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ORIGINAL ARTICLE

Effects of the COVID-19 pandemic on short-term postoperative outcomes for colorectal perforation: A nationwide study in Japan based on the National Clinical Database

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Abstract

Aim: Possible negative effects of the COVID-19 pandemic on short-term postoperative outcomes for colorectal perforation in Japan were examined in this study.

Methods: The National Clinical Database (NCD) is a large-scale database including more than 95% of surgical cases in Japan. We analyzed 13 107 cases of colorectal perforation from 2019 to 2021. National data were analyzed, and subgroup analyses were conducted for subjects in prefectures with high infection levels (HILs) and metropolitan areas (Tokyo Met. and Osaka Pref.). Postoperative 30-day mortality, surgical mortality, and postoperative complications (Clavien–Dindo grade ≥3) were examined. Months were considered to have significantly high or low mortality or complication

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rates, if the 95% confidence interval (CI) of the standardized mortality (morbidity) ratio (SMR) does not contain 1.

Results: In the NCD, postoperative 30-day mortality occurred in 1371 subjects (10.5%), surgical mortality in 1805 (13.8%), and postoperative complications in 3950 (30.1%). Significantly higher SMRs were found for 30-day mortality in November 2020 (14.6%, 1.39 [95% CI: 1.04–1.83]) and February 2021 (14.6%, 1.48 [95% CI: 1.10–1.96]), and for postoperative complications in June 2020 (37.3%, 1.28 [95% CI: 1.08–1.52]) and November 2020 (36.4%, 1.21 [95% CI: 1.01–1.44]). The SMRs for surgical mortality were not significantly high in any month. In prefectures with HILs and large metropolitan areas, there were few months with significantly higher SMRs.

Conclusions: The COVID-19 pandemic had limited negative effects on postoperative outcomes in patients with colorectal perforation. These findings suggest that the emergency system for colorectal perforation in Japan was generally maintained during the pandemic.

KEYWORDS
colorectal perforation, COVID-19, National Clinical Database, postoperative short-term outcomes

1 | INTRODUCTION

Coronavirus disease 2019 (COVID-19) began in Wuhan, China and spread rapidly worldwide, resulting in a pandemic.[1] The COVID-19 outbreak also had many effects on medical practice, including patients fearing infection and not attending clinic visits and cancer screening.[2,3] Additionally, health facilities were required to treat COVID-19 patients and consequently had reduced staff for other care, fewer inpatient beds, and withheld nonurgent care except for COVID-19, resulting in discontinuation or postponement of some surgeries.[4,5] In 190 UN member countries, 28.4 million surgeries are believed to have been discontinued or postponed in the first 12 weeks after the COVID-19 pandemic began in March 2020, and it is estimated that 45 weeks are needed to catch up with this delay, even if surgeries are performed at a 20% higher rate after the COVID-19 pandemic ends.[6]

Cases of acute abdomen are common in emergency medical facilities. Colorectal perforation particularly complicates peritonitis and results in serious complications and sepsis if diagnosis and intervention are delayed; therefore, early intervention after onset is required.[7] There have been several studies on the changes in the number of surgical cases of diffuse peritonitis and postoperative short-term outcomes during the pandemic, but none on surgery for colorectal perforation alone.[8,9] Delayed therapeutic intervention for emergency diseases during the pandemic suggests a possible negative effect on outcomes for colorectal perforation.[10,11] Therefore, in this study, the effects of the COVID-19 pandemic on short-term postoperative outcomes for colorectal perforation were examined.

2 | METHODS

2.1 | Patients

This study was conducted using data from the National Clinical Database (NCD) in Japan.[12,13] The NCD was established in 2010 by Japanese surgical societies as a database of surgical cases for the medical specialist qualification system. The NCD is a large-scale database in which more than 95% of surgical cases in Japan are registered, with more than 1.5 million cases registered since 2016. Therefore, analysis of NCD cases provided a clear reflection of the therapeutic outcomes of colorectal perforation surgery in Japan. This study was supported by the Ministry of Health, Labour, and Welfare Research Program on Emerging and Reemerging Infectious Diseases (Grant Number JPMH21HA2011) after being recommended as a research project by the Japanese Society for Abdominal Emergency Medicine.

The subjects were patients with colorectal perforation among those who had acute diffuse peritonitis and underwent surgery between January 1st, 2019, and December 31st, 2021. The cause of peritonitis was gastrointestinal perforation, and the culprit sites were the right colon (cecum, ascending colon), transverse colon, left colon (descending colon, sigmoid colon), and rectum. Patients who were under 18 years old, had elective surgery, had missing values in observations or had a disease other than colorectal perforation were excluded from this study. This study was approved by the ethics committee of Tokyo Women's Medical University (approval no. 2022-0041) and the Japanese Society for Abdominal Emergency Medicine (approval no. 22-04).

2.2 | Endpoints

The primary endpoints were postoperative 30-day mortality, surgical mortality, and postoperative complications (Clavien–Dindo classification grade ≥3 [CD ≥3]). Surgical mortality was defined as overall 30-day mortality or in-hospital death within 90 days. In addition to the analysis of all subjects in Japan, subgroup analyses were conducted for two groups: prefectures with and without high infection levels (HILs) and between Tokyo Metropolis (Met.) and Osaka Prefecture (Pref.) and other prefectures to assess effects in areas with high numbers of infections and large metropolitan areas. The HIL regions included Aichi, Chiba, Fukuoka, Hokkaido, Hyogo, Kanagawa, Kyoto, Nara, Okinawa, Osaka, Saitama, and Tokyo. These regions were defined as HIL based on the cumulative number of infected people per population using the index for the degree of infection reported by Ikeda et al.[5]

2.3 | Statistical analysis

The monthly standardized mortality (morbidity) ratio (SMR) was used for statistical analysis, with the SMR defined as observed mortality (morbidity)/expected mortality (morbidity). Logistic regression was used to estimate the expected mortality (morbidity) using factors associated with acute diffuse peritonitis reported in previous studies (age, sex, body mass index [BMI], American Society of Anesthesiologists [ASA] score, performance status [PS], activities of daily living [ADLs], sepsis, malignant tumor, acute renal failure, hypertension, chronic obstructive pulmonary disease [COPD], bleeding risk, long-term steroids, smoking, drinking, diabetes, leukocyte count, hemoglobin, platelet count, C-reactive protein [CRP], total bilirubin, creatinine, prothrombin time with an international normalized ratio [PT-INR], activated partial thromboplastin time [APTT], laparoscopy, and emergency transport).[14] Months were considered to have significantly high or low mortality (morbidity), if the 95% confidence interval of the SMR does not contain 1. Data were compared by *t*-test, chi-square test, and Mann–Whitney *U* test, with two-sided $p<0.05$ considered significant. R version 4.1.2 (2021; R Foundation for Statistical Computing, Vienna, Austria) was used for statistical analysis.

