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The impact of COVID-19 on acute Trauma and Orthopaedic referrals and surgery in the UK during the 'peak weeks': lessons learnt from the largest and longest national multi-centre observational study.

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1 The impact of COVID-19 on acute Trauma and Orthopaedic referrals and surgery in the UK
 2 during the ‘peak weeks’: lessons learnt from the largest and longest national multi-centre
 3 observational study.

4
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1
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3 51 **Keywords:** *COVID-19; orthopaedic trauma; UK multi-centre; pandemic wave; mortality*
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6 52

7 53 **Contributor & guarantor information**

9 54 The corresponding author attests that all listed authors meet authorship criteria and that no
10 55 others meeting the criteria have been omitted. All listed authors from all centres have
11 56 contributed by mining and analysing data. KS, AA, CP and KMS conceptualised the study
12 57 and agreed on the methodology. KS wrote the first draft and analysed the entire dataset. The
13 58 dataset was then reviewed for accuracy by all authors within Imperial College Healthcare
14 59 NHS Trust as well as contributing to subsequent drafts of the manuscripts. The final version
15 60 was reviewed and signed off by each Consultant representative from each contributing centre.
16 61 KS finalised the submission, and he is both the primary and corresponding author.
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3 62 **Abstract**
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6 64 **Objective:** This is the first national study observing the impact of the COVID-19 pandemic
7
8
9 65 on orthopaedic trauma with respect to referrals, operative caseload and mortality during its
10
11 66 peak.

13 67 **Design:** A longitudinal, national, multi-centre, retrospective, observational, cohort study was
14
15
16 68 conducted for 6 weeks (namely the 'peak weeks') from March 17, 2020 compared to the
17
18 69 same period in 2019.

20 70 **Setting:** Hospitals from seven major urban cities were recruited around the UK, including
21
22
23 71 London.

25 72 **Participants:** A total of 4840 clinical encounters were initially recorded. 4668 clinical
26
27 73 encounters were analysed post-exclusion.

29 74 **Primary and secondary outcome measures:** Primary outcomes included the number of
30
31
32 75 acute trauma referrals and those undergoing operative intervention, mortality rates, and the
33
34 76 proportion of patients contracting COVID-19. Secondary outcomes consisted of the
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36 77 mechanism of injury, type of operative intervention and proportion of aerosolising-generating
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38
39 78 anaesthesia utilised.

41 79 **Results:** During the COVID-19 period there was a 34% reduction in acute orthopaedic
42
43
44 80 trauma referrals compared to 2019 (1792 down to 1183 referrals), and 29.5% less surgical
45
46 81 interventions (993 down to 700 operations). The mortality rate significantly (both statistically
47
48 82 and clinically) more than doubled for both risk and odds ratios during the COVID period in
49
50 83 all referrals (1.3% vs 3.8%, $p=0.0005$) and in those undergoing operative intervention (2.2%
51
52 84 vs 4.9%, $p=0.004$). Moreover, mortality due to COVID-related complications (versus non-
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54
55 85 COVID causes) had greater odds by a factor of at least 20 times. For the operative cohort
56
57 86 during COVID, there was a greater odds of aerosolising-generating anaesthesia (including
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3 87 those with superimposed regional blocks) by three-quarters as well as doubled odds of a
4
5 88 Consultant acting as the primary surgeon.
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10 90 **Conclusion:** Although there was a reduction of acute trauma referrals and those undergoing
11
12 91 operative intervention, the mortality rate still more than doubled in odds during the peak of
13
14 92 the pandemic compared to the same time interval one year ago.
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17 93
18
19 94 **Keywords:** COVID-19; orthopaedic trauma; UK multi-centre; pandemic wave; mortality
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24 96 **Article summary: Strengths and limitations of this study**
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- 27 97
- 28 • This was the first representative observational study of the UK looking into the
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30 impact of COVID-19 pandemic on general Trauma and Orthopaedic surgical
31 98
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33 specialty.
34 99
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 - 36 100 • There is a valid comparison between two timeframes, exactly one year apart to
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38 represent pre-COVID and during COVID.
39 101
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 - 42 102 • Other studies thus far have only shed light on local scales or cross-speciality within a
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44 shorter timeframe than this study and not necessarily commenting on mortality rates
45 103
46
47 like this study.
48 104
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 - 51 105 • Weaknesses included loss of data points which have been accounted for in the tables
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54 (i.e. labelled as unknown) which did not affect the final analysis of data points.
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- 107 • Operations conducted outside the specific study periods will not account for all those
108 operations required such as for hip fractures.

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109 **Introduction**

110 111 *The Global Impact of COVID-19*

112 The COVID-19 pandemic will be remembered as one of the most unprecedented global
113 health crises in modern history. With over 3 million deaths and over 141 million recorded
114 cases globally, the pandemic has had a permanent impact on healthcare at the time of article
115 submission.¹ The viral outbreak was first reported in December 2019 with the first patient
116 hospitalized in the city of Wuhan, China.² By mid-March the outbreak affected over 190
117 countries with over 450,000 cases and over 20,000 deaths, thus being declared a pandemic
118 and a global public health emergency by the World Health Organization.³ On January 24th
119 2020 Europe reported its first case followed by a case in the United Kingdom (UK) 5 days
120 later.⁴

122 *The British Response to the pandemic*

123 The English government responded by implementing social distancing measures on the 17th
124 March 2020 in an attempt to reduce the rate of transmission and therefore the demands on the
125 National Health Service (NHS).⁵ This was followed a week later by more stringent measures,
126 commonly referred to as a societal 'lockdown'.⁶ As of the 23rd March 2020, all members of
127 the public were required to stay at home. The NHS has also been deeply affected by the strain
128 imposed by the virus as the healthcare infrastructure has had to evolve to cope with the
129 overwhelming and unexpected pressures on staff, resources and finances. There has been a
130 complete renovation of Emergency Medicine and Orthopaedic services to manage
131 musculoskeletal disease and trauma. In response to the NHS emergency declaration,⁷ the
132 Royal Colleges of Surgeons⁸ and the British Orthopaedic Association⁹ both issued statements
133 and guidelines for delivering emergency Trauma and Orthopaedic care during the COVID-19
134 outbreak. The lockdown to limit the spread of the virus has had an unforeseen effect in

1
2
3 135 significantly reducing the acute trauma workload described in several single centre studies.¹⁰⁻
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5 136 ¹³ There has however not been a national reflection of the impact of the COVID-19 pandemic
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7 137 on the orthopaedic workload and its potential impact on the mortality.
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10 138
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13 139 **Aim**
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15 140 To observe the impact of COVID-19 on Trauma and Orthopaedic acute referrals, operative
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17 141 casemix and mortality rates during the 'peak weeks' of the pandemic compared to the same
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19 142 time interval in 2019.
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23 143
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25
26 144 **Outcomes/objectives**
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28 145 Primary outcomes included the number of acute trauma referrals and those undergoing
29

30 146 operative intervention, post-operative complications, mortality rates, and the proportion of
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32 147 patients contracting COVID-19. Secondary outcomes consisted of the mechanism of injury,
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34 148 type of operative intervention and proportion of aerosolising-generating anaesthesia utilised.
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41 150 **Alternative hypothesis**
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43
44 151 The alternative hypothesis was that when comparing both years, there would be a difference
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46 152 in the prevalence of acute orthopaedic referrals, orthopaedic trauma casemix and aerosol-
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48 153 generating anaesthetic procedures due to social distancing/lockdown. Mortality rates and
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50 154 survival probabilities were also hypothesised to differ due to the first COVID-19 outbreak.
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3 **156 Methods**
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6 *157 Study design:* This is the first national, multi-centre longitudinal observational study
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8 *158* observing patients who were acutely referred to the Trauma and Orthopaedic departments as
9
10 *159* well as those operated on within the same six-week interval comparing 2019 to 2020.
11
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14 **160**
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16 *161 Patient sampling:* All acute referrals, operative notes, inpatient medical records and discharge
17
18 *162* summaries were accessed using electronic medical system at each contributing hospital trust.
19
20

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22 **163**
23

24 *164 Study period:* The six-week study period was from the start of social distancing on Tuesday
25
26 *165* 17th March 2020 to Tuesday 31st April 2020 which encompassed the national ‘lockdown’
27
28 *166* measures instigated on the 23rd March 2020. This period was considered the ‘golden peak’ of
29
30 *167* the epidemic in the UK. This was compared to the same six-week interval from Tuesday 19th
31
32 *168* March to Tuesday 30th April 2019 (i.e. prior to any COVID-19 related measures) to compare
33
34 *169* the impact of the pandemic one year apart.
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39 **170**
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41 *171 Inclusion criteria:* All acute orthopaedic trauma referrals presenting to the Emergency
42
43 *172* Department during the intervals one year apart were included. All orthopaedic trauma cases
44
45 *173* that required an operation, including those from acute orthopaedic trauma referrals, within
46
47 *174* the intervals one year apart. Those patients listed for an operation prior to time period of data
48
49 *175* collection were included in the final analysis. We adhered to STROBE guidelines for
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51 *176* observational studies.
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56 **177**
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178 *Exclusion criteria:* Any cases being referred internally from other specialties for Trauma and
 179 Orthopaedic advice and input, as well as referrals from any external centre asking for tertiary
 180 advice were excluded from further analysis. Any patients with post-operative complications
 181 arising from the period prior to the data collection were excluded. For operative trauma cases,
 182 those undergoing spinal procedures were excluded as these are jointly treated by
 183 Neurosurgery in most hospitals. All non-urgent semi-elective procedures were excluded from
 184 analysis as well, as they would inaccurately assess the impact of any social distancing
 185 measures on the trauma workload. Routine elective orthopaedic cases were excluded.

186 *Data points:* Demographics including age, sex and ASA grades were recorded for all
 187 patients. Injury characteristics were recorded, including the anatomical location and if the
 188 injury was open or closed. The mechanism of injury was categorised and whether the patient
 189 was referred as a trauma call. The nature of the operative procedures and the anaesthetic
 190 techniques were recorded. Patients undergoing multiple procedures were recorded for every
 191 episode where they were taken to theatre. Six-week mortality rate was recorded as well as the
 192 COVID-19 status of any symptomatic patients or suspected cases. Data points were divided
 193 into acute referrals and operative casemix as seen in table 1.

194
 195 *Table 1: data points for acute referrals and operative casemix*

Age (years)	Gender (Male / female by birth)	ASA (1-5)	Date of injury / presentation
Injury	Mechanism of injury	Open Vs Closed fracture	Trauma Call (Yes / No)
Operative procedure	Anaesthetic Technique (AGP vs non-AGP)	Seniority of Surgeon (Consultants vs trainees)	Comorbidities
Six-week mortality	Post-op complications	Surgery time since admission (hours)	COVID status (from PCR swabs)

196

197 • *Anaesthetic techniques:* This was divided into anaesthetic aerosolising-generating
198 procedures (AGP) which consisted of any intubation (including laryngeal mask
199 airway and endotracheal intubation) for a general anaesthetic. All other anaesthetic
200 techniques including regional and local anaesthetics were deemed as non-AGPs.

201 • *COVID status:* groups of patients were divided into either not swabbed, swabbed due
202 to presence of documented symptoms, negative swabs and positive results.

203 *Statistical analysis:* All the data were recorded, anonymised and verified by four members of
204 the study group for their accuracy. The data were processed using Microsoft Excel
205 (Microsoft, Washington, USA). Shapiro-Wilk test indicated a normal distribution for patient
206 demographics. Hence, the mean (\pm standard deviation; 95% CI) were calculated for both age,
207 ASA grade and days to discharge from hospital. Both prevalence or risk and odds ratios were
208 calculated as well as a Fisher's exact test for statistical significance for categorical data,
209 defined as $p \leq 0.05$. Percentages and confidence intervals were rounded off to one decimal
210 place.

211 *Ethics and permissions:* All data points were utilised for routine auditing purposes to reflect
212 departmental activity and service provision without altering clinical care pathways. Each
213 centre contributing data to this study registered their interests with local authority and the
214 auditing or clinical governance departments. No informed consent was required as there was
215 no identifiable data. All data were anonymised at the time of collection and submission. Each
216 patient was assigned a unique identification number which was cross-referenced with the
217 patients' individual hospital identification or medical record numbers. This cross-referenced
218 list remained internally within the hospital trust computer server handled by the contributing
219 team from each trust. The data was transferred and stored using the NHS.net email server
220 which has been approved for transfer of patient data. Data protection compliance was abided

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2
3 221 by at all times. The lead centre was Imperial College Healthcare NHS Trust where this study
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5 222 was first approved as a clinical audit prior to expanding onto a national scale.
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8 223 All centres gave permission for the use of their data. This study was assessed using the
9
10 224 UKRI/MRC/NHS Health Research Authority Ethics Decision Tool and was considered an
11
12 225 'audit/not research'; and therefore it was not subject to further ethical review by the NHS
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14 226 Research Ethics Committee (NHS REC).
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20 229
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22 230 *Data sharing statement:* Underlying data, code and supporting documentation may be made
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38 237 *The collaborative:* The COVID Emergency Related Trauma and orthopaedics (COVERT)
39
40 238 Collaborative was founded at Imperial College Healthcare NHS Trust. It is currently a
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42 239 member of the COVID Research Group and it has been endorsed by the Royal College of
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44 240 Surgeons of England and Imperial College Healthcare NHS Trust.
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51 242 *Patient and Public Involvement:* This was a retrospective study observing clinical outcomes.
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53 243 Patients were not involved in the study design, recruitment or conduct. The anonymous data
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55 244 will be disseminated through publication.
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245 Results

246 A total of 4840 clinical encounters took place between the study periods. A total of 172
 247 spinal operations and presentations were excluded from the final analysis. Table 2 outlined
 248 demographic data. Figures 1 and 2 have categorized these clinical encounters into acute
 249 referrals and operative cases between both years respectively.

250

251 *Table 2: Demographic data of pre- and post-COVID*

		Pre-COVID (2019)		COVID (2020)	
	Total	1792		1183	
Acute referrals	<i>Male</i>	935	52.2%	560	47.3%
	<i>Female</i>	857	47.8%	623	52.7%
	<i>Mean age ± SD</i> <i>(95% CI)</i>	52.2 ± 27.9 (50.9 - 53.5)		55.8 ± 27.9 (54.3 - 57.4)	
	Total	993		700	
Operative cases	<i>Male</i>	499	50.3%	320	45.7%
	<i>Female</i>	494	49.7%	380	54.3%
	<i>Mean Age ± SD</i> <i>(95% CI)</i>	51.7 ± 28.1 (50 - 53.5)		57.7 ± 26.7 (55.7 - 59.6)	
	<i>Mean ASA ± SD</i> <i>(95% CI)</i>	2 ± 1 (2 - 2)		2 ± 1 (2 - 2)	

252

253 *Figure 1a: Types and mechanisms of injuries for acute referrals*

254 *Figure 1b: Types and mechanisms of injuries for operative cases*

255 *Figure 2: operative and anaesthetic techniques compared between pre- and post-COVID*

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3 258 **COVID status**
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5 259 At the time, COVID was being diagnosed with polymerase chain reaction (PCR) from nasal
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7 260 and oropharyngeal swabs with a duration of 1 to 4 days where the sample was tested both
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10 261 locally in the hospital lab as well as corroborated with national lab testing to reduce risk of
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12 262 unequivocacy. COVID status for overall patient groups in acute referrals and operative
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14 263 casemix were demonstrated in figure 3, whereas the COVID status of all mortalities were
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17 264 outlined in figure 4.
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21 266 *Figure 3: COVID status for acute referrals and operative cases as a measure of proportions*
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25 267 *Figure 4: COVID status of all mortalities (with 5% error bars)*
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270 *Risk (or prevalence) and odds ratios*271 *Table 3: Risk (or prevalence) and odds ratios for acute referrals and operative caseloads*

		Acute referrals			Operative caseload		
		RR	OR	p-value	RR	OR	p-value
Morbidity & Mortality	Mortality	2.50	2.55	0.0005	2.19	2.25	0.004
	Mortality due to COVID-related complications vs non-COVID causes	14.2	19.7	0.004	15.1	22.0	0.004
	Peri-/post-operative complications including COVID				5.88	6.09	0.00001
	Peri-/post-operative complications excluding COVID				3.65	3.72	0.003
	Peri-/post-operative COVID positive testing				32.6	23.4	0.0009
	Anaesthetic technique	General anaesthetic only				1.22	1.61
General anaesthetic ± block					1.23	1.75	0.00001
Consultant involvement	Consultant-led operation				1.36	2.08	0.00001
Operation technique	Open reduction + internal fixation				0.81	0.74	0.007
	Dynamic hip screw				2.02	2.11	0.00001
	Removal of metal/foreign body				0.24	0.23	0.003
	Road traffic accident	0.58	0.56	0.001	0.45	0.43	0.00001

Mechanism of injury	Fall (<1.5m)	1.19	1.54	0.00001	1.17	1.49	0.0001
	Sporting injury	0.63	0.60	0.0005	0.64	0.61	0.003
	Infection	0.69	0.66	0.001	1.70	1.77	0.005
	Trauma call				0.55	0.52	0.0005
Type of injury	Neck of femur (NOF) fracture	1.44	1.57	0.00001	1.51	1.79	0.00001
	Lower limb (excl. NOF)	0.89	0.84	0.04	0.74	0.65	0.0001
Gender	Male	0.91	0.82	0.01			

272

273 Table 3 outlined the risk (or prevalence) and prevalence odds ratios alongside their 95%
 274 confidence intervals and statistical significance. The risk ratio is synonymous with the
 275 prevalence ratio. Only those factors that were statistically significant within the acute
 276 referrals and operative caseloads were included.

277 Although the expectation was to minimize the use of aerosolising-generating anaesthetic
 278 procedures, there was in fact an increased prevalence of using general anaesthesia ± block up
 279 to an odds of 75%, perhaps to create a ‘closed circuit’ for the airways. As the anaesthetic
 280 methods was not well documented in the pre-COVID era in a fifth (21.3%) of cases, this
 281 could have skewed the data as it may have been difficult to extract that data from last year.
 282 The odds of a Consultant-led operation doubled (OR=2.08) during the COVID period as a
 283 consequence of all elective operations being suspended and more Consultants being relocated
 284 to trauma theatre and increased pressure within the theatre environments leading to
 285 Consultant-delivered, rather than Consultant-led care. With respect to surgical procedures,
 286 there was a significant reduction in prevalence ratio of open reduction and internal fixation
 287 by a fifth (PR=0.81) and removal of metalwork and foreign bodies by three-quarters

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3 288 (PR=0.24), while there was a doubling (PR=2.02) in dynamic hip screw fixation in the
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5 289 COVID era.

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8 290 With respect to the acute referrals, patients had half (OR=0.52) the odds of presenting as a
9
10 291 trauma call. This could be due to the odds ratios of road traffic accidents, sporting injuries,
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12 292 infection, and lower limb injuries were significantly less (by 34-44%; OR=0.56-0.66) during
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14 293 the COVID period. Yet, the odds of presenting with a neck of femur fracture and having falls
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16 294 less than 1.5m height increased by 54% (OR=1.54).

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21 22 23 296 **Morbidity and Mortality**

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25 297 Table 3 indicated that the mortality rate more than doubled significantly for both prevalence
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27 298 (or risk; RR=2.19-2.50) and odds (OR=2.25-2.55) ratios during the COVID period. This
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29 299 certainly has both statistical as well as clinical significance. COVID-related complications
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31 300 were still responsible for increasing the odds of mortality by 20 to 22 times within all
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33 301 mortalities from both acute referrals and operative cases (as compared to non-COVID causes
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35 302 for all mortality in the year 2019). Table 4 confirmed that the mean age of mortalities across
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37 303 the board were in the elderly patient population with a high mean ASA grade. Males were
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39 304 consistently in the minority, while neck of femur fracture was the modal diagnosis due to
40
41 305 falls and persistently in the majority, followed by lower limb injuries (figures 5a and b). At
42
43 306 least 82% of operations were related to neck of femur fractures in which half of all operations
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45 307 during the COVID period involved anaesthetic AGPs. Whereas the mortalities from pre-
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47 308 COVID operations did not have Consultant-led (as primary surgeon) surgery, that increased
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49 309 to three-fifths of all operations conducted during the COVID period (figure 5c). The mean
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51 310 date of presentation to hospital was one week ahead in year 2020 compared to a year ago but
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53 311 the time from admission to mortality differed only by a mean of less than a day in both
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3 312 categories. Although, COVID positive swabs were confirmed in 29% of acute referrals and in
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5 313 a 32% of operative cases (figure 3), mortalities in each cohort were 6% and 8.1%
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8 314 respectively. However, only 0.9% and 1.6% were confirmed with COVID positive PCR
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10 315 swabs within one week of the date of mortality (figure 4).
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318 Table 4: Patient demographics, date of injuries, and time to mortality

	<i>Acute referrals</i>				<i>Operative casemix</i>			
	2019		2020		2019		2020	
	(n=23)		(n=38)		(n=22)		(n=34)	
Mortality	1.3%		3.2%		2.2%		4.9%	
Mortality with COVID positive PCR result			0.9%				1.6%	
Post-op morbidity					0.7%		4.1%	
Age (years; mean±SD; 95% CI)	80.2 ± 16.4 (73.2 - 87.2)		77 ± 23 (67 - 88)		83.9±12.2 (78.7 - 89.1)		84.0±13.5 (79.4 - 88.5)	
Male	9	39%	16	42%	8	36%	15	44%
ASA (mean±SD; 95% CI)					3 ± 0 (3 to 3)		3 ± 1 (3 to 3)	
Date of injury (mean days±SD; 95%CI)	6/4 ± 11 (1/4 - 10/4)		31/3 ± 12 (26/3 - 5/4)		6/4 ± 12 (1/4 - 11/4)		30/3 ± 14.2 (25/3 - 4/4)	
Time from admission to mortality (mean days±SD; 95%CI)	10.3 ± 7.5 (7.1 - 13.5)		11 ± 10 (7 - 15)		14.3 ± 10.4 (9.8 - 18.7)		13.8 ± 10.4 (10.2 - 17.3)	

319

320 *Figure 5a: types and mechanism of injury for mortalities in acute referral cohorts*321 *Figure 5b: types and mechanism of injury for mortalities in operative casemix cohorts*322 *Figure 5c: Surgical and anaesthetic techniques utilized in mortalities as a means of*

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proportions

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3 325 Taking into account that COVID was a peri-operative complication since patients may have
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5 326 been symptomatic with COVID manifestations pre-operatively but only had the swab results
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7 327 return with a positive finding either pre- or post-operatively; the commonest post-operative
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9 328 complication in the COVID period was a hospital-acquired pneumonia but with negative
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11 329 COVID swab results or the decision not to test at all. The second most common post-
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13 330 operative complication in the year 2020 was extra-pulmonary sepsis (figure 6). The
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15 331 proportion of post-operative complications had significantly increased when including or
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17 332 excluding COVID as a peri- or post-operative complication in 2020 (0.70% vs. 2.57-4.14%;
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19 333 $p=0.003$) with varying odds (3.72-23.4) and risk (3.65-32.6) ratios (table 3).
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27 335 *Figure 6: Post-operative complications for both years*
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31 337 Figures 7a and b focused on the total number and nature of comorbidities within the mortality
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33 338 groups. Multiple contingency chi-square test was insignificant for both number of
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35 339 comorbidities and individual comorbidities between both years, except for cardiovascular and
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37 340 cerebrovascular disease in acute referrals. This was corroborated by the COVIDSurg
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39 341 publication¹⁴ which confirmed a significant association of mortality with myocardial
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41 342 infarction and congestive heart failure. However, hypertension and stroke/transient ischemic
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43 343 attacks were not significantly associated. In our study, all cardiovascular diseases (including
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45 344 peripheral vascular, arrhythmias, hypertension, heart failure, myocardial infarction and acute
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47 345 coronary syndromes) were combined with cerebrovascular diseases (consisting of strokes and
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49 346 transient ischemic attacks). Unlike their study, our study did not find a significant association
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51 347 with chronic kidney disease, chronic obstructive disease (which included asthma) and
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53 348 dementia in all mortalities during the 2020 timeframe regardless of the COVID status. The
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55 349 differences may stem from that their study looked at the comparison of mortality rates within
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3 350 the same cohort during the COVID era, whereas this study is sub-analysing the entire
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5 351 mortality cohort on its own to observe for specific associations and risks.
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10 353 *Figure 7a: Type of comorbidities for all mortalities in both years*

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13 354 *Figure 7b: number of comorbidities for all mortalities in both years*

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16 356 **Survival probability**

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18 357 A six-week Kaplan-Meier survival probability analysis for mortalities between both years
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20 358 was plotted in figure 8a.
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28 360 *Figure 8a: Six-week Kaplan-Meier survival probability analysis for mortalities between pre-*
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30 361 *and post-COVID for acutely referred from the Emergency Department*

