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St Andrew's COVID-19 surgery safety (StACS) study: Elective plastic surgery, trauma & burns

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Summary *Introduction:* This study evaluates COVID-19 related patient risk, when undergoing management within one of the largest specialist centres in Europe, which rapidly implemented national COVID-19 safety guidelines.

Method: A prospective cohort study was undertaken in all patients who underwent surgical ($n = 1429$) or non-operative ($n = 191$) management during the UK COVID-19 pandemic peak (April–May 2020); all were evaluated for 30-day COVID-19 related death. A representative sample of elective/trauma/burns patients (surgery group, $n = 729$) were selected and also sub-analysed within a controlled cohort study design. Comparison was made to a random selection of non-operatively managed (non-operative group, $n = 100$) or waiting list (control group, $n = 250$) patients. These groups were prospectively followed-up and telephoned from the end of June (control group) or at 30 days post-first assessment (non-operative group)/post-operatively (surgery group).

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Results: Complex general (9.2%, 136/1483) or regional (5.0%, 74/1483) anaesthesia cases represented 14.2% (210/1483) of operations undertaken. There were no 30-day post-operative (0/1429)/first assessment (0/191) COVID-19 related deaths. Neither the three sub-speciality plastic surgery, or non-operative groups, displayed increases in post-operative/first assessment symptoms in comparison to each other, or to control. The proportion of COVID-19 positive tests were: 7.1% (1/14) (non-operative), 5.9% (2/34) (burns) and 3.0% (3/99) (trauma); there were however no significant differences between these groups, the elective (0%, 0/54) and control (0%, 0/24) groups ($p=0.236$).

Conclusion: We demonstrate that even heterogeneous sub-speciality patient groups, who required operative/non-operative management, did not incur an increased COVID-19 risk compared to each other or to control. These highly encouraging results were achieved with described, rapidly implemented service changes that were tailored to protect each patient group and staff.

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Introduction

Great challenges have been faced by hospital services worldwide during the COVID-19 pandemic.¹ On 31 December 2019, the World Health Organization (WHO) received the first report of a cluster of pneumonia cases of unknown aetiology, in Wuhan City, Hubei Province of China.² They subsequently reported the first novel coronavirus case in Thailand on 13 January 2020, in a traveller from Wuhan who had been hospitalised on 8 January 2020.² By 30 January 2020, 7818 cases had been confirmed worldwide, with 82 of these reported in 18 countries outside of China.³ With further global disease spread, a pandemic was officially declared by the WHO on 11 March 2020; at the time of writing (July 2020), there have been over 680,000 deaths and over 17.5 million confirmed COVID-19 cases reported.⁴

While long-term data are required to improve the interpretable accuracy of reported statistics, the COVID-19 clinical spectrum ranges from asymptomatic to critically ill, with the majority of patients presenting with mild symptoms and a good prognosis.^{5,6} However, up to 15% of patients may develop pneumonia, acute respiratory distress syndrome (ARDS), cardiac injury, renal injury, or multi-organ failure around 7-10 days after hospitalisation; a subset of these patients will require intensive care unit (ICU) admission for life-supporting treatment such as invasive ventilation or extracorporeal membrane oxygenation.^{5,6} In studies of hospitalised patients that originate from the Hubei province of China, ICU admission rates of up to 32%, non-invasive ventilation requirements in up to 24% and intubation requirements of up to 12% have been reported.⁷⁻⁹ After ICU admission, the percentage of fatalities range from 20% to 62% depending on how critically ill patients become.^{10,11} In terms of surgery, an international multicentre cohort study of 1128 patients who underwent either emergency (74.0%) or elective (24.8%) operations confirmed SARS-Cov-2 infection pre-operatively in 26.1% (294/1128) and a 30 day mortality of 21.1% (62/294).¹²

As a result of these early findings, a prolonged period of healthcare and economic instability continues to present significant challenges to surgical services worldwide, with many healthcare systems having been largely unprepared for the scale of the pandemic; adaptation is vital to en-

sure that a successful recovery restores high-quality healthcare service provision.¹³⁻¹⁵ There has therefore been a requirement for National Health Service (NHS) Plastic Surgery, Trauma and Burns Centres to rapidly adapt to evolving guidelines, while maintaining crucial cancer, trauma and burns services for patients.¹⁶ As a result, NHS-endorsed intercollegiate COVID-19 guidelines have been published, which prioritise patients who require surgery according to 4 levels (Table 1).¹⁷

AIM

St Andrew's Centre for Plastic Surgery & Burns is amongst the largest of specialist centres in Europe; in 2019, there were 23,966 new tertiary referrals, with 13,845 operations undertaken for patients (Figure 1). The UK has been amongst the worst-affected countries by COVID-19; at the end of this study period (June 2020), there were approximately 280,000 confirmed cases and 44,000 deaths since the UK outbreak in March 2020.⁴ The primary aim of the StACS study is to prospectively evaluate patient safety during the UK COVID-19 pandemic peak; in particular, the purpose is to evaluate the COVID-19 related risk to patients, when undergoing management within a tertiary referral centre that rapidly implemented significant service safety adaptations according to national guidelines.¹⁷⁻²⁰ Secondary aims include investigating any risk differences between non-operative and operative management.

Method

A prospective cohort study was undertaken, using STROBE guidelines, in general plastic surgery, trauma and burns patients who underwent management during the UK COVID-19 pandemic peak (April-May 2020); Clinical Governance Board approval was granted (CA20-012).²¹ Patients were prospectively registered on the Centre's electronic database, and 'real-time' 30-day deceased data were collected from the hospital database; this updates in line with local and national registration information.