3 | RESULTS

3.1 | Patient characteristics

Of 47 084 patients with acute diffuse peritonitis who underwent surgery between January 1st, 2019, and December 31st, 2021, 13 107 patients with colorectal perforation were included in this study. Among the excluded patients, 655 were under 18 years old, 3371 underwent elective surgery, 262 had missing values, and 29 689 had a disease other than colorectal perforation (Figure 1). In subgroup analyses, 6993 subjects lived in HIL prefectures and 6114 in non-HIL areas, and 1973 lived in Tokyo Met. or Osaka Pref. and 11 134 in other areas. Background factors are shown in Table 1. The mean numbers of subjects per month were 367.2 in 2019 and 362.5 in 2020 and 2021, with no significant difference between the periods ($p=0.61$). Similarly, the mean number of subjects per month by subgroup did not differ significantly between 2019 and 2020–2021. The overall postoperative 30-day mortality was 10.5% (1371 subjects), surgical mortality was 13.8% (1805 subjects), and postoperative complications (CD ≥3) occurred in 3950 subjects (30.1%). There was a significantly higher rate of postoperative complications in HIL areas than in non-HIL areas (2195 (31.4%) vs. 1755 (28.7%) subjects, ($p=0.001$), but there was no significant difference in 30-day or surgical mortality. There were no significant differences between Tokyo Met. and Osaka Pref. and other areas.

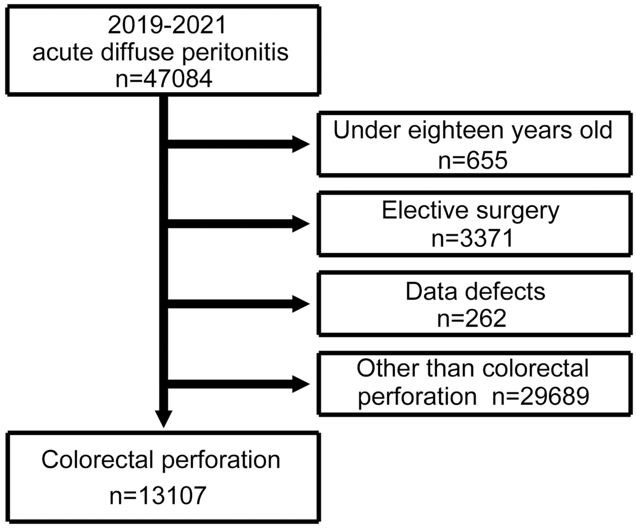

FIGURE 1 Flowchart of the patient selection process.

3.2 | SMRs for national data

The postoperative 30-day mortality was 460 (10.4%) in 2019 and 991 (10.5%) in 2020 and 2021. The SMR for 30-day mortality was significantly high in November 2020 (14.6%, 1.39 [95% CI: 1.04–1.83]) and February 2021 (14.6%, 1.48 [95% CI: 1.10–1.96]) and significantly low in September 2021 (6.9%, 0.64 [95% CI: 0.41–0.95]). The surgical mortality was 615 (14.0%) in 2019 and 1190 (13.7%) in 2020 and 2021. The SMR for surgical mortality was not significantly high in any month but was significantly low in September 2021 (10.0%, 0.71 [95% CI: 0.50–0.99]). Postoperative complications occurred in 1364 subjects (31.0%) in 2019 and 2586 (29.7%) in 2020 and 2021. The SMR for complications was significantly higher in June 2020 (37.3%, 1.28 [95% CI: 1.08–1.52]) and November 2020 (36.4%, 1.21 [95% CI: 1.01–1.44]) (Figure 2).

3.3 | SMRs in HIL and non-HIL prefectures

A significantly high SMR in HIL prefectures was found for postoperative complications in June 2020 (39.4%, 1.31 [95% CI: 1.04–1.64]),

TABLE 1 Characteristics of patients.

	Overall	Prefectures with high infection levels	Prefectures without high infection levels		Tokyo Met. and Osaka prefecture	Other prefectures	
n	13 107	6993	6114		1973	11 134	
Age (y) (%)				<0.001			<0.001
<59	2175 (16.6)	1268 (18.1)	907 (14.8)		402 (20.4)	1773 (15.9)	
≥60, <64	967 (7.4)	529 (7.6)	438 (7.2)		157 (8.0)	810 (7.3)	
≥65, <69	1483 (11.3)	780 (11.2)	703 (11.5)		211 (10.7)	1272 (11.4)	
≥70, <74	2085 (15.9)	1103 (15.8)	982 (16.1)		341 (17.3)	1744 (15.7)	
≥75, <79	1966 (15.0)	1079 (15.4)	887 (14.5)		291 (14.7)	1675 (15.0)	
≥80	4431 (33.8)	2234 (31.9)	2197 (35.9)		571 (28.9)	3860 (34.7)	
Sex (%)				0.62			0.92
Male	6901 (52.7)	3696 (52.9)	3205 (52.4)		1041 (52.8)	5860 (52.6)	
Female	6206 (47.3)	3297 (47.1)	2909 (47.6)		932 (47.2)	5274 (47.4)	
Body mass index (BMI) (%)				0.53			0.58
<18.5 kg/m^2	2818 (21.5)	1477 (21.1)	1341 (21.9)		439 (22.3)	2379 (21.4)	
≥18.5, <25 kg/m^2	7774 (59.3)	4170 (59.6)	3604 (58.9)		1168 (59.2)	6606 (59.3)	
≥25 kg/m^2	2515 (19.2)	1346 (19.2)	1169 (19.1)		366 (18.6)	2149 (19.3)	
ASA PS (%)				<0.001			0.58
ASA1	596 (4.5)	341 (4.9)	255 (4.2)		93 (4.7)	503 (4.5)	
ASA2	4852 (37.0)	2676 (38.3)	2176 (35.6)		748 (37.9)	4104 (36.9)	
ASA3-5	7659 (58.4)	3976 (56.9)	3683 (60.2)		1132 (57.4)	6527 (58.6)	
Independence in ADL (%)				<0.001			<0.001
+	3704 (28.3)	1872 (26.8)	1832 (30.0)		479 (24.3)	3225 (29.0)	
Sepsis (%)				0.23			0.62
None	10 279 (78.4)	5448 (77.9)	4831 (79.0)		1531 (77.6)	8748 (78.6)	
Sepsis	1329 (10.1)	716 (10.2)	613 (10.0)		209 (10.6)	1120 (10.1)	
Septic shock	1499 (11.4)	829 (11.9)	670 (11.0)		233 (11.8)	1266 (11.4)	
Malignancy (%)				0.74			0.31
+	2737 (20.9)	1468 (21.0)	1269 (20.8)		395 (20.0)	2342 (21.0)	
Acute renal failure (%)				0.11			0.11
+	393 (3.0)	194 (2.8)	199 (3.3)		52 (2.6)	341 (3.1)	
Hypertension (%)				<0.001			<0.001
+	5788 (44.2)	2912 (41.6)	2876 (47.0)		744 (37.7)	5044 (45.3)	
COPD (%)				0.36			0.92
+	430 (3.3)	220 (3.1)	210 (3.4)		64 (3.2)	366 (3.3)	
Risk of hemorrhage (%)				<0.001			0.10
+	1512 (11.5)	721 (10.3)	791 (12.9)		206 (10.4)	1306 (11.7)	
Long-term steroid use (%)				0.01			0.31
+	887 (6.8)	437 (6.2)	450 (7.4)		123 (6.2)	764 (6.9)	
Smoking (%)				0.85			0.13
+	2180 (16.6)	1159 (16.6)	1021 (16.7)		305 (15.5)	1875 (16.8)	