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35 363 There were similar patterns of survival probability between both cohorts (i.e. 2019 vs 2020
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37 364 cumulative). However, the lowest survival probability and the shortest timeframe were
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39 365 observed in the confirmed COVID positive cohort as seen in figure 8a. This may be due to
40
41 366 the most vulnerable patient profile. 8 (72.7%) patients had femoral trauma, most being neck
42
43 367 of femur fractures, distal femur fracture and a dislocated hip hemiarthroplasty post-fracture.
44
45 368 Other patients presented with septic arthritis, post-operative complication and knee swelling;
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47 369 yet every patient also suffered from multiple comorbidities including those leading to
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49 370 immunosuppression as seen in figures 7a and b. Although these patients were prioritised in
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51 371 the Emergency Department and recognised for their poor physiological reserve, due to the
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53 372 stresses of the acute and emergency services, these patients may have had to wait longer to be
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55 373 treated acutely and appropriately admitted.
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6 375 *Figure 8b: Six-week Kaplan-Meier survival probability analysis for mortalities between pre-*
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8 376 *and post-COVID for those undergoing surgery*9
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11 37712
13 378 Unexpectedly, there was a reversal of trends observed for the six-week Kaplan-Meier
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15 379 survival analysis once admitted and operated on in figure 8b. Mortalities within the pre-
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17 380 COVID period had the lowest survival probability compared to the post-COVID cohort. The
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19 381 COVID positive mortalities were observed to have the highest survival probability 11 days
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21 382 prior to converging with those mortalities without COVID symptoms. This was most likely to
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23 383 be due to multifactorial factors.
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29 386 During the pandemic, wards were ring-fenced to host confirmed COVID positive patients
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31 387 with a heightened care of nursing, medical cover and personal protective equipment. Prior to
32
33 388 the onset of a possible vaccination to counteract the virus, symptomatic management and
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35 389 shielding were the mainstay treatments for COVID positive patients. None of these patients
36
37 390 were stepped up to the Intensive Treatment Unit due to being categorised as high-risk
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39 391 stratification for mortality based on age and extent of comorbidities.
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41 39242
43 39344
45 394 If these 'at risk' patients were symptomatic with the virus, then aggressive pre-operative
46
47 395 optimisation would occur. Since 91% (n=10) of COVID positive patients had sustained a
48
49 396 neck of femur fracture, the National Hip Fracture Database best practice tariff of operating
50
51 397 within an ideal 36-hour window set by the Royal College of Physicians was suspended until
52
53 398 the patient was stabilised. All hip fracture patients in this cohort were operated on and had
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55 399 dedicated orthogeriatric input commencing from hospital admission. Hence the early peri-
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57 400 operative period and surgery encompassed within the 10-day period post-admission.
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3 399 Moreover, neck of femur fractures are recognised as a pre-terminal illness and are known to
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5 400 carry a high risk of mortality in the first month which is trebled in the first year after the
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7 401 injury.¹⁵
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402 Discussion

403 Statement of principal findings

404 There was a significant difference between pre- and post-COVID periods at its 'peak weeks'.

405 The alternative hypothesis was not rejected with respect to prevalence of (i) acute
406 orthopaedic trauma referrals (reduced by 34%), (ii) surgical interventions (reduced by
407 29.5%), (iii) anaesthetic aerosolising-generating procedures, (iv) mortality rates (more than
408 doubled in the COVID period), and (v) survival probability between pre- and post-COVID
409 eras. The 34% reduction in acute trauma referrals is in keeping with previous single centre
410 studies performed in the UK with results ranging between 26-59%.^{10-13,16,17} As described in
411 these previous studies we would attribute the overall reduction of trauma workload to be due
412 to reduction in travel and outdoor activities during the national lockdown.

413

414 MacDonald *et al.*¹⁸ described a similar effect in their multi-centre study with a reduction of
415 operative workload by 26.5% compared to 29.5% in our study. Sites recruited for this study
416 confirmed that they continued to operate at their own facilities during the data collection
417 period whereas some later used alternative and external facilities including private hospitals
418 through NHS England pathways (as mentioned by Dayananda *et al.*¹⁹), which may have
419 impacted nosocomial rates of COVID, morbidity and mortality. However, this would be
420 difficult to assess since it would also depend on the diversions of the ambulance services to
421 'clean' and 'contaminated' hospital sites.

422

423 There was a significant decline in the odds of trauma calls, road traffic accidents, sporting
424 injuries and lower limb fractures. Conversely, there was a significant rise in the odds of neck
425 of femur fractures, falls, the use of anaesthetic AGP and Consultant-led operations; a finding

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3 426 also reflected by Arafa *et al.*²⁰. Since the aetiology of neck of femur fracture are often low
4
5 427 energy falls in the home environment, it is not unexpected to observe a consistency of neck of
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7 428 femur fractures in the elderly and the vulnerable during lockdown. Odds of falls may have
8
9 429 increased due to prodromal symptoms and clinical manifestations of COVID.
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15 431 **Morbidity and Mortality rates**

17 432 Mortality rates significantly doubled for both prevalence (or risk) and odds ratios during the
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19 433 COVID-19 period and a third (29-32%) of those deaths had a positive COVID-19 diagnosis.
20
21 434 Comparatively, the COVIDSurg Collaborative observed a 30-day mortality rate of 28.8%
22
23 435 ($p < 0.0001$) of Orthopaedic patients who underwent surgery (both elective and trauma) within
24
25 436 the first quarter of the year.¹⁴ Those with neck of femur fractures remain at greatest risk of
26
27 437 mortality and there have been further studies evaluating the risk of COVID-19 on this
28
29 438 inherently high risk cohort.²¹⁻²⁴ The increased mortality reflect the increased proportion of
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31 439 NOFF patients that have a higher baseline mortality which has been echoed by the Scottish
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33 440 IMPACT-Restart study.²⁴
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41 442 A subgroup analysis separating NOFF to non-NOFF mortality is demonstrated in table 4.
42
43 443 There was no statistical difference in the odds and risk ratios between both years for mortality
44
45 444 rate in NOFF. The numbers have not changed much, but because of a drop off of other cases,
46
47 445 the percentage of NOFF markedly rose. Hence, the mortality expressed as a percentage of
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49 446 cases is notably higher for all operations, and not necessarily if stripped down to hip fractures
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51 447 alone.
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56 449 As lockdown measures in the UK and globally eases and the incidence of trauma returns to
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58 450 pre-lockdown trends, it is imperative that we understand the true increased risk of mortality
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3 451 in the acute trauma patient during the COVID-19 era. A recent publication by Kader et al.²⁵
4
5 452 has suggested that the rate of mortality from COVID-19 for elective Orthopaedic patients is
6
7 453 low; yet this is the first nationwide study to quantify mortality risk for trauma patients.

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10 454 Trauma procedures due to the nature of the injuries are necessary and time-critical, and
11
12 455 nobody can afford to postpone trauma care even during a global pandemic.²⁶
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17 457 Furthermore, the Corona Hands Collaborative²⁷ published that upper limb trauma patients
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19 458 had SARS-CoV-2 complication rate of 0.18% (n=2) with 0.09% (n=1) overall mortality at
20
21 459 the peak of the first wave in April 2020. However, their collaborative looked into a shorter
22
23 460 post-operative period (30 vs 42 days) but they agreed that patients who had been hospitalised
24
25 461 for a prolonged period before their surgery were at increased risk of both COVID-related and
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27 462 post-operative complications. Most of their patient cohort, who were both younger and fitter
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29 463 than our cohorts, would be classified as the 'walking wounded' and could usually be day-case
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31 464 procedures.
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37 466 Although the trends in mechanisms of injury in our study were reflective of those within a
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39 467 US multi-centre study, there was an opposing trend in the number medical/surgical
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41 468 procedures.²⁸ That could be due to their study encompassing on level 1 trauma centres with a
42
43 469 mean younger patient population. However, we do agree that with time and from experiential
44
45 470 learning, hospitals improved their coping strategies with the pandemic and enhanced patient
46
47 471 safety by enforcing personal protection equipment, hosting dedicated theatres for COVID-
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49 472 positive patients, separating sites as clean and contaminated, ringfencing COVID-positive
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51 473 patients to dedicated wards, and promoting routine COVID PCR swabs for all admissions
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53 474 and pre-operative checklists.
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3 476 With an overall mortality risk in 2020 doubled that of 2019, clinicians need to counsel
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5 477 patients presenting with acute orthopaedic trauma of the increased risk in the COVID-19 era,
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7 478 especially for those identified as increased risk stratification with multiple underlying
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9 479 comorbidities, elderly and frailty. With the ongoing risk of a second wave and resurgence of
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11 480 COVID-19 cases on top of the inevitable winter pressures, this data is of critical importance
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13 481 in the risk management, decision-making and policymaking of trauma patients both in the
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15 482 UK and across the globe.
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484 **Strengths and weaknesses of the study and in relation to other studies**

23 485 This was the first representative observational study of the UK looking into the impact of
24
25 486 COVID-19 pandemic on general Trauma and Orthopaedic surgical specialty. Studies thus far
26
27 487 have only shed light on local scales or cross-speciality.¹⁰⁻¹⁴ Weaknesses included loss of data
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29 488 points which have been accounted for in the tables (i.e. labelled as unknown). However this
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31 489 did not affect the final analysis of data points. Operations conducted outside the specific
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33 490 study periods will not account for all those operations required such as for NOFF. It does not
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35 491 suggest that the number of NOFF not accounted for have been managed conservatively (as
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37 492 discovered by Cherevu et al.²⁹), since some NOFFs may breach time to surgery due to
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39 493 medical reasons and allowing for international guidelines.³⁰
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495 **Limitations and future research**

496 It is vital to continue exploring the impact of the pandemic on a larger scale. Ideally, more
497 secondary care providers consisting of district general hospitals and major trauma centres
498 will submit data. The diagnosis of COVID was dependent on positive PCR swabs for this
499 study rather than non-specific changes seen on chest CT or plain radiographs. This does not
500 account for false negatives with clinical respiratory symptomatology or true positives in those
501 asymptomatic. Nevertheless, this issue with data has been speculated on in another national
502 study.²⁷ Data ought to be submitted during the peak of the pandemic as well as at various
503 time intervals as the lockdown measures ease resulting in more freedom of movement while
504 also accounting for the continued risk of subsequent waves and national lockdowns.³¹ Further
505 studies will also require to compare the impact of the pandemic on the speciality in the UK
506 compared to other countries on other continents.

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2
3 507 **Conclusion**
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5 508 This was the first, longest and largest national representation of the impact of COVID-19
6
7 509 pandemic on acute Orthopaedic trauma referrals and mortality between mid-March to end-
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9 510 April, representing the ‘peak weeks’ during the lockdown. The mortality rate for acute
10
11 511 referrals, as well as those undergoing operative intervention, more than doubled in odds when
12
13 512 compared to the same time interval one year ago. The majority of mortalities consisted of the
14
15 513 elderly with neck of femur fractures and cardiovascular and/or cerebrovascular diseases. This
16
17 514 study will aid clinicians in counselling trauma patients of the increased risk of mortality
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19 515 during the era of COVID-19 and also aid in both healthcare infrastructure, resource
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21 516 allocation, decision-making and policymaking as we continue to battle with the pandemic.
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Figure 1b: Types and mechanisms of injuries for operative cases

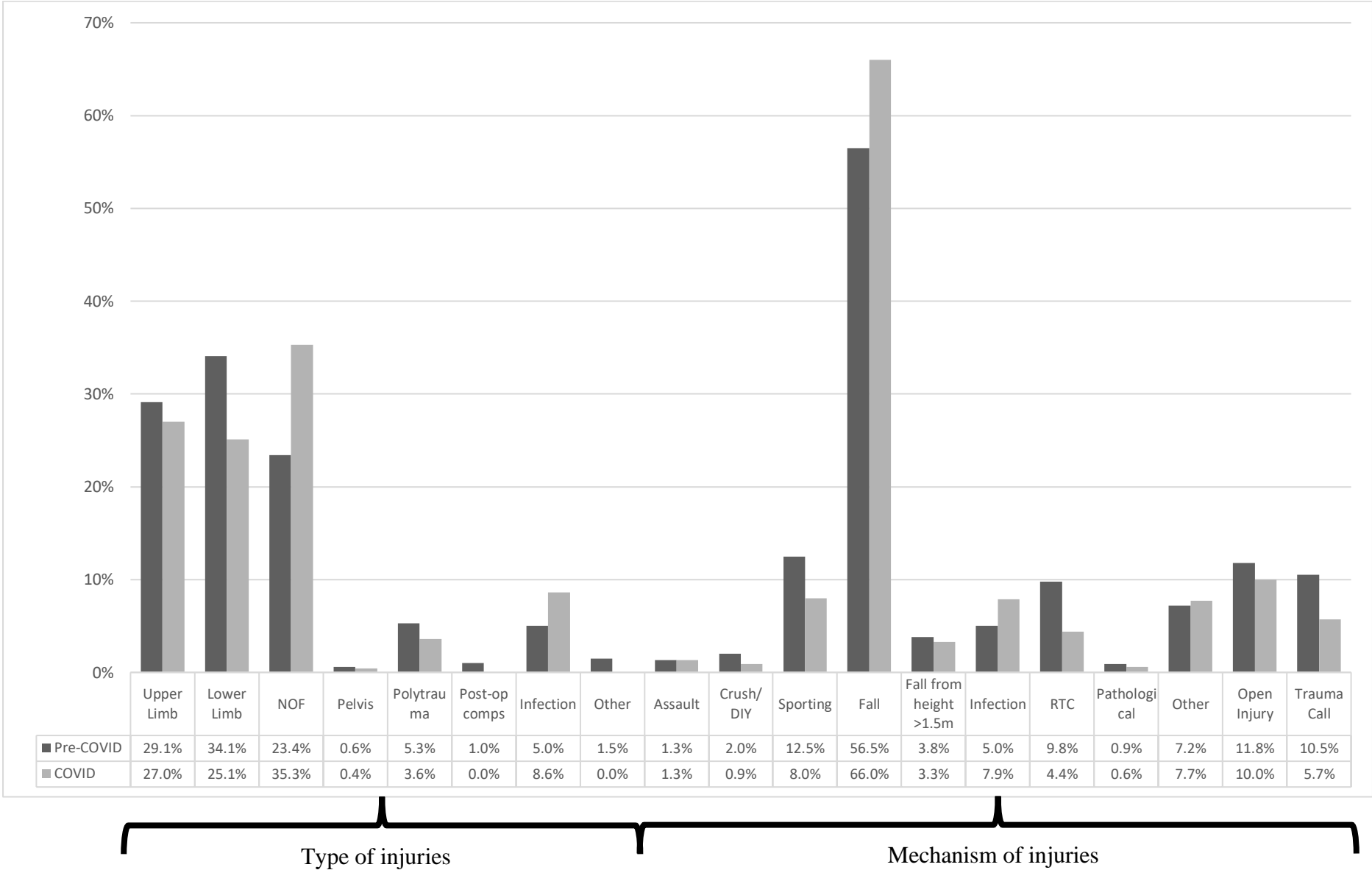
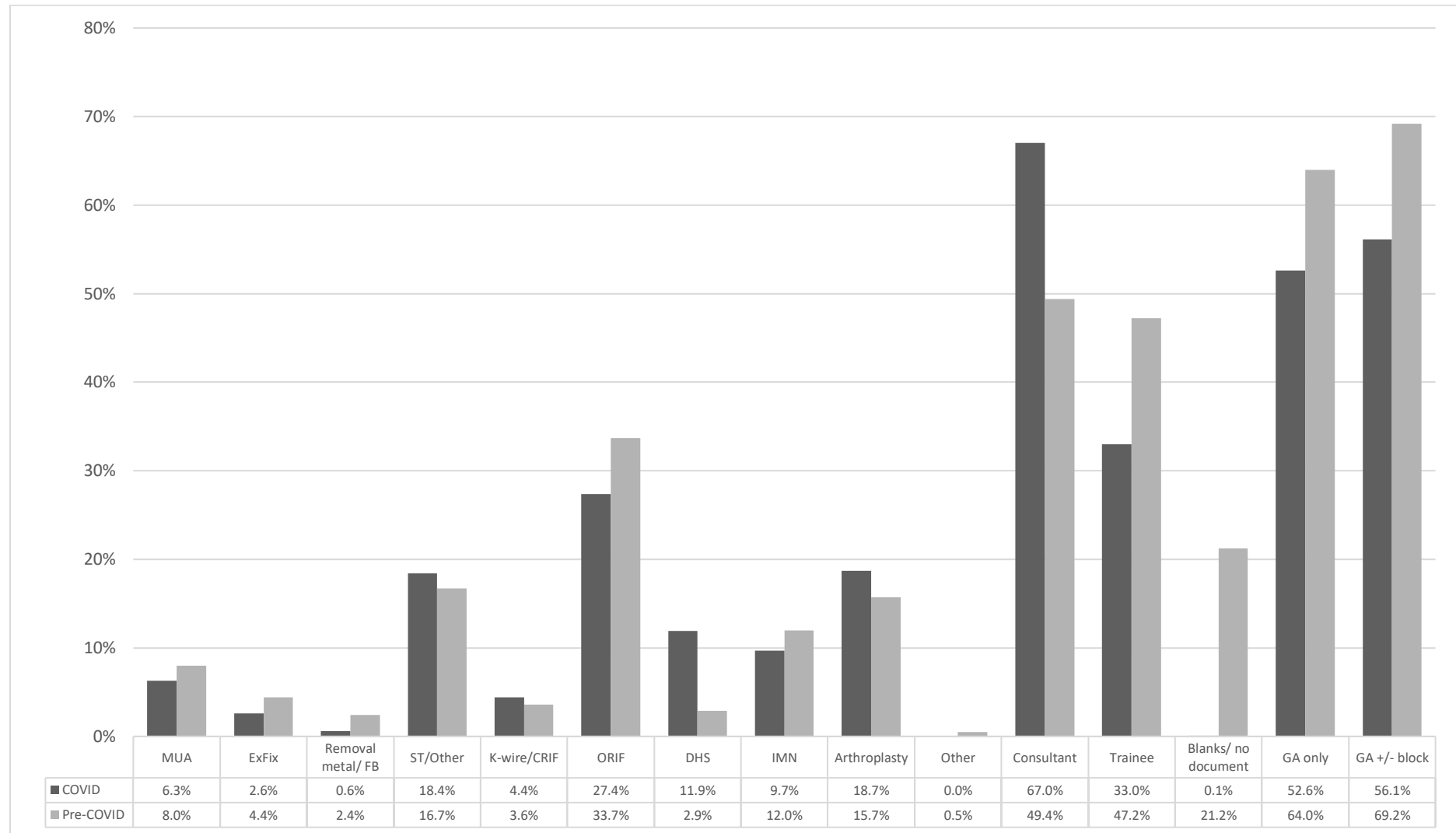


Figure 2: operative and anaesthetic techniques compared between pre- and post-COVID



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Type of injuries
Primary surgeon
Anaesthetic technique

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Figure 3: COVID status for acute referrals and operative cases as a measure of proportions (with 5% error bars)

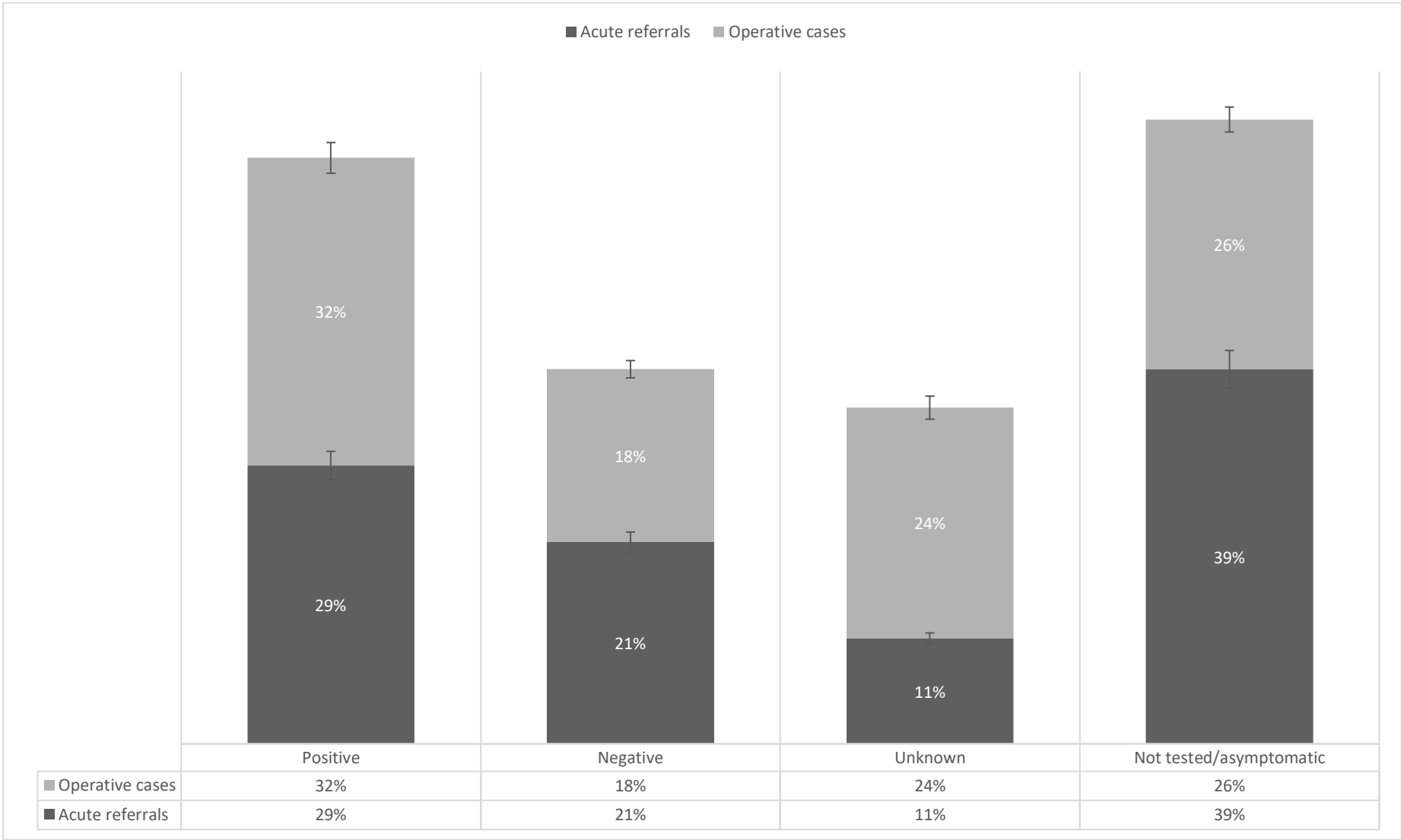
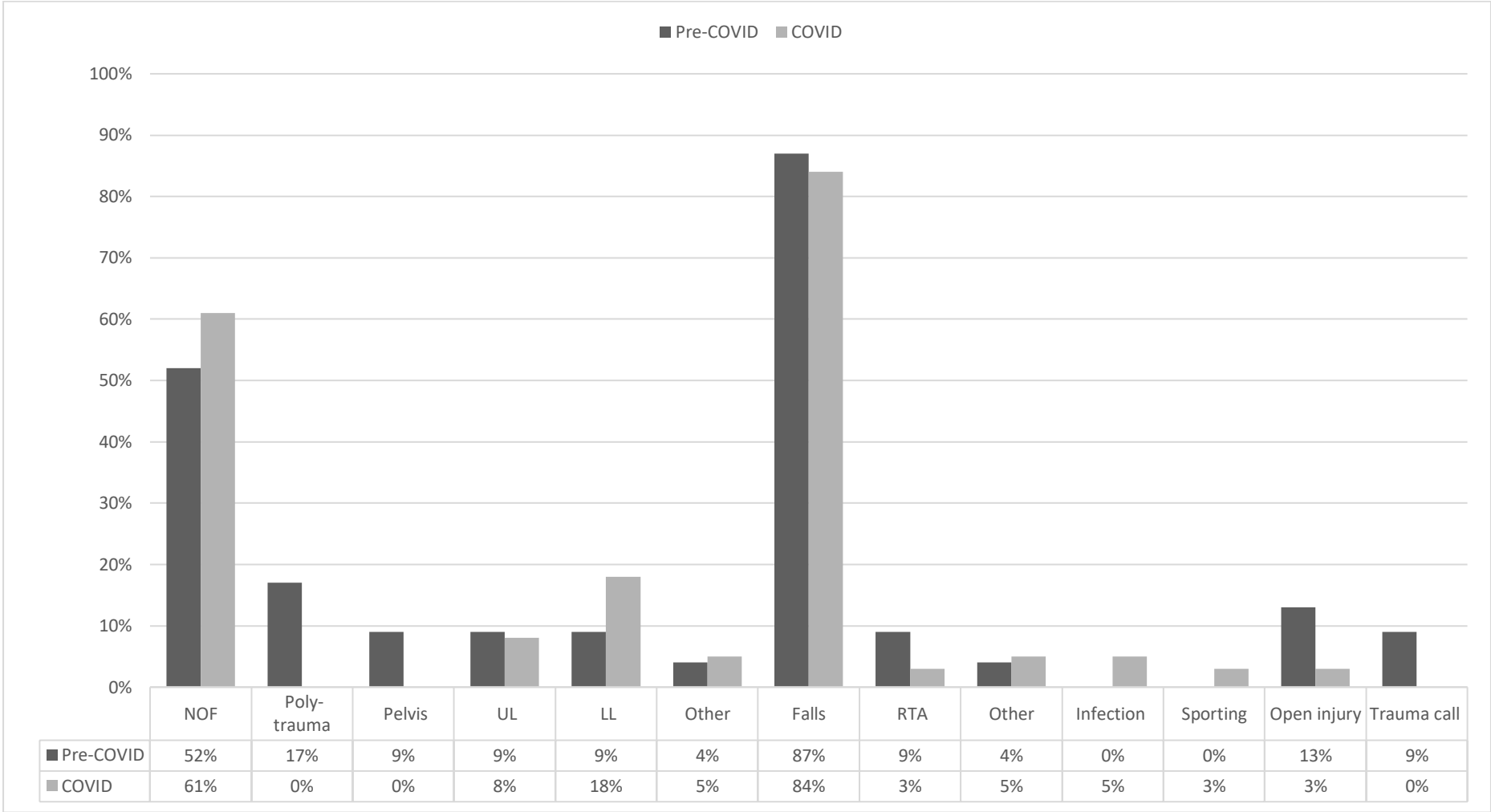