Table 1 Overview of Plastic Surgery & Burns NHS Intercollegiate Guidelines for Surgical Prioritisation During the Coronavirus Pandemic.¹⁷

Level	Prioritisation Time	Example Cases
1a	Emergency <24h	Major Burns, Chemical Burns, Revascularisation / Replant, Open Fracture, Contaminated Wound, Necrotising Fasciitis, Soft Tissue Infection, Infected Prosthesis Removal.
1b	Urgent <72h	Burns for Resuscitation / Debridement / High Infection Risk, Tendon & Nerve Repair, Fracture Fixation, Finger Tip / Nail Bed Repairs / Terminalisation, Major Limb Trauma Reconstruction, Soft Tissue Infection, Delayed Primary Wound Closure.
2	Can Defer ≤4 Weeks	Unhealed Burns, Burns Reconstruction for Severe Eyelid Closure Problems / Microstomia / Joint & Neck Contracture, Prosthesis Removal when Unresponsive to Conservative Treatment, Major Soft Tissue Tumour Resection, Melanoma, Poorly Differentiated Cancer / Nodal Disease.
3	Can Delay ≤3 Months	Burns Reconstruction for Non-Severe Eyelid Closure Problems / Microstomia / Joint & Neck Contracture, Limb Contractures.
4	Can Delay >3 Months	Other Burn Contractures / Scars, Limb Trauma Sequelae e.g. Scarring / Reconstruction, Breast Reconstruction, Cleft Lip & Palate Surgery, BCC Without Vital Structure Compromise, Benign Lesions.

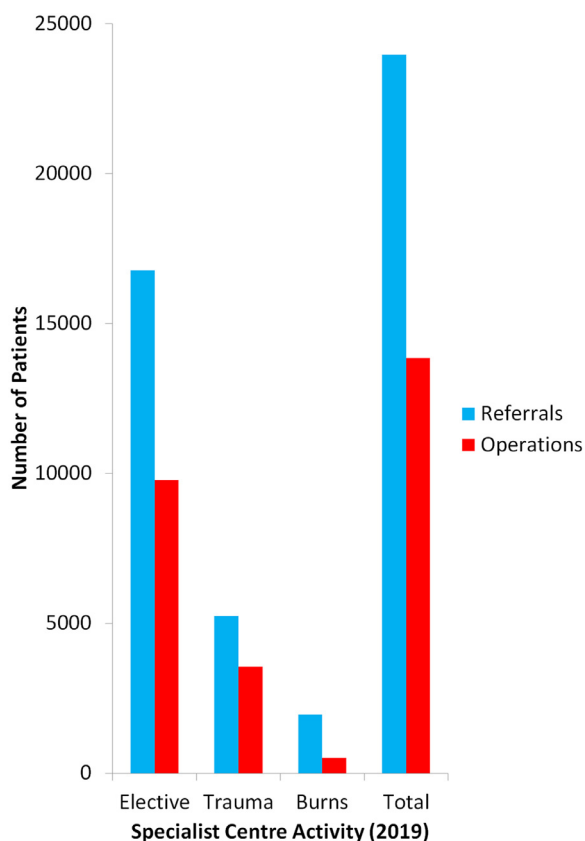


Figure 1 Specialist Centre Activity (2019). There were 23,966 new tertiary referrals, and 13,845 operations performed between January and December 2019. There were 16,767 elective, 5240 trauma and 1959 new burns referrals. There were 9775 elective, 3556 trauma and 514 burns operations performed for patients.

Furthermore, random selection was undertaken for patients who were still on the waiting list during the UK pandemic peak and did not have hospital contact during this time (control group), and for patients who had non-

operative management for trauma (non-operative group). A third group (surgery group) comprised a 50% random selection of sub-speciality patients who underwent elective plastic surgery or trauma operations, as well as 39 burns inpatients. These three groups were prospectively followed up within a controlled cohort study design and telephoned from the end of June (control group), at 30 days post first intervention (non-operative group) or at 30 days post-operatively (surgery group). Sub-analysis of the three sub-specialties was also undertaken. Demographic data and clinical outcomes were recorded as patients progressed through treatment; details of the various pathways, created specifically to address the COVID-19-related risk posed to patients, are outlined below. Data relating to service and treatment outcome satisfaction, in-hospital or virtual clinic attendance numbers, details regarding pre- and post-operative contact with COVID-19 positive individuals, isolation status, COVID-19 symptoms, formal testing, post-operative hospital/ICU admissions, and ventilation requirements, were collected.

Data were analysed using SPSS.¹¹ Shapiro-Wilk's test was performed to assess normal distribution. Parametric data were reported as means (standard deviation) and non-parametric data as medians (interquartile range). Categorical variables, in two or multiple group settings, were analysed using the Chi² test (Fisher test for expected numbers <5), with multiple group comparisons undergoing post-hoc analysis. For continuous variables, parametric data were compared with the *t*-test (two groups) or ANOVA (multiple groups), with the latter undergoing post-hoc analysis. Non-parametric data were compared with the Mann-Whitney U test (two groups) or the Kruskal-Wallis H test (multiple groups). Significance was set at $p < 0.05$. Whenever normally distributed data did not meet the assumptions required for the selected parametric test, the nonparametric test equivalent was used. Whenever post-hoc analysis was performed, a Bonferroni correction was applied to reduce type 1 error. Therefore, a significant test for all groups considered together did not necessarily translate to a significant test between two specific groups.