(Continues)

TABLE 1 (Continued)

	Overall	Prefectures with high infection levels	Prefectures without high infection levels		Tokyo Met. and Osaka prefecture	Other prefectures	
Habitual alcohol consumption (%)				0.72			0.27
+	2936 (22.4)	1558 (22.3)	1378 (22.5)		461 (23.4)	2475 (22.2)	
Diabetes mellitus (%)				0.69			0.10
+	2017 (15.4)	1068 (15.3)	949 (15.5)		279 (14.1)	1738 (15.6)	
WBC count (%)				0.22			0.55
<3500/μL	2353 (18.0)	1216 (17.4)	1137 (18.6)		343 (17.4)	2010 (18.1)	
≥3500, <9000/μL	4964 (37.9)	2656 (38.0)	2308 (37.7)		730 (37.0)	4234 (38.0)	
≥9000/μL	5767 (44.0)	3111 (44.5)	2656 (43.4)		897 (45.5)	4870 (43.7)	
Unknown	23 (0.2)	10 (0.1)	13 (0.2)		3 (0.2)	20 (0.2)	
Hemoglobin (%)				0.85			0.60
M: <13.5 g/dL, F: <11.5 g/dL	6956 (53.1)	3688 (52.7)	3268 (53.5)		1051 (53.3)	5905 (53.0)	
M: ≥13.5 g/dL, ≤17.0 g/dL, F ≥ 11.5 g/dL, ≤15.0 g/dL	5674 (43.3)	3045 (43.5)	2629 (43.0)		850 (43.1)	4824 (43.3)	
M: >17.0 g/dL, F: 15 g/dL	438 (3.3)	239 (3.4)	199 (3.3)		69 (3.5)	369 (3.3)	
Unknown	39 (0.3)	21 (0.3)	18 (0.3)		3 (0.2)	36 (0.3)	
Platelets (%)				0.03			0.38
<150 000	1939 (14.8)	1007 (14.4)	932 (15.2)		282 (14.3)	1657 (14.9)	
≥150 000, ≤350 000	9116 (69.6)	4846 (69.3)	4270 (69.8)		1364 (69.1)	7752 (69.6)	
>350 000	2026 (15.5)	1130 (16.2)	896 (14.7)		325 (16.5)	1701 (15.3)	
Unknown	26 (0.2)	10 (0.1)	16 (0.3)		2 (0.1)	24 (0.2)	
C-reactive protein (CRP) (%)				<0.001			<0.001
≤0.1 mg/dL	1620 (12.4)	790 (11.3)	830 (13.6)		212 (10.7)	1408 (12.6)	
>0.1 mg/dL, ≤1.0 mg/dL	1789 (13.6)	875 (12.5)	914 (14.9)		212 (10.7)	1577 (14.2)	
>1.0 mg/dL, ≤5.0 mg/dL	1778 (13.6)	975 (13.9)	803 (13.1)		283 (14.3)	1495 (13.4)	
>5.0 mg/dL, ≤10.0 mg/dL	1393 (10.6)	776 (11.1)	617 (10.1)		238 (12.1)	1155 (10.4)	
>10.0 mg/dL	6282 (47.9)	3480 (49.8)	2802 (45.8)		1006 (51.0)	5276 (47.4)	
Unknown	245 (1.9)	97 (1.4)	148 (2.4)		22 (1.1)	223 (2.0)	
Total bilirubin (%)				0.40			0.22
≤1.0 mg/dL	10 555 (80.5)	5647 (80.8)	4908 (80.3)		1564 (79.3)	8991 (80.8)	
>1.0 mg/dL	2440 (18.6)	1293 (18.5)	1147 (18.8)		388 (19.7)	2052 (18.4)	
Unknown	112 (0.9)	53 (0.8)	59 (1.0)		21 (1.1)	91 (0.8)	
Creatinine (%)				0.04			0.004
≤1.0 mg/dL	7699 (58.7)	4179 (59.8)	3520 (57.6)		1223 (62.0)	6476 (58.2)	
>1.0 mg/dL	5351 (40.8)	2786 (39.8)	2565 (42.0)		745 (37.8)	4606 (41.4)	
Unknown	57 (0.4)	28 (0.4)	29 (0.5)		5 (0.3)	52 (0.5)	

TABLE 1 (Continued)

	Overall	Prefectures with high infection levels	Prefectures without high infection levels		Tokyo Met. and Osaka prefecture	Other prefectures	
PT-INR (%)				<0.001			0.04
<0.9	285 (2.2)	138 (2.0)	147 (2.4)		39 (2.0)	246 (2.2)	
≥0.9, ≤1.1	7226 (55.1)	3744 (53.5)	3482 (57.0)		1035 (52.5)	6191 (55.6)	
>1.1	4859 (37.1)	2685 (38.4)	2174 (35.6)		773 (39.2)	4086 (36.7)	
Unknown	737 (5.6)	426 (6.1)	311 (5.1)		126 (6.4)	611 (5.5)	
APTT (%)				0.07			0.01
<30 s	3800 (29.0)	2047 (29.3)	1753 (28.7)		543 (27.5)	3257 (29.3)	
≥30 s, ≤40 s	6754 (51.5)	3540 (50.6)	3214 (52.6)		1028 (52.1)	5726 (51.4)	
>40 s	1734 (13.2)	941 (13.5)	793 (13.0)		247 (12.5)	1487 (13.4)	
Unknown	819 (6.2)	465 (6.6)	354 (5.8)		155 (7.9)	664 (6.0)	
Laparoscopic surgery (%)				<0.001			<0.001
+	1510 (11.5)	966 (13.8)	544 (8.9)		324 (16.4)	1186 (10.7)	
Ambulance transportation (%)				0.25			<0.001
+	6446 (49.2)	3406 (48.7)	3040 (49.7)		874 (44.3)	5572 (50.0)	
30-day mortality (%)				0.98			0.19
	1371 (10.5)	732 (10.5)	639 (10.5)		190 (9.6)	1181 (10.6)	
Surgical mortality (%)				0.48			0.14
	1805 (13.8)	977 (14.0)	828 (13.5)		251 (12.7)	1554 (14.0)	
Complications (CD ≥3) (%)				0.001			0.73
	3950 (30.1)	2195 (31.4)	1755 (28.7)		588 (29.8)	3362 (30.2)	
Postoperative hospital stays, days (median [IQR])				0.002			0.95
	27 [16, 46]	27 [17, 47]	26 [16, 45]		27 [16, 46]	26 [16, 46]	