Figure 4: COVID status of all mortalities (with 5% error bars)

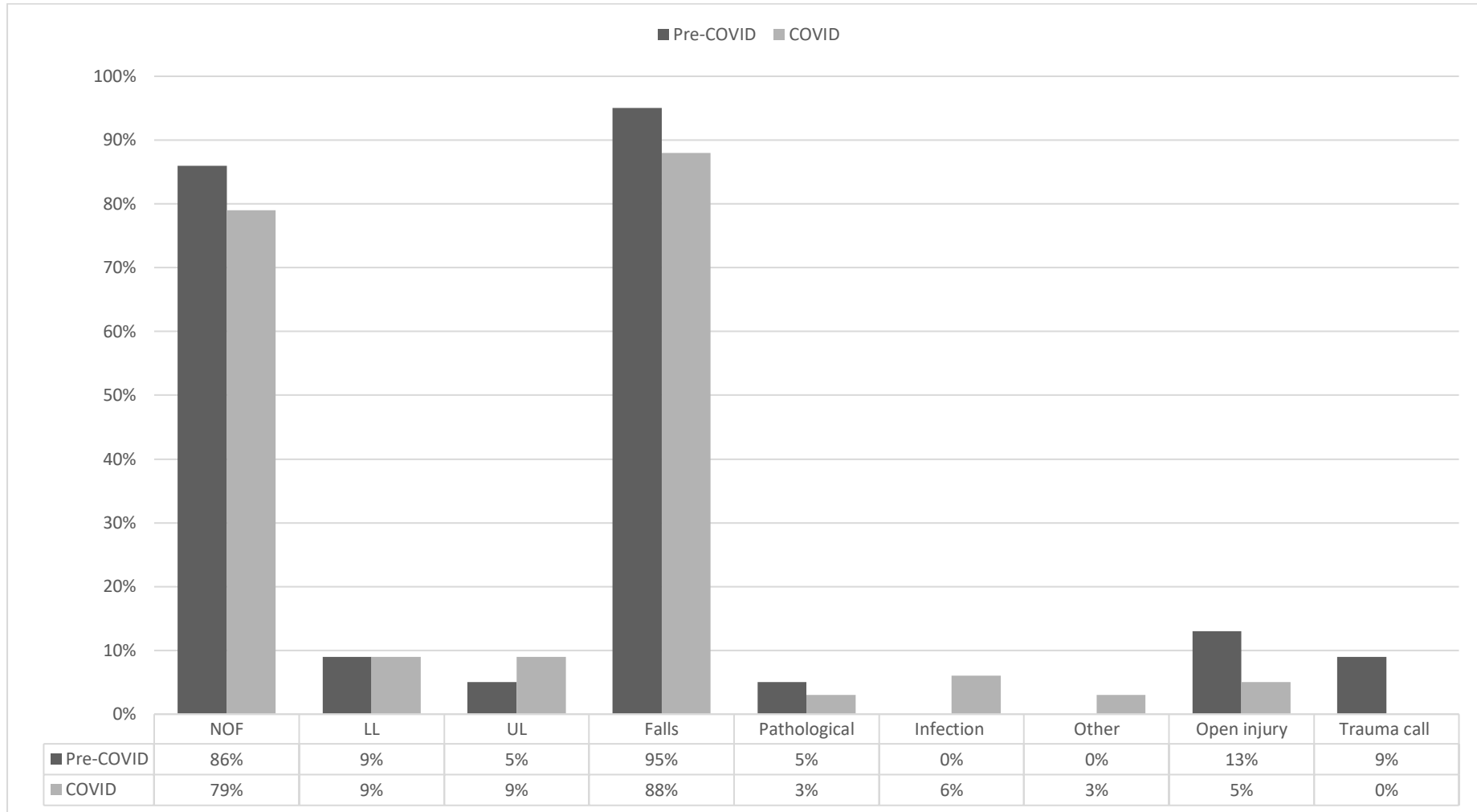


Figure 5a: types and mechanism of injury for mortalities in acute referral cohorts



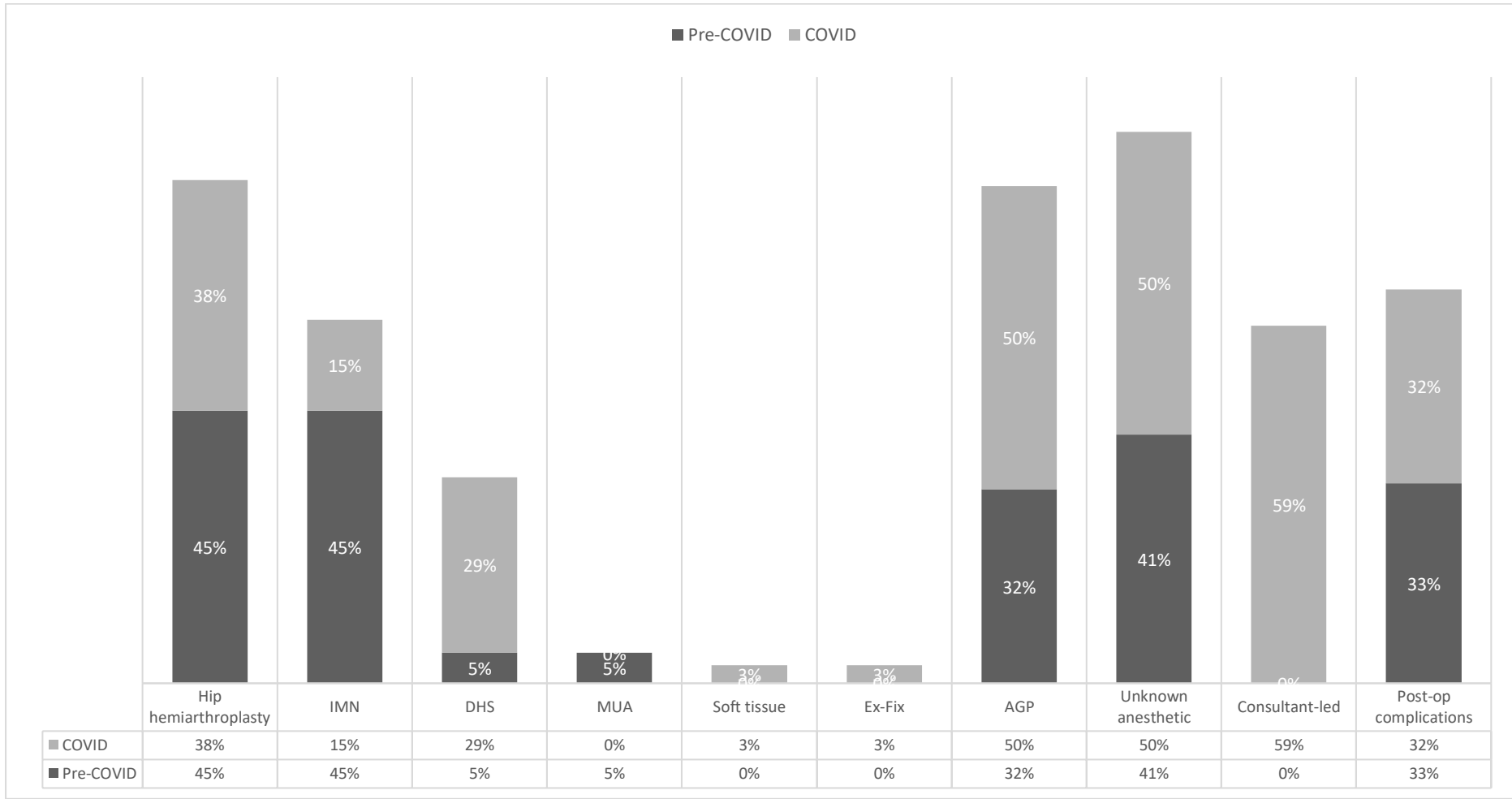
Key: UL: upper limb / LL: lower limb / RTA: road traffic accidents

Figure 5b: types and mechanism of injury for mortalities in operative casemix cohorts



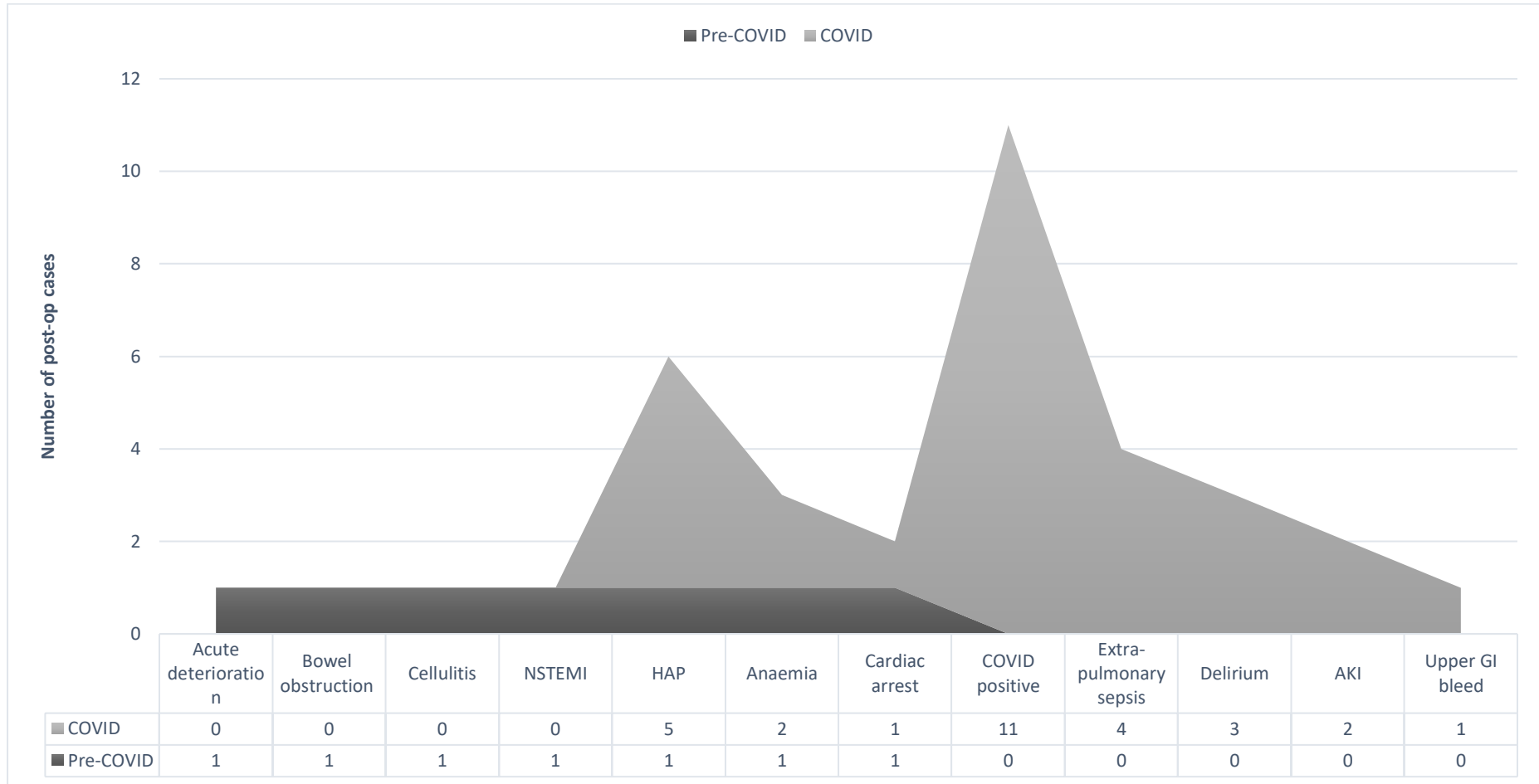
Key: NOF: neck of femur fracture / UL: upper limb / LL: lower limb

Figure 5c: Surgical and anaesthetic techniques utilized in mortalities as a means of proportions



Key: IMN: intramedullary nailing / DHS: dynamic hip screw / MUA: manipulation under anaesthesia / Ex-Fix: external fixation / AGP: aerosolizing-generating procedures

Figure 6: Post-operative complications for both years



Key: NSTEMI: non-ST elevated myocardial infarction, HAP: hospital-acquired pneumonia, AKI: acute kidney injury, GI: gastrointestinal

Figure 7a: Type of comorbidities for all mortalities in both years

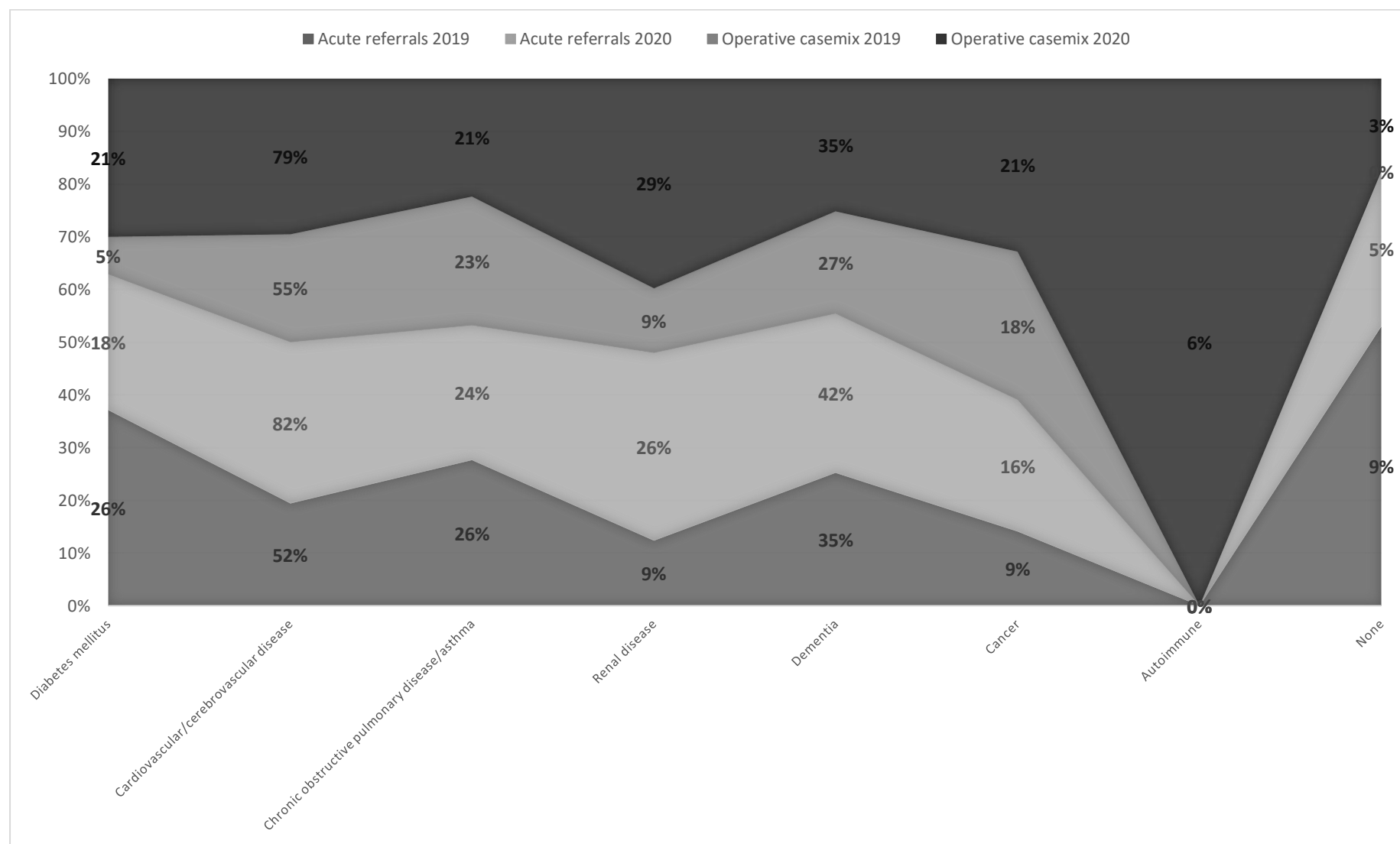


Figure 7b: number of comorbidities for all mortalities in both years

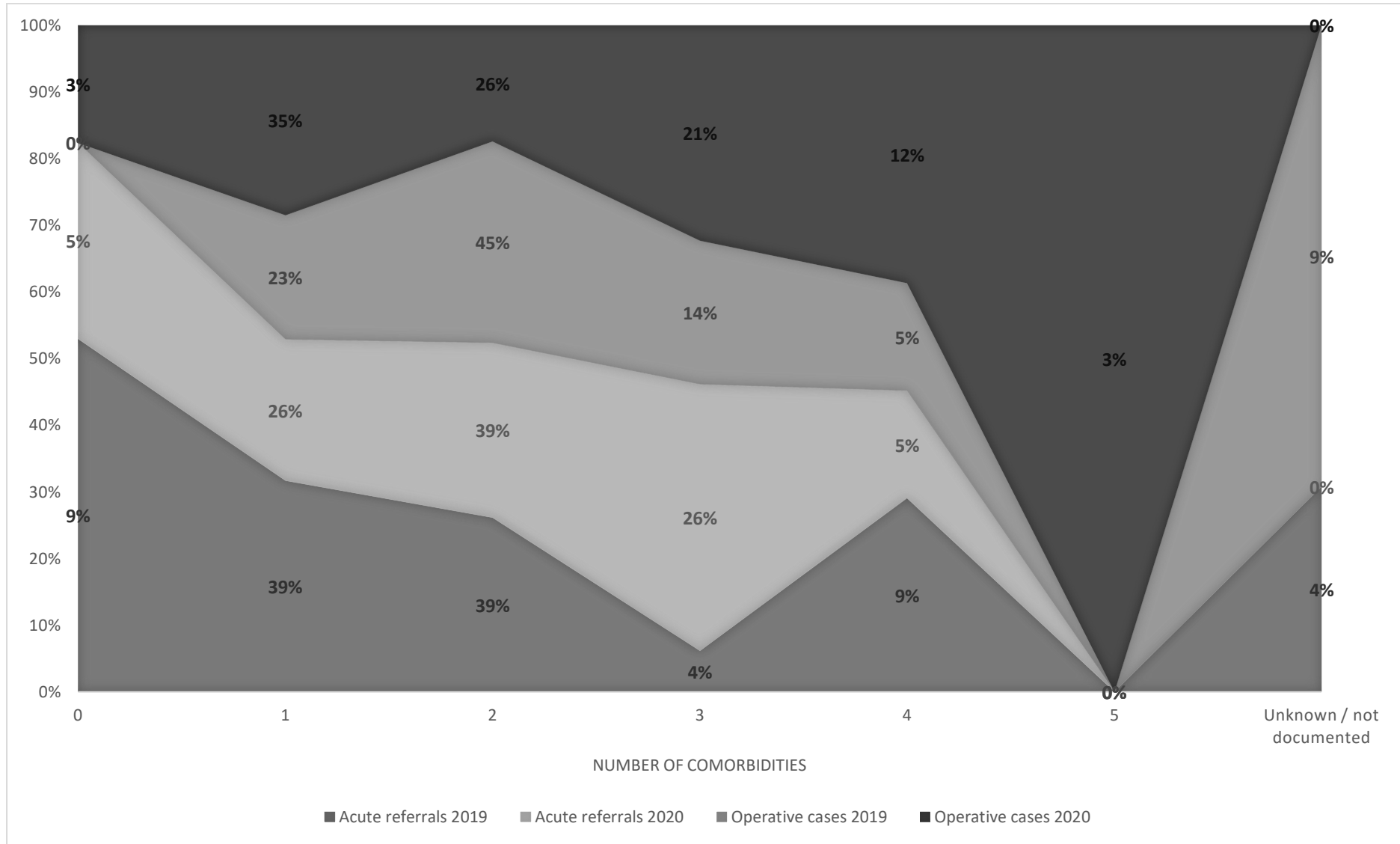


Figure 8a: Six-week Kaplan-Meier survival probability analysis for mortalities between pre- and post-COVID for acutely referred from the Emergency Department