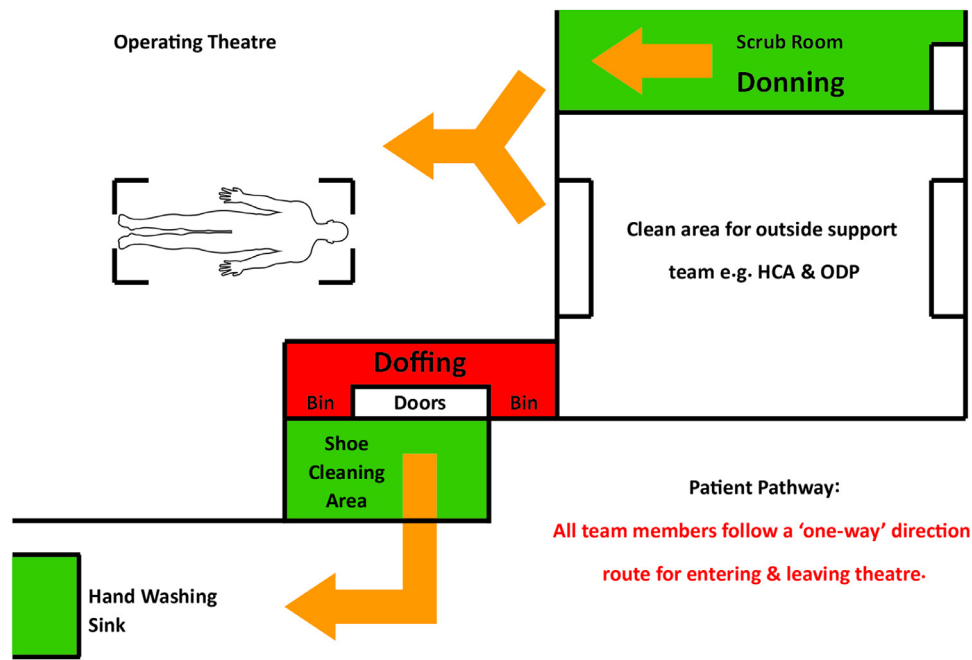


Figure 2 One-way traffic operating pathway. Arrows indicate the direction of flow through theatre, for both patients and staff. HCA = Health Care Assistant; ODP = Operating Department Practitioner.

Generic service adaptations

All face-to-face consultations were undertaken using surgical masks, gloves and gowns; virtual follow-up clinics were also set-up within Broomfield Hospital. Waiting room measures were implemented to facilitate strict social distancing (>2 metres between patients). During consultation and surgery, COVID-19 suspected/confirmed patients, and those undergoing high risk procedures, were attended by healthcare professionals wearing filtering face piece level 3 (FFP3) masks and eye protection. Patients undergoing elective operations were asked to isolate for 2 weeks prior to, and 1 week after, their surgery date; on the day of surgery, patients were required to be asymptomatic and with a temperature <37.8 °C. High-risk operations were classified as those likely to generate aerosol or droplets; these included all general anaesthetic (GA), head and neck, burns and high-speed instrumentation procedures, e.g. bone drilling or Kirschner wire insertion. All high-risk operations were undertaken using a robust 'one-way traffic' operating pathway to minimise cross-contamination risk, with 20 min of 'theatre downtime' between patients (Figure 2); induction and extubation were performed 'on-table', and theatre teams adhered to strict hand washing, donning/doffing and shoe-cleaning instructions.

Elective surgery

Two private satellite hospitals were designated for asymptomatic local anaesthetic (LA) elective cases, which were predominantly skin cancer related. Patients with pacemakers, sedation or GA requirements, were allocated operative slots at the beginning of the Broomfield Hospital trauma

list; this facilitated relevant speciality support and anaesthetic team access. Both satellite hospitals had dressing clinics on-site, with one also having new and follow-up outpatient facilities. Patients were allocated face-to-face or virtual clinic follow-up appointments according to clinical need. In terms of complex head and neck surgery resection/reconstruction, all patients had COVID-19 throat swabs at 72 h and 24 h pre-operatively, with additional chest computed tomography (CT) at 24 h pre-operatively. Only patients with negative tests subsequently received operations; these were undertaken in a 'COVID-clean' operating theatre, with 'COVID-clean' post-operative recovery, high-dependency unit and side room tracheostomy nursing as appropriate.

Trauma

Significant service adaptations were implemented according to published joint national trauma guidelines; a fully integrated hand trauma service was implemented, as the case mix was predominantly hand trauma related.²⁰ Same or next day, day-case emergency operating was implemented for complex injuries. There was a 'one-stop' streamlined care model from triage, through to assessment, treatment and discharge, with only minimal face-to-face follow up as required.²⁰ Where possible, non-operative management was preferred, otherwise LA or regional anaesthetic (RA) techniques were employed; GA procedures were undertaken if necessary.²⁰ Additional outpatient and minor operations areas were identified for manipulations or procedures, with mini C-arm access; where possible, remote video/telephone appointments were undertaken.²⁰

