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RESEARCH

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Impact of COVID-19 on urgent gastrointestinal surgery outcomes: increased mortality in 2020

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Abstract

Background The COVID-19 pandemic significantly disrupted healthcare systems. In France, non-urgent procedures were postponed, leading to a 52% decrease in elective surgical activity in public hospitals in Paris during the first wave. We aimed to assess the impact on gastro-intestinal emergency surgeries of health strategies implemented during this pandemic.

Methods This multicenter retrospective cohort study enrolled patients from sixteen public hospitals over five periods: March and April, 2018, and 2019 (pre-pandemic), 2020 (first wave), 2021 (third wave), and 2022 (post-pandemic). All adult patients requiring urgent gastrointestinal surgery admitted through the Emergency Department were included. Statistical tests were performed with the chi-square test, ANOVA test, Student test, Kruskall Wallis or Fisher exact test. Univariate and multivariate logistic regression were performed to investigate the relationship between mortality at day 90 and the primary data recorded.

Results 2692 patients' stay were included: 54% male, median age 48 [32;68], 12% ICU admission rate, median Charlson score 2 [0;5], and 6% mortality rate at day 90. The number of abdominal emergency cases decreased during the first wave (− 37% in 2020 compared to 2019). In the multivariate regression model, ICU admission, Charlson comorbidity score, and surgery in 2020 were independently associated with mortality at day 90 (as hospital length of stay, to a lower extent).

Conclusion Undergoing emergency surgery during the first lockdown was an independent mortality risk factor, independent of the COVID-19 infectious status. Whatever major healthcare issue is ongoing, all efforts should be made to maintain healthcare access to all, including urgent surgical procedures.

Trial registration: Not applicable.

Keywords Emergency surgery, Digestive system surgical procedures, COVID-19, Outcome, Epidemiology, Gastrointestinal surgery

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Introduction

The coronavirus disease (COVID-19) pandemic, due to the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was one of the most devastating worldwide crises in recent years. The first French case was diagnosed on January 24th, 2020 [1]. Almost all countries have rapidly reported an overwhelming number of hospitalized patients with substantial use of the Intensive Care Unit (ICU) resources. The number of patients requiring ICU care and mechanical ventilation kept increasing, surpassing France's restricted ICU bed capacity. As such, a prediction model had estimated that, in the worst-case scenario, 22,420 ICU beds would be needed by April 14th, 2020, with 15,940 patients requiring mechanical ventilation [2], while ICU bed capacity was estimated in France at around 5000. Thus, the organization of hospitals has been substantially disrupted during the COVID-19 pandemic to allow management of this overwhelming number of patients with COVID-19.

Non-urgent procedures were postponed. Some medical and paramedical staff and some material equipment were relocated to patients with COVID-19. This led to 52%, 5%, and 15% decreases in elective surgical activity in public hospitals in Paris during the first (March–April 2020), second (November–December 2020), and third (March–April 2021) waves, respectively (https://www.aphp.fr/connaitre-lap-hp/nous-connaitre/rapports-annuels-de-lap-hp) [2]. This strategy was reported in several countries, such as Great Britain, with a 34% reduction in surgical activity in 2020 compared to the predicted number [3]. Little information is available on the effect of COVID-19 on urgent surgical activity. Some have reported lower daily admissions of general surgical patients with higher frailty scores [5], with higher mortality rates in some studies [4, 5].

Although not restricted by governmental measures, this pandemic did impact urgent surgical activity. A reduction of traumatic surgery can be expected due to the diminished road traffic, and thus fewer public road accidents, as well as the general decrease in people's mobility due to confinement, especially during the first wave. However, urgent gastrointestinal surgery should not be affected as the virus or the look-down is not supposed to significantly influence it.

We previously performed a monocentric cohort study, including all adult patients who were admitted through the Emergency Department requiring urgent gastrointestinal surgery [6]. A 51.5% decrease in urgent digestive surgery activity was observed in March–April 2020 compared to March–April 2019. In the multivariate analysis, ICU admission, surgery in 2020, and age, but to a lesser extent, were associated with a fatal outcome 90 days after surgery.

We decided to perform a multicentric study to validate these results and to compare the two most critical periods of the COVID-19 outbreak in Paris and its region, the first and third waves, with a control period before and after the pandemic for comparison. The main objective of our study was to assess the epidemiological modifications of urgent gastrointestinal surgery and its consequences, particularly regarding 90-day mortality.