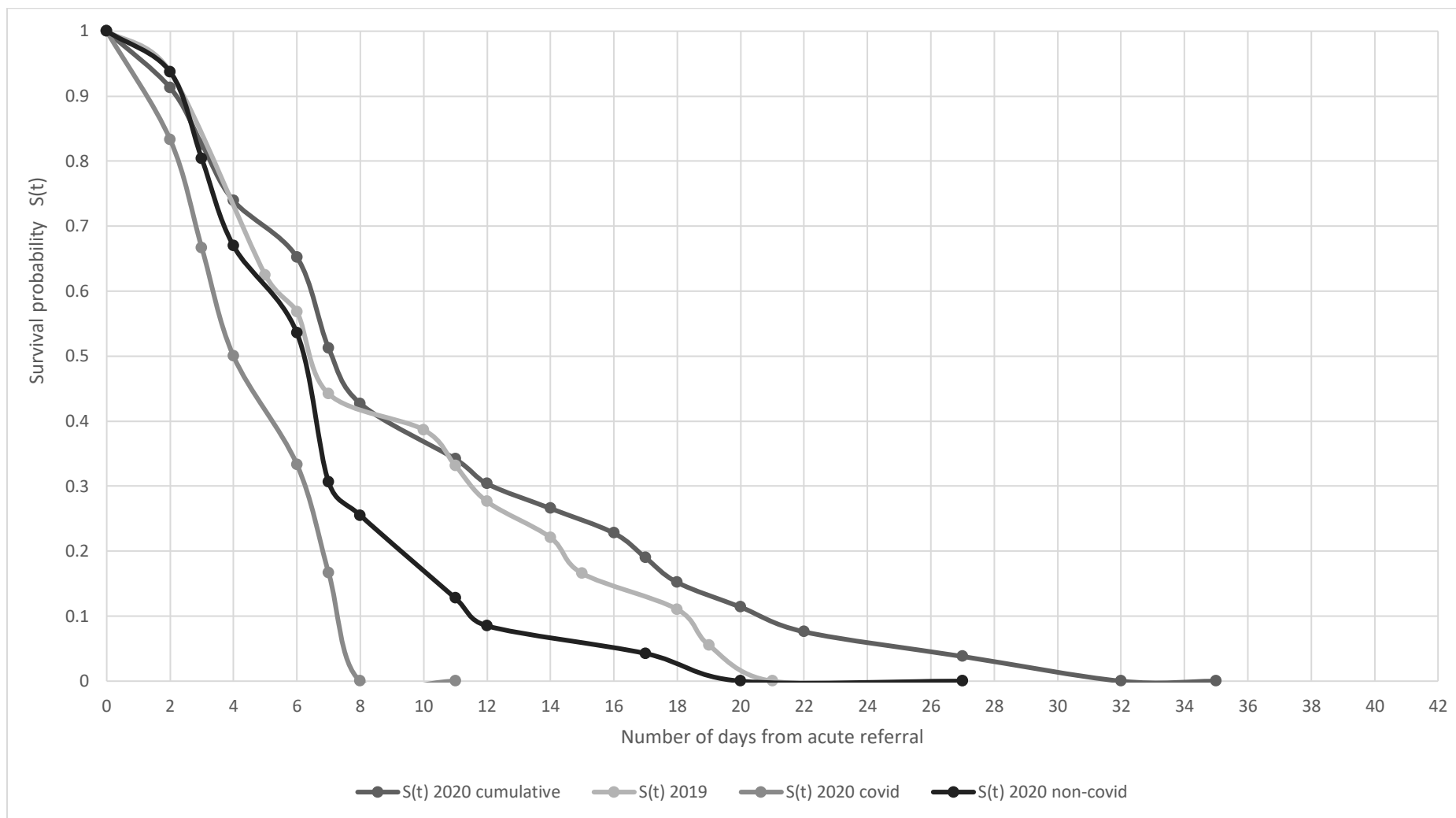
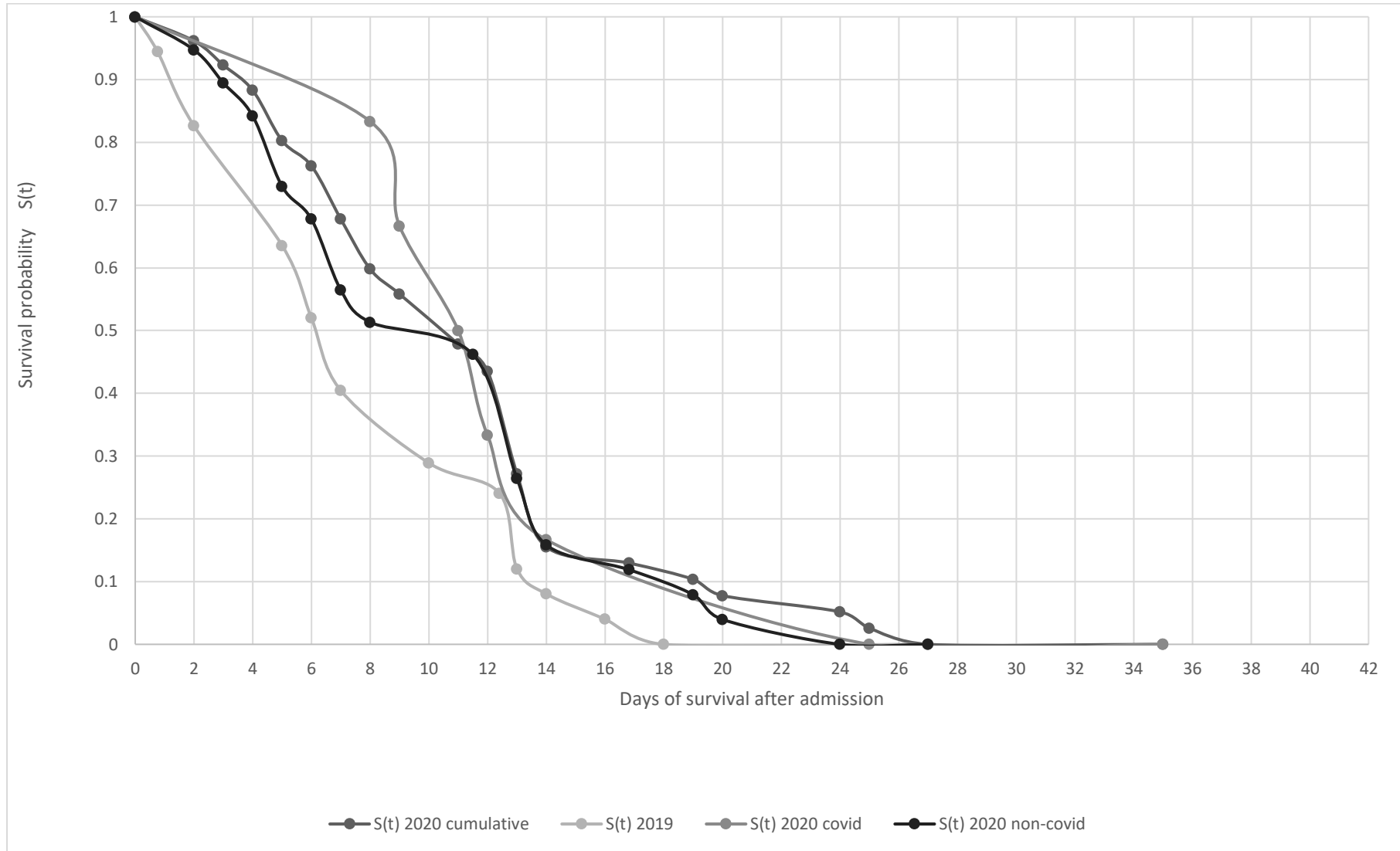


Figure 8b: Six-week Kaplan-Meier survival probability analysis for mortalities between pre- and post-COVID for those undergoing surgery



STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up <i>Case-control study</i> —Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls <i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants (b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed <i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed <i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed <i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Continued on next page

Results

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time <i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure <i>Cross-sectional study</i> —Report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses

Discussion

Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results

Other information

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

The impact of COVID-19 on acute trauma and orthopaedic referrals and surgery in the UK during the first wave of the pandemic: a multicentre observational study

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Primary Subject Heading:	Surgery
Secondary Subject Heading:	Emergency medicine, Epidemiology, Surgery, Medical management, Health services research
Keywords:	COVID-19, TRAUMA MANAGEMENT, ORTHOPAEDIC & TRAUMA SURGERY, EPIDEMIOLOGY

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57 17 **Keywords:** COVID-19; orthopaedic trauma; UK multi-centre; pandemic wave; mortality
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19 **Word count: 4000 words**

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3 **20 Abstract**
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7 **22 Objective:** This is the first British multi-centre study observing the impact of the COVID-19
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9 **23** pandemic on orthopaedic trauma with respect to referrals, operative caseload and mortality
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11 **24** during its peak.

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13 **25 Design:** A longitudinal, multi-centre, retrospective, observational, cohort study was
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16 **26** conducted during the peak 6 weeks of the first wave from March 17, 2020 compared to the
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18 **27** same period in 2019.

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20 **28 Setting:** Hospitals from six major urban cities were recruited around the UK, including
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23 **29** London.

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25 **30 Participants:** A total of 4840 clinical encounters were initially recorded. 4668 clinical
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27 **31** encounters were analysed post-exclusion.

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29 **32 Primary and secondary outcome measures:** Primary outcomes included the number of
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32 acute trauma referrals and those undergoing operative intervention, mortality rates, and the
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34 **34** proportion of patients contracting COVID-19. Secondary outcomes consisted of the
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36 **35** mechanism of injury, type of operative intervention and proportion of aerosolising-generating
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38 **36** anaesthesia utilised.

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40 **37 Results:** During the COVID-19 period there was a 34% reduction in acute orthopaedic
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43 **38** trauma referrals compared to 2019 (1792 down to 1183 referrals), and 29.5% less surgical
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46 **39** interventions (993 down to 700 operations). The mortality rate significantly (both statistically
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48 **40** and clinically) more than doubled for both risk and odds ratios during the COVID period in
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50 **41** all referrals (1.3% vs 3.8%, $p=0.0005$) and in those undergoing operative intervention (2.2%
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52 **42** vs 4.9%, $p=0.004$). Moreover, mortality due to COVID-related complications (versus non-
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54 **43** COVID causes) had greater odds by a factor of at least 20 times. For the operative cohort
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56 **44** during COVID, there was a greater odds of aerosolising-generating anaesthesia (including
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3 45 those with superimposed regional blocks) by three-quarters as well as doubled odds of a
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5 46 Consultant acting as the primary surgeon.
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10 48 **Conclusion:** Although there was a reduction of acute trauma referrals and those undergoing
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12 49 operative intervention, the mortality rate still more than doubled in odds during the peak of
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14 50 the pandemic compared to the same time interval one year ago.
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19 52 **Keywords:** COVID-19; orthopaedic trauma; UK multi-centre; pandemic wave; mortality
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24 54 **Article summary: Strengths and limitations of this study**
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- 26
27 55
- 28 • This was the first representative observational study of the UK looking into the
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31 56 impact of COVID-19 pandemic on general trauma and orthopaedic surgical specialty.
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 - 34 57 • There is a valid comparison between two timeframes, exactly one year apart to
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37 58 represent pre-COVID and during COVID.
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41 59 • Other studies thus far have only shed light on local scales or cross-speciality within a
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44 60 shorter timeframe than this study and not necessarily commenting on mortality rates
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47 61 like this study.
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51 62 • Weaknesses included loss of data points which have been accounted for in the tables
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54 63 (i.e. labelled as unknown) which did not affect the final analysis of data points.
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4 64 • Operations conducted outside the specific study periods will not account for all those
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7 65 operations required such as for hip fractures.
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For peer review only

66 **Introduction**

68 *The Global Impact of COVID-19*

69 The COVID-19 pandemic will be remembered as one of the most unprecedented global
70 health crises in modern history. With over 4.5 million deaths and over 224 million recorded
71 cases globally, the pandemic has had a permanent impact on healthcare at the time of article
72 submission.¹ The viral outbreak was first reported in December 2019 with the first patient
73 hospitalised in the city of Wuhan, China.² By mid-March the outbreak affected over 190
74 countries with over 450,000 cases and over 20,000 deaths, thus being declared a pandemic
75 and a global public health emergency by the World Health Organization.³ On January 24th
76 2020 Europe reported its first case followed by a case in the United Kingdom (UK) 5 days
77 later.⁴

79 *The British Response to the pandemic*

80 The English government responded by implementing social distancing measures on the 17th
81 March 2020 in an attempt to reduce the rate of transmission and therefore the demands on the
82 National Health Service (NHS).⁵ This was followed a week later by more stringent measures,
83 commonly referred to as a societal 'lockdown'.⁶ As of the 23rd March 2020, all members of
84 the public were required to stay at home. The NHS has also been deeply affected by the strain
85 imposed by the virus as the healthcare infrastructure has had to evolve to cope with the
86 overwhelming and unexpected pressures on staff, resources and finances. There has been a
87 complete renovation of emergency medicine and orthopaedic services to manage
88 musculoskeletal disease and trauma. In response to the NHS emergency declaration,⁷ the
89 Royal Colleges of Surgeons⁸ and the British Orthopaedic Association⁹ both issued statements
90 and guidelines for delivering emergency trauma and orthopaedic care during the COVID-19
91 outbreak. The lockdown to limit the spread of the virus has had an unforeseen effect in

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3 92 significantly reducing the acute trauma workload described in several single centre studies.¹⁰⁻
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5 93 ¹³ There has however not been a British multi-centre reflection of the impact of the COVID-
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7 94 19 pandemic on the orthopaedic workload and its potential impact on the mortality.
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13 96 **Aim**

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15 97 To observe the impact of COVID-19 on trauma and orthopaedic acute referrals, operative
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17 98 casemix and mortality rates during the peak 6 weeks of the first wave of the pandemic
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19 99 compared to the same time interval in 2019.
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26 101 **Alternative hypothesis**

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28 102 When comparing both years, there would be a difference in the prevalence of acute
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30 103 orthopaedic referrals, orthopaedic trauma casemix and aerosol-generating anaesthetic
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32 104 procedures due to social distancing/lockdown. Mortality rates and survival probabilities were
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34 105 also hypothesised to differ due to the first COVID-19 outbreak.
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107 **Methods**

108 *Study design:* This is the first multi-centre longitudinal observational study observing patients
109 who were acutely referred to the trauma and orthopaedic departments as well as those
110 operated on within the same 6-week interval comparing 2019 to 2020.

111
112 *Setting:* 7 principal hospitals contributed data from 6 major urban cities including London,
113 Gateshead, Middlesbrough, Dartford, Newport, and Reading.

114
115 *Patient sampling:* All acute referrals, operative notes, inpatient medical records and discharge
116 summaries were accessed using electronic medical system at each contributing hospital trust.

117
118 *Study period:* The 6-week study period was from the start of social distancing on Tuesday
119 17th March 2020 to Tuesday 28th April 2020 which encompassed the national lockdown
120 measures instigated on the 23rd March 2020. This period was considered the peak 6 weeks of
121 the epidemic in the UK as outlined by the recorded mortality rates and R-values published by
122 the Office of National Statistics.¹⁴ This time period was compared to the same 6-week
123 interval from Tuesday 19th March to Tuesday 30th April 2019 (i.e. prior to any COVID-19
124 related measures) to compare the impact of the pandemic one year apart.

125
126 *Outcomes/objectives:* Primary outcomes included the number of acute trauma referrals and
127 those undergoing operative intervention, post-operative complications, mortality rates, and
128 the proportion of patients contracting COVID-19. Secondary outcomes consisted of the

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3 129 mechanism of injury, type of operative intervention and proportion of aerosolising-generating
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5 130 anaesthesia utilised.

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11 132 *Inclusion criteria:* All acute orthopaedic trauma referrals presenting to the Emergency
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13 133 Department during the intervals one year apart were included. All orthopaedic trauma cases
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15 134 that required an operation, including those from acute orthopaedic trauma referrals, within
16
17 135 the intervals one year apart. Those patients listed for an operation due to orthopaedic trauma
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19 136 prior to time period of data collection were included in the final analysis. We adhered to
20
21 137 STROBE guidelines for observational studies.

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28 139 *Exclusion criteria:* Any cases being referred internally from other specialties for trauma and
29
30 140 orthopaedic advice and input, as well as referrals from any external centre asking for tertiary
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32 141 advice were excluded from further analysis. Any patients with post-operative complications
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34 142 arising from the period prior to the data collection were excluded. For operative trauma cases,
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36 143 those undergoing spinal procedures were excluded as these are jointly treated by
37
38 144 Neurosurgery in most hospitals. All non-urgent semi-elective procedures were excluded from
39
40 145 analysis as well, as they would inaccurately assess the impact of any social distancing
41
42 146 measures on the trauma workload. Routine elective orthopaedic cases were excluded.

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49 148 *Data points:* Demographics including age, sex and ASA grades were recorded for all
50
51 149 patients. Injury characteristics were recorded, including the anatomical location and if the
52
53 150 injury was open or closed. The mechanism of injury was categorised and whether the patient
54
55 151 was referred as a trauma call. The nature of the operative procedures and the anaesthetic
56
57 152 techniques were recorded. Patients undergoing multiple procedures were recorded for every
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153 episode where they were taken to theatre. 6-week mortality rate was recorded as well as the
 154 COVID-19 status of any symptomatic patients or suspected cases. Data points were divided
 155 into acute referrals and operative casemix as seen in table 1.

156

157 *Table 1: data points for acute referrals and operative casemix*

Age (years)	Gender (Male / female by birth)	ASA (1-5)	Date of injury / presentation
Injury	Mechanism of injury	Open Vs Closed fracture	Trauma Call (Yes / No)
Operative procedure	Anaesthetic Technique (AGP vs non-AGP)	Seniority of Surgeon (Consultants vs trainees)	Comorbidities
Six-week mortality	Post-op complications	Surgery time since admission (hours)	COVID status (from PCR swabs)

158

- 159 • *Anaesthetic techniques:* This was divided into anaesthetic aerosolising-generating
 160 procedures (AGP) which consisted of any intubation (including laryngeal mask
 161 airway and endotracheal intubation) for a general anaesthetic. All other anaesthetic
 162 techniques including regional and local anaesthetics were deemed as non-AGPs.
- 163 • *COVID status:* At the time, COVID was being diagnosed with polymerase chain
 164 reaction (PCR) from nasal and oropharyngeal swabs with a duration of 1 to 4 days
 165 where the sample was tested both locally in the hospital lab as well as corroborated
 166 with national lab testing to reduce risk of unequivocacy. Groups of patients were
 167 divided into either not swabbed (due to being asymptomatic) or swabbed due to
 168 presence of documented symptoms which yielded either negative or positive results.

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6 170 *Statistical analysis:* All the data were recorded, anonymised and verified by four members of
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8 171 the study group for their accuracy. The data were processed using Microsoft Excel
9
10 172 (Microsoft, Washington, USA). Shapiro-Wilk test indicated a normal distribution for age and
11
12 173 days to discharge from hospital; hence, the mean (\pm standard deviation; 95% CI) were
13
14 174 calculated for both. ASA did not follow normality and was analysed using median (\pm median
15
16 175 absolute deviation [MAD]) and interquartile range (IQR). Both prevalence or risk and odds
17
18 176 ratios were calculated as well as a Fisher's exact test for statistical significance for
19
20 177 categorical data, defined as $p \leq 0.05$. Percentages and confidence intervals were rounded off
21
22 178 to one decimal place.
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29 180 *The collaborative:* The COVID Emergency Related Trauma and orthopaedics (COVERT)
30
31 181 Collaborative was founded at Imperial College Healthcare NHS Trust. It is currently a
32
33 182 member of the COVID Research Group and it has been endorsed by the Royal College of
34
35 183 Surgeons of England and Imperial College Healthcare NHS Trust.
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41 185 *Patient and Public Involvement:* Patients and the public were not involved in the study
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43 186 design, recruitment or conduct.
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187 Results

188 A total of 4840 clinical encounters took place between the study periods. A total of 172
 189 spinal operations and presentations were excluded from the final analysis. Table 2 outlined
 190 demographic data. During the COVID-19 period there was a 34% reduction in acute
 191 orthopaedic trauma referrals compared to 2019 (1792 down to 1183 referrals), and 29.5% less
 192 surgical interventions (993 down to 700 operations). Figures 1-3 have categorised these
 193 clinical encounters into acute referrals and operative cases between both years respectively.

194
 195 *Table 2: Demographic data of pre- and post-COVID*

		Pre-COVID (2019)		COVID (2020)	
	Total	1792		1183	
Acute referrals	<i>Male</i>	935	52.2%	560	47.3%
	<i>Female</i>	857	47.8%	623	52.7%
	<i>Mean Age ± SD (95% CI)</i>	52.2 ± 27.9 (50.9 - 53.5)		55.8 ± 27.9 (54.3 - 57.4)	
	Total	993		700	
Operative cases	<i>Male</i>	499	50.3%	320	45.7%
	<i>Female</i>	494	49.7%	380	54.3%
	<i>Mean Age ± SD (95% CI)</i>	51.7 ± 28.1 (50 - 53.5)		57.7 ± 26.7 (55.7 - 59.6)	
	<i>Median ASA ± MAD (IQR)</i>	2 ± 1 (2)		2 ± 1 (2)	

196

197 *Figure 1: Types and mechanisms of injuries for acute referrals*

198 *Figure 2: Types and mechanisms of injuries for operative cases*

199 *Figure 3: operative and anaesthetic techniques compared between pre- and post-COVID*

200

201 **COVID status**

202 COVID status for overall patient groups including positive results in the mortalities in acute
 203 referrals and operative casemix were demonstrated in figure 4. Overall mortalities with
 204 positive swab results were confirmed prior to the event of death.

205

206 *Figure 4: COVID status for acute referrals and operative cases as a measure of proportions*

207

208 **Risk (or prevalence) and odds ratios**

209 *Table 3: Risk (or prevalence) and odds ratios for acute referrals and operative caseloads.*

210 *Comparisons are made between COVID period against the pre-COVID period. Value >1*

211 *indicated greater odds or risk during the COVID period.*

		Acute referrals			Operative caseload		
		RR	OR	p-value	RR	OR	p-value
Morbidity & Mortality	Mortality	2.50	2.55	0.0005	2.19	2.25	0.004
	Mortality due to COVID-related complications vs non-COVID causes	14.2	19.7	0.004	15.1	22.0	0.004
	Peri-/post-operative complications including COVID				5.88	6.09	0.00001
	Peri-/post-operative complications excluding COVID				3.65	3.72	0.003
	Peri-/post-operative COVID positive testing				32.6	23.4	0.0009

Anaesthetic technique	General anaesthetic only				1.22	1.61	0.00001
	General anaesthetic ± block				1.23	1.75	0.00001
Consultant involvement	Consultant-led operation				1.36	2.08	0.00001
Operation technique	Open reduction + internal fixation				0.81	0.74	0.007
	Dynamic hip screw				2.02	2.11	0.00001
	Removal of metal/foreign body				0.24	0.23	0.003
Mechanism of injury	Road traffic accident	0.58	0.56	0.001	0.45	0.43	0.00001
	Fall (<1.5m)	1.19	1.54	0.00001	1.17	1.49	0.0001
	Sporting injury	0.63	0.60	0.0005	0.64	0.61	0.003
	Infection	0.69	0.66	0.001	1.70	1.77	0.005
	Trauma call				0.55	0.52	0.0005
Type of injury	Neck of femur (NOF) fracture	1.44	1.57	0.00001	1.51	1.79	0.00001
	Lower limb (excl. NOF)	0.89	0.84	0.04	0.74	0.65	0.0001
Gender	Male	0.91	0.82	0.01			

212

213 Table 3 outlined the risk [RR] (or prevalence [PR]) and odds ratios [OR] alongside their 95%
 214 confidence intervals and statistical significance. The risk ratio is synonymous with the
 215 prevalence ratio. Only those factors that were statistically significant within the acute
 216 referrals and operative caseloads were included.

217

218 Morbidity and Mortality

219 Table 3 indicated that the mortality rate more than doubled significantly for both risk
 220 (RR=2.19-2.50) and odds (OR=2.25-2.55) ratios during the COVID period. This certainly has
 221 both statistical as well as clinical significance. COVID-related complications were still
 222 responsible for increasing the odds of mortality by 20 to 22 times within all mortalities from
 223 both acute referrals and operative cases (as compared to non-COVID causes for all mortality
 224 in the year 2019). Table 4 confirmed that the mean age of mortalities across the board were in
 225 the elderly patient population with a high median ASA grade. Males were consistently in the
 226 minority, while neck of femur fracture was the modal diagnosis due to falls and persistently
 227 in the majority, followed by lower limb injuries (figures 5-6).

228 At least 82% of operations were related to neck of femur fractures in which half of all
 229 operations during the COVID period involved anaesthetic AGPs. Whereas the mortalities
 230 from pre-COVID operations did not have Consultant-led (as primary surgeon) surgery, that
 231 increased to three-fifths of all operations conducted during the COVID period (figure 7). The
 232 mean date of presentation to hospital was one week ahead in year 2020 compared to a year
 233 ago but the time from admission to mortality differed only by a mean of less than a day in
 234 both categories.

235
 236 *Table 4: Patient demographics, date of injuries, and time to mortality*

	<i>Acute referrals</i>		<i>Operative casemix</i>	
	2019 (n=23)	2020 (n=38)	2019 (n=22)	2020 (n=34)
Mortality	1.3%	3.2%	2.2%	4.9%
Mortality with COVID positive PCR result		0.9% (total) 28.0% (mortality cohort)		1.6% (total) 32.9% (mortality cohort)
Post-op morbidity			0.7%	4.1%

Age (years; mean±SD; 95% CI)	80.2 ± 16.4 (73.2 - 87.2)	77 ± 23 (67 - 88)	83.9±12.2 (78.7 - 89.1)	84.0±13.5 (79.4 - 88.5)
Male	9 39%	16 42%	8 36%	15 44%
ASA (median±MAD; IQR)			3 ± 0 (1)	3 ± 0 (0)
Date of injury (mean days±SD; 95%CI)	6/4 ± 11 (1/4 - 10/4)	31/3 ± 12 (26/3 - 5/4)	6/4 ± 12 (1/4 - 11/4)	30/3 ± 14 (25/3 - 4/4)
Time from admission to mortality (mean days±SD; 95%CI)	10.3 ± 7.5 (7.1 - 13.5)	11 ± 10 (7 - 15)	14.3 ± 10.4 (9.8 - 18.7)	13.8 ± 10.4 (10.2 - 17.3)

237

238 *Figure 5: types and mechanism of injury for mortalities in acute referral cohorts*

239 *Figure 6: types and mechanism of injury for mortalities in operative casemix cohorts*

240 *Figure 7: Surgical and anaesthetic techniques utilised in mortalities as a means of proportions*

241

242 Taking into account that COVID was a peri-operative complication since patients may have
 243 been symptomatic with COVID manifestations pre-operatively but only had the swab results
 244 return with a positive finding either pre- or post-operatively; the commonest post-operative
 245 complication in the COVID period was a hospital-acquired pneumonia but with negative
 246 COVID swab results or the decision not to test at all. The second most common post-
 247 operative complication in the year 2020 was extra-pulmonary sepsis (figure 8). The
 248 proportion of post-operative complications had significantly increased when including or
 249 excluding COVID as a peri- or post-operative complication in 2020 (0.70% vs. 2.57-4.14%;
 250 p=0.003) with varying odds (3.72-23.4) and risk (3.65-32.6) ratios (table 3).