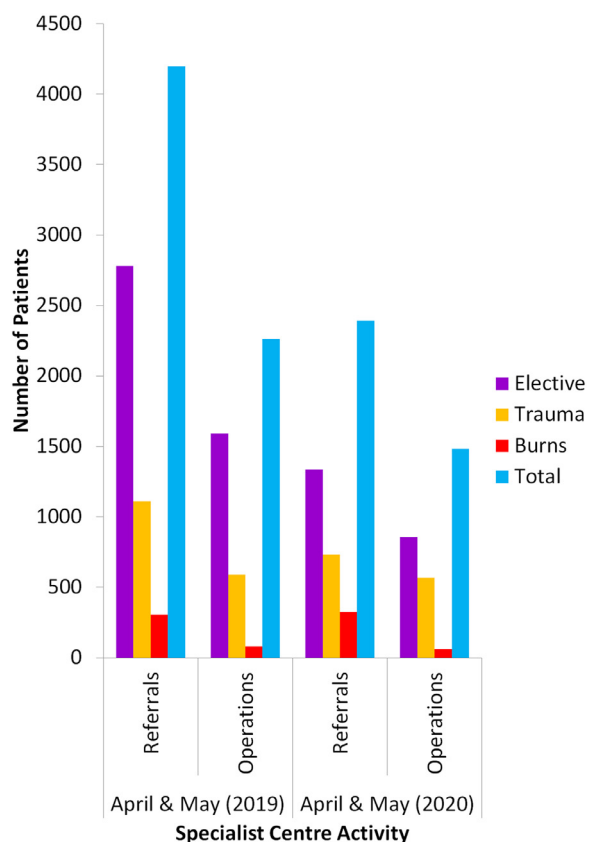


Figure 3 Specialist centre activity during the COVID-19 UK pandemic peak (April-May 2020) and previous year (April-May 2019). A total of 2391 referrals, and 1482 operations were performed during the UK pandemic peak (April-May 2020); this represented a decrease by 43% in referrals (4196) and by 34% in performed operations (2262) compared to the previous year (April-May 2019). There were 1337 elective, 731 trauma and 323 burns referrals during April-May 2020, versus 2780 elective, 1112 trauma and 304 burns referrals during April-May 2019. There were 855 elective, 566 trauma and 61 burns operations performed during April-May 2020, versus 1592 elective, 589 trauma and 81 burns operations performed during April-May 2019.

Burns

Where appropriate, patients were given the option of dressing their own wounds at home, and emailing photos for immediate assessment; this minimised patient risk by removing face-to-face in-hospital contact. Inpatients received COVID-19 swabs on admission, then every 5 days following. In addition to 'on-table' induction and extubation, patients were recovered in theatre; ICU patients were recovered in ICU.

Results

There were 2391 new referrals and 1483 operations undertaken for 1429 patients (April-May 2020) (Figure 3); this represented a 43% decrease in new referrals, and a 34% decrease in operations performed, compared to the previ-

ous year (April-May 2019) (Figure 3). Complex cases requiring GA (9.2%, 136/1483) or RA (5.0%, 74/1483), represented 14.2% (210/1483) of the total operations undertaken; these included trauma (7.1%, 106/1483), burns (4.1%, 61/1483), skin cancer resection/reconstruction/lymphadenectomy (1.2%, 18/1483), elective hand surgery (2.0% 29/1483) and breast/head and neck cancer resection/reconstruction (0.4%, 6/1483). The 30 day COVID-related post-operative and 30 day post-first assessment death rates were 0% (0/1429) and 0% (0/191) respectively.

For the controlled cohort study design, the surgery group comprised a 50% random sample of operated elective plastic surgery ($n=420$) and trauma ($n=270$) patients, who were all successfully telephone-contacted at 30 days post-operatively; as there were only 51 operated burns inpatients during the study period, all were telephoned, 76% (39/51) were contactable and therefore also included within the surgery group (Table 2). A random sample of 100/191 trauma patients who received non-operative treatment including dressings/hand therapy (non-operative group) and 250 patients who were on the elective waiting list during the study period (control group) were also included (Table 2).

Full data for all three controlled cohort study groups are presented (Table 2). All three groups were well matched for ethnicity ($p=0.283$) and BMI ($p=0.276$). While the surgery (58.15 ± 22.76) and control (59.01 ± 23.49) groups were well matched for mean age, the non-operative group mean age was lower (50.14 ± 17.11) ($p<0.05$); however, as these mean ages all fall within the 50-60 years range, they remain 'similar' in real terms. The non-operative and surgery groups were also well matched for pre-operative/first assessment symptoms (1%, 1/100 vs. 3.4%, 25/729; $p=0.191$); however, more patients in the surgery group were able to isolate pre-operatively (45.8%, 334/729 vs. 18.0%, 18/100; $p<0.001$) due to a greater proportion of elective cases. While the surgery and control groups were well matched for comorbidities (53.8%, 392/729 vs. 57.6%, 144/250) and smoking (12.3%, 90/729 vs. 10.8%, 27/250), the non-operative group had fewer comorbidities (40%, 40/100; $p<0.05$) and more smokers (25.0%, 25/100; $p<0.05$). There were differences between all three groups in terms of post-operative/first assessment isolation versus control ($p<0.001$); however, only post-operative positive contact was significantly lower versus control (1.0%, 7/729 vs. 3.6%, 9/250; $p<0.05$). Despite these observations, there were no differences in post-operative/first assessment symptoms reported between the non-operative (1%, 1/100) and surgery (1.2%, 9/729) groups, nor between the non-operative and control (10.4%, 26/250) groups, and the proportion reported by patients in the surgery group were actually lower versus control ($p<0.05$). There were also no differences between the three groups with respect to the proportion of positive COVID-19 test results ($p=0.349$). There were no differences in the high patient-reported median treatment outcome ratings 10/10 (IQR = 9-10) and service satisfaction scores 10/10 (IQR=9-10) in the non-operative and surgery groups.

Sub-speciality sub-analysis is presented (Table 3). There were various differences observed between the sub-speciality groups in terms of age, ethnicity, comorbidities and smoking status, but not for BMI; these findings

Table 2 Controlled cohort study overview of patient demographics, appointments, service satisfaction, treatment outcome and COVID-19 related data. */**=statistical significance ($p < 0.05$) between groups using post-hoc test after Bonferroni correction; ***=absolute value given due to there being only one patient; df=degrees of freedom; AN=one-way ANOVA; KW=Kruskal-Wallis H test; CS=chi² test; F=Fisher test; MW=Mann-Whitney U test; LA=local anaesthesia; RA=regional anaesthesia; GA=general anaesthesia; DC=dressings clinic; OPD=doctors outpatient department consultation; HT=hand therapy clinic.