Material and methods

Data source

This retrospective cohort study used the institutional Clinical Data Warehouse of Greater Paris University Hospitals (Entrepôt de Données de Santé [EDS], https://eds.aphp.fr/). It includes the electronic health record (EHR)-based clinical and administrative data and spans demographic data, diagnoses, and procedures elements from the 39 greater-Paris-area university hospitals (Assistance Publique - Hôpitaux de Paris [AP-HP]). It has been leveraged in numerous prior studies, especially on COVID-19 patients [7–9]. The study was approved by the ethics committee of EDS (IRB00011591). This warehouse has been the subject of CNIL authorization: Deliberation No. 2017–013 of January 19, 2017 authorizing the Assistance Publique – Hôpitaux de Paris to implement automated processing of personal data for the purpose of a health data warehouse, called "EDS". (authorization request No. 1980120). Patients opposed to the use of their data are excluded from the database upstream.

Global surgical activities data were obtained from "Direction Stratégie et Tranformation" from AP-HP. No patient or public were involved in this research.

Study population and case definition

This multicentric retrospective cohort study was conducted over two months from March 1 to April 30, 2018, and 2019 (pre-pandemic), 2020 (first wave), 2021 (third wave), and 2022 (post-pandemic).

Inclusion criteria included adult patients requiring urgent gastrointestinal surgery who were admitted through the Emergency Department in any of the 39 hospitals in the database, 16 of which reported receiving patients. Patients were first identified in the EHR using K00 to K93 codes (diseases of the digestive system) of the International Classification of Diseases (ICD-10) codes (https://icd.who.int/browse10/2019/en) (Supplemental Table 1). Digestive surgical indications were identified through the diagnosis-related groups (DRGs), a method of classifying patients having a similar process of care, including 06CXXX, 07CXXX, 09C081, 09C082, 09C083, 09C084. As previously published, this method of diagnosis-related groups can be used to classify hospitalized patients with a similar care process and a predictable

range of services [10]. Exclusion criteria included patients under 18, an elective surgical intervention, or non-gastrointestinal surgery procedures.

Definition of comorbidities

Subsequent surgery was any new surgery with a gastrointestinal indication that would occur within 90 days after the index admission date. Any other hospital stays within 90 days after the admission date was considered as a subsequent hospitalization.

The hospital and intensive care unit (ICU) length of stay (LOS) was considered from admission to discharge either from the hospital or from the ICU. The comorbidity burden was estimated using the Charlson comorbidity index (Supplemental Table 2) [11, 12]. COVID-19 infectious status (U071 ICD-10 code, Supplemental Table 3) was recorded in the EHR [12].

Outcome criteria

As defined per protocol, the first evaluation criteria was 90 days mortality (following admission date). Secondary criteria included hospital and ICU LOS, ICU stay, and postoperative complications extracted from the HER (Supplemental Table 4) [12]. Sensitivity analyses focused on mortality at hospital, at days 30 and 60.

Statistical analysis

Statistical tests were two-sided, with a 5% type I error rate. Data are presented as median with interquartile range, or as percentages. When applicable, comparisons were performed with the chi-square test, ANOVA test, Student test, Kruskall Wallis or Fisher exact test. Univariate and multivariate logistic regression analyses were used to investigate the relationship between vital status at day 90 and the primary data recorded (for key variables and those with $p < 0.2$). Age was not included because of its collinearity with the Charlson score.). This study was conducted in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement for the reporting of observational studies in epidemiology (http://www.strobe-statement.org/; see Supplemental Table 5). Statistical analyses were performed with R version 4.1.0 software (R foundation, Vienna, Austria) in a JupyterLab remoted environment.

Results

Cohort selection and initial data curation

Inpatient encounters with digestive pathologies and surgeries in EDS with admission dates between August 1, 2017 and September 25, 2023 led to a cohort of 34,492 patients and 35,617 encounters. After restricting to patients admitted in March or April 2018–2022, the subset consisted of 3600 patients and 3628 encounters. With restriction to adult patients above 18 years old, without incomplete data and subsequent hospitalization, the final cohort included 2692 patients' stay (2685 patients) who were the subject of this current analysis (Fig. 1).

17 patients had 2 hospital stays corresponding to inclusion criteria during a single study-period. Among them, after an expert review of ICD-10 codes, 5 stays were considered aberrant and were not included in the analysis, 12 stays with the same surgical indication happened a month after the index stay and were therefore considered as a subsequent surgery. For seven patients, a new stay occurred during a different period than the first stay and were thus considered as a new patient stay.