Abbreviations: ADL, activities of daily living; APTT: activated partial thromboplastin time; ASA PS, American Society of Anesthesiologists physical status; CD, Clavien–Dindo classification grade; COPD, chronic obstructive pulmonary disease; IQR, interquartile range; PT-INR, prothrombin time-international normalized ratio; WBC, white blood cell.

but none were found for 30-day or surgical mortality. In contrast, in non-HIL prefectures, there were significantly high SMRs for 30-day mortality in February 2021 (16.0%, 1.74 [95% CI: 1.13–2.57]) and August 2021 (17.2%, 1.80 [95% CI: 1.19–2.60]) and surgical mortality in February 2021 (18.6%, 1.52 [95% CI: 1.02–2.19]) and August 2021 (19.0%, 1.54 [95% CI: 1.05–2.19]), but there were no significant SMRs for postoperative complications (Figures 3 and 4).

3.4 | SMRs in Tokyo Met. and Osaka Pref. and in other areas

In Tokyo Met. and Osaka Pref., no high SMR for 30-day mortality, surgical mortality, or postoperative complications was found in any month. In other areas, there were significantly high SMRs for 30-day mortality in November 2020 (14.8%, 1.43 [95% CI: 1.04–1.91]) and February 2021 (15.1%, 1.49 [95% CI: 1.08–2.02]), surgical mortality in November 2020 (18.1%, 1.34 [95% CI: 1.01–1.74]), and postoperative complications in June 2020 (37.7%, 1.29 [95% CI: 1.07–1.54]) and November 2020 (36.2%, 1.22 [95% CI: 1.00–1.47]) (Figures 5 and 6; Tables S1-S3).

4 | DISCUSSION

In 2020 and 2021, during the spread of COVID-19, there were only 2 months with significantly high SMRs for 30-day mortality and complications (CD ≥3) and none for surgical mortality. These

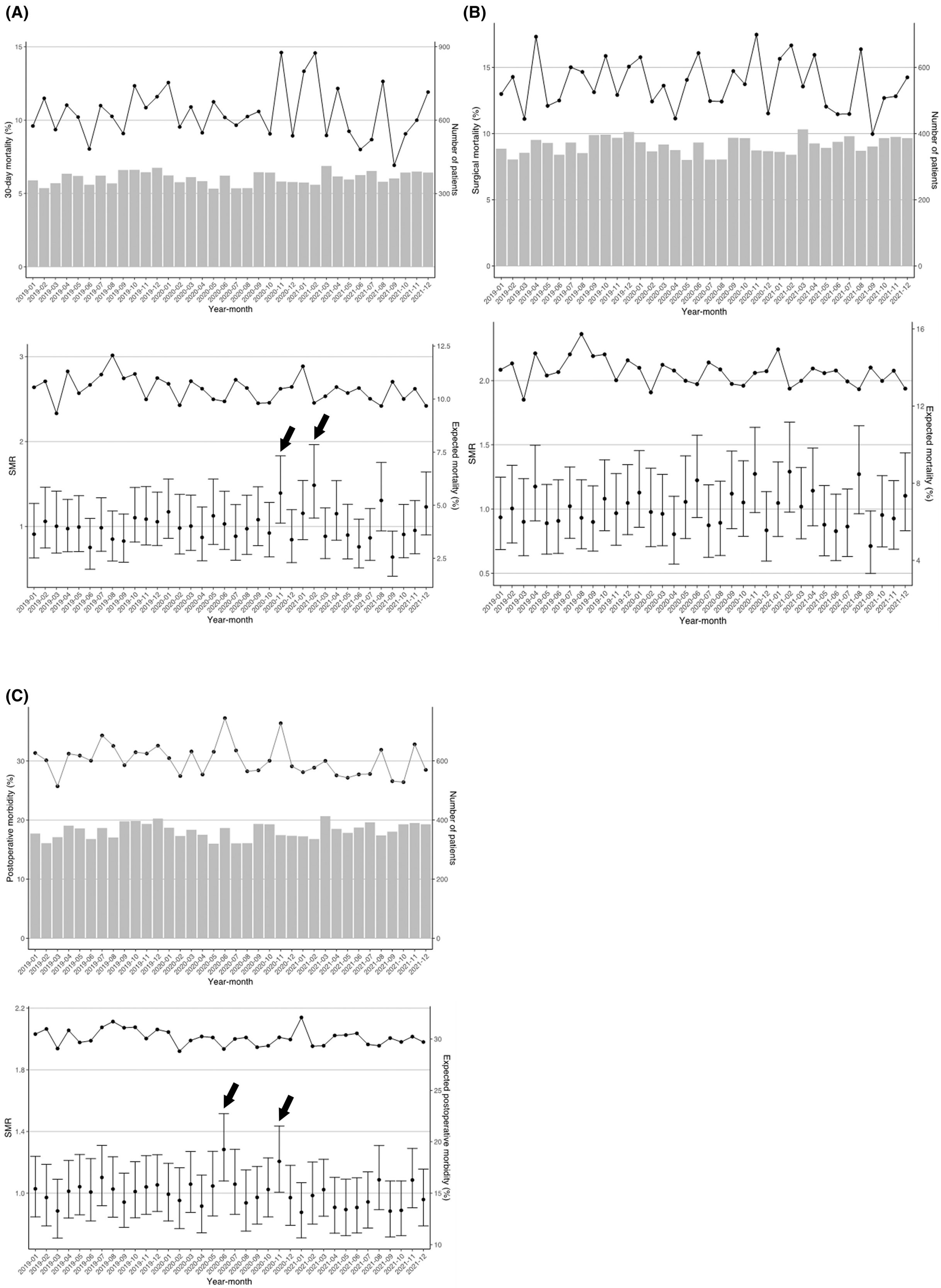

FIGURE 2 Standardized mortality (morbidity) ratio (SMR) by month for all subjects. (A) Top: 30-day mortality and number of patients. Bottom: SMR and expected mortality. → indicates months when the SMR was significantly higher. (B) Top: surgical mortality and number of patients. Bottom: SMR and expected mortality. (C) Top: postoperative complications (Clavien–Dindo classification grade ≥3) and number of patients. Bottom: SMR and expected morbidity. → indicates months when the SMR was significantly higher.

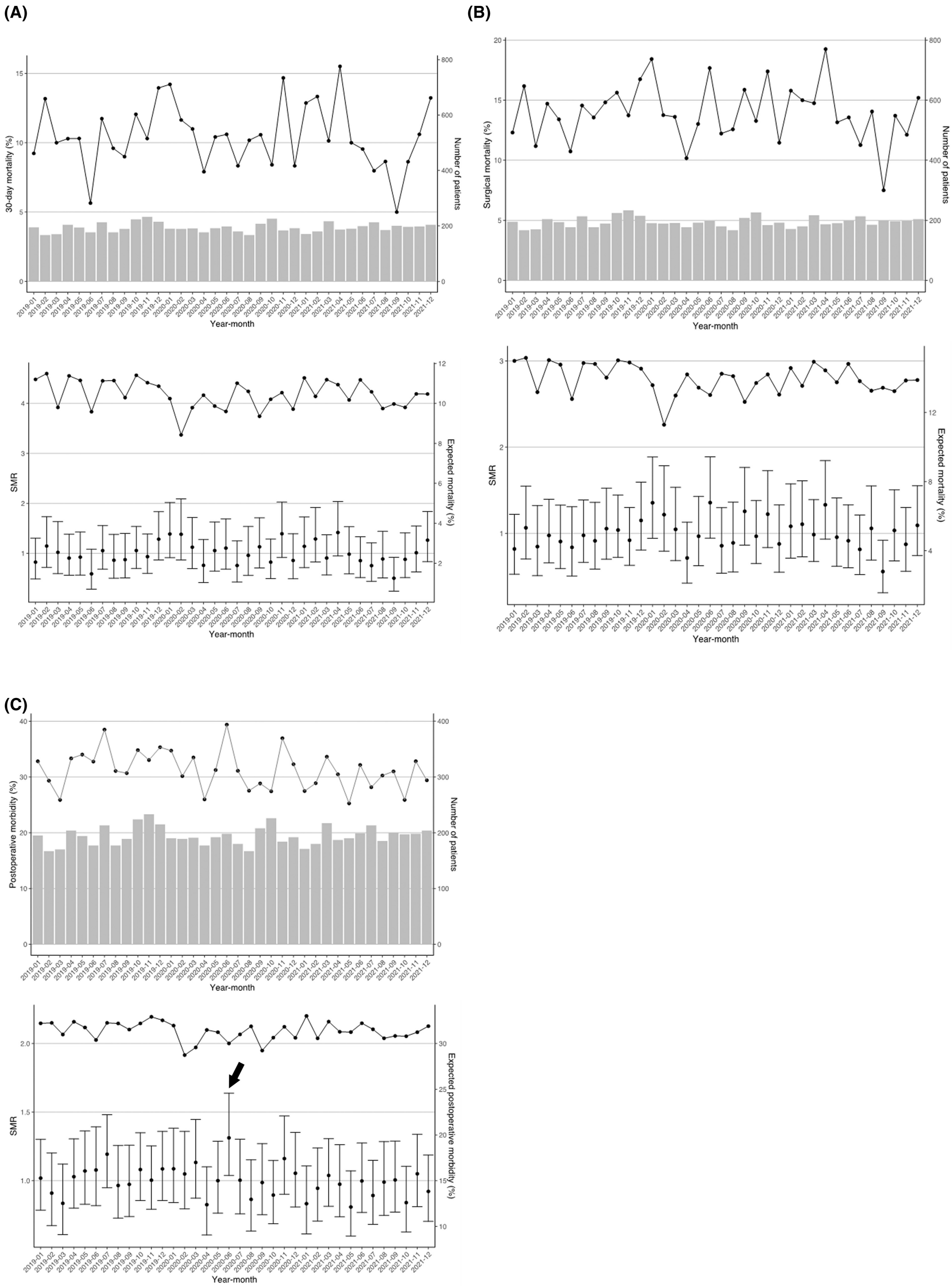

FIGURE 3 Standardized mortality (morbidity) ratio (SMR) by month for prefectures with high infection levels. (A) Top: 30-day mortality and number of patients. Bottom: SMR and expected mortality. (B) Top: surgical mortality and number of patients. Bottom: SMR and expected mortality. (C) Top: postoperative complications (Clavien–Dindo classification grade ≥3) and number of patients. Bottom: SMR and expected morbidity. → indicates months when the SMR was significantly higher.