Variables	Control Group (n = 250)	Non-Operative Group (n = 100)	Surgery Group (n = 729)	Test Statistic	df	P
Age, mean (SD)	59.01 (±23.49)*	50.14 (±17.11)*,**	58.15 (±22.76)**	9.851	2	<0.001 ^{AN}
Sex, n (%)				46.918	2	<0.001 ^{CS}
Female	154 (61.6)*,**	38 (38)*	270 (37.0)**			
Male	96 (38.4)*,**	62 (62)*	459 (63.0)**			
Ethnicity, n (%)				4.8	-	0.283 ^F
White	242 (96.8)	96 (96)	693 (95.1)			
Black	5 (2.0)	0 (0)	15 (2.1)			
Asian	3 (1.2)	4 (4)	21 (2.9)			
BMI, mean (SD)	26.21 (±5.28)	27.36 (±6.27)	26.73 (±5.49)	2.578	2	0.276 ^{KW}
Comorbidities, n (%)	144 (57.6)*	40 (40)*,**	392 (53.8)**	9.028	2	<0.05 ^{CS}
Number of comorbidities, median (IQR)	2 (1-2)	1 (1-2)	2 (1 - 2)	4.330	2	0.115 ^{KW}
Smoker, n (%)	27 (10.8)*	25 (25)*,**	90 (12.3)**	13.908	2	<0.001 ^{CS}
Surgery type, n (%)						
Day case	NA	NA	656 (90.0)	-	-	-
Inpatient	NA	NA	73 (10.0)			
Anaesthetic modality, n (%)						
LA	NA	NA	577 (79.1)	-	-	-
RA	NA	NA	68 (9.3)			
GA	NA	NA	84 (11.5)			
Length of stay, median (IQR)	NA	NA	0 (0 - 0)	-	-	-
Post-operative/1st assessment hospital visits, median (IQR)	NA	1 (0-1)	1 (0 - 3)	-3.241	-	<0.001 ^{MW}
Hospital post-operative/1st assessment appointments, median (IQR)						
DC	NA	0 (0-0)	1 (0 - 2)	-8.742	-	<0.001 ^{MW}
OPD	NA	0 (0-0)	0 (0 - 0)	-0.671	-	0.502 ^{MW}
HT	NA	0 (0-1)	0 (0 - 0)	-5.867	-	<0.001 ^{MW}
Remote post-operative/1st assessment appointments, median (IQR)						
DC	NA	0 (0-0)	0 (0 - 0)	-1.158	-	0.247 ^{MW}
OPD	NA	0 (0-0)	1 (0 - 1)	-9.233	-	<0.001 ^{MW}
HT	NA	0 (0-0)	0 (0 - 0)	-2.721	-	<0.05 ^{MW}
Service satisfaction score (/10), median (IQR)	NA	10 (10-10)	10 (10 - 10)	-0.215	-	0.829 ^{MW}
Treatment outcome rating (/10), median (IQR)	NA	10 (9-10)	10 (9 - 10)	-0.357	-	0.721 ^{MW}
Pre-operative/1st assessment positive contact, n (%)	NA	1 (1.0)	17 (2.3)	0.734	1	0.391 ^{CS}
Pre-operative/1st assessment isolation, n (%)	NA	18 (18)	334 (45.8)	27.962	1	<0.001 ^{CS}
Pre-operative/1st assessment symptoms, n (%)	NA	1 (1)	25 (3.4)	1.708	1	0.191 ^{CS}
Any (control) vs. Post-operative/1st assessment positive contact, n (%)	9 (3.6)*	3 (3)	7 (1.0)*	8.477	2	<0.05 ^{CS}
Any (control) vs. Post-operative/1st assessment isolation, n (%)	158 (63.2)*,**	19 (19)*,**	307 (42.1)**,**	63.256	2	<0.001 ^{CS}
Any (control) vs. Post-operative/1st assessment symptoms, n (%)	16 (6.4)*	1 (1)	9 (1.2)*	22.054	2	<0.001 ^{CS}
Test performed, n (%)	26 (10.4)	14 (14)	187 (25.7)	6.500	1	<0.05 ^{CS}
Positive test, n (%)	0	1 (7.1)	5 (2.7)	0.877	1	0.349 ^{CS}
Mortality during study period (control) vs. at 30 days, n (%)	0	0	0	-	-	-

Table 3 Sub-group analysis for controlled cohort study patient demographics, appointments, service satisfaction, treatment outcome and COVID-19 related data. *, 2*, 3*, 4*, 5*, 6*, 7* = statistical significance ($p < 0.05$) between groups using post-hoc test after Bonferroni correction. *** = absolute value given due to there being only one patient; df = degrees of freedom; AN = one-way ANOVA; KW = Kruskal-Wallis H test; CS = χ^2 test; F = Fisher test; MW = Mann-Whitney U test; LA = local anaesthesia; RA = regional anaesthesia; GA = general anaesthesia; DC = dressings clinic; OPD = doctors outpatient department consultation; HT = hand therapy clinic; SOB = shortness of breath.

Variables	Control Group (n = 250)	Non-Operative Group (n = 100)	Elective Plastic Surgery Group (n = 420)	Trauma Group (n = 270)	Burns Group (n = 39)	Test Statistic	df	P
Age, mean (SD)	59.01 (±23.49) ^{*,3*,4*,6*}	50.14 (±17.11) ^{*,2*}	69.45 (±15.53) ^{2*,3*,5*,7*}	44.52 (±20.74) ^{4*,5*}	32.97 (±28.46) ^{6*,7*}	267.171	4	<0.001 ^{KW}
Sex, n (%)								
Female	154 (61.6) ^{*,2*,3*,4*}	38 (38) [*]	175 (41.7) ^{4*}	84 (31.1) ^{3*}	11 (28.2) ^{2*}	55.710	4	<0.001 ^{CS}
Male	96 (38.4) ^{*,2*,3*,4*}	62 (62) [*]	245 (58.3) ^{4*}	186 (68.9) ^{3*}	28 (71.8) ^{2*}			
Ethnicity, n (%)								
White	242 (96.8) ^{2*}	96 (96) [*]	417 (99.3) ^{4*,5*}	249 (92.2) ^{3*,5*}	27 (69.2) ^{*,2*,3*,4*}	62.919	-	<0.001 ^F
Black	5 (2.0) ^{2*}	0 (0) [*]	2 (0.5) ^{4*}	7 (2.6) ^{3*}	6 (15.4) ^{*,2*,3*,4*}			
Asian	3 (1.2) ^{2*}	4 (4) [*]	1 (0.2) ^{*,3*,4*}	14 (5.2) ^{4*}	6 (15.4) ^{2*,3*}			
BMI, mean (SD)	26.21 (±5.28)	27.36 (±6.27)	26.77 (±4.81)	27.00 (±6.27)	24.45 (±6.18)	10.306	4	<0.05 ^{KW}
Comorbidities, n (%)	144 (57.6) ^{*,3*}	40 (40) ^{*,2*}	283 (67.4) ^{2*,4*,5*}	93 (34.4) ^{3*,5*}	16 (41.0) ^{4*}	83.361	4	<0.001 ^{CS}
Number of comorbidities, median (IQR)	2 (1-2) [*]	1 (1-2) ^{3*}	2 (1 - 3) ^{2*,3*}	1 (1 - 1) ^{*,2*}	2 (1 - 2)	44.102	4	<0.001 ^{KW}
Smoker, n (%)	27 (10.8) ^{*,3*}	25 (25) ^{*,2*}	24 (5.7) ^{2*,4*,5*}	58 (21.5) ^{3*,5*}	8 (20.5) ^{4*}	52.064	4	<0.001 ^{CS}
Surgery type, n (%)								
Day case	NA	NA	414 (98.6) ^{*,2*}	242 (89.6) 2*,3*	0 ^{*,3*}	384.858	2	<0.001 ^{CS}
Inpatient	NA	NA	6 (1.4) ^{*,2*}	28 (10.4) 2*,3*	39 (100) ^{*,3*}			
Anaesthetic modality, n (%)								
LA	NA	NA	392 (93.3) ^{*,2*}	185 (68.5) 2*,3*	0 ^{*,3*}			
RA	NA	NA	12 (2.9) ^{*,2*}	52 (19.3) [*]	4 (10.3) ^{2*}	231.727	2	<0.001 ^{CS}
GA	NA	NA	16 (3.8) ^{*,3*}	33 (12.2) 2*,3*	35 (89.7) ^{*,2*}			

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Table 3 (continued)

Variables	Control Group (n = 250)	Non-Operative Group (n = 100)	Elective Plastic Surgery Group (n = 420)	Trauma Group (n = 270)	Burns Group (n = 39)	Test Statistic	df	P
Length of stay, median (IQR)	NA	NA	0 (0 - 0) ^{*,2*}	0 (0 - 0) ^{2*,3*}	5 (3.75 - 13.25) ^{*,3*}	386.335	2	<0.001 ^{KW}
Post-operative/1st assessment hospital visits, median (IQR)	NA	1 (0-1) ^{*,2*}	1 (0 - 1) ^{4*,5*}	2 (2 - 6) ^{2*,3*,5*}	4 (0 - 4) ^{*,3*,4*}	116.816	3	<0.001 ^{KW}
Hospital post-operative/1st assessment appointments, median (IQR)								
DC	NA	0 (0-0) ^{*,2*,3*}	1 (0-1) ^{3*,5*}	1 (0-2) ^{2*,4*,5*}	4 (2-5) ^{*,4*}	156.277	3	<0.001 ^{KW}
OPD	NA	0 (0-0)	0 (0-0) [*]	0 (0-0) [*]	0 (0-0)	23.228	3	<0.001 ^{KW}
HT	NA	0 (0-1) ^{*,2*}	0 (0-0) ^{2*,4*}	0 (0-2) ^{3*,4*}	0 (0-1) ^{*,3*}	170.848	3	<0.001 ^{KW}
Remote post-operative/1st assessment appointments, median (IQR)								
DC	NA	0 (0-0)	0 (0-0) [*]	0 (0-0) [*]	0 (0-0)	13.858	3	<0.05 ^{KW}
OPD	NA	0 (0-0) [*]	1 (1-1) ^{*,2*,3*}	0 (0-0) ^{3*}	0 ^{2*}	746.322	3	<0.001 ^{KW}
HT	NA	0 (0-0) [*]	0 (0-0) ^{*,2*}	0 (0-0) ^{2*}	0	15.723	3	<0.05 ^{KW}
Service satisfaction score (/10), median (IQR)	NA	10 (10-10)	10 (9-10) [*]	10 (10-10) [*]	10 (9-10)	11.989	3	<0.05 ^{KW}
Treatment outcome rating (/10), median (IQR)	NA	10 (9-10)	10 (9-10)	10 (9-10)	10 (9-10)	2.129	3	0.546 ^{KW}
Pre-operative/1st assessment positive contact, n (%)	NA	1 (1)	7 (1.7)	10 (3.7)	0	5.000	3	0.172 ^{CS}
Family contact, n (%)	NA	1 (100)	5 (71.4)	7 (70)	-	0.626	-	0.999 ^F
How many days, median (IQR)	NA	28 ^{***}	60 (60 - 90)	30 (18 - 43.75)	-	4.975	2	0.083 ^{KW}
Pre-operative/1st assessment isolation, n (%)	NA	18 (18) [*]	269 (64) ^{*,2*,3*}	61 (22.7) ^{3*}	4 (10.3) ^{2*}	164.197	3	<0.001 ^{CS}
How many days, median (IQR)	NA	60.00 (22.5-48.75)	21 (14 - 49.50)	35 (21 - 49)	31.5 (28.75 - 35.75)	5.471	3	0.140 ^{KW}
Pre-operative/1st assessment symptoms, n (%)	NA	1 (1)	9 (2.1)	14 (5.2)	2 (5.1)	7.107	3	0.069 ^{CS}

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Table 3 (continued)