Center description

During the 5 study periods, 134,554 patients benefited from a surgical procedure in one of 254 operating rooms (ORs) of the 16 centers (Supplemental Tables S6, and S7). Among the centers, 24% of the OR were dedicated to general surgery during weekdays (elective and urgent). Only 6 centers had ORs dedicated to urgent procedures during weekdays (whatever surgical procedures), for a total of 11 ORs. The mean number of surgical rooms opened daily during these periods among all the hospitals involved in this analysis was 250 in 2018, 253 in 2019, 152 in 2020, 209 in 2021, 241 in 2022, and 242 in 2023.

Surgical indications

The number of abdominal emergency cases decreased during the first wave (−27 and −37% in 2020 compared to 2018 and 2019, respectively), with a return to average values (Supplemental Figure S1). Patient characteristics are presented in Table 1 (and in Supplemental Table S8) without any significant change over time except for SARS-CoV-2, death and subsequent hospitalization. Among the cohort, main patients' characteristics are: 54% male, median age 48 [32; 68], 12% ICU admission rate and median Charlson score 2 [0; 5]. The clinical features related to the surgical diagnoses are presented in Table 2, with appendicitis (1121, 42% of stays) and peritonitis and intra-abdominal infections (888, 33% of stays) presenting the two primary surgical indications. No change in the proportion of surgical diagnoses was observed over time (Fig. 2).

Outcome

Mortality rate at day 90 was 6% (3.5% at day 30, and 5% at day 60). There were no differences among the study periods on complications, such as acute kidney failure, acute respiratory failure, acute liver failure, aspiration or bacterial pneumonia, pulmonary embolism (Table 1). The comparison of the clinical and outcome characteristics collected in the 2018 and 2019 cohorts

Table 1 Patients' characteristics and outcome data

	Overall n = 2692	2018 n = 541	2019 n = 624	2020 n = 394	2021 n = 533	2022 n = 600	*P*
Demographic data							
Age, years, median [IQR]	47.9[31.6–67.6]	46.2[30.5–65.5]	47.5[31.4–67]	47.7[31.4–69.2]	52.8[33.3–70.5]	46.7[31.3–67]	0.060§
Charlson score, median [IQR]	2[0–5]	2[0–5]	1[0–4]	2[0–5]	2[0–5]	1[0–5]	0.258§
Male gender, n (%)	1461(54.3%)	301(55.6%)	361(57.9%)	201(51%)	286(53.7%)	312(52%)	0.151°
SARS-CoV-2 positive, n (%)	84(3.1%)			15(3.8%)	37(6.9%)	32(5.3%)	0.000°
Post-operative complications							
ICU admission, n (%)	331(12.3%)	69(12.8%)	75(12%)	60(15.2%)	66(12.4%)	61(10.2%)	0.203°
ICU LOS, days, median [IQR]	0.8[0.5–2.5]	0.8[0.5–3.7]	0.9[0.6–3.6]	0.7[0.5–1]	0.8[0.5–1.1]	0.8[0.6–2.7]	0.770§
Acute kidney failure, n (%)	180(6.7%)	38(7%)	39(6.2%)	28(7.1%)	39(7.3%)	36(6%)	0.875°
Acute respiratory failure, n (%)	135(5%)	29(5.4%)	36(5.8%)	22(5.6%)	27(5.1%)	21(3.5%)	0.359°
Bacterial pneumonia, n (%)	60(2.2%)	15(2.8%)	15(2.4%)	8(2%)	11(2.1%)	11(1.8%)	0.864°
Aspiration pneumonia, n (%)	67(2.5%)	12(2.2%)	13(2.1%)	13(3.3%)	14(2.6%)	15(2.5%)	0.781°
Acute liver failure, n (%)	22(0.8%)	5(0.9%)	2(0.3%)	5(1.3%)	5(0.9%)	5(0.8%)	0.458*
Pulmonary embolism, n (%)	24(0.9%)	3(0.6%)	4(0.6%)	8(2%)	4(0.8%)	5(0.8%)	0.207*
LOS, days, median [IQR]	3.9[1.7–9.6]	3.8[1.8–9.8]	4[1.8–9.8]	3.7[1.6–10.1]	4.2[1.7–9.6]	3.8[1.6–8.6]	0.269§
Subsequent surgery, n (%)	133(4.9%)	19(3.5%)	25(4%)	19(4.8%)	28(5.3%)	42(7%)	0.063°
Subsequent hospitalization, n (%)	419(15.6%)	78(14.4%)	84(13.5%)	52(13.2%)	92(17.3%)	113(18.8%)	0.039°
Death at day 90, n (%)	157(5.8%)	32(5.9%)	26(4.2%)	40(10.2%)	26(4.9%)	33(5.5%)	0.005°

Results are expressed as n (%) or median [IQR]

LOS, Length of Stay; ICU, Intensive Care Unit

*Fisher's exact test; § Anova; °Khi-2 test

did not show any difference between the two populations (Supplemental Table S9). Interestingly, in the multivariate regression model, ICU admission, and Charlson comorbidity score were independently associated with mortality at day 90 (such as hospital LOS, but to a lower extent) (Table 3). Being operated in 2020 was independently associated with mortality at day 90 compared to 2019, 2021, and 2022 (Table 3) (same results in the sensitivity analysis, presented in Supplemental Tables S10, S11, and S12).

Discussion

This study provides an extensive overview of urgent general surgery activities in the Parisian region over six years, focusing on the COVID-19 pandemic's consequences on surgery types and patients' outcomes. We report a reduction of 230 (37%) and 91 (15%) procedures in gastrointestinal urgent surgical procedures during the first and third COVID-19-related lockdowns compared to 2019 as a control, respectively. In this large dataset, including 2692 patients' stay (among 2685 patients), the postoperative mortality was independently associated with the year 2020 as the year of the surgical procedure, with the Charlson comorbidity score, and ICU admission, independently of the COVID-19 infectious status.

COVID-19 consequences on elective surgeries

During COVID-19-related lockdowns, several strategies were implemented to ensure optimal surgical care to those who needed it and to avoid postoperative ICU surveillance to optimize healthcare resources. Elective surgeries were postponed, and whenever possible, malignant tumors were treated with systemic treatments. The COVIDsurg collaborative identified in an international prospective cohort that one in seven patients in regions with full lockdowns did not undergo their planned cancer surgery. Others experienced might have even experienced longer preoperative delays [13].

The other reason supporting the non-urgent surgery postponement was the increased postoperative complications rate identified in COVID-19-positive patients. The COVIDsurg collaborative reported in May 2020 a 30-day mortality rate of 24% in more than 1100 COVID-19 patients after elective (74%) and urgent (26%) surgeries [14]. Among other factors, 30-day mortality was strongly associated with male gender, age above 70, American Society of Anesthesiologists (ASA) grades 3–5 versus grades 1–2, and emergency versus elective surgery [14]. This was also reported with twofold and tenfold increased mortality rates after any elective digestive resections for asymptomatic and symptomatic COVID-19 infections, respectively [12].

Table 2 Main clinical features related to the surgical diagnoses

	Appendicitis (n = 1121)	Peritonitis and intra-abdominal infections (n = 888)	Occlusion (n = 713)	Parietal hernias (n = 323)	Anal and perianal diseases (n = 277)	Malignant digestive tumors (n = 134)	Sigmoid and inflammatory bowel diseases (n = 101)	Gastro-duodenal ulcer (n = 93)	Vascular intestinal diseases (n = 69)	Haemoperitoneum and digestive haemorrhage (n = 56)
Age, years, median [IQR]	33[26–47]	48[31–65]	67[51–81]	66[49–80]	39[30–54]	71[60–81]	61[40–76]	57[45–66]	75[59–80]	61[37–73]
Charlson Score, median [IQR]	0[0–1]	2[0–5]	52–7]	4[2–6]	1[0–3]	9[6–12]	3[1–6]	4[2–6]	7[5–8]	4[0–8]
Male gender, n (%)	628(56)	511(58)	322(45)	173(54)	185(67)	77(57)	60(59)	68(73)	33(48)	56
SARS-CoV-2 positive, n (%)	25(2)	31(3)	23(3)	12(4)	11(4)	7(5)	3(3)	6(6)	3(4)	4(7)
LOS, days, median [IQR]	2[1–4]	6[3–13]	7[4–14]	4[2–7]	2[1–4]	18[9–30]	15[10–24]	9[6–18]	15[5–34]	10[3–26]
ICU admission, n (%)	10(1)	160(18)	118(17)	28(9)	12(4)	40(30)	28(28)	31(33)	45(65)	28(50)
Subsequent surgery, n (%)	9(1)	57(6)	34(5)	10(3)	26(9)	8(6)	26(26)	3(3)	14(20)	3(5)
Subsequent hospital stay, n (%)	86(8)	152(17)	139(19)	49(15)	41(15)	45(34)	40(40)	12(13)	22(32)	8(14)
Death, n (%)	2(0)	66(7)	64(9)	16(5)	4(1)	23(17)	8(8)	11(12)	28(41)	8(14)
Post-operative complications										
Acute renal failure, n (%)	5(0)	95(11)	71(10)	17(5)	4(1)	23(17)	10(10)	18(19)	31(45)	8(14)
Acute respiratory failure, n (%)	4(0)	73(8)	50(7)	9(3)	3(1)	12(9)	11(11)	13(14)	18(26)	8(14)
Bacterial pneumonia, n (%)	2(0)	31(3)	21(3)	7(2)	2(1)	8(6)	4(4)	7(8)	11(16)	9(16)
Aspiration pneumonia, n (%)	1(0)	18(2)	46(6)	8(2)	1(0)	9(7)	2(2)	2(2)	5(7)	1(2)
Acute hepatic failure, n (%)	1(0)	10(1)	8(1)	2(1)		4(3)	2(2)	2(2)	7(10)	1(2)
Pulmonary embolism, n (%)	1(0)	14(2)	5(1)	3(1)		4(3)	1(1)	3(3)	1(1)	2(4)
Study period										
2018, n (%)	224(20)	193(22)	134(19)	64(20)	68(25)	22(16)	20(20)	23(25)	14(20)	12(21)
2019, n (%)	277(25)	243(27)	143(20)	62(19)	71(26)	25(19)	27(27)	20(22)	13(19)	9(16)
2020, n (%)	161(14)	109(12)	112(16)	42(13)	38(14)	24(18)	12(12)	11(12)	15(22)	16(29)