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3 252 *Figure 8: Post-operative complications for both years*

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8 254 Figures 9-10 focused on the total number and nature of comorbidities within the mortality
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10 255 groups. Multiple contingency chi-square test was insignificant for both number of
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12 256 comorbidities and individual comorbidities between both years, except for cardiovascular and
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14 257 cerebrovascular disease in acute referrals.
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20 259 *Figure 9: Type of comorbidities for all mortalities in both years*

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23 260 *Figure 10: number of comorbidities for all mortalities in both years*

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27 262 **Survival probability**

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30 263 A six-week Kaplan-Meier survival probability analysis for mortalities between both years
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32 264 was plotted in figures 11-12.
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38 266 *Figure 11: Six-week Kaplan-Meier survival probability analysis for mortalities between pre-*
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40 267 *and post-COVID for acutely referred from the Emergency Department*

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43 268 *Figure 12: Six-week Kaplan-Meier survival probability analysis for mortalities between pre-*
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45 269 *and post-COVID for those undergoing surgery*
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271 **Discussion**

272 *Comment on alternative hypothesis*

273 There was a significant difference between pre- and post-COVID periods at its peak. The
274 alternative hypothesis was not rejected with respect to prevalence of (i) acute orthopaedic
275 trauma referrals (reduced by 34%), (ii) surgical interventions (reduced by 29.5%), (iii)
276 anaesthetic aerosolising-generating procedures, (iv) mortality rates (more than doubled in the
277 COVID period), and (v) survival probability between pre- and post-COVID eras.

278

279 *Corroboration of our results with current literature*

280 The 34% reduction in acute trauma referrals is in keeping with previous single centre studies
281 performed in the UK with results ranging between 26-59%.^{10-13,15,16} As described in these
282 previous studies we would attribute the overall reduction of trauma workload to be due to
283 reduction in travel and outdoor activities during the national lockdown. MacDonald *et al.*¹⁷
284 described a similar effect in their multi-centre study with a reduction of operative workload
285 by 26.5% compared to 29.5% in our study. Sites recruited for this study confirmed that they
286 continued to operate at their own facilities during the data collection period whereas some
287 later used alternative and external facilities including private hospitals through NHS England
288 pathways (as mentioned by Dayananda *et al.*¹⁸), which may have impacted nosocomial rates
289 of COVID, morbidity and mortality. However, this would be difficult to assess since it would
290 also depend on the diversions of the ambulance services to ‘clean’ versus ‘contaminated’
291 hospital sites.

292

293 *Changes in trends during COVID*

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3 294 With respect to the acute referrals, patients had half (OR=0.52) the odds of presenting as a
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5 295 trauma call. This was due to the odds ratios of road traffic accidents, sporting injuries,
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7 296 infection, and lower limb injuries were significantly less (by 34-44%; OR=0.56-0.66) during
8
9 297 the COVID period. Conversely, there was a significant rise in the odds of neck of femur
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11 298 fractures, falls, the use of anaesthetic AGP and Consultant-led operations; a finding also
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13 299 reflected by Arafa *et al.*¹⁹
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17 300 Although the expectation was to minimise the use of aerosolising-generating anaesthetic
18
19 301 procedures, there was in fact an increased prevalence of using general anaesthesia ± block up
20
21 302 to an odds of 75%, in order to create a ‘closed circuit’ for the airways. As the anaesthetic
22
23 303 methods was not well documented in the pre-COVID era in a fifth (21.3%) of cases, this
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25 304 skewed the data as it may have been difficult to extract that data from last year. The odds of a
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27 305 Consultant-led operation doubled (OR=2.08) during the COVID period as a consequence of
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29 306 all elective operations being suspended, more Consultants being relocated to trauma theatre
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31 307 and increased pressure within the theatre environments leading to Consultant-delivered,
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33 308 rather than Consultant-led care. With respect to surgical procedures, there was a significant
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35 309 reduction in prevalence ratio of open reduction and internal fixation by a fifth (PR=0.81) and
36
37 310 removal of metalwork and foreign bodies by three-quarters (PR=0.24), while there was a
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39 311 doubling (PR=2.02) in dynamic hip screw fixation in the COVID era.
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313 ***Morbidity and Mortality rates***

314 *Mortality during COVID-19 timeframe*

315 Overall 6-week mortality rates significantly doubled for both prevalence (or risk) and odds
316 ratios during the COVID-19 period (table 3). For mortalities within all acute referrals, 0.9%
317 (figure 4) of the entire cohort and 28.9% of those mortalities tested positive for COVID. For
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3 318 mortalities within the operative casemix, 1.6% (figure 4) of the entire cohort and 32.4% of
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5 319 those mortalities had a confirmed positive COVID-19 diagnosis prior to their death.
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10 321 Comparatively, the COVIDSurg Collaborative observed a mortality rate of 28.8% ($p < 0.0001$)
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12 322 of orthopaedic patients who underwent surgery (both elective and trauma) within the first
13
14 323 quarter of the year.²⁰ The increased mortality during the pandemic is partly due to selection
15
16 324 of cases that required surgical intervention. The decrease in acute referrals and operations
17
18 325 indicated a higher threshold for treatment (due to a redistribution of hospital resources during
19
20 326 the pandemic). However, no such case was denied surgery but in the worst-case scenario
21
22 327 patients were offered postponed treatment. There are many cases with less severe orthopaedic
23
24 328 trauma where there is a 2–3 week window of opportunity for acute operative management.
25
26 329 Table 2 demonstrated that the COVID cohort on average was 6.9% older for the acute
27
28 330 referrals and 11.6% older for the operative casemix which could be proportional to the risk of
29
30 331 developing age-related and involuntional morbidities and frailty.
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333 *Role of morbidity in mortality during COVID-19*

40 334 Results from figures 8-10 were corroborated by the COVIDSurg publication²⁰ which
41
42 335 confirmed a significant association of mortality with myocardial infarction and congestive
43
44 336 heart failure. However, hypertension and stroke/transient ischemic attacks were not
45
46 337 significantly associated. In our study, all cardiovascular diseases (including peripheral
47
48 338 vascular, arrhythmias, hypertension, heart failure, myocardial infarction and acute coronary
49
50 339 syndromes) were combined with cerebrovascular diseases (consisting of strokes and transient
51
52 340 ischemic attacks). Unlike their study, our study did not find a significant association with
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54 341 chronic kidney disease, chronic obstructive disease (which included asthma) and dementia in
55
56 342 all mortalities during the 2020 timeframe regardless of the COVID status. The differences
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3 343 may stem from that their study looked at the comparison of mortality rates within the same
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5 344 cohort during the COVID era, whereas this study is sub-analysing the entire mortality cohort
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8 345 on its own to observe for specific associations and risks.
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12 347 *Survival probability between both years*
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14
15 348 There were similar patterns of survival probability between both cohorts (i.e. 2019 vs 2020
16
17 349 cumulative). However, the lowest survival probability and the shortest timeframe were
18
19
20 350 observed in the confirmed COVID positive cohort as seen in figure 11. This was due to the
21
22 351 most vulnerable patient profile. 8 (72.7%) patients had femoral trauma, most being neck of
23
24 352 femur fractures, distal femur fracture and a dislocated hip hemiarthroplasty post-fracture.
25
26 353 Other patients presented with septic arthritis, post-operative complication and knee swelling;
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28
29 354 yet every patient also suffered from multiple comorbidities including those leading to
30
31 355 immunosuppression as seen in figures 11-12. Although these patients were prioritised in the
32
33 356 Emergency Department and recognised for their poor physiological reserve, due to the
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35
36 357 stresses of the acute and emergency services, these patients may have had to wait longer to be
37
38 358 treated acutely and appropriately admitted.
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43 360 Unexpectedly, there was a reversal of trends observed for the 6-week Kaplan-Meier survival
44
45 361 analysis once admitted and operated on in figure 12. Mortalities within the pre-COVID
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48 362 period had the lowest survival probability compared to the post-COVID cohort. The COVID
49
50 363 positive mortalities were observed to have the highest survival probability 11 days prior to
51
52 364 converging with those mortalities without COVID symptoms.
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56
57 366 During the pandemic, wards were ring-fenced to host confirmed COVID positive patients
58
59 367 with a heightened care of nursing, medical cover and personal protective equipment. Prior to
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1
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3 368 the onset of a possible vaccination to counteract the virus, symptomatic management and
4
5 369 shielding were the mainstay treatments for COVID positive patients. None of these patients
6
7 370 were stepped up to the Intensive Treatment Unit due to being categorised as high-risk
8
9
10 371 stratification for mortality based on age and extent of comorbidities.
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12 372

13
14 373 *Justification of conducting this study*

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17 374 As lockdown measures in the UK and globally eases and the incidence of trauma returns to
18
19 375 pre-lockdown trends, it is imperative that we understand the true increased risk of mortality
20
21 376 in the acute trauma patient during the COVID-19 era. A recent publication by Kader et al.²¹
22
23 377 has suggested that the rate of mortality from COVID-19 for elective orthopaedic patients is
24
25 378 low; yet this is the first British multi-centre study to quantify mortality risk for trauma
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27 379 patients. Trauma procedures due to the nature of the injuries are necessary and time-critical,
28
29 380 and nobody can afford to postpone trauma care even during a global pandemic.²²
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35 382 Furthermore, the Corona Hands Collaborative²³ published that upper limb trauma patients
36
37 383 had SARS-CoV-2 complication rate of 0.18% (n=2) with 0.09% (n=1) overall mortality at
38
39 384 the peak of the first wave in April 2020. However, their collaborative looked into a shorter
40
41 385 post-operative period (30 vs 42 days) but they agreed that patients who had been hospitalised
42
43 386 for a prolonged period before their surgery were at increased risk of both COVID-related and
44
45 387 post-operative complications. Most of their patient cohort, who were both younger and fitter
46
47 388 than our cohorts, would be classified as the 'walking wounded' and could usually be day-case
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49 389 procedures.
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55 391 Although the trends in mechanisms of injury in our study were reflective of those within a
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57 392 US multi-centre study, there was an opposing trend in the number medical/surgical
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3 393 procedures.²⁴ That could be due to their study encompassing on level 1 trauma centres with a
4
5 394 mean younger patient population. However, we do agree that with time and from experiential
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8 395 learning, hospitals improved their coping strategies with the pandemic and enhanced patient
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10 396 safety by enforcing personal protection equipment, hosting dedicated theatres for COVID-
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12 397 positive patients, separating sites as clean and contaminated, ringfencing COVID-positive
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14 398 patients to dedicated wards, and promoting routine COVID PCR swabs for all admissions
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16
17 399 and pre-operative checklists.

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21 401 With an overall mortality risk in 2020 doubled that of 2019, clinicians need to counsel
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23 402 patients presenting with acute orthopaedic trauma of the increased risk in the COVID-19 era,
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25 403 especially for those identified as increased risk stratification with multiple underlying
26
27 404 comorbidities, elderly and frailty. With the ongoing risk of a subsequent wave and resurgence
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29 405 of COVID-19 cases on top of the inevitable winter pressures, this data is of critical
30
31 406 importance in the risk management, decision-making and policymaking of trauma patients
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33 407 both in the UK and across the globe.

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409 *Observations of hip fractures and mortality*

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42 410 Since the aetiology of neck of femur fracture are often low energy falls in the home
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44 411 environment, it is not unexpected to observe a consistency of neck of femur fractures in the
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46 412 elderly and the vulnerable during lockdown as seen in figures 1-2. Those with neck of femur
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48 413 fractures remain at greatest risk of mortality and there have been further studies evaluating
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50 414 the risk of COVID-19 on this inherently high-risk cohort.²⁵⁻²⁸ COVID-19 itself has been
51
52 415 identified as an independent risk factor in increasing mortality in neck of femur fractures.²⁹

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3 417 The increased mortality reflect the increased proportion of NOFF patients that have a higher
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5 418 baseline mortality which has been echoed by the Scottish IMPACT-Restart study.²⁸ There are
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7 419 several justifications such as reduced help, lack of assistance and staff shortages due to the
8
9 420 effect of the national lockdown which required elderly patients to be more independent,
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11 421 unsupervised and at higher risk of falling. Nevertheless, it should be considered that odds of
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13 422 falls may have increased due to prodromal symptoms and clinical manifestations of COVID.
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19 424 However on subgroup analysis of hip fractures that were operated on in 2020, 20.2% tested
20
21 425 positive for COVID, 47.3% tested negative and the remaining 32.4% were not tested due to
22
23 426 being asymptomatic. Furthermore, 82.3% of all mortalities in 2020 sustained a neck of femur
24
25 427 fracture in which only 35.7% of this cohort had a positive swab result, 21.4% with negative
26
27 428 swab results and the remaining 42.9% were not swabbed due to being asymptomatic. There
28
29 429 was no statistical difference in the odds and risk ratios between both years for mortality rate
30
31 430 in NOFF. The numbers have not changed much, but because of a drop off of other cases, the
32
33 431 percentage of NOFF markedly rose. Hence, the mortality expressed as a percentage of cases
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35 432 is notably higher for all operations, and not necessarily if stripped down to hip fractures
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37 433 alone.
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44 435 If these 'at risk' patients were symptomatic with the virus, then aggressive pre-operative
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46 436 optimisation would occur. Since 91% (n=10) of COVID positive patients had sustained a
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48 437 neck of femur fracture, the National Hip Fracture Database best practice tariff of operating
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50 438 within an ideal 36-hour window set by the Royal College of Physicians was suspended until
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52 439 the patient was stabilised. All hip fracture patients in this cohort were operated on and had
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54 440 dedicated orthogeriatric input commencing from hospital admission. Hence the early peri-
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56 441 operative period and surgery encompassed within the 10-day period post-admission.
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3 442 Moreover, neck of femur fractures are recognised as a pre-terminal illness and are known to
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5 443 carry a high risk of mortality in the first month which is trebled in the first year after the
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7 444 injury.³⁰
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11 446 ***Strengths and weaknesses of the study and in relation to other studies***

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14 447 This was the first representative observational multi-centre study of the UK looking into the
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16 448 impact of COVID-19 pandemic on general trauma and orthopaedic surgical specialty. Studies
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18 449 thus far have only shed light on local scales or cross-speciality.^{10-13,20} Weaknesses included
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20 450 loss of data points which have been accounted for in the tables (i.e. labelled as unknown).
21
22 451 However this did not affect the final analysis of data points. Operations conducted outside the
23
24 452 specific study periods will not account for all those operations required such as for NOFF. It
25
26 453 does not suggest that the number of NOFF not accounted for have been managed
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28 454 conservatively (as discovered by Cherevu et al.³¹), since some NOFFs may breach time to
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30 455 surgery due to medical reasons or being influenced by international guidelines.³²
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36 457 ***Limitations and future research***

37
38 458 It is vital to continue exploring the impact of the pandemic on a larger scale. Ideally, more
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40 459 secondary care providers consisting of district general hospitals and major trauma centres
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42 460 will submit data. The diagnosis of COVID was dependent on positive PCR swabs for this
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44 461 study rather than non-specific changes seen on chest CT or plain radiographs. This does not
45
46 462 account for false negatives with clinical respiratory symptomatology or true positives in those
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48 463 asymptomatic. Nevertheless, this issue with data has been speculated on in another national
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50 464 study.²³ Data ought to be submitted during the peak of the pandemic as well as at various
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52 465 time intervals as the lockdown measures ease resulting in more freedom of movement while
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54 466 also accounting for the continued risk of subsequent waves and national lockdowns.³³ Further
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467 studies will also require to compare the impact of the pandemic on the speciality in the UK
468 compared to other countries on other continents.

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3 469 **Conclusion**
4

5 470 This was the first, longest and largest British multi-centre representation of the impact of
6
7 471 COVID-19 pandemic on acute orthopaedic trauma referrals and mortality between mid-
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9 472 March to end-April, representing the peak of the first wave during the lockdown. The
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11 473 mortality rate for acute referrals, as well as those undergoing operative intervention, more
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13 474 than doubled in odds when compared to the same time interval one year ago. The majority of
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15 475 mortalities consisted of the elderly with neck of femur fractures and cardiovascular and/or
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17 476 cerebrovascular diseases. This study will aid clinicians in counselling trauma patients of the
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19 477 increased risk of mortality during the era of COVID-19 and also aid in both healthcare
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21 478 infrastructure, resource allocation, decision-making and policymaking as we continue to
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23 479 battle with the pandemic.
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3 480 **Research Ethics Approval - Human Participants:** This study involves human participants
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5 481 but an Ethics Committee(s) or Institutional Board(s) exempted this study. All data points
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7 482 were utilised for routine auditing purposes to reflect departmental activity and service
8
9 483 provision without altering clinical care pathways. Each centre contributing data to this study
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11 484 registered their interests with local authority and the auditing or clinical governance
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13 485 departments. No informed consent was required as there was no identifiable data. All data
14
15 486 were anonymised at the time of collection and submission. Each patient was assigned a
16
17 487 unique identification number which was cross-referenced with the patients' individual
18
19 488 hospital identification or medical record numbers. This cross-referenced list remained
20
21 489 internally within the hospital trust computer server handled by the contributing team from
22
23 490 each trust. The data was transferred and stored using the NHS.net email server which has
24
25 491 been approved for transfer of patient data. Data protection compliance was abided by at all
26
27 492 times. The lead centre was Imperial College Healthcare NHS Trust where this study was first
28
29 493 approved as a clinical audit prior to expanding onto a national scale. All centres gave
30
31 494 permission for the use of their data. This study was assessed using the UKRI/MRC/NHS
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33 495 Health Research Authority Ethics Decision Tool and was considered an 'audit/not research';
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35 496 and therefore it was not subject to further ethical review by the NHS Research Ethics
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37 497 Committee (NHS REC).
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47 499 **Competing Interests:** None declared

48
49 500 **Funding:** Nil

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54 502 **Data sharing statement:** Underlying data, code and supporting documentation may be made
55
56 503 available as a redacted version to interested parties, subject to the completion of a protocol
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58 504 and signing of a Data Transfer Agreement.
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506 **Acknowledgements:** none

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4 612 **Contributorship statement according to the ICMJE guidelines**

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7 613 We have read the ICJME guidelines attentively and have outlined the collaborative
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10 614 contributors below who have all satisfied the criteria to be recognised as a collaborative co-
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13 615 author if this study is published. The core committee of the collaborative consists of KS, AA,
14
15
16 616 CP and KMS who all conceptualised the study, led the
17
18
19 617 planning/investigation/methodology/design, supervised the collaborative contributors' roles,
20
21
22 618 as well as the initial and final version of the manuscript. Additionally, KS (primary author)
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24
25 619 was also leading data curation, project administration and resource allocation with KMS. KS
26
27
28 620 was also leading on validation. KS, CP and AA led the data analysis and the reporting of the
29
30
31 621 results. All other collaborative members, from the seven centres and outside the core
32
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34 622 committee, were involved in data curation, formal analysis and in resource allocation
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36
37 623 internally under consultant supervision (i.e. those with FRCS). Individual contributions from
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40 624 the core committee and every collaborative member has been outlined below:
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50 626 **COVERT Collaborative members, their affiliations and extent of contribution**

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53 627 **Core Committee**

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Name	Qualifi- cation	Contribution	E-mail
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Figure 2: Types and mechanisms of injuries for operative cases

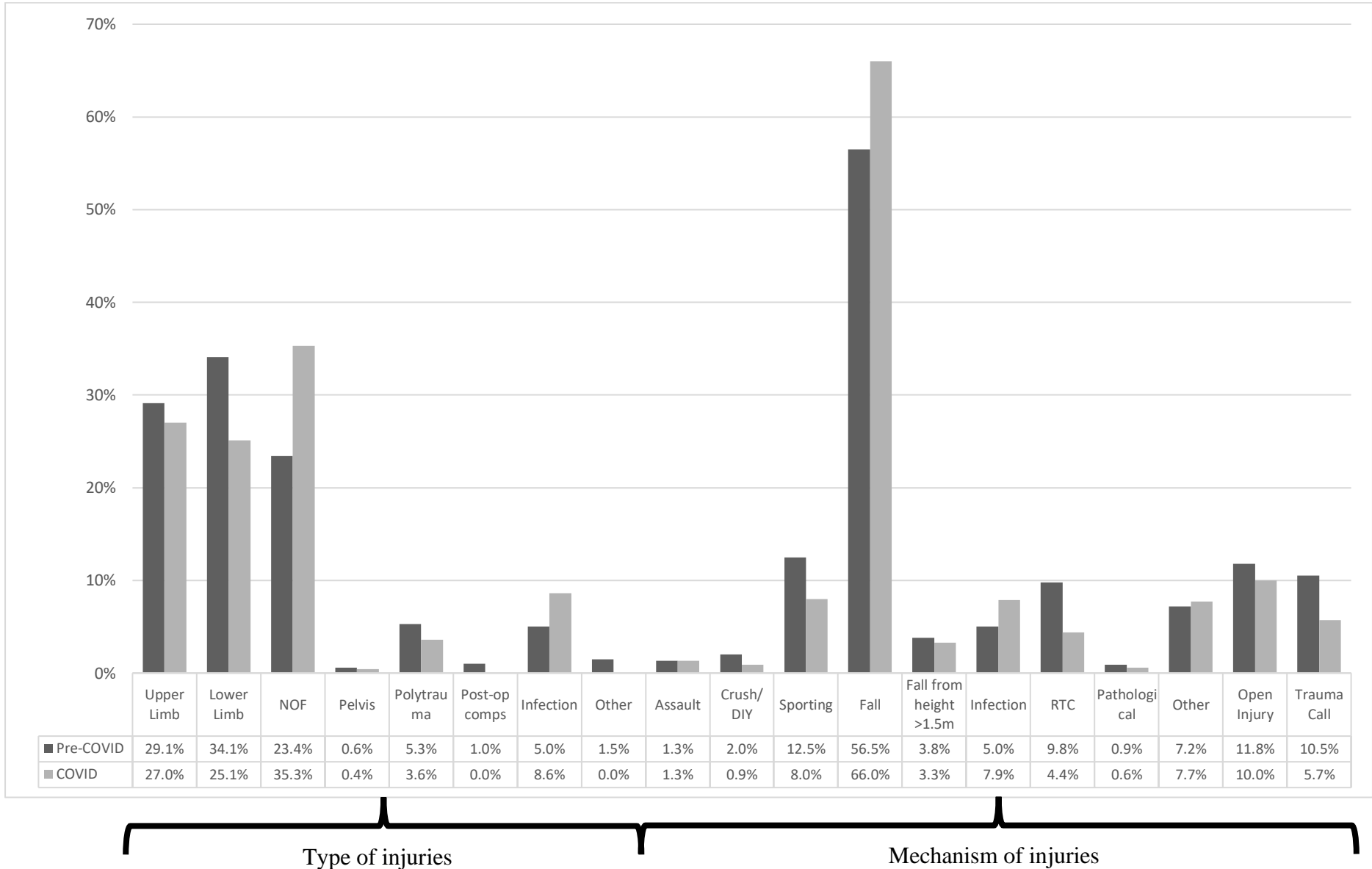
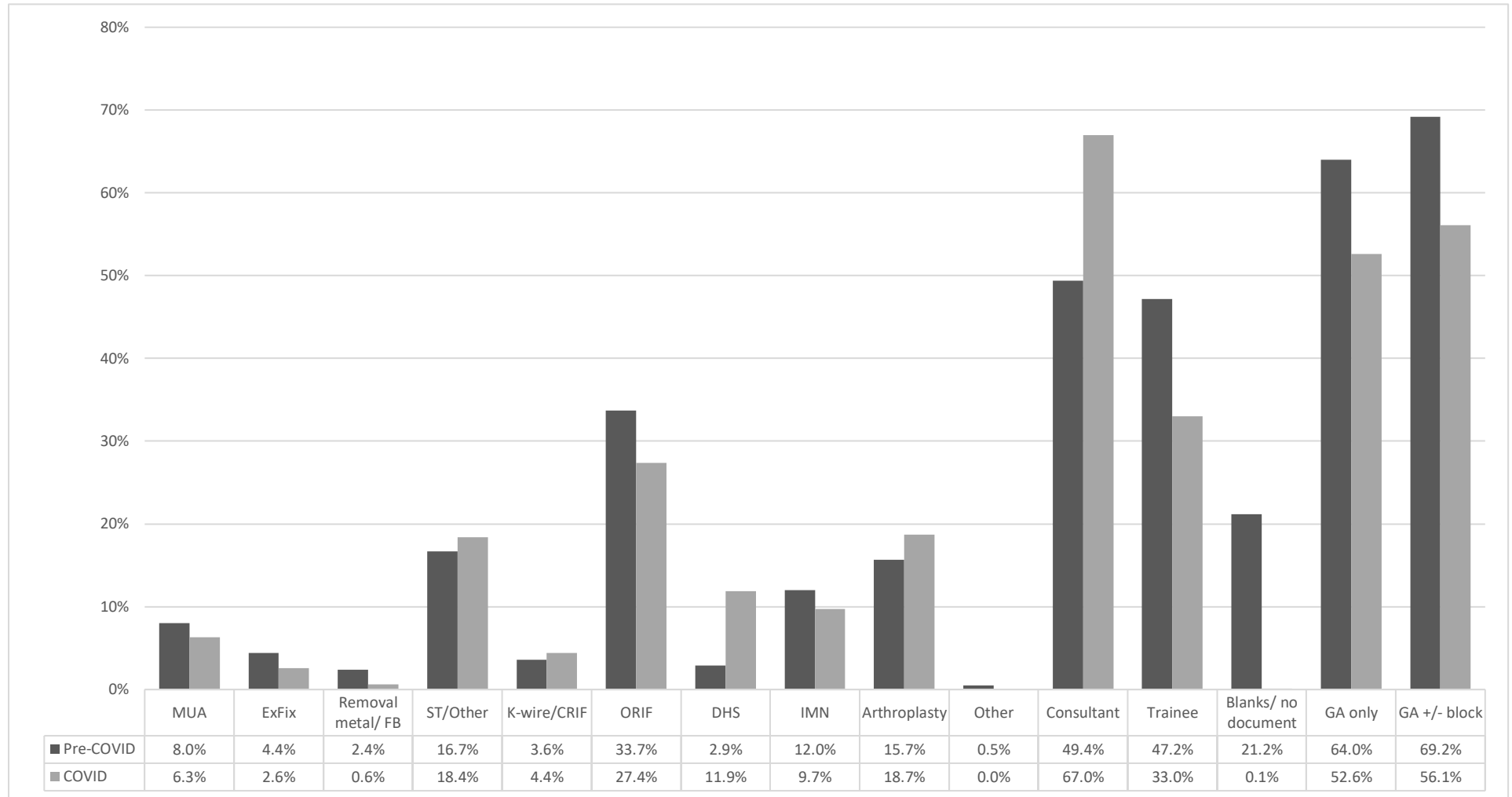


Figure 3: operative and anaesthetic techniques compared between pre- and post-COVID



Type of injuries
Primary surgeon
Anaesthetic technique

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Figure 4: COVID status of both cohorts including positive results in all mortalities (with 5% error bars)

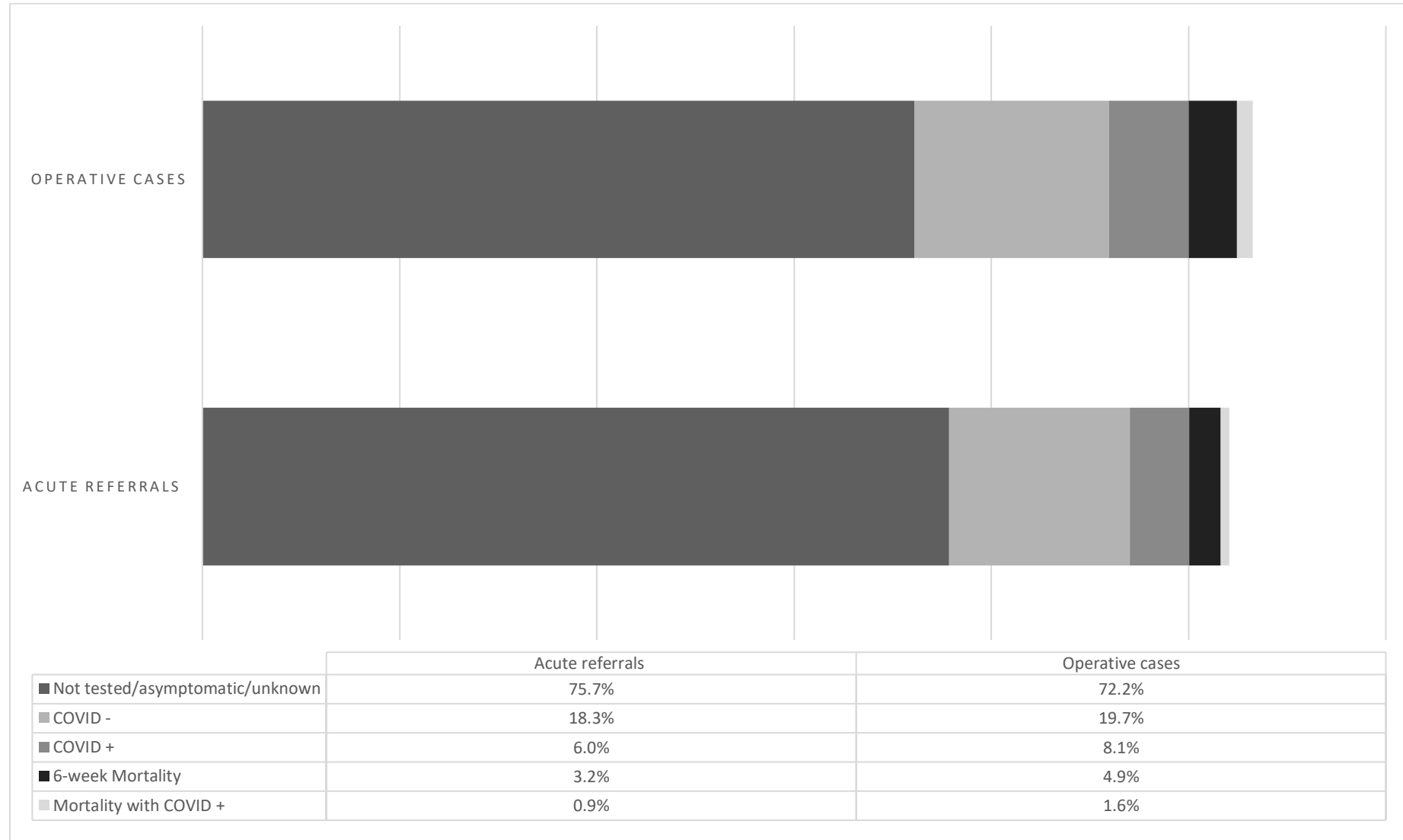
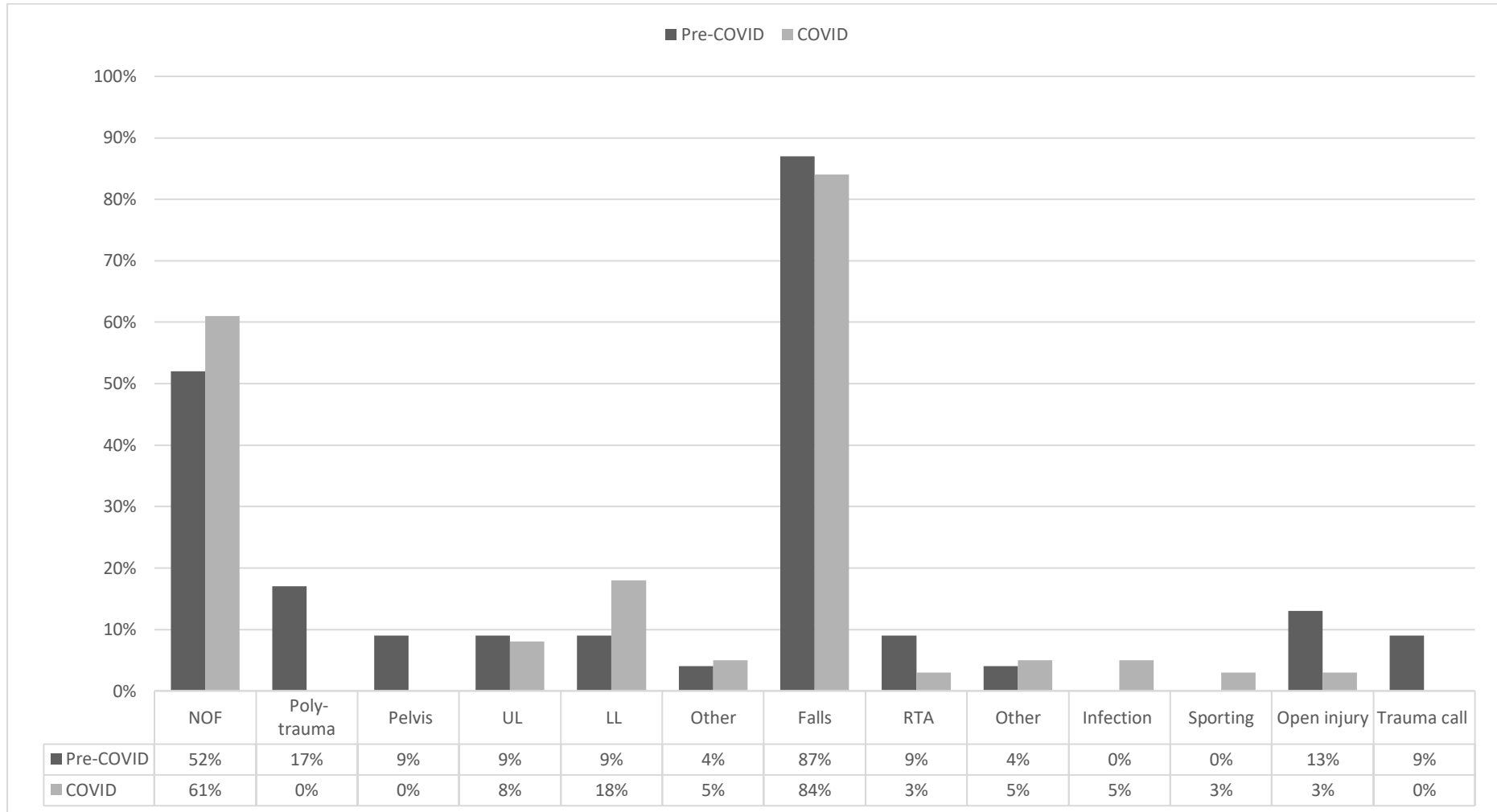
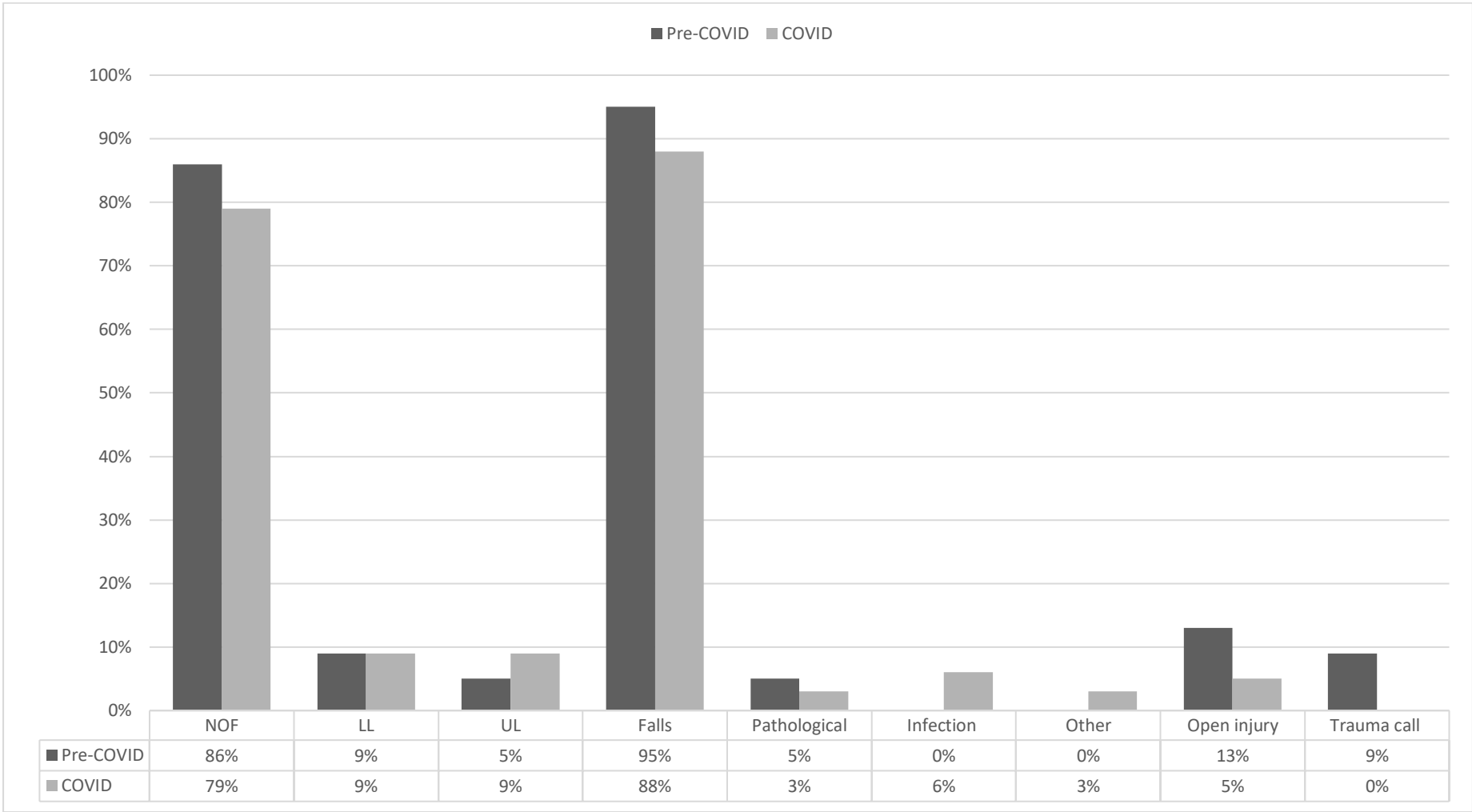


Figure 5: types and mechanism of injury for mortalities in acute referral cohorts



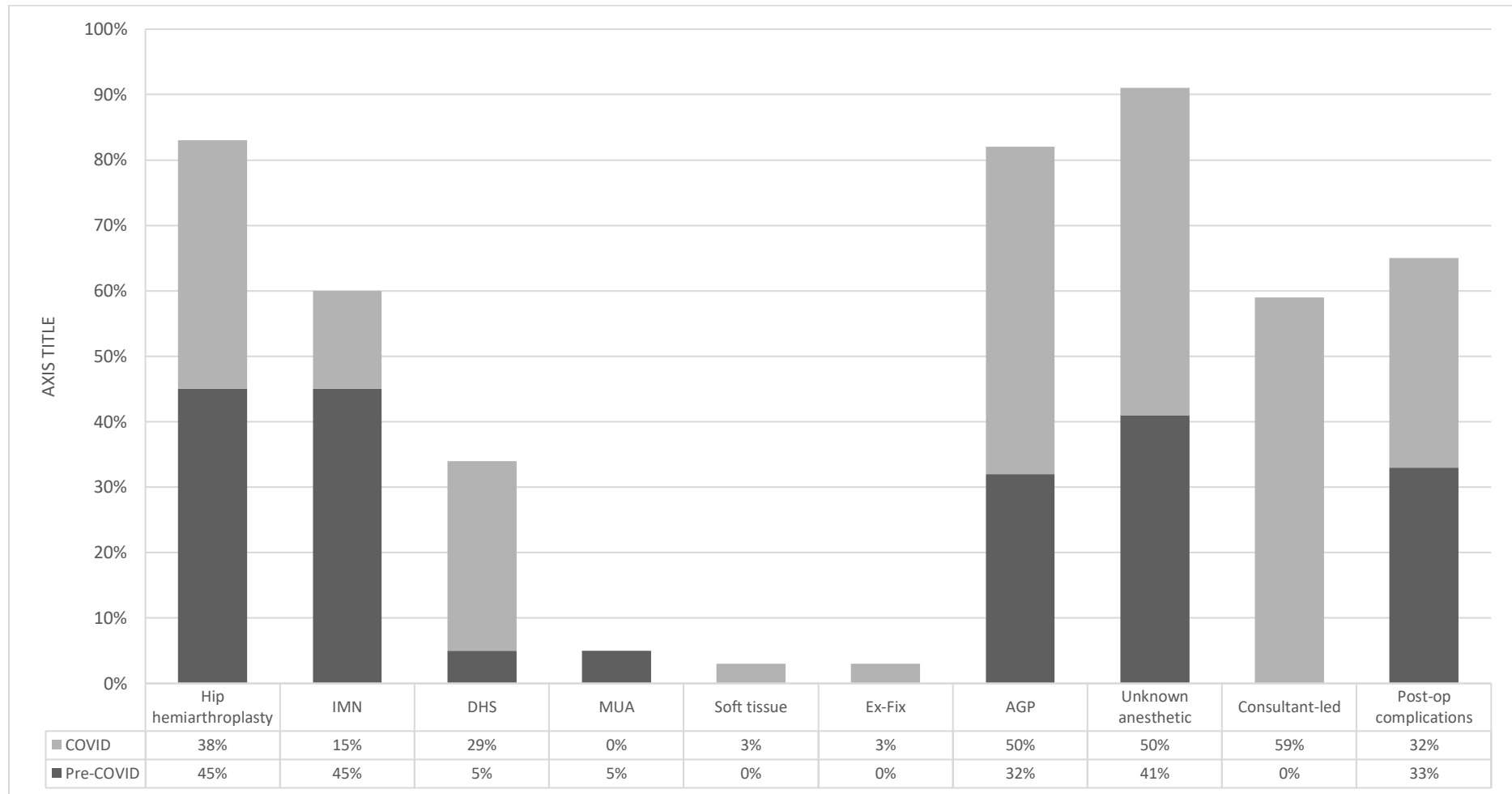
Key: UL: upper limb / LL: lower limb / RTA: road traffic accidents

Figure 6: types and mechanism of injury for mortalities in operative casemix cohorts



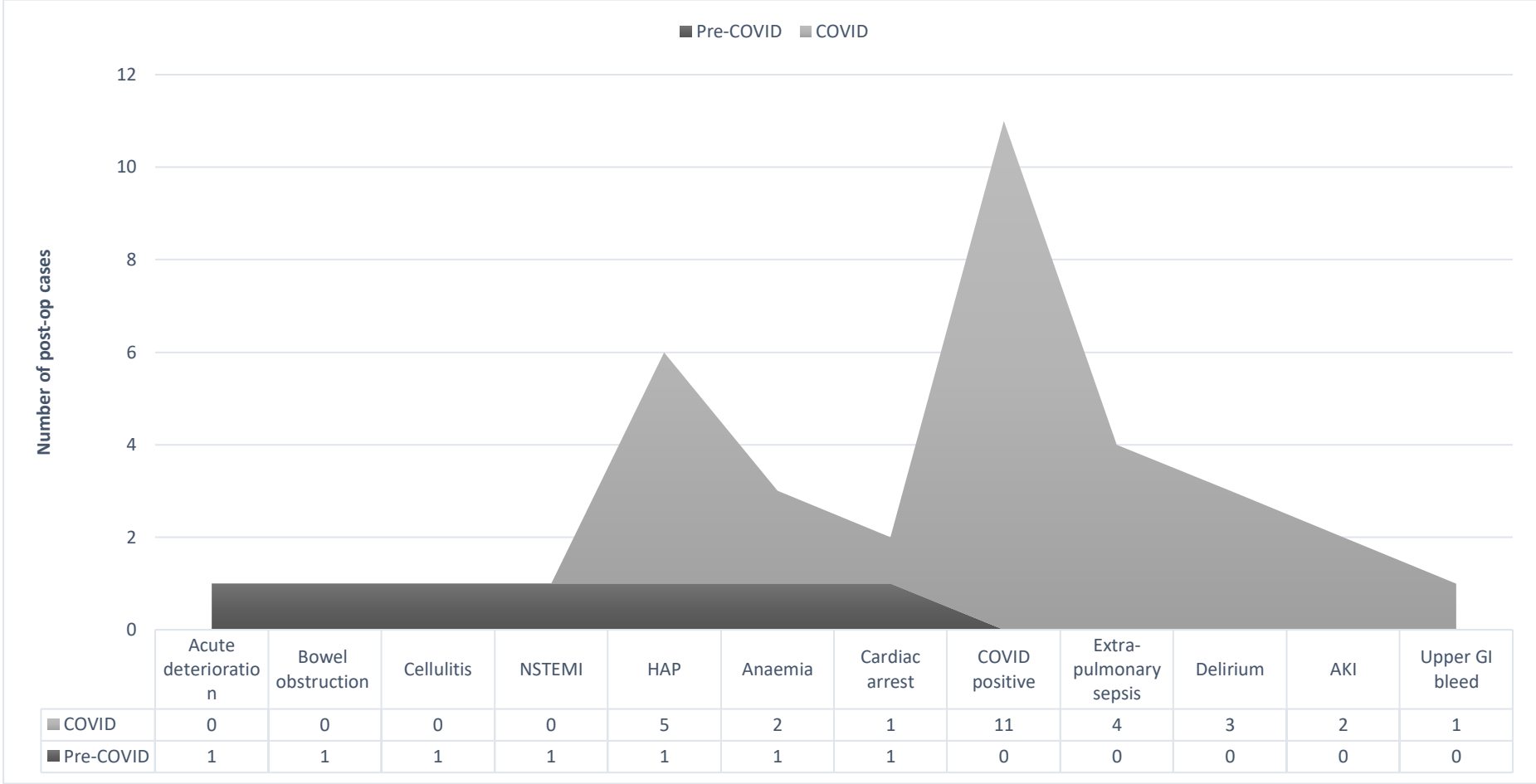
Key: NOF: neck of femur fracture / UL: upper limb / LL: lower limb

Figure 7: Surgical and anaesthetic techniques utilised in mortalities as a means of proportions



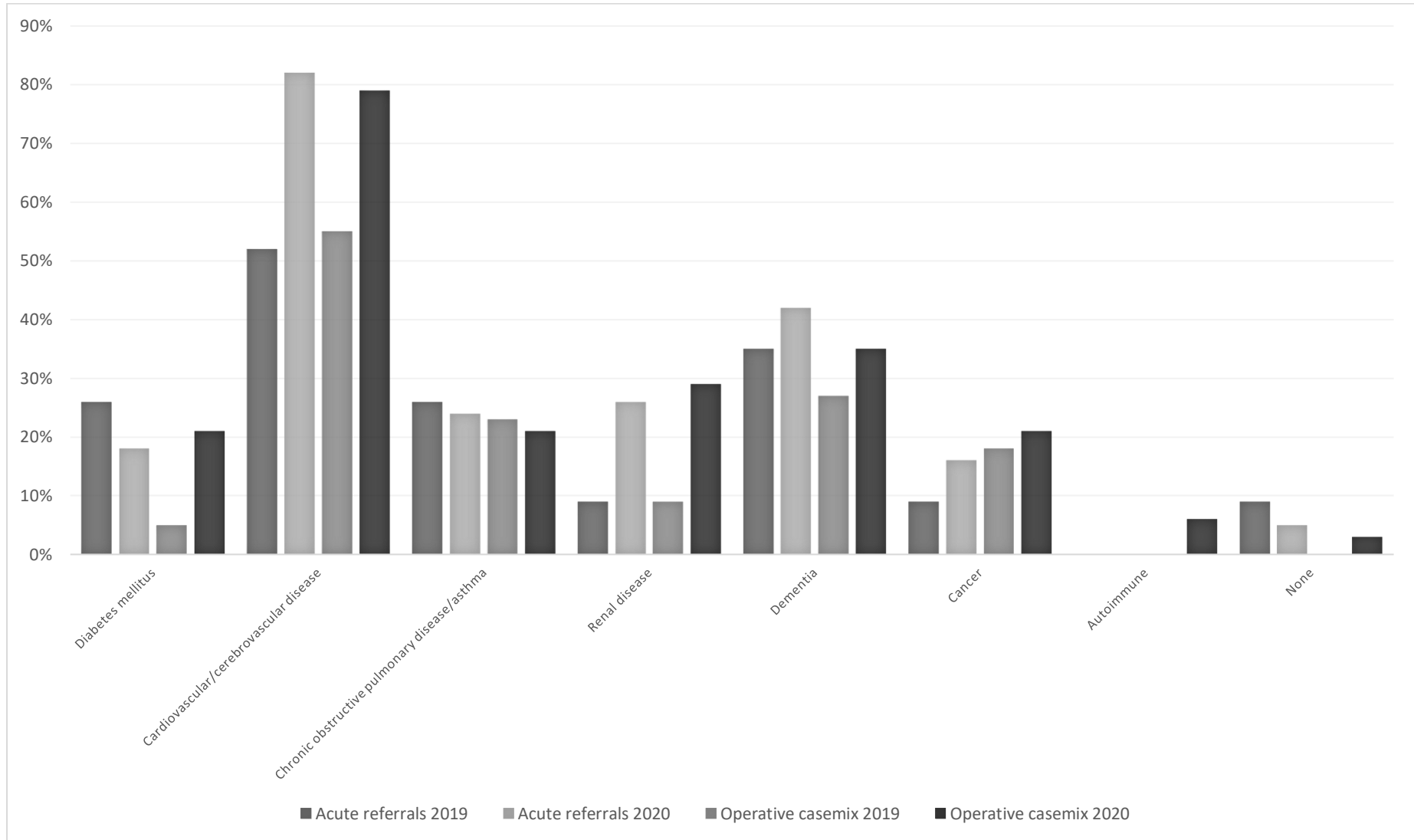
Key: IMN: intramedullary nailing / DHS: dynamic hip screw / MUA: manipulation under anaesthesia / Ex-Fix: external fixation / AGP: aerosolizing-generating procedures

Figure 8: Post-operative complications for both years



Key: NSTEMI: non-ST elevated myocardial infarction, HAP: hospital-acquired pneumonia, AKI: acute kidney injury, GI: gastrointestinal

Figure 9: Type of comorbidities for all mortalities in both years



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Figure 10: number of comorbidities for all mortalities in both years

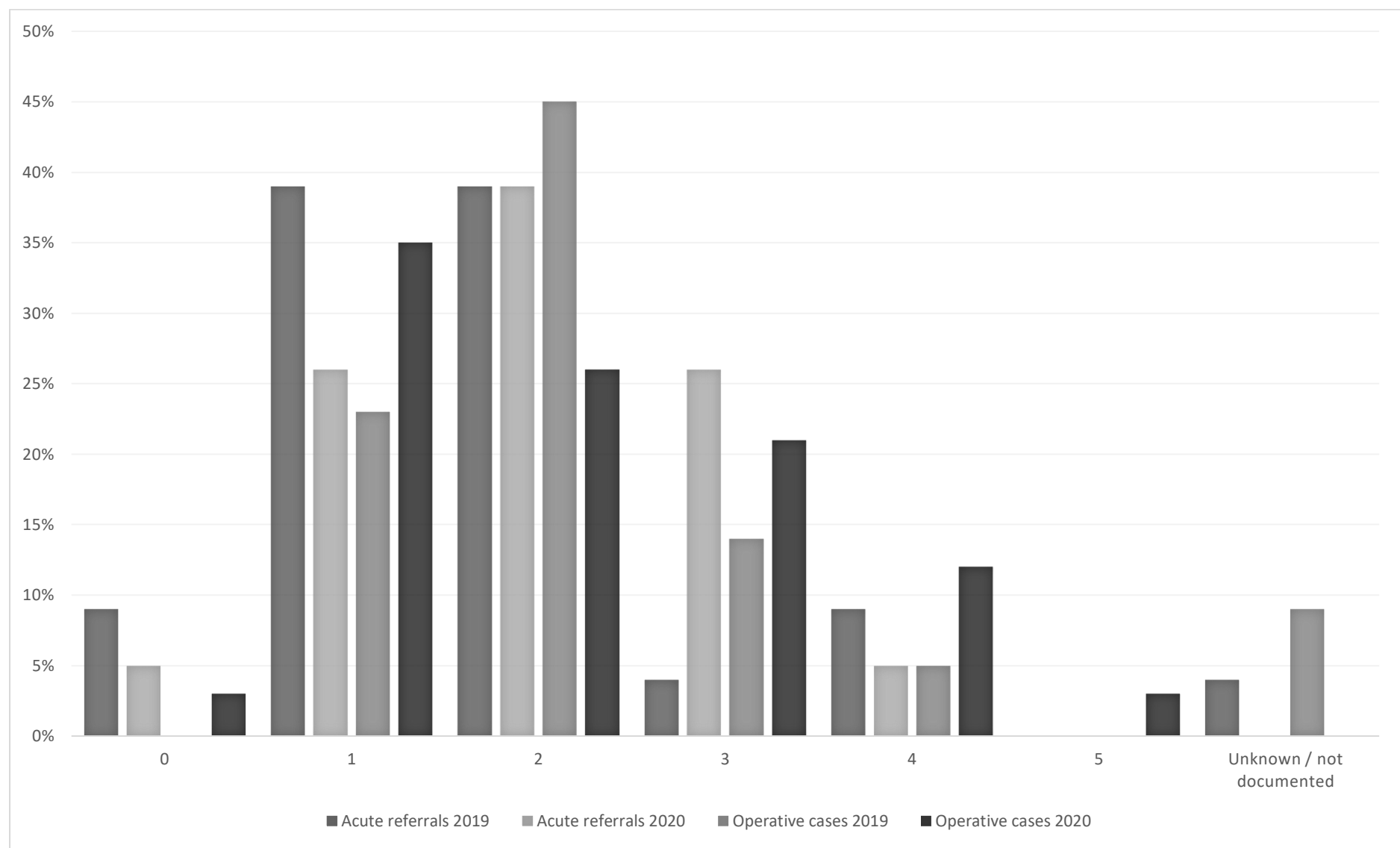


Figure 11: Six-week Kaplan-Meier survival probability analysis for mortalities between pre- and post-COVID for acutely referred from the Emergency Department

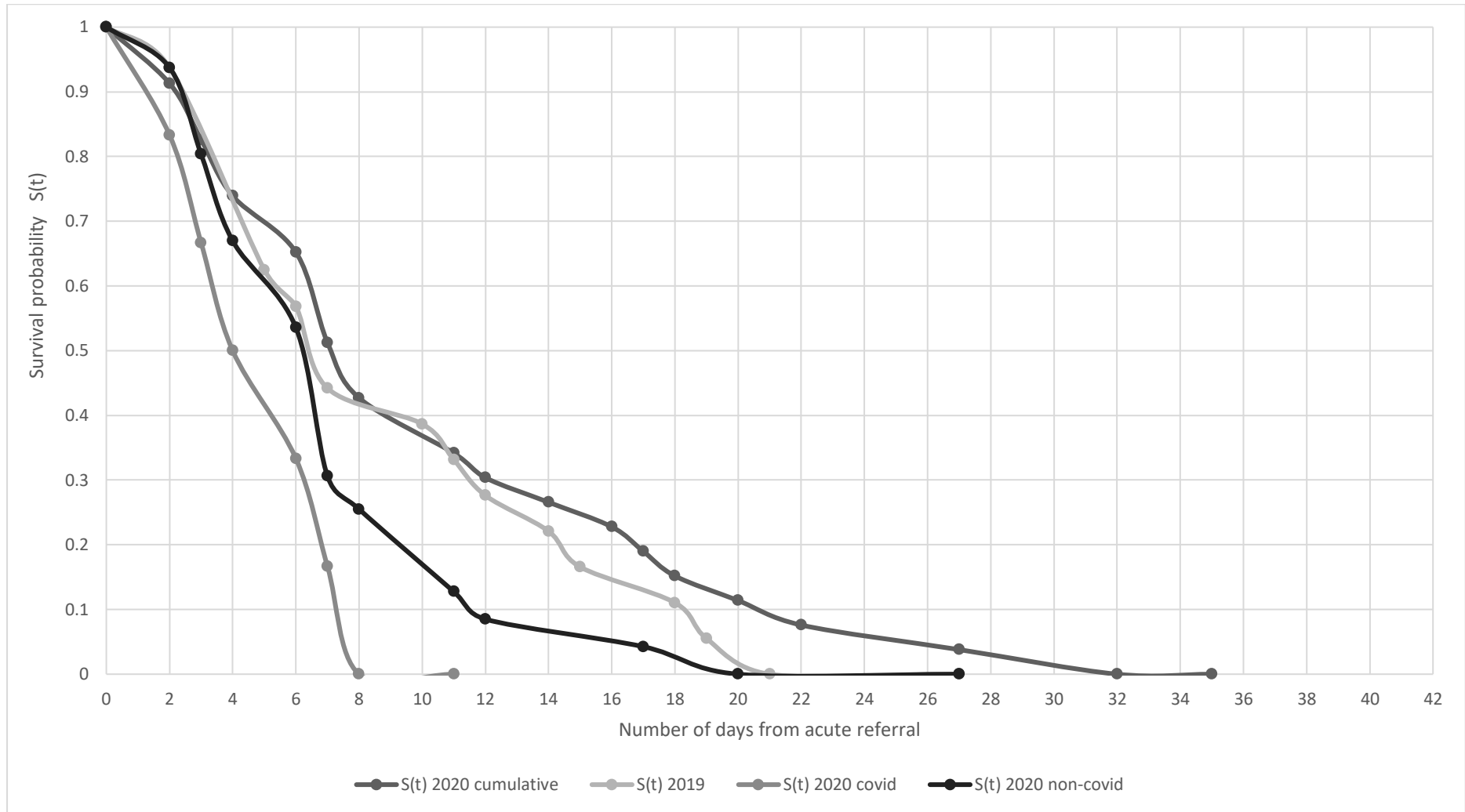
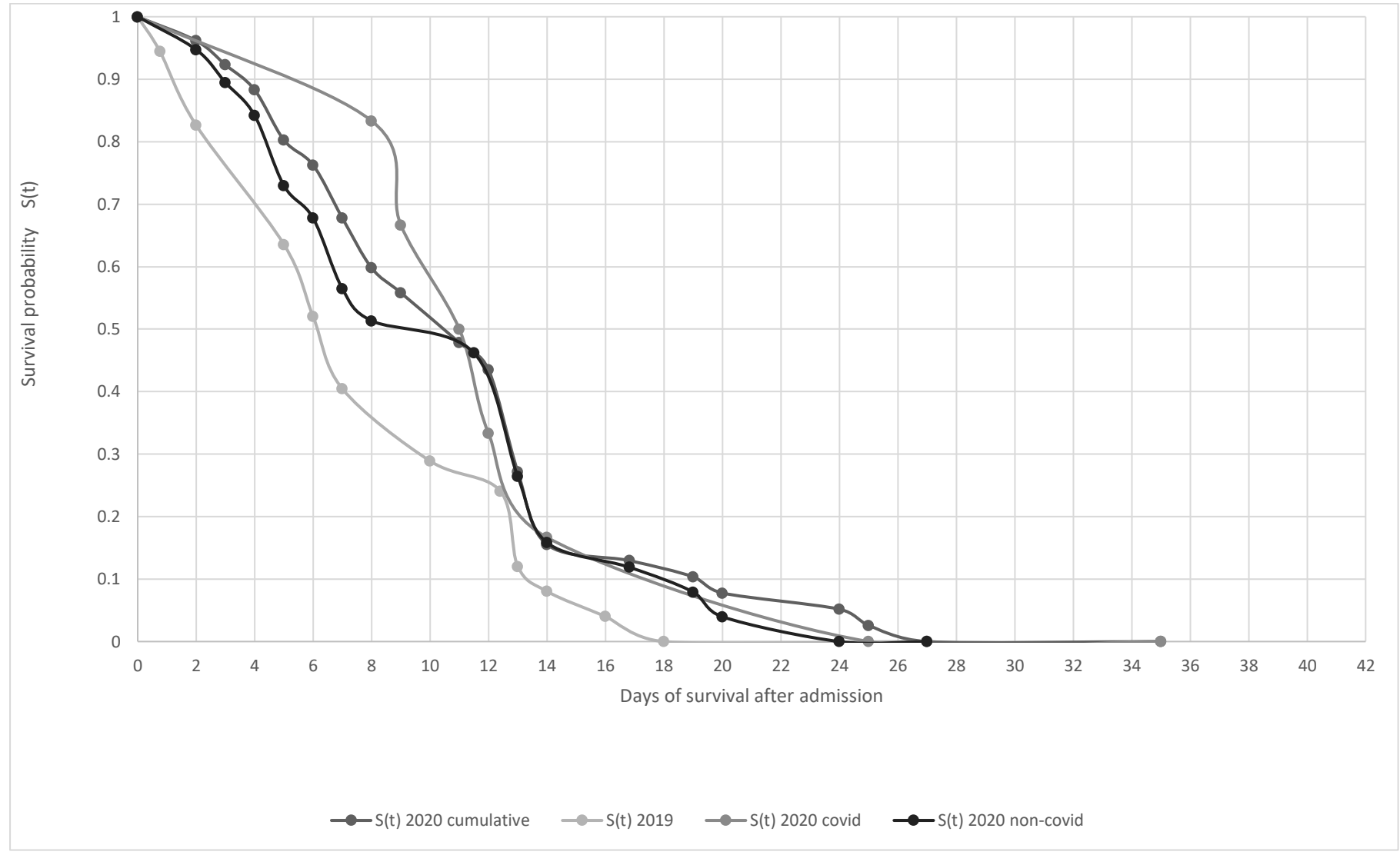


Figure 12: Six-week Kaplan-Meier survival probability analysis for mortalities between pre- and post-COVID for those undergoing surgery



STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	1, 7-8 8
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	9-10
Objectives	3	State specific objectives, including any prespecified hypotheses	10
Methods			
Study design	4	Present key elements of study design early in the paper	11
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	11-12
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (b) For matched studies, give matching criteria and number of exposed and unexposed	12 12
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11-13 Table 1
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	11,14
Bias	9	Describe any efforts to address potential sources of bias	11-12
Study size	10	Explain how the study size was arrived at	11-12
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-12, 14
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, explain how loss to follow-up was addressed (e) Describe any sensitivity analyses	14 14 29 n/a n/a
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	16 Table 2, Figs 1-3 16 n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	16 Table 2, Figs 1-3 Figs 1-4 n/a

1	Outcome data	15*	Report numbers of outcome events or summary measures over time	Tables 2-4, Figures 1-12
2				
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6	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-15, Tables 2-4, Figs 1-12
7			(b) Report category boundaries when continuous variables were categorized	n/a
8			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Table 3
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15	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	20-21 Table 4 Figs 8-12
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20	Discussion			
21	Key results	18	Summarise key results with reference to study objectives	22-29
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23	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	29-30
24				
25	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	22-29
26				
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28	Generalisability	21	Discuss the generalisability (external validity) of the study results	22-29
29				
30	Other information			
31	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15
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34 *Give information separately for exposed and unexposed groups.

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37 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.

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BMJ Open

The impact of COVID-19 on acute trauma and orthopaedic referrals and surgery in the UK during the first wave of the pandemic: a multicentre observational study from the COVID-Emergency Related Trauma and orthopaedics (COVERT) Collaborative

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-054919.R2
Article Type:	Original research
Date Submitted by the Author:	13-Dec-2021
Complete List of Authors:	Sugand, Kapil; Imperial College London, MSk Lab Aframian, Arash; Imperial College London, MSk Lab Park, Chang; Imperial College London, Trauma and orthopaedics Sarraf , Khaled; Imperial College London, Trauma and Orthopaedics Collaborative, COVERT; Imperial College London
Primary Subject Heading:	Surgery
Secondary Subject Heading:	Emergency medicine, Epidemiology, Surgery, Medical management, Health services research
Keywords:	COVID-19, TRAUMA MANAGEMENT, ORTHOPAEDIC & TRAUMA SURGERY, EPIDEMIOLOGY

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4 1 **The impact of COVID-19 on acute trauma and orthopaedic referrals and surgery in the UK**
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7 2 **during the first wave of the pandemic: a multicentre observational study from the COVid-**
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10 3 **Emergency Related Trauma and orthopaedics (COVERT) Collaborative**

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17 5 Kapil Sugand, Arash Aframian, Chang Park, Khaled M Sarraf, COVERT Collaborative

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53 16 **Keywords:** COVID-19; orthopaedic trauma; UK multi-centre; pandemic wave; mortality

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59 18 **Word count: 4000 words**

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2
3 19 **Abstract**
4 20

6 21 **Objective:** This is the first British multi-centre study observing the impact of the COVID-19
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9 22 pandemic on orthopaedic trauma with respect to referrals, operative caseload and mortality
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11 23 during its peak.

13 24 **Design:** A longitudinal, multi-centre, retrospective, observational, cohort study was
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15
16 25 conducted during the peak 6 weeks of the first wave from March 17, 2020 compared to the
17
18 26 same period in 2019.

20 27 **Setting:** Hospitals from six major urban cities were recruited around the UK, including
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23 28 London.

25 29 **Participants:** A total of 4840 clinical encounters were initially recorded. 4668 clinical
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27 30 encounters were analysed post-exclusion.

29 31 **Primary and secondary outcome measures:** Primary outcomes included the number of
30
31 32 acute trauma referrals and those undergoing operative intervention, mortality rates, and the
32
33 33 proportion of patients contracting COVID-19. Secondary outcomes consisted of the
34
35 34 mechanism of injury, type of operative intervention and proportion of aerosolising-generating
36
37 35 anaesthesia utilised.

40 36 **Results:** During the COVID-19 period there was a 34% reduction in acute orthopaedic
41
42 37 trauma referrals compared to 2019 (1792 down to 1183 referrals), and a 29.5% reduction in
43
44 38 surgical interventions (993 down to 700 operations). The mortality rate was more than
45
46 39 doubled for both risk and odds ratios during the COVID period for all referrals (1.3% vs
47
48 40 3.8%, $p=0.0005$) and for those undergoing operative intervention (2.2% vs 4.9%, $p=0.004$).
49
50 41 Moreover, mortality due to COVID-related complications (versus non-COVID causes) had
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52 42 greater odds by a factor of at least 20 times. For the operative cohort during COVID, there
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54 43 was an increase in odds of aerosolising-generating anaesthesia (including those with
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3 44 superimposed regional blocks) by three-quarters, as well as doubled odds of a consultant
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5 45 acting as the primary surgeon.
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10 47 **Conclusion:** Although there was a reduction of acute trauma referrals and those undergoing
11
12 48 operative intervention, the mortality rate still more than doubled in odds during the peak of
13
14 49 the pandemic compared to the same time interval one year previous.
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16

17 50
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19 51 **Keywords:** COVID-19; orthopaedic trauma; UK multi-centre; pandemic wave; mortality
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24 53 **Strengths and limitations of this study**
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27 54
- 28 • This was the first representative observational study of the UK looking into the
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31 55 impact of COVID-19 pandemic on general trauma and orthopaedic surgical specialty.
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34 56
 - 35 • There is a valid comparison between two timeframes, exactly one year apart to
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38 57 represent pre-COVID and during COVID.
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41 58
 - 42 • Other studies thus far have only shed light on local scales or cross-speciality within a
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44 59 shorter timeframe than this study and not necessarily commenting on mortality rates
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46
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48 60 like this study.
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51 61
 - 52 • Weaknesses included loss of data points which have been accounted for in the tables
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54 62 (i.e. labelled as unknown) which did not affect the final analysis of data points.
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- 63 • Operations conducted outside the specific study periods will not account for all those
64 operations required such as for hip fractures.

For peer review only

65 **Introduction**

67 *The Global Impact of COVID-19*

68 The COVID-19 pandemic will be remembered as one of the most unprecedented global
69 health crises in modern history. With over 5 million deaths and over 263 million recorded
70 cases globally, the pandemic has had a permanent impact on healthcare at the time of article
71 submission.¹ The viral outbreak was first reported in December 2019 with the first patient
72 hospitalised in the city of Wuhan, China.² By mid-March the outbreak affected over 190
73 countries with over 450,000 cases and over 20,000 deaths, thus being declared a pandemic
74 and a global public health emergency by the World Health Organization.³ On January 24th
75 2020 Europe reported its first case followed by a case in the United Kingdom (UK) 5 days
76 later.⁴

78 *The British Response to the pandemic*

79 The English government responded by implementing social distancing measures on the 17th
80 March 2020 in an attempt to reduce the rate of transmission and therefore the demands on the
81 National Health Service (NHS).⁵ This was followed a week later by more stringent measures,
82 commonly referred to as a societal 'lockdown'.⁶ As of the 23rd March 2020, all members of
83 the public were required to stay at home. The NHS has also been deeply affected by the strain
84 imposed by the virus as the healthcare infrastructure has had to evolve to cope with the
85 overwhelming and unexpected pressures on staff, resources and finances. There has been a
86 complete renovation of emergency medicine and orthopaedic services to manage
87 musculoskeletal disease and trauma. In response to the NHS emergency declaration,⁷ the
88 Royal Colleges of Surgeons⁸ and the British Orthopaedic Association⁹ both issued statements
89 and guidelines for delivering emergency trauma and orthopaedic care during the COVID-19
90 outbreak. The lockdown to limit the spread of the virus has had an unforeseen effect in

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3 91 significantly reducing the acute trauma workload described in several single centre studies.¹⁰⁻
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5 92 ¹³ There has however not been a British multi-centre reflection of the impact of the COVID-
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8 93 19 pandemic on the orthopaedic workload and its potential impact on the mortality.
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13 95 **Aim**
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15 96 To observe the impact of COVID-19 on trauma and orthopaedic acute referrals, operative
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17 97 casemix and mortality rates during the peak 6 weeks of the first wave of the pandemic
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19 98 compared to the same time interval in 2019.
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26 100 **Alternative hypothesis**
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28 101 When comparing both years, there would be a difference in the prevalence of acute
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30 102 orthopaedic referrals, orthopaedic trauma casemix and aerosol-generating anaesthetic
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32 103 procedures due to social distancing/lockdown. Mortality rates and survival probabilities were
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34 104 also hypothesised to differ due to the first COVID-19 outbreak.
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3 **106 Methods**
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6 *107 Study design:* This is the first multi-centre longitudinal observational study observing patients
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8 *108* who were acutely referred to the trauma and orthopaedic departments as well as those
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10 *109* operated on within the same 6-week interval comparing 2019 to 2020.
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13 *110*
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16 *111 Setting:* Seven principal hospitals contributed data from 6 major urban cities including
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18 *112* London, Gateshead, Middlesbrough, Dartford, Newport, and Reading.
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21 *113*
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24 *114 Patient sampling:* All acute referrals, operative notes, inpatient medical records and discharge
25
26 *115* summaries were accessed using electronic medical system at each contributing hospital trust.
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29 *116*
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32 *117 Study period:* The 6-week study period was from the start of social distancing on Tuesday
33
34 *118* 17th March 2020 to Tuesday 28th April 2020 which encompassed the national lockdown
35
36 *119* measures instigated on the 23rd March 2020. This period was considered the peak 6 weeks of
37
38 *120* the epidemic in the UK as outlined by the recorded mortality rates and R-values published by
39
40 *121* the Office of National Statistics.¹⁴ This time period was compared to the same 6-week
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42 *122* interval from Tuesday 19th March to Tuesday 30th April 2019 (i.e. prior to any COVID-19
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44 *123* related measures) to compare the impact of the pandemic one year apart.
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48 *124*
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51 *125 Outcomes/objectives:* Primary outcomes included the number of acute trauma referrals and
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53 *126* those undergoing operative intervention, post-operative complications, mortality rates, and
54
55 *127* the proportion of patients contracting COVID-19. Secondary outcomes consisted of the
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3 128 mechanism of injury, type of operative intervention and proportion of aerosolising-generating
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5 129 anaesthesia utilised.

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11 131 *Inclusion criteria:* All acute orthopaedic trauma referrals presenting to the Emergency
12
13 132 Department during the intervals one year apart were included. All orthopaedic trauma cases
14
15 133 that required an operation, including those from acute orthopaedic trauma referrals, within
16
17 134 the intervals one year apart. Those patients listed for an operation due to orthopaedic trauma
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19 135 prior to time period of data collection were included in the final analysis. We adhered to
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21 136 STROBE guidelines for observational studies.

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28 138 *Exclusion criteria:* Any cases being referred internally from other specialties for trauma and
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30 139 orthopaedic advice and input, as well as referrals from any external centre asking for tertiary
31
32 140 advice were excluded from further analysis. Any patients with post-operative complications
33
34 141 arising from the period prior to the data collection were excluded. For operative trauma cases,
35
36 142 those undergoing spinal procedures were excluded as these are jointly treated by
37
38 143 Neurosurgery in most hospitals. All non-urgent semi-elective procedures were excluded from
39
40 144 analysis as well, as they would inaccurately assess the impact of any social distancing
41
42 145 measures on the trauma workload. Routine elective orthopaedic cases were excluded.

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50 147 *Data points:* Demographics including age, sex and ASA grades were recorded for all
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52 148 patients. Injury characteristics were recorded, including the anatomical location and if the
53
54 149 injury was open or closed. The mechanism of injury was categorised and whether the patient
55
56 150 was referred as a trauma call. The nature of the operative procedures and the anaesthetic
57
58 151 techniques were recorded. Patients undergoing multiple procedures were recorded for every
59
60

152 episode where they were taken to theatre. 6-week mortality rate was recorded as well as the
 153 COVID-19 status of any symptomatic patients or suspected cases. Data points were divided
 154 into acute referrals and operative casemix as seen in table 1.

155

156 *Table 1: data points for acute referrals and operative casemix*

Age (years)	Gender (Male / female by birth)	ASA (1-5)	Date of injury / presentation
Injury	Mechanism of injury	Open Vs Closed fracture	Trauma Call (Yes / No)
Operative procedure	Anaesthetic Technique (AGP vs non-AGP)	Seniority of Surgeon (Consultants vs trainees)	Comorbidities
6-week mortality	Post-op complications	Surgery time since admission (hours)	COVID status (from PCR swabs)

157

- 158 • *Anaesthetic techniques:* This was divided into anaesthetic aerosolising-generating
 159 procedures (AGP) which consisted of any intubation (including laryngeal mask
 160 airway and endotracheal intubation) for a general anaesthetic. All other anaesthetic
 161 techniques including regional and local anaesthetics were deemed as non-AGPs.
- 162 • *COVID status:* At the time, COVID was being diagnosed with polymerase chain
 163 reaction (PCR) from nasal and oropharyngeal swabs with a duration of 1 to 4 days
 164 where the sample was tested both locally in the hospital lab as well as corroborated
 165 with national lab testing to reduce risk of unequivocacy. Groups of patients were
 166 divided into either not swabbed (due to being asymptomatic) or swabbed due to
 167 presence of documented symptoms which yielded either negative or positive results.

168

169 *Statistical analysis:* All the data were recorded, anonymised and verified by four members of
170 the study group for their accuracy. The data were processed using Microsoft Excel
171 (Microsoft, Washington, USA). Shapiro-Wilk test indicated a normal distribution for age and
172 days to discharge from hospital; hence, the mean (\pm standard deviation; 95% CI) were
173 calculated for both. ASA did not follow normality and was analysed using median (\pm median
174 absolute deviation [MAD]) and interquartile range (IQR). Both prevalence or risk and odds
175 ratios were calculated as well as a Fisher's exact test for statistical significance for
176 categorical data, defined as $p \leq 0.05$. Percentages and confidence intervals were rounded off
177 to one decimal place.

178

179 *The collaborative:* The COVID Emergency Related Trauma and orthopaedics (COVERT)
180 Collaborative was founded at Imperial College Healthcare NHS Trust. It is currently a
181 member of the COVID Research Group and it has been endorsed by the Royal College of
182 Surgeons of England and Imperial College Healthcare NHS Trust.

183

184 *Patient and Public Involvement:* Patients and the public were not involved in the study
185 design, recruitment or conduct.

186 Results

187 A total of 4840 clinical encounters took place between the study periods. A total of 172
 188 spinal operations and presentations were excluded from the final analysis. Table 2 outlined
 189 demographic data. During the COVID-19 period there was a 34% reduction in acute
 190 orthopaedic trauma referrals compared to 2019 (1792 down to 1183 referrals), and 29.5% less
 191 surgical interventions (993 down to 700 operations). Figures 1-3 have categorised these
 192 clinical encounters into types and mechanisms of injury for both acute referrals and operative
 193 cases between both years respectively.

194

195 *Table 2: Demographic data of pre- and post-COVID*

		Pre-COVID (2019)		COVID (2020)	
	Total	1792		1183	
Acute referrals	<i>Male</i>	935	52.2%	560	47.3%
	<i>Female</i>	857	47.8%	623	52.7%
	<i>Mean Age ± SD</i>	52.2 ± 27.9		55.8 ± 27.9	
	<i>(95% CI)</i>	(50.9 - 53.5)		(54.3 - 57.4)	
Operative cases	Total	993		700	
	<i>Male</i>	499	50.3%	320	45.7%
	<i>Female</i>	494	49.7%	380	54.3%
	<i>Mean Age ± SD</i>	51.7 ± 28.1		57.7 ± 26.7	
	<i>(95% CI)</i>	(50 - 53.5)		(55.7 - 59.6)	
	<i>Median ASA ± MAD</i>	2 ± 1		2 ± 1	
	<i>(IQR)</i>	(2)		(2)	

196

197 *Figure 1: Types and mechanisms of injuries for acute referrals*

198 *Figure 2: Types and mechanisms of injuries for operative cases*

199 *Figure 3: operative and anaesthetic techniques compared between pre- and post-COVID*

200

201 **COVID status**

202 COVID status for both acute referrals and operative casemix including results in all
 203 mortalities were demonstrated in figure 4. Mortalities with positive swab results were
 204 confirmed prior to the event of death within 6-weeks post-presentation. Approximately three-
 205 quarters were not tested and a fifth had negative results. 0.9% of the acute referrals resulted
 206 in deaths and 28.9% of those mortalities tested positive for COVID. Furthermore, post-
 207 operative mortalities represented 1.6% of the entire operative casemix, and 32.4% of those
 208 mortalities had a confirmed positive COVID-19 diagnosis prior to their death.

209

210 *Figure 4: COVID status for acute referrals and operative cases as a measure of proportions*

211

212 **Risk (or prevalence) and odds ratios**

213 *Table 3: Risk (or prevalence) and odds ratios for acute referrals and operative caseloads.*

214 *Comparisons are made between COVID period against the pre-COVID period. Value >1*

215 *indicated greater odds or risk during the COVID period.*

	Acute referrals			Operative caseload		
	RR	OR	p-value	RR	OR	p-value
Mortality	2.50	2.55	0.0005	2.19	2.25	0.004
Mortality due to COVID-related complications vs non-COVID causes	14.2	19.7	0.004	15.1	22.0	0.004

Morbidity & Mortality	Peri-/post-operative complications including COVID				5.88	6.09	0.00001
	Peri-/post-operative complications excluding COVID				3.65	3.72	0.003
	Peri-/post-operative COVID positive testing				32.6	23.4	0.0009
Anaesthetic technique	General anaesthetic only				1.22	1.61	0.00001
	General anaesthetic ± block				1.23	1.75	0.00001
Consultant involvement	Consultant-led operation				1.36	2.08	0.00001
Operation technique	Open reduction + internal fixation				0.81	0.74	0.007
	Dynamic hip screw				2.02	2.11	0.00001
	Removal of metal/foreign body				0.24	0.23	0.003
Mechanism of injury	Road traffic accident	0.58	0.56	0.001	0.45	0.43	0.00001
	Fall (<1.5m)	1.19	1.54	0.00001	1.17	1.49	0.0001
	Sporting injury	0.63	0.60	0.0005	0.64	0.61	0.003
	Infection	0.69	0.66	0.001	1.70	1.77	0.005
	Trauma call				0.55	0.52	0.0005
Type of injury	Neck of femur (NOF) fracture	1.44	1.57	0.00001	1.51	1.79	0.00001
	Lower limb (excl. NOF)	0.89	0.84	0.04	0.74	0.65	0.0001
Gender	Male	0.91	0.82	0.01			

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3 217 Table 3 outlined the risk [RR] (or prevalence [PR]) and odds ratios [OR] alongside their 95%
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5 218 confidence intervals and statistical significance. The risk ratio is synonymous with the
6
7 219 prevalence ratio. Only those factors that were statistically significant within the acute
8
9 220 referrals and operative caseloads were included. There were trends demonstrating increase in
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11 221 mortality rates, use of anaesthetic AGPs, Consultant-led operations, hip fracture surgery and
12
13 222 falls; but a decrease in other lower limb operations, open reduction and internal fixation,
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15 223 removal of metalwork and foreign bodies, road traffic accidents, sporting injuries and
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17 224 infection.
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25 226 **Mortality**

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27 227 Table 3 indicated that the 6-week mortality rate more than doubled significantly for both risk
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29 228 (RR=2.19-2.50) and odds (OR=2.25-2.55) ratios during the COVID period. COVID-related
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31 229 complications were still responsible for increasing the odds of mortality by 20 to 22 times
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33 230 within all mortalities from both acute referrals and operative cases (as compared to non-
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35 231 COVID causes for all mortality in the year 2019). Table 4 confirmed that the mean age of
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37 232 mortalities across the board were in the elderly patient population with a high median ASA
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39 233 grade. Males were consistently in the minority, while neck of femur fracture was the modal
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41 234 diagnosis due to falls and persistently in the majority, followed by lower limb injuries
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43 235 (figures 5-6). At least 82% of operations were related to neck of femur fractures in which half
44
45 236 of all operations during the COVID period involved anaesthetic AGPs. Whereas the
46
47 237 mortalities from pre-COVID operations did not have Consultant-led (as primary surgeon)
48
49 238 surgery, that increased to three-fifths of all operations conducted during the COVID period
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51 239 (figure 7).
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59 241 *Table 4: Patient demographics, date of injuries, and time to mortality*

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	<i>Acute referrals</i>				<i>Operative casemix</i>			
	2019		2020		2019		2020	
	(n=23)		(n=38)		(n=22)		(n=34)	
Mortality	1.3%		3.2%		2.2%		4.9%	
Mortality with COVID positive PCR result			0.9% (total) 28.0% (mortality cohort)				1.6% (total) 32.9% (mortality cohort)	
Post-op morbidity					0.7%		4.1%	
Age (years; mean±SD; 95% CI)	80.2 ± 16.4 (73.2 - 87.2)		77 ± 23 (67 - 88)		83.9±12.2 (78.7 - 89.1)		84.0±13.5 (79.4 - 88.5)	
Male	9	39%	16	42%	8	36%	15	44%
ASA (median±MAD; IQR)					3 ± 0 (1)		3 ± 0 (0)	
Date of injury (mean days±SD; 95%CI)	6/4 ± 11 (1/4 - 10/4)		31/3 ± 12 (26/3 - 5/4)		6/4 ± 12 (1/4 - 11/4)		30/3 ± 14 (25/3 - 4/4)	
Time from admission to mortality (mean days±SD; 95%CI)	10.3 ± 7.5 (7.1 - 13.5)		11 ± 10 (7 - 15)		14.3 ± 10.4 (9.8 - 18.7)		13.8 ± 10.4 (10.2 - 17.3)	

Figure 5: types and mechanism of injury for mortalities in acute referral cohorts

Figure 6: types and mechanism of injury for mortalities in operative casemix cohorts

Figure 7: Surgical and anaesthetic techniques utilised in mortalities as a means of proportions

Sub-group analysis for neck of femur fracture

A subgroup analysis of hip fractures was conducted due to its recognised risk of mortality within orthopaedic trauma. Those who were operated on in 2020, 20.2% tested positive for COVID, 47.3% tested negative and the remaining 32.4% were not tested due to being asymptomatic. Furthermore, 82.3% of all mortalities in 2020 sustained a neck of femur

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3 252 fracture in which only 35.7% of this cohort had a positive swab result, 21.4% with negative
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5 253 swab results and the remaining 42.9% were not swabbed due to being asymptomatic. There
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7
8 254 was no statistical difference in the odds and risk ratios between both years for mortality rate
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10 255 in NOFF (table 3). The absolute numbers did not change much, but because of a drop in other
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12 256 presentations, the relative percentage of NOFF markedly rose. Hence, the mortality expressed
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15 257 as a percentage of cases is notably higher for all operations, and not necessarily if stripped
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17 258 down to hip fractures alone.
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20 21 260 **Pre- and post-operative morbidity**

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24 261 Taking into account that COVID was a peri-operative complication since patients may have
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26 262 been symptomatic with COVID manifestations pre-operatively but only had the swab results
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29 263 return with a positive finding either pre- or post-operatively; the commonest post-operative
30
31 264 complication in the COVID period was a hospital-acquired pneumonia but with negative
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33 265 COVID swab results or the decision not to test at all. The second most common post-
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36 266 operative complication in the year 2020 was extra-pulmonary sepsis (Appendix 1). The
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38 267 proportion of post-operative complications had significantly increased when including or
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40 268 excluding COVID as a peri- or post-operative complication in 2020 (0.70% vs. 2.57-4.14%;
41
42 269 $p=0.003$) with varying odds (3.72-23.4) and risk (3.65-32.6) ratios (table 3). Appendices 2-3
43
44
45 270 focused on the total number and nature of comorbidities within the mortality groups. Multiple
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47 271 contingency chi-square test was insignificant for both number of comorbidities and individual
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49 272 comorbidities between both years, except for cardiovascular and cerebrovascular disease in
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52 273 acute referrals.
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56 275 *Appendix 1: Post-operative complications for both years*

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59 276 *Appendix 2: Type of comorbidities for all mortalities in both years*
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277 *Appendix 3: number of comorbidities for all mortalities in both years*

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279 **Survival probability**

280 6-week Kaplan-Meier survival probability analysis for mortalities between both years were
281 plotted in figures 8-9. There were similar patterns of survival probability between both
282 cohorts (i.e. 2019 vs 2020 cumulative). However, the lowest survival probability and the
283 shortest timeframe were observed in the confirmed COVID positive cohorts (figure 8). 8
284 (72.7%) patients had femoral trauma, most being neck of femur fractures, distal femur
285 fracture and a dislocated hip hemiarthroplasty post-fracture. Unexpectedly, there was a
286 reversal of trends observed for the 6-week Kaplan-Meier survival analysis once admitted and
287 operated on in figure 9. Mortalities within the pre-COVID period had the lowest survival
288 probability compared to the post-COVID cohort. The COVID positive mortalities were
289 observed to have the highest survival probability 11 days prior to converging with those
290 mortalities without COVID symptoms.

291

292 *Figure 8: Six-week Kaplan-Meier survival probability analysis for mortalities between pre-*
293 *and post-COVID for acutely referred from the Emergency Department*

294 *Figure 9: Six-week Kaplan-Meier survival probability analysis for mortalities between pre-*
295 *and post-COVID for those undergoing surgery*

296

297 **Discussion**

298 *Comment on alternative hypothesis*

299 There was a significant difference between pre- and post-COVID periods at its peak. The
300 alternative hypothesis was not rejected with respect to prevalence of (i) acute orthopaedic
301 trauma referrals (reduced by 34%), (ii) surgical interventions (reduced by 29.5%), (iii)
302 anaesthetic aerosolising-generating procedures, (iv) 6-week mortality rates (more than
303 doubled in the COVID period), and (v) survival probability between pre- and post-COVID
304 eras.

305

306 *Corroboration of our results with current literature*

307 The 34% reduction in acute trauma referrals is in keeping with previous single centre studies
308 performed in the UK with results ranging between 26-59%.^{10-13,15,16} As described in these
309 previous studies we would attribute the overall reduction of trauma workload to be due to
310 reduction in travel and outdoor activities during the national lockdown. MacDonald *et al.*¹⁷
311 described a similar effect in their multi-centre study with a reduction of operative workload
312 by 26.5% compared to 29.5% in our study. Sites recruited for this study confirmed that they
313 continued to operate at their own facilities during the data collection period whereas some
314 later used alternative and external facilities including private hospitals through NHS England
315 pathways (as mentioned by Dayananda *et al.*¹⁸), which may have impacted nosocomial rates
316 of COVID, morbidity and mortality. However, this would be difficult to assess since it would
317 also depend on the diversions of the ambulance services to 'clean' versus 'contaminated'
318 hospital sites.

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320 *Changes in trends during the peak of COVID*

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3 321 With respect to the operative caseload (table 3), patients had half (OR=0.52, p<0.001) the
4
5 322 odds of presenting as a trauma call. This was due to the odds ratios of road traffic accidents,
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7 323 sporting injuries, infection, and lower limb injuries were significantly less (by 34-44%;
8
9 324 OR=0.56-0.66, p<0.01) during the COVID period. Conversely, there was a significant rise in
10
11 325 the odds of neck of femur fractures, falls, the use of anaesthetic AGP and Consultant-led
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13 326 operations; a finding also reflected by Arafa *et al.*¹⁹
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17 327 Although the expectation was to minimise the use of aerosolising-generating anaesthetic
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19 328 procedures, there was in fact an increased prevalence of using general anaesthesia ± block up
20
21 329 to an odds of 75%, in order to create a ‘closed circuit’ for the airways. As the anaesthetic
22
23 330 methods was not well documented in the pre-COVID era in a fifth (21.3%) of cases, this
24
25 331 skewed the data as it may have been difficult to extract that data from 2019. The odds of a
26
27 332 Consultant-led operation doubled (OR=2.08) during the COVID period as a consequence of
28
29 333 all elective operations being suspended, hence more Consultants were relocated to trauma
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31 334 theatre and increased pressure within the theatre environments led to Consultant-delivered,
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33 335 rather than Consultant-led care. With respect to surgical procedures, there was a significant
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35 336 reduction in prevalence ratio of open reduction and internal fixation by a fifth (PR=0.81) and
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37 337 removal of metalwork and foreign bodies by three-quarters (PR=0.24), while there was a
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39 338 doubling (PR=2.02) in dynamic hip screw fixation in the COVID era.
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340 ***Mortality and Morbidity***

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342 *Mortality during COVID-19 timeframe*

343 Comparatively, the COVIDSurg Collaborative observed a mortality rate of 28.8% (p<0.0001)
344 of orthopaedic patients who underwent surgery (both elective and trauma) within the first
345 quarter of the year.²⁰ The increased mortality during the pandemic is partly due to selection

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3 346 of cases that required surgical intervention. The decrease in acute referrals and operations
4
5 347 indicated a higher threshold for treatment (due to a redistribution of hospital resources during
6
7 348 the pandemic). However, no such case was denied surgery but in the worst-case scenario
8
9 349 patients were offered postponed treatment which is acceptable practice (i.e. within 2 weeks).
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14 351 *Role of morbidity in mortality during COVID-19*

16 352 Results from figures 5-7 and appendices 1-3 were corroborated with the COVIDSurg
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18 353 publication²⁰ which confirmed a significant association of mortality with myocardial
19
20 354 infarction and congestive heart failure. However, hypertension and stroke/transient ischemic
21
22 355 attacks were not significantly associated. In our study, all cardiovascular diseases (including
23
24 356 peripheral vascular, arrhythmias, hypertension, heart failure, myocardial infarction and acute
25
26 357 coronary syndromes) were combined with cerebrovascular diseases (consisting of strokes and
27
28 358 transient ischemic attacks). Unlike their study, our study did not find a significant association
29
30 359 with chronic kidney disease, chronic obstructive disease (which included asthma) and
31
32 360 dementia in all mortalities during the 2020 timeframe regardless of the COVID status. The
33
34 361 differences may stem from that their study looked at the comparison of mortality rates within
35
36 362 the same cohort during the COVID era, whereas this study is sub-analysing the entire
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38 363 mortality cohort on its own to observe for specific associations and risks.
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48 365 *Survival probability between both years*

49 366 As expected, reduced survival probability reflected the most vulnerable patient profiles,
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51 367 usually with multiple pre- and post-operative comorbidities (appendix 1-3). A reason for a
52
53 368 transient increase, and unexpected reversal, in 6-week survival probability in the operative
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55 369 COVID cohort (figures 8-9) may be explained by dedicated wards being ring-fenced to host
56
57 370 confirmed COVID positive patients with a heightened care of nursing, medical cover and
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3 371 personal protective equipment. Prior to the onset of a possible vaccination, symptomatic
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5 372 management and shielding were the mainstay treatments for COVID positive patients. None
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7
8 373 of these patients were stepped up to the Intensive Treatment Unit due to being categorised as
9
10 374 high-risk stratification for mortality based on age and extent of comorbidities.

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14 376 *Justification of conducting this study*

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17 377 As lockdown measures in the UK and globally eases and the incidence of trauma returns to
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19 378 pre-lockdown trends, it is imperative that we understand the true increased risk of mortality
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21 379 in acute trauma during the COVID-19 era. A recent publication by Kader et al.²¹ has
22
23 380 suggested that the rate of mortality from COVID-19 for elective orthopaedic patients is low;
24
25 381 yet this is the first British multi-centre study to quantify mortality risk for trauma patients.
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27 382 Trauma procedures due to the nature of the injuries are necessary and time-critical, and
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29 383 nobody can afford to postpone trauma care even during a global pandemic.²²

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35 385 Furthermore, the Corona Hands Collaborative²³ published that upper limb trauma patients
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37 386 had SARS-CoV-2 complication rate of 0.18% (n=2) with 0.09% (n=1) overall mortality at
38
39 387 the peak of the first wave in April 2020. However, their collaborative looked into a shorter
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41 388 post-operative period (30 vs 42 days) but they agreed that patients who had been hospitalised
42
43 389 for a prolonged period before their surgery were at increased risk of both COVID-related and
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45 390 post-operative complications. Most of their patient cohort, who were both younger and fitter
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47 391 than our cohorts, would be classified as the 'walking wounded' and could usually be
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49 392 managed as day-case procedures.

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55 394 Although the trends in mechanisms of injury in our study were reflective of those within a
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57 395 US multi-centre study, there was an opposing trend in the number medical/surgical
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3 396 procedures.²⁴ That could be due to their study encompassing level 1 trauma centres with a
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5 397 mean younger patient population. However, we do agree that with time and from experiential
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7 398 learning, hospitals improved their coping strategies with the pandemic and enhanced patient
8
9 399 safety by enforcing personal protection equipment, hosting dedicated theatres for COVID-
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11 400 positive patients, separating sites as clean and contaminated, ringfencing COVID-positive
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13 401 patients to dedicated wards, and promoting routine COVID PCR swabs for all admissions
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15 402 and pre-operative checklists.
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21 404 With an overall mortality risk in 2020 doubled that of 2019, clinicians need to counsel
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23 405 patients presenting with acute orthopaedic trauma of the increased risk in the COVID-19 era,
24
25 406 especially for those identified as increased risk stratification with multiple underlying
26
27 407 comorbidities, elderly and frailty. With the ongoing risk of a subsequent wave and resurgence
28
29 408 of COVID-19 cases on top of the inevitable winter pressures, this data is of critical
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31 409 importance in the risk management, decision-making and policymaking of trauma patients
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33 410 both in the UK and across the globe.
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40 412 *Neck of femur fractures*

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42 413 Since the aetiology of neck of femur fracture is often low energy falls in the home
43
44 414 environment, it is not unexpected to observe a consistency of neck of femur fractures in the
45
46 415 elderly and the vulnerable during lockdown as seen in figures 1-2. Those with neck of femur
47
48 416 fractures remain at greatest risk of mortality and there have been further studies evaluating
49
50 417 the risk of COVID-19 on this inherently high-risk cohort.²⁵⁻²⁸ COVID-19 itself has been
51
52 418 identified as an independent risk factor in increasing mortality in neck of femur fractures.^{29,30}
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3 420 The increased mortality reflect the increased proportion of NOFF patients that have a higher
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5 421 baseline mortality which has been echoed by the Scottish IMPACT-Restart study.²⁸ There are
6
7 422 several justifications such as reduced help, lack of assistance and staff shortages due to the
8
9 423 effect of the national lockdown which required elderly patients to be more independent,
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11 424 unsupervised and at higher risk of falling. Nevertheless, it should be considered that odds of
12
13 425 falls may have increased due to prodromal symptoms and clinical manifestations of COVID.
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19 427 If these 'at risk' patients were symptomatic with the virus, then aggressive pre-operative
20
21 428 optimisation would occur. Since 91% (n=10) of COVID positive patients had sustained a
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23 429 neck of femur fracture, the National Hip Fracture Database best practice tariff of operating
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25 430 within an ideal 36-hour window set by the Royal College of Physicians was suspended until
26
27 431 the patient was stabilised. All hip fracture patients in this cohort were operated on and had
28
29 432 dedicated orthogeriatric input commencing from hospital admission. Hence the early peri-
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31 433 operative period and surgery encompassed within the 10-day period post-admission.
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35 434 Moreover, neck of femur fractures are recognised as a pre-terminal illness and are known to
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37 435 carry a high risk of mortality in the first month which is trebled in the first year after the
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39 436 injury.³¹
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43 438 ***Strengths and weaknesses of the study and in relation to other studies***

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45
46 439 This was the first representative observational multi-centre study of the UK looking into the
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48 440 impact of COVID-19 pandemic on general trauma and orthopaedic surgical specialty. Studies
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50 441 thus far have only shed light on local scales, cross-speciality, reflecting a fraction of our
51
52 442 study population or contain 30-day mortality at most.^{10-13,20,30,32,33} Weaknesses included loss
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54 443 of data points which have been accounted for in the tables (i.e. labelled as unknown).
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57
58 444 However this did not affect the final analysis of data points (table 1). Operations conducted
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3 445 outside the specific study periods will not account for all those operations required such as
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5 446 for NOFF. It does not suggest that the number of NOFF not accounted for have been
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7 447 managed conservatively (as discovered by Cherevu et al.³⁴), since some NOFFs may have
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9 448 breached time to surgery due to medical reasons or being influenced by international
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11 449 guidelines.³⁵
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16 451 ***Limitations and future research***

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18 452 It is vital to continue exploring the impact of the pandemic on a larger scale. Ideally, more
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20 453 secondary care providers consisting of district general hospitals and major trauma centres
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22 454 will submit data. The diagnosis of COVID was dependent on positive PCR swabs for this
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24 455 study rather than non-specific changes seen on chest CT or plain radiographs. This does not
25
26 456 account for false negatives with clinical respiratory symptