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representation of inadequate analgesic loading rather than an effect of the block method itself. It is therefore important to tailor analgesic regimes to expected post-surgical pain expectations.

Declarations of interest

The authors declare no conflicts of interest.

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Outcome of surgical patients during the first wave of the COVID-19 pandemic in US hospitals

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Editor—During the early coronavirus disease 2019 (COVID-19) pandemic, there was nationwide guidance from institutions and policymakers in the USA to postpone elective surgeries,^{1,2} leading to a significant decrease surgical volume in March 2020.³ However, the global impact of the early pandemic on postoperative mortality remains unexplored.

We performed this retrospective cohort study among adult patients undergoing surgery between January 6, 2020 and June 28, 2020 across US hospitals in the Multicenter Perioperative Outcomes Group (MPOG) database, to explore the association between the early phase of the pandemic with postoperative mortality (full methods in [Supplemental Methods](#)). The primary endpoint was 30 day mortality. A mixed-effect Cox proportional hazard model was used to analyse the risk of 30 day mortality after surgery. Patients discharged alive before day 30 or still alive at 30 days after surgery were censored. The Cox model was adjusted for age, sex, ASA physical status, emergency status, hospital admission status, comorbidities derived from the preoperative score to predict postoperative mortality⁴ (cardiac arrhythmia, congestive heart failure, peripheral vascular disease, paralysis, chronic pulmonary disease, alcohol

abuse, cancer, diabetes mellitus, renal failure), BMI, surgical subspecialty, and pandemic period (period of a three-phase pandemic model as described below). A random effect for the institution ID and week number and an interaction term between the pandemic period and the COVID-19 regional severity quartile was included in the model. Surgical case volume trends across all included MPOG institutions were identified using joinpoint regression. The identified joinpoints were used to split the study into three periods of surgical volumes: surgeries performed from January 6, 2020 through March 15, 2020 were defined as 'pre-pandemic'; surgeries performed during the nadir surgical volume period from March 16, 2020 through April 5, 2020 were defined as 'nadir pandemic'; and surgeries performed from April 6, 2020 through June 28, 2020 were defined as 'restart pandemic' ([Supplementary Fig. S1](#)). States in the USA were distributed into quartiles based on cumulative COVID-19 mortality *per capita* on June 30, 2020 to assess regional COVID-19 severity ([Supplementary Fig. S2](#)).

A total of 618 251 surgeries across 36 MPOG institutions were analysed. The average weekly surgical case volume in the cohort was 35 876 cases per week at baseline during the week of

January 6, 2020 and decreased the week of March 16, 2020, before increasing again the week of April 6, 2020. There was heterogeneity in weekly surgical volume decline from baseline to nadir between institutions, with the most severely affected institution having a 99% decrease from baseline surgical volume and the least severely affected institution having a 49% decrease from baseline surgical volume (Supplementary Fig. S3).

When compared with pre-pandemic surgical patients, nadir pandemic surgical patients tended to be younger (53 [17] yr vs 56 [18] yr, $P < 0.001$), less likely to be outpatient (39.1% vs 57.1%, $P < 0.001$), and more likely to be undergoing emergency surgery (8.8% vs 4.2%, $P < 0.001$) (Table 1). They were more likely to have comorbid conditions, including arrhythmia, coagulopathy, congestive heart failure, hypertension, and renal failure, and had higher 30 day mortality (hazard ratio, 1.75; 95% confidence interval [CI], 1.61–1.93). After adjustment, there was no difference in 30 day surgical mortality during the nadir pandemic period when compared with the pre-pandemic period (hazard ratio, 1.09; 95% CI, 0.77–1.41), nor was there a significant difference between pandemic nadir and restart periods. There was an increase in 30 day surgical mortality at hospitals from COVID-19 regional severity quartiles Q4, Q3, and Q1 during the nadir pandemic period when compared with the pre-pandemic period, with the greatest increase at hospitals in the highest COVID-19 regional severity quartile (30 day surgical mortality hazard ratio, 2.18 [95% CI, 1.94–2.45] in Q4; 1.43 [1.07–1.93] in Q3; 1.13 [0.90–1.43] in Q2; and 1.42 [1.13–1.80] in Q1). After risk adjustment, there was no significant difference in 30 day surgical mortality at hospitals within any of the COVID-19 severity quartiles during the nadir pandemic period when compared with the pre-pandemic period (Supplementary Table S1).

Previous studies have shown worse postoperative outcomes in individual patients with COVID-19 infection,^{5,6} even

in settings with low overall incidence of perioperative COVID-19 infection.^{7,8} However, there has been little evidence on the outcome of patients undergoing surgery during the early phase of the pandemic regardless of the infective status. The lack of association of early pandemic COVID-19 regional severity with adjusted surgical mortality in our study would suggest that despite any health system limitations in perioperative staff, intensive care unit beds, ventilators, medications, testing, or risk of viral transmission, outcomes of patients undergoing surgery were not compromised even in states with the highest COVID-19 severity.