Variables	Control Group (n = 250)	Non-Operative Group (n = 100)	Elective Plastic Surgery Group (n = 420)	Trauma Group (n = 270)	Burns Group (n = 39)	Test Statistic	df	P
How many days, median (IQR)	NA	90***	60 (46.50 - 105)	35 (12.25 - 60)	18.5 (-)	7.586	3	0.055 ^{KW}
Symptom duration, median (IQR)	NA	7***	14 (7 - 14)	5 (3.75 - 7.75)	8 (-)	6.098	3	0.107 ^{KW}
Temperature, n (%)	NA	1 (100)	7 (77.8)*	3 (21.4)*	1 (50)	8.211	-	<0.05 ^F
Chills, n (%)	NA	0	1 (11.1)	2 (14.3)	0	1.372	-	0.999 ^F
Cough, n (%)	NA	0	7 (77.8)	9 (64.3)	1 (50)	2.825	-	0.478 ^F
Sore throat, n (%)	NA	0	4 (44.4)	2 (14.3)	0	3.401	-	0.325 ^F
SOB, n (%)	NA	1 (100)	0	3 (21.4)	0	5.766	-	0.139 ^F
Body aches, n (%)	NA	0	7 (77.8)*	5 (35.7)*	0	8.548	-	<0.05 ^F
Loss of taste/smell, n (%)	NA	1 (100)	3 (33.3)	0	0	2.516	-	0.586 ^F
Lethargy, n (%)	NA	0	3 (33.3)	3 (21.4)	0	1.439	-	0.837 ^F
Headache, n (%)	NA	0	1 (11.1)	1 (7.1)	0	2.045	-	0.999 ^F
Runny nose, n (%)	NA	0	0	0	1 (50)	7.237	-	0.117 ^F
Any (control) vs. Post-operative/1st assessment positive contact, n (%)	9 (3.6)	3 (3)	4 (1.0)	3 (1.1)	0	7.417	-	0.081 ^F
Family contact, n (%)	6 (66.7)	1 (33.3)	2 (50)	2 (66.7)	-	1.511	-	0.911 ^F
How many days, median (IQR)	99 (79.5 - 113.5)*	7 (-)*	42 (11.25 - 52.5)	21 (-)	-	12.886	3	<0.05 ^{KW}
Any (control) vs. Post-operative/1st assessment isolation, n (%)	158 (63.2)*,2*,3*	19 (19)*,4*	253 (60.2) ^{4*,5*,6*}	51 (18.9) ^{3*,6*}	3 (7.7) ^{2*,5*}	196.592	4	<0.001 ^{CS}
How many days, median (IQR)	98 (91 - 105)*,2*,3*,4*	21 (21-30)*	28 (14 - 38.50) ^{4*}	37 (14 - 60) ^{3*}	14 (-) ^{2*}	278.953	4	<0.001 ^{KW}

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Table 3 (continued)

Variables	Control Group (n = 250)	Non-Operative Group (n = 100)	Elective Plastic Surgery Group (n = 420)	Trauma Group (n = 270)	Burns Group (n = 39)	Test Statistic	df	P
Any (control) vs. Post-operative/1st assessment symptoms, n (%)	16 (6.4) ^{*,2*}	1 (1)	5 (1.2) ^{2*}	4 (1.5) [*]	0	22.380	4	<0.001 ^{CS}
How many days postop, median (IQR)	95.5 (77.25 - 118) [*]	14 ^{***}	7 (2 - 24.5) [*]	17.50 (14 - 36.75)	-	15.775	3	<0.05 ^{KW}
Symptom duration, median (IQR)	14 (4 - 19.25)	36 ^{***}	21 (2 - 24.5)	4.50 (4 - 6.50)	-	4.259	3	0.235 ^{KW}
Temperature, n (%)	8 (50)	0	2 (40)	2 (50)	-	1.205	-	0.999 ^F
Chills, n (%)	1 (6.3)	0	0	0	-	2.839	-	0.999 ^F
Cough, n (%)	13 (81.3)	1 (100)	4 (80)	0	-	1.443	-	0.999 ^F
Sore throat, n (%)	1 (6.3)	0	0	1 (25)	-	3.161	-	0.381 ^F
SOB, n (%)	3 (18.8)	1 (100)	0	0	-	4.662	-	0.169 ^F
Body aches, n (%)	3 (18.8)	1 (100)	1 (20)	2 (50)	-	5.617	-	0.065 ^F
Loss of taste/smell, n (%)	5 (31.3)	1 (100)	0	1 (25)	-	2.383	-	0.635 ^F
Nausea/vomiting, n (%)	1 (6.3)	0	0	0	-	2.839	-	0.999 ^F
Rash, n (%)	0	0	1 (20)	0	-	5.165	-	0.385 ^F
Lethargy, n (%)	2 (12.5)	0	0	0	-	1.904	-	0.999 ^F
Headache, n (%)	1 (6.3)	0	0	0	-	2.839	-	0.999 ^F
Diarrhoea, n (%)	3 (18.8)	1 (100)	0	1 (25)	-	4.323	-	0.173 ^F
Test performed, n (%)	26 (10.4) ^{2*,6*}	14 (14) ^{*,5*}	54 (12.9) ^{4*,7*}	99 (36.7) ^{3*,5*,6*,7*}	34 (87.2) ^{*,2*,3*,4*}	179.338	4	<0.001 ^{CS}
Positive test, n (%)	0	1 (7.1)	0	3 (3.0)	2 (5.9)	4.643	-	0.236 ^F
Hospital admission due to COVID, n (%)	-	0	-	1 (33.3)	0	1.659	-	0.999 ^F
Duration (days), median (IQR)	-	-	-	35 ^{***}	-	-	-	-
ICU admission due to COVID, n (%)	-	0	-	1 (33.3)	0	1.659	-	0.999 ^F
Duration (days), median (IQR)	-	-	-	7 ^{***}	-	-	-	-
Ventilated, n (%)	-	0	-	1 (33.3)	0	1.659	-	0.999 ^F
Duration (days), median (IQR)	-	-	-	5 ^{***}	-	-	-	-
Mortality during study period (control) vs. at 30 days, n (%)	0	0	0	0	0	-	-	-