Table 2 (continued)

	Appendicitis (n = 1121)	Peritonitis and intra-abdominal infections (n = 888)	Occlusion (n = 713)	Parietal hernias (n = 323)	Anal and perianal diseases (n = 277)	Malignant digestive tumors (n = 134)	Sigmoid and inflammatory bowel diseases (n = 101)	Gastro-duodenal ulcer (n = 93)	Vascular intestinal diseases (n = 69)	Haemoperitoneum and digestive haemorrhage (n = 56)
2021, n (%)	208(19)	168(19)	159(22)	89(28)	41(15)	31(23)	20(20)	21(23)	14(20)	9(16)
2022, n (%)	251(22)	175(20)	165(23)	66(20)	59(21)	32(24)	22(22)	18(19)	13(19)	10(18)

Results are expressed as n (%) or median [IQR]

1601 visits had one diagnosis code, 1040 visits had two diagnosis codes and 51 had more than two diagnosis codes

Table 3 Univariate and multivariate logistic regression (for key variables and variables with $p < 0.2$)

	Outcome 90 days after surgery		Univariate (n = 2692)			Multivariate (n = 2692)		
	Alive	Deceased	OR	CI	*P*	OR	CI	*P*
Charlson score (n = 2692)	1[0–4]	8[6–12]	1.4	1.3–1.4	$< 10^{-3}$	1.4	1.3–1.4	$< 10^{-3}$
Male gender (n = 1461)	1381(54.5%)	80(51.0%)	0.9	0.6–1.2	0.390	0.7	0.5–1.1	0.092
ICU admission (n = 331)	240(9.5%)	91(58.0%)	13.2	9.4–18.6	$< 10^{-3}$	6.9	4.6–10.4	$< 10^{-3}$
SARS-CoV-2 positive (n = 184)	74(2.9%)	10(6.4%)	2.3	1.1–4.3	0.019	1.2	0.5–2.8	0.638
LOS, days (n = 2692)	3.76[1.7–8.8]	11.59[3.5–29.5]	1.0	1.0–1.0	$< 10^{-3}$	1.0	1.0–1.0	0.039
Year of surgery								
2018 (n = 541)	509(20.1%)	32(20.4%)	0.6	0.3–0.9	0.018	0.6	0.4–1.2	0.134
2019 (n = 624)	598(23.6%)	26(16.6%)	0.4	0.2–0.6	< 10–3	0.4	0.2–0.7	0.001
2020 (n = 394)	354(14.0%)	40(25.5%)		–	–		–	–
2021 (n = 533)	507(20%)	26(16.6%)	0.5	0.3–0.8	0.002	0.4	0.2–0.8	0.009
2022 (n = 600)	567(22.4%)	33(21.0%)	0.5	0.3–0.8	0.007	0.5	0.3–1.0	0.040

Results are expressed as n (%) or median [IQR]

COVID-19 consequences on urgent surgeries

Many national and international guidelines raised recommendations on elective surgeries during the COVID-19 pandemic, primarily because of anaesthesiologist and nursing staff reallocation. However, no restriction was expected on urgent procedures, except for the surgeries that could be postponed after antibiotic treatment, such as cholecystitis—this paralleled cancer patients who received higher neoadjuvant treatment during the lockdown period [12]. We have been able to analyse the hospitalizations' monthly incidence for urgent visceral surgeries among the public Parisian hospitals, between August 2017 and June 2023 indicating a sharp decrease in March–April 2020 (Supplemental Figure S1).

