19 pandemic, which was the most disruptive for clinical practice. Because most of the backlogged surgeries tended to have a low-priority, shifting the patients to ambulatory surgery centers or hospitals with no hospitalized COVID-19 positive patients in the same medical area may be one solution. Since the second wave, the number of scheduled surgeries has been gradually recovering, partly because the healthcare system has been more organized. However, it is still unlikely that there will be a full recovery compared to pre-pandemic levels, or even an increase in the number of surgeries to deal with the backlogged surgeries. The decrease in the number of surgeries can be attributed to various factors such as a decrease in the number of affected patients, patients refraining from pursuing medical care, and delays in surgeries. Therefore, it is important to examine what kind of surgery leads to quick recovery.

Our study is associated with several limitations. First, our target hospitals included 254 QIP participants who voluntarily provided DPC data. This study population may

not have been comprehensive enough to be representative of the current situation in Japan because there are more than 8000 hospitals in Japan. In this study, participant hospitals had a variety of backgrounds, such as private, public, and teaching hospitals. COVID-19-positive patients were admitted in at least about half of the hospitals. We believe that the selection bias associated with this study was not very significant, and this result was important for understanding the future course of the pandemic. Second, we did not consider whether there was a trend for surgery originally performed in an inpatient setting for ambulatory surgery because of the COVID-19 pandemic. The Centers for Disease Control and Prevention has recommended that some inpatient surgeries should be shifted to ambulatory surgery when possible and it is safe to do so, and the Ambulatory Surgery Center Association also cited the recommendation because of the risk of infection for medical staff and patients and the efficiency of medical resources [35]. Ambulatory surgery centers need to be prepared for the possibility of performing surgeries such as trauma and backlog surgeries that have never been experienced before depending on how the COVID-19 pandemic develops in the future.

In conclusion, we herein demonstrated and validated the trend of surgical volume reduction in Japan based on the surgical triage announced by each surgical society by applying ITS analyses. Almost all surgeries, except for oncological and critical procedures, tended to be significantly affected by COVID-19. Even in an emergency like this pandemic, the fact that surgical triage was performed in accordance with the statement suggests that medical care was provided efficiently in Japan. Future research should examine how hospitals recovered efficiently from the backlog of surgeries to prepare for the next possible pandemic wave.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s00595-021-02286-6>.

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## Declarations

**Conflict of interest** The authors declare that they have no conflicts of interest.

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