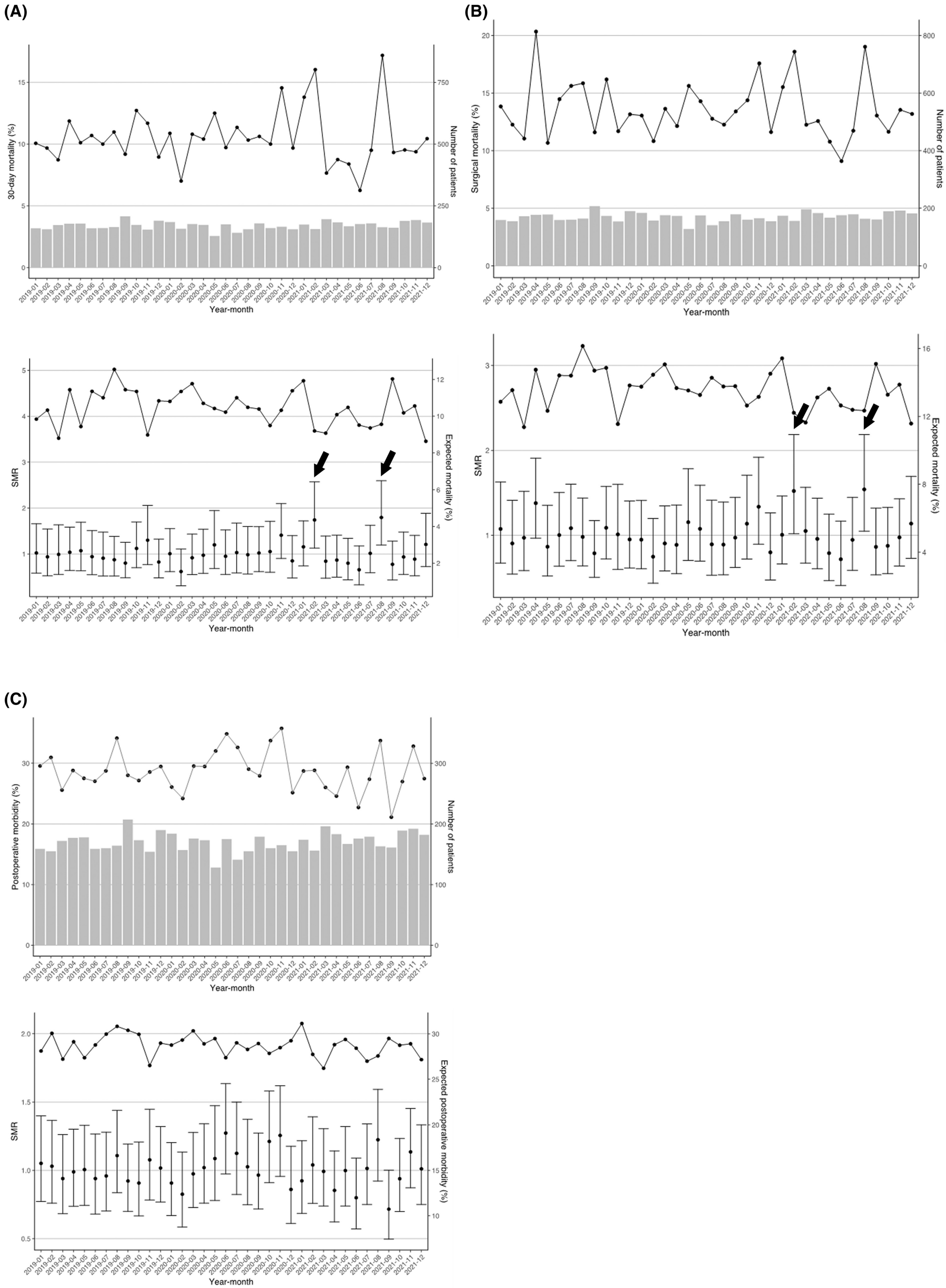

FIGURE 4 Standardized mortality (morbidity) ratio (SMR) by month for prefectures without high infection levels. (A) Top: 30-day mortality and number of patients. Bottom: SMR and expected mortality. → indicates months when the SMR was significantly higher. (B) Top: surgical mortality and number of patients. Bottom: SMR and expected mortality. → indicates months when the SMR was significantly higher. (C) Top: postoperative complications (Clavien–Dindo classification grade ≥3) and number of patients. Bottom: SMR and expected morbidity.

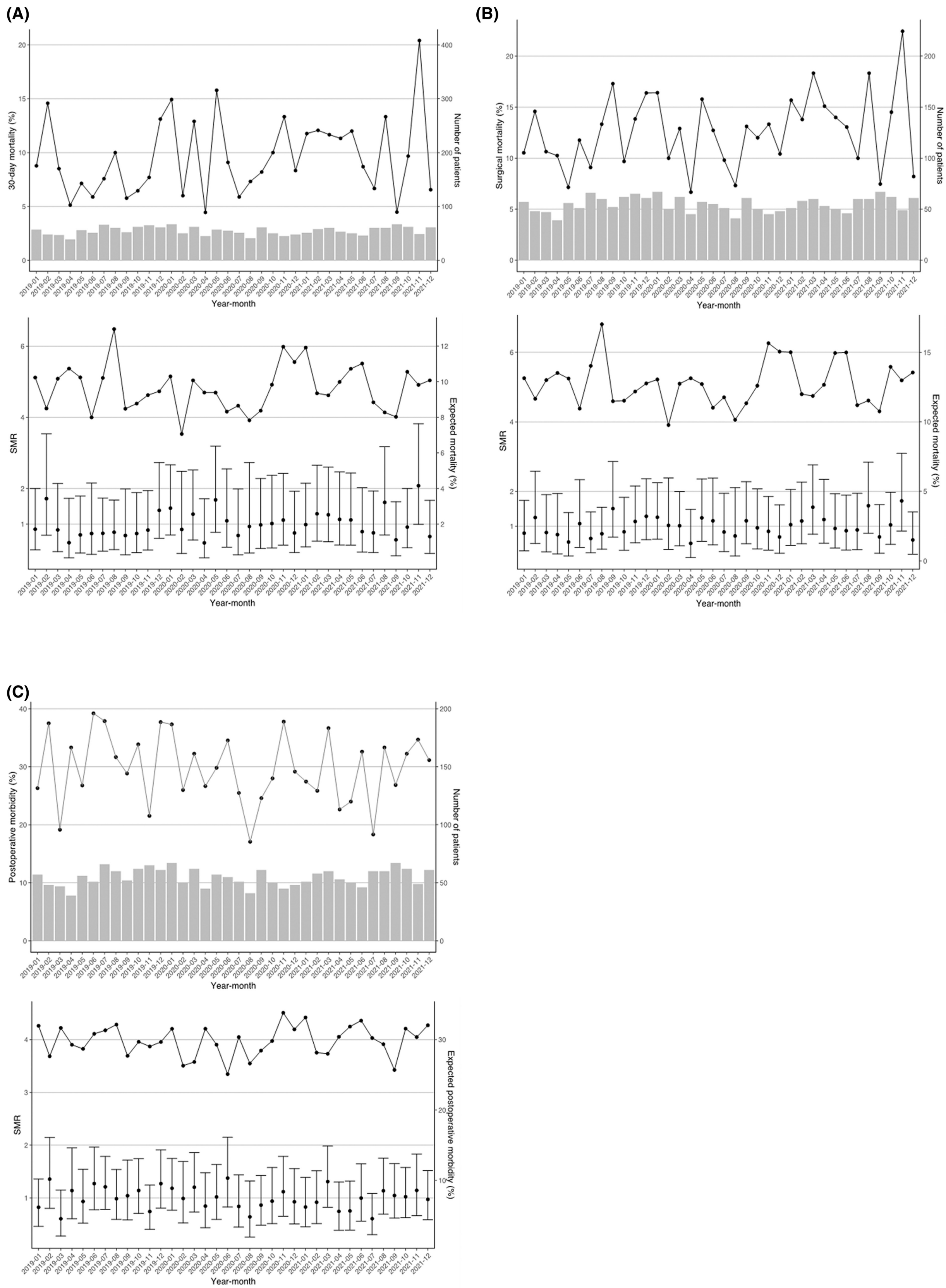

FIGURE 5 Standardized mortality (morbidity) ratio (SMR) by month for Tokyo Met. and Osaka Pref. (A) Top: 30-day mortality and number of patients. Bottom: SMR and expected mortality. (B) Top: surgical mortality and number of patients. Bottom: SMR and expected mortality. (C) Top: postoperative complications (Clavien–Dindo classification grade ≥3) and number of patients. Bottom: SMR and expected morbidity.