Few studies have been published on urgent surgical procedures, epidemiology, and outcomes during the COVID-19 pandemic. Based on a French national database from March 17 to May 11, 2020, and the equivalent period in 2019, a 20.9% reduction in hospital admissions rate for acute surgical conditions was reported, with differences varying primarily based on COVID-19 prevalence [15]. Patients' mortality rate was significantly increased (OR 1.22, 95%CI 1.06 to 1.40) in high-COVID-19 prevalence regions [15]. In a retrospective study in Vietnam, Nguyen et al. considered the all-year period (2019–2020–2021), with the significant wave being 2021 in Vietnam. This study revealed in 2021 a decreased number of appendicitis, with a higher incidence of complicated acute appendicectomy, without any difference in patients' outcomes [16]. Identical results were reported in Latvia, although the period of interest was different because of the virus circulation differences worldwide [17]. Only the Netherlands reported no differences in acute appendicitis numbers during COVID-19 outbreaks [18]. In a nationwide German cohort, a 9.7% decrease in hospitalizations for acute mesenteric ischemia was reported during their first COVID-19 wave in spring 2020 [19]. From a national perspective, this decrease is intriguing as the hypothesis of people delocalization could not be raised and because no lockdown should influence the occurrence of acute mesenteric ischemia. For diverticulitis, a national EHR-based retrospective analysis in Germany reported an overall decrease in admission rates, with higher conservative treatment during lockdowns (70.7% versus 66.9%). When patients required surgical treatment for diverticulitis, higher rates of ostomy, surgical revision, and in-hospital mortality were reported during the two country lockdowns [20]. This study was initially motivated by the clinical feeling from surgeons and anaesthesiologists that, during lockdowns, patients were reluctant to come to the hospital, resulting in an increased delay from symptom onset to hospital presentation [21, 22] and in patients' severity. While this result was reported in our previous monocentric analysis [6], we could confirm in the multivariate analysis in this sizeable multicentric study that urgent digestive surgery performed during March or April 2020 was associated with an increased 90-day mortality rate compared to other years. These results should be considered during future lockdowns with appropriate communication dedicated to the population to avoid scary messages preventing all patients from going to the hospital. The message should be delivered that whenever a patient requires urgent health care, the hospital can welcome them and take care of all patients, whether they are infected by the emerging disease occurring or not.