Our study has limitations. Owing to the need to preserve anonymity of the MPOG institutions meeting inclusion criteria of this study, it was not possible to ascertain the COVID-19 mortality rate within individual institutions being studied, or their precise geography; as such, some granularity as to COVID-19 regional severity was compromised by only associating institutional surgical volumes and patient outcomes with national quartiles of COVID-19 mortality rates. COVID-19 severity in this study was evaluated based on June 30, 2020 COVID-19 statistics. It is possible that this assessment of COVID-19 severity does not correlate completely with early COVID-19 regional severity. Furthermore, only mortality was explored as an outcome, whereas other potentially meaningful outcomes (e.g. postoperative infections) were not explored. Although the MPOG consortium includes a mix of private and public hospitals from across the USA, we had an overrepresentation of centres from states most severely impacted. Furthermore, county hospitals might be underrepresented.

To conclude, patients undergoing surgery during the early phase of the pandemic had a greater burden of comorbidities, were more frequently undergoing emergency surgeries and had higher 30 day mortality, with the highest surgical mortality noted at hospitals with highest COVID-19 regional severity.

Table 1 Patient characteristics and outcomes across 36 US hospitals in the pre-pandemic, nadir pandemic, and restart pandemic periods. CI, confidence interval; HR, hazard ratio; sd, standard deviation.

Characteristics	Pre-pandemic (340 505)	Nadir pandemic (38 833)	Nadir vs pre-pandemic P value	Restart pandemic (238 913)	Restart vs pre-pandemic P value
Age, yr (sd)	55.8 (17.3)	53.3 (18.3)	<0.001	54.2 (18.0)	<0.001
Race (%)					
African-American	48 758 (14.3%)	5778 (14.9%)	0.003	35 321 (14.8%)	<0.001
White	247 183 (72.6%)	27 967 (72.0%)	0.02	173 246 (72.5%)	0.51
Other/unknown	44 564 (13.1%)	5088 (13.1%)	0.94	30 346 (12.7%)	<0.001
Sex, female (%)	192 157 (56.4%)	22 384 (57.6%)	<0.001	135 193 (56.6%)	0.27
Outpatient (%)	194 308 (57.1%)	15 195 (39.1%)	<0.001	113 921 (47.7%)	<0.001
Emergency case (%)	14 134 (4.2%)	3399 (8.8%)	<0.001	16 104 (6.7%)	<0.001
ASA physical status					
1–2	161 643 (47.5%)	13 853 (39.6%)	<0.001	104 691 (43.9%)	<0.001
3–5	177 381 (52.1%)	23 166 (59.7%)	<0.001	132 865 (55.6%)	<0.001
Patient comorbidities, number (%)					
Arrhythmia	49 778 (14.6%)	7507 (19.3%)	<0.001	40 620 (17.0%)	<0.001
Coagulopathy	15 521 (4.6%)	2944 (7.6%)	<0.001	15 597 (6.5%)	<0.001
Diabetes mellitus, complicated	13 595 (4.0%)	2181 (5.6%)	<0.001	11 479 (4.8%)	<0.001
Heart failure	23 472 (6.9%)	3640 (9.4%)	<0.001	19 763 (8.3%)	<0.001
Hypertension, complicated	32 370 (9.5%)	5067 (13.0%)	<0.001	26 834 (11.2%)	<0.001
Metastatic cancer	16 723 (4.9%)	3425 (8.8%)	<0.001	14 129 (5.9%)	<0.001
Peripheral vascular disease	20 076 (5.9%)	3211 (8.3%)	<0.001	17 072 (7.1%)	<0.001
Renal failure	28 128 (8.3%)	4461 (11.5%)	<0.001	23 661 (9.9%)	<0.001
30-day mortality (%)	2817 (0.8%)	561 (1.4%)	<0.001	2559 (1.1%)	<0.001
HR unadjusted 30-day mortality (95% CI)	1	1.75 (1.61–1.93)		1.30 (1.23–1.37)	
HR risk-adjusted 30-day mortality (95% CI)	1	1.09 (0.77–1.41)		0.95 (0.74–1.15)	

However, after adjusting for patient risk factors, surgical mortality was not different across regions of varying COVID-19 regional severity, suggesting that this finding was related to an inherently sicker patient population undergoing higher-risk surgeries, rather than impact from regional COVID-19 severity *per se*. Taken together, these findings support that the quality of care and safety of anaesthesia, surgery and perioperative medicine were maintained during the early phase of the pandemic.

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Declarations of interest

The authors declare no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.bja.2021.09.023>.

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Risk stratification of individuals undergoing surgery after COVID-19 recovery

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