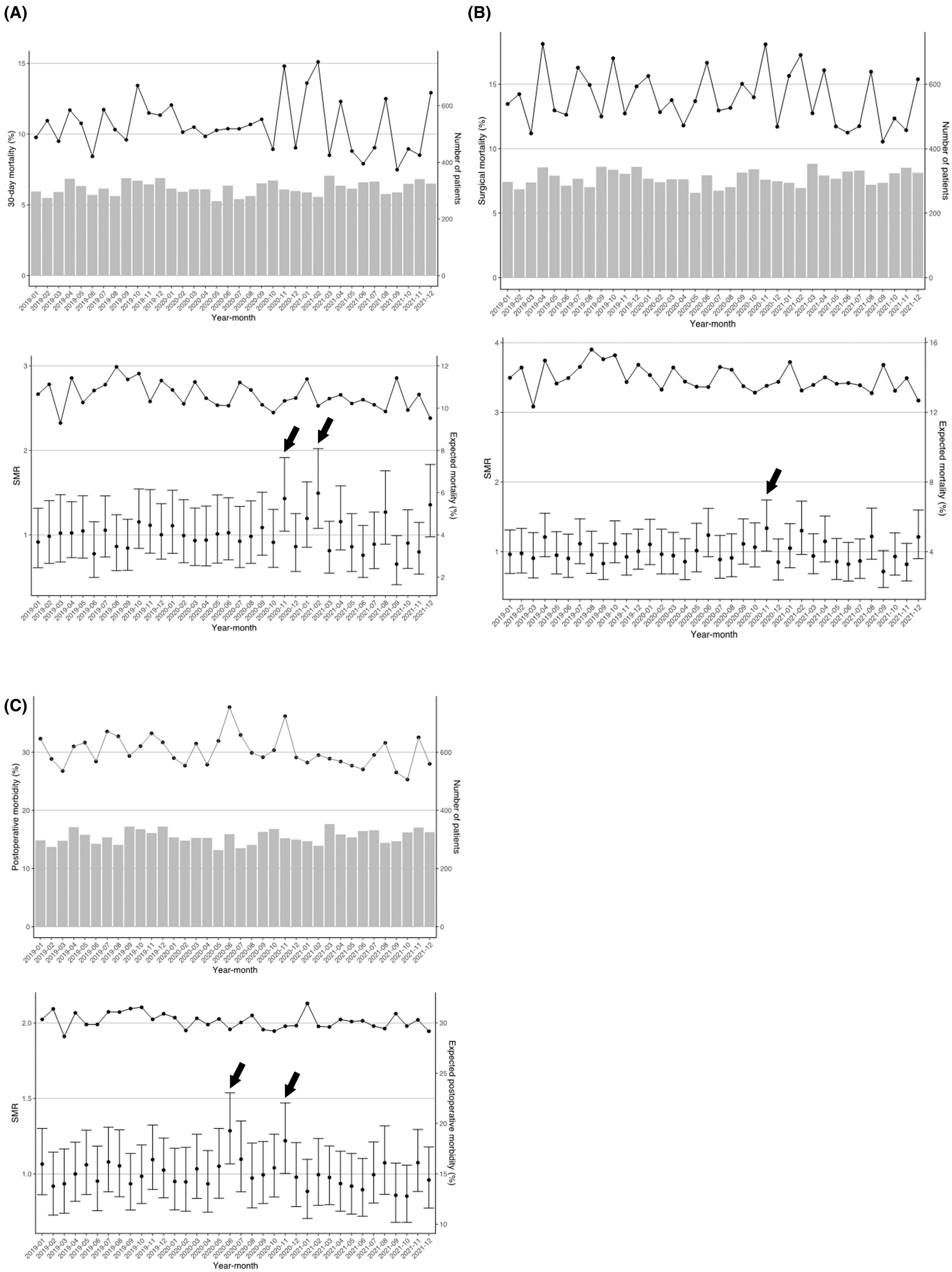

FIGURE 6 Standardized mortality (morbidity) ratio (SMR) by month for prefectures other than Tokyo Met. and Osaka Pref. (A) Top: 30-day mortality and number of patients. Bottom: SMR and expected mortality. → indicates months when the SMR was significantly higher. (B) Top: surgical mortality and number of patients. Bottom: SMR and expected mortality. → indicates months when the SMR was significantly higher. (C) Top: postoperative complications (Clavien–Dindo classification grade ≥3) and number of patients. Bottom: SMR and expected morbidity. → indicates months when the SMR was significantly higher.

results indicate that the negative effects of the COVID-19 pandemic on postoperative outcomes for colorectal perforation were limited.

Emergency surgery for gastrointestinal disorders is mainly performed for uncontrollable gastrointestinal bleeding, intestinal obstruction and gastrointestinal perforation.[15,16] Patients often have peritonitis and undergo surgery with worse systemic conditions than those who undergo elective surgery, resulting in a poor postoperative prognosis.[16,17] Colorectal perforation is more likely to cause severe sepsis and has high complication rates and mortality compared with other gastrointestinal perforations because fecal leakage frequently induces bacterial proliferation and contamination. Many studies have reported complication rates of 30%–50% and mortality rates of 10%–30%.[15,18–22]

Delayed therapeutic intervention for acute abdomen, including colorectal perforation, increases complication rates and grades and has a negative impact on outcomes. Therefore, early diagnosis and intervention are necessary.[23] With the spread of COVID-19, many elective surgeries were not performed or postponed,[4,5] and the number of emergency surgeries also decreased.[9,24] For example, in Italy, 60% fewer emergency surgeries were performed in 2020 than in 2019, and in Spain, emergency surgeries in three tertiary care hospitals (special hospitals for acute care surgery) decreased by 58.9% during the pandemic.

The COVID-19 pandemic caused delayed therapeutic intervention for urgent diseases and had a negative impact on outcomes. One study in Spain found that the time from disease onset to arrival at an emergency outpatient service was 71.0 h during the pandemic, which was significantly longer than the pre-pandemic time of 44.6 h, and the complication rate during the pandemic was 47.1%, which was significantly higher than the pre-pandemic rate of 34.7%.[24] Another study in Italy that compared surgeries from March to May 2020 during lockdown with those in March to May 2019 before the pandemic showed a rate of delayed visits to emergency outpatient services of 15.5% during lockdown and significantly higher complication rates.[10] The study also compared delayed and non-delayed patients during lockdown and found that delayed patients had significantly higher risks for postoperative complications and 30-day mortality. These findings show that the COVID-19 pandemic reduced emergency surgeries, delayed therapeutic interventions, and had a negative influence on treatment outcomes.[25]

In contrast to previous findings, a decrease in patients and negative effects on treatment outcomes during the pandemic were not found in this study. The mean number of subjects per month in 2019 did not differ from that in 2020 and 2021, with similar results in the subgroup analyses. Previous studies using the NCD have shown that the number of 20 major surgical procedures performed in Japan in 2020 decreased by 10%–15% from that in 2018 and 2019, and almost all tumor-related and cardiovascular surgeries were also reduced.[5] A study of five surgical procedures for gastroenterological cancer and acute diffuse peritonitis (ADP) using the NCD found that distal gastrectomies for gastric cancer and low anterior resections for rectal cancer decreased from May to December 2020 compared to January 2018 to April 2020; however, the number of ADP surgeries did not change.[8] Although this study was limited to colorectal perforation surgery among ADP cases, our findings are consistent with these results. Therefore, it appears that patients in Japan with acute abdomen, including colorectal perforation, underwent surgery regardless of the pandemic and at a similar rate to that before the pandemic.

Short-term postoperative outcomes were also examined in a previous study.[8] Among ADP patients who underwent surgery from May to December 2020, the 30-day mortality, surgical mortality, and postoperative complication (CD ≥3) rates of 8.1%, 11.3%, and 25.6%, respectively, did not differ significantly from those from January 2018 to April 2020. In the current study, these respective rates were 10.5%, 13.7%, and 29.7% in 2020 and 2021 and were higher than those for ADP patients.[8] This result reflects the poorer short-term postoperative prognoses of patients with colorectal perforation compared to those with other diseases that resulted in ADP; however, the results are similar to or lower than those of previous reports.[15,18–22]

Short-term outcomes after surgery for colorectal perforation are affected by various factors, including the site of perforation, surgical procedure, age, comorbidities, and cause of perforation, and may not be directly compared due to bias in the patient population.[10,17] Therefore, in the current study, we examined not only the mortality rate and complication rate but also the SMR that was risk adjusted to eliminate the influence of confounding as much as possible. Furthermore, the numbers of patients with new COVID-19 infections and of serious patients are not uniform and change daily. Monthly analyses were conducted because the effect of COVID-19 may be underestimated by yearly analyses.

In subgroup analyses, HIL prefectures and metropolitan areas were examined as regions that were potentially influenced more by COVID-19; however, SMR in HIL prefectures was significantly high in only 1 month for postoperative complications, and SMR in metropolitan areas was not significantly high in any months. In contrast, SMR in non-HIL prefectures was significantly high in 2 months for 30-day mortality and surgical mortality, and SMR in non-metropolitan areas was significantly high in 2 months for 30-day mortality and postoperative complications and in 1 month for surgical mortality. These outcomes were not consistent with the expected SMRs from the first to fifth wave of COVID-19.[26] The reason for this result is unclear, but these may be incidental statistical findings. The effects on short-term postoperative outcomes were considered to be limited based on the results of the subgroup analysis.

The reasons for these limited effects of COVID-19 may be as follows. The lack of reduction in the number of surgeries is likely to be due to the absence of alternative treatment and the need for emergency surgery in most patients with colorectal perforation. The "Guidelines for performing surgical triage during the COVID-19 pandemic" of the Japan Surgical Society, indicate that in surgical triage emergency surgery should be limited to disease level C cases, in which nonoperative treatment cannot be chosen after careful consideration. Colorectal perforation meets this criterion.[27] The limited effect on treatment outcomes among COVID-19 patients and serious patients in Japan in comparison with other countries may be due to fewer restrictions on medical conditions in Japan and the limited impact on the emergency department.[26] Willingness to abide by infection control measures and cooperation in adhering to behavioral restrictions among Japanese people may also have resulted in a smaller spread of COVID-19 in Japan than in other countries.

This study was conducted using risk-adjusted SMRs for which confounders were controlled as much as possible. Nevertheless, the time from onset of disease to therapeutic intervention and the capacity and function of treatment facilities are not included in the NCD data. Delayed treatment has a negative effect on treatment outcomes. In addition, colorectal perforation can develop rapidly at any time of the day or night, and patients need strict intensive care after surgery. Therefore, treatment facilities must have capacity and function, including sufficient staff, out-of-hours service, and intensive care units; consequently, suitable facilities are limited,[28] and most are core regional facilities that proactively perform COVID-19 treatment. Therefore, colorectal perforation might have been treated under unusual and specific conditions. In the national and subgroup analyses, the effects on treatment outcomes were limited, but effects at all facilities may not have been similarly limited. Therefore, an analysis may be required by the facility. When medical facilities that usually care for many patients with colorectal perforation had to limit these patients due to care of COVID-19 patients, neighboring facilities may have cared for patients with colorectal perforation instead, i.e., it is possible that the community-scale follow-up system functioned well and that treatment outcomes were maintained in Japan as a whole.

This study has the following limitations. First, cases in 2020 and 2021 probably included COVID-19 patients with colorectal perforation, but the number of such patients was unclear, and the effect on postoperative outcomes could not be evaluated. Elective surgery may have had to be postponed for patients infected with COVID-19; however, surgery for colorectal perforation is difficult to postpone, and consequently, patients might have had complications due to COVID-19 and undergone surgery. Reportedly, surgical patients infected with COVID-19 had higher complications and mortality than noninfected patients.[29,30] Further studies are needed to evaluate the effect of COVID-19 infection on treatment outcomes for colorectal perforation. Second, this study was conducted based on data collected until 2021. In Japan, there were periods of increasing new infections from the first to fifth waves. During the fifth wave, on August 13th, 2021, 25 995 new infections were reported. In 2022 and afterwards, the peak was 100 921 cases on February 5th during the sixth wave and 261 004 cases on August 19th during the seventh wave, which were periods of explosive increases in new infections in comparison with 2020 and 2021.[26] Thus, there is a need to examine outcomes in periods with more new COVID-19 cases.

5 | CONCLUSION

This study was conducted using data from the NCD, in which most surgeries in Japan are registered. Thus, these data reflect the number of surgeries for colorectal perforation before and during the COVID-19 pandemic and the short-term postoperative outcomes in Japan. A significantly high SMR was detected in a few months, but the negative effects of the COVID-19 pandemic on postoperative outcomes for colorectal perforation were limited. In addition to the dedicated efforts of each facility, the emergency service system in Japan is supported by guidelines such as those of the Japanese Surgical Society. Our findings indicate that this system for colorectal perforation was generally well-maintained during the COVID-19 pandemic in Japan.

AUTHOR CONTRIBUTIONS

Study conception and study design: Shimpei Ogawa, Hideki Endo, Masahiro Yoshida, Tomomitsu Tsuru, Michio Itabashi, and Hiroyuki Yamamoto. Data acquisition, data analysis, and interpretation: Shimpei Ogawa, Hideki Endo, Masahiro Yoshida, Tomomitsu Tsuru, Michio Itabashi, Hiroyuki Yamamoto, Yoshihiro Kakeji, and Hideki Ueno. Manuscript revision: all authors. Final manuscript approval: all authors.

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CONFLICT OF INTEREST STATEMENT

Hideki Endo and Hiroyuki Yamamoto are affiliated with the Department of Healthcare Quality Assessment at the University of Tokyo. The department is a social collaboration department supported by grants from the National Clinical Database, Intuitive Surgical Sarl, Johnson & Johnson K.K., and Nipro Co. Yuko Kitagawa is Editor-in-Chief of *Annals of Gastroenterological Surgery*. Masaki Mori is Emeritus Editor-in-Chief of *Annals of Gastroenterological Surgery*. Yoshihiro Kakeji and Hideki Ueno are Associate Editors of *Annals of Gastroenterological Surgery* dealing with the lower digestive tract. The other authors declare no conflicts of interest for this article.

ETHICS STATEMENT

Ethics approval and consent to participate: This study was approved by the ethics committee of Tokyo Women's Medical University (approval no. 2022-0041) and the Japanese Society for Abdominal Emergency Medicine (approval no. 22-04). Patients agreed to inclusion of their data in this study through presumed consent with opt-out through a web page and/or a notice from each center.

Registry and the Registration No. of the study/trial: N/A.

Animal Studies: N/A.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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