confirm that the characteristics of treated patients differed between the three sub-specialties. The proportion of treated inpatients, was significantly higher for the burns (100%, 39/39) versus trauma (10.4%, 28/270) and elective (1.4%, 6/420) groups ($p < 0.05$); this was also true for the trauma versus elective group ($p < 0.05$). The median inpatient stay duration was also significantly higher for the burns (5, IQR=3.75-13.25) versus trauma (0, IQR=0-0) and elective (0, IQR=0-0) groups ($p < 0.05$). Furthermore, the median number of in-hospital follow-up appointments were again significantly higher for the burns (4, IQR=0-4) versus trauma (2, IQR=2-6) and elective (1, IQR=0-1) groups ($p < 0.05$); this was also true for the trauma versus elective group ($p < 0.05$). These observations confirm that burns patients were significantly more exposed to the hospital inpatient environment during treatment, versus those requiring treatment by other sub-specialties. There were no differences between the three sub-specialty surgery and non-operative groups, with respect to pre-operative/first assessment positive contact ($p = 0.172$) or reported symptoms ($p = 0.069$). There were also no post-operative/first assessment positive contact differences between the three sub-specialty surgery and non-operative groups, and also between positive contact in the control group ($p = 0.081$). In terms of postoperative/first assessment symptoms, these were less frequently reported in both the trauma (1.5%, 4/270) and elective (1.2%, 5/420) groups versus the control (6.4%, 16/250) group; there were no further group differences demonstrated here. There were also no differences between the three sub-specialty surgery, non-operative and control groups with respect to the proportion of positive tests ($p = 0.236$).

Discussion

Despite the international implementation of practice modification to address the COVID-19 pandemic, there still remains a paucity of prospective, patient-centred and controlled studies regarding the safety of continuing surgery for patients.^{18,19,22-27} By the end of this study period (June 2020), the estimated UK prevalence and death rate were approximately 4400 and 600 per million population respectively; at this time, the UK was amongst the top 5 most affected countries in terms of confirmed cases and deaths per million population.^{4,28} This represents a stark contrast to other highly populated countries, such as India, who at this time were amongst the top 5 most affected countries by having 590,000 confirmed cases and 17,000 deaths, but were amongst the least affected countries by disease spread through the population; this in part is reflected in a lower prevalence (400 per million population) and death rate (12 per million population).⁴

In a series of 484 elective major cancer surgeries, performed between 23 March and 30 April 2020 at Tata Memorial Hospital, there were no post-operative deaths.²⁵ The authors partly attribute these figures to adopting a 'COVID-19 centric policy'; however, they also acknowledge that the extent of the Indian national lockdown significantly truncated COVID-19 prevalence during the study period; as such these data only apply to the least affected countries and where mortality is < 10 /million population.²⁵ Another large

study of 702 patients managed at Singapore General Hospital (February-March 2020) describes an enhanced acute care surgery system implemented to safeguard against COVID-19 transmission. While there was no mortality increase reported versus the previous year, by the end of the study period Singapore had reported around 900 cases and 3 deaths; therefore, these results are also only applicable to countries that were least affected by the pandemic.²⁸

The proportion of COVID-19 positive tests were: 7.1% (1/14) (non-operative), 5.9% (2/34) (burns) and 3.0% (3/99) (trauma); there were however no significant differences between these groups, the elective (0%, 0/54) and control (0%, 0/26) groups ($p = 0.236$). The non-operative group patient was symptomatic 1 week after traceable positive contact and her symptoms lasted for 32 days. Of the burns group patients who tested positive, one was positive at routine admission screening, the other at admission day 9 (4 days post-operatively); neither of these patients were symptomatic. Of the three trauma group patients who tested positive, one was asymptomatic and tested positive at routine admission screening and another became symptomatic 30 days pre-operatively after positive contact. The third positive trauma group patient was also the only patient in the study who had a COVID-related hospital admission (35 days), requiring 5 days of ventilation during a 7 day ICU admission; she sustained an extravasation injury during this admission, following which she recovered with two negative swabs prior to surgery (Table 3). Furthermore, neither the three sub-specialty surgery groups nor the non-operative group displayed any increase in post-operative/first-assessment symptoms in comparison to each other, or to the control group. When considered together, these findings suggest that there is no increase in COVID-19-related risk to patients undergoing surgery or non-operative management. Despite the prospective study design and controlled patient groups, routine patient COVID-19 testing was only introduced during the middle of May 2020; as such, some data were driven by symptomatology, although this represents the true risk to patients.

Conclusion

This prospective cohort study examines 1429 referred patients (1483 operations) who required plastic surgery, trauma or burns treatment during the UK COVID-19 pandemic peak (April-May 2020), with complex GA (9.2%, 136/1483) or RA (5.0%, 74/148) cases representing 14.2% (210/1483) of operations undertaken; there were no 30-day COVID-related deaths (0%, 0/1429). Despite being amongst the most affected countries worldwide, we demonstrate low COVID-19 infection rates and positive patient outcomes. We further demonstrate, using a prospective and controlled cohort study design, that heterogeneous sub-specialty patient groups, who required both operative and non-operative management, did not incur an increase in this risk compared to each other or to a control group. These highly encouraging results were achieved with significant service changes that were tailored to the three sub-specialties, as described, and implemented to protect patients and staff.²⁰ Healthcare service provision has been significantly limited internationally to mitigate COVID-19

related risk; our findings are therefore vital for health-care providers when considering service adaptations to reinstate patient treatment.^{1, 15, 26, 29} We continue to adapt according to the literature and national guidelines to maintain a safe and efficient patient service.

Declaration of Competing Interest

None.

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Contributors

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