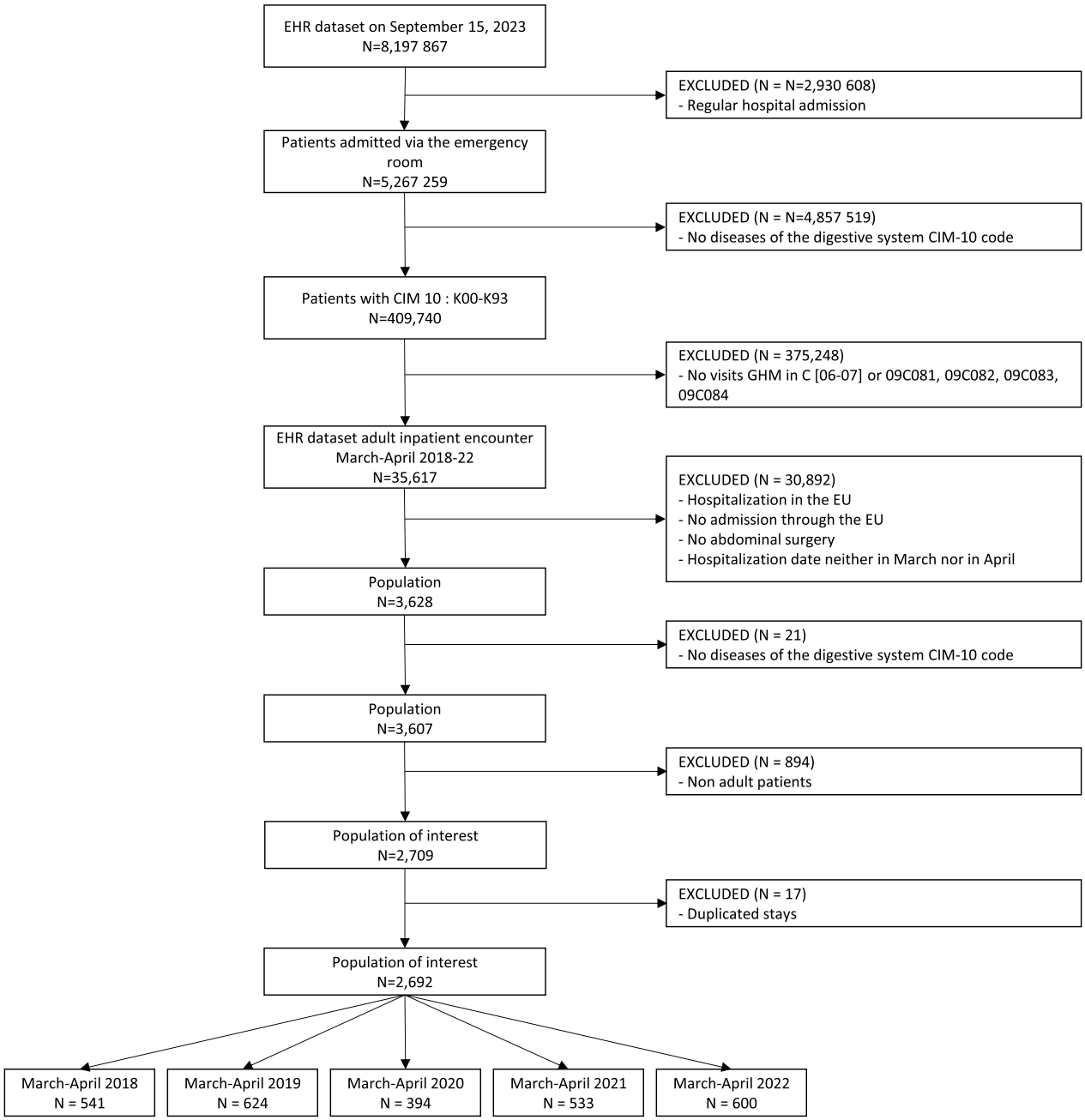

Fig. 1 Case selection flowchart. EU, emergency unit

Surgical procedures types

In France, a 12% decrease in surgical activity for malignant liver tumors was identified, with fewer patients benefiting from a surgical approach compared to control years, without any difference in morbidity and mortality over the periods [23]. A similar reduction activity was also reported for otorhinolaryngology surgeries (10.9%) without any outcome differences [2]. In a French nationwide retrospective analysis comparing hospital admissions from March 17 to May 11 (the first lockdown) in 2020 and 2019 (as the control period), an overall reduction of 37% in elective digestive resections surgical activity was reported, without any difference in mortality rate [12].

During the five-year study period, the proportions of surgical procedures remained stable compared to each other. Acute appendicitis represented the most frequent diagnosis requiring surgery in our study. The reduction

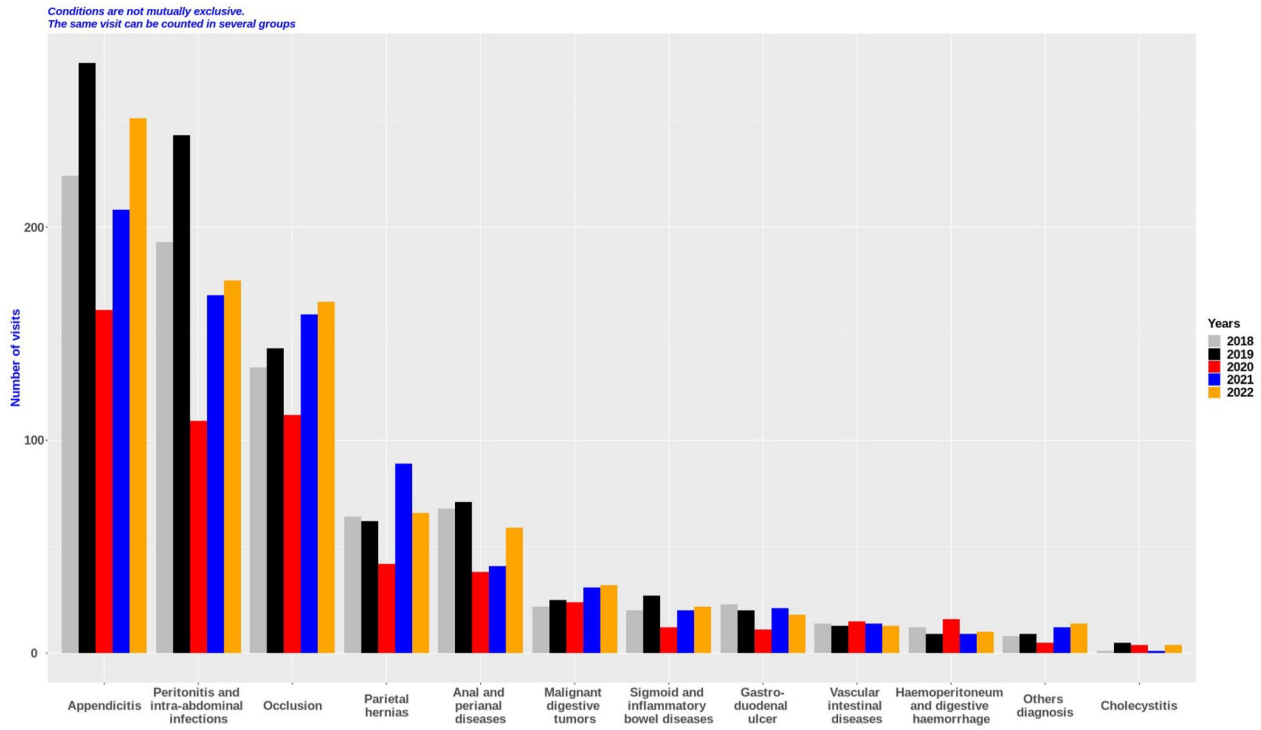

Fig. 2 Surgery type distribution among the study periods

during the first lockdown (March–April 200) might be related to people relocation, which reason could not be raised for March–April 2021, where no lockdown was required. As previously stated, the reduction in cholecystectomies performed in 2020 might be linked to dietary changes and the broader use of antibiotics [24]. A significantly increased incidence of gastrointestinal cancer causing obstruction following the 2020 lockdown had been reported because of delays in presentation, difficulties in accessing general practice, less availability of cancer screening during the pandemic, or a fear of the hospital [25]. In our cohort, while 16%, 19% and 18% of stays are related to an urgent surgical procedure for malignant digestive tumors respectively in 2018, 2019 and 2020. This proportion increased to 23% and 24% in 2021 and 2022. These results must constitute a warning for healthcare professionals and the healthcare system to continue early cancer detection efforts and ensure regular access to general practitioners.

Our study has several limitations, mainly related to its design. The retrospective use of the EHR enabled us to analyze an essential cohort of patients but prevented us from including other data that could have been of importance in this analysis. The PMSI database is mandatory in all hospitals in France and thus provides a global picture of surgical activity. However, it is not connected to the patient data software and contains no clinical data and few biological data or procedure codes. Although all hospital stays are supposed to be made available in the EDS, incomplete data returns cannot be ruled out. Notifications of deaths of patients outside hospitals may sometimes be delayed. COVID-19 infection status is reliable, but only once routine testing became available in all hospitals and are not date-stamped. We are thus unable to assess if the infection occurred before or after the surgical procedure. For the same reason, we could not retrieve the patients' ASA scores. Instead, we used the Charlson comorbidity index. The PMSI database was provided to us unnamed and did not provide the cause of death. We were thus unable to analyze patients' charts to retrieve additional information, such as delay from symptom onset to hospital presentation, severity at admission, and other nonsurgical approaches tested before the surgery.

Conclusion

This study is the first to report an extensive overview of urgent digestive surgical procedures and the patients' outcomes during different COVID-19 waves and over consecutive years. Undergoing surgery during the first lockdown was an independent mortality risk factor, independent of the COVID-19 infectious status. During the first and third waves of the COVID-19 pandemic in

the Parisian region, a reduction of one third in urgent gastrointestinal surgery activity was observed, with an increased rate of bowel obstruction or perforation due to intestinal cancer. These findings support that, whatever major healthcare issue is ongoing, all efforts should be made to maintain healthcare access to all who need it, especially for urgent surgical procedures and cancer diagnosis and treatment.

Abbreviations

AP-HP	Assistance Publique - Hôpitaux de Paris
COVID-19	Coronavirus disease
EDS	Clinical Data Warehouse of Greater Paris University Hospitals (Entrepôt de Données de Santé)
EHR	Electronic Health Record
ICU	Intensive Care Unit
LOS	Length of Stay
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
OR	Operating Room

Supplementary Information

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Additional file 1.

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Author contributions
AGC, PM, and AD designed the study protocol. AGC and AD were in charge of the submission to the EHR committee. SS and KS performed the data management and the statistical analysis, which was reviewed by AGC, PM, and AD. AGC and PM wrote the first draft of the manuscript. AD, SS, and KS amended it. All authors approved the final version of the manuscript. All authors fulfill the ICJME criteria for authorship.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Competing interests
All authors have completed the ICMJE uniform disclosure form at www.icmje.org/disclosure-of-interest/. The authors declare no financial relationships with any organizations that might have had an interest in the submitted work in the previous three years; no other relationships or activities could appear to have influenced the submitted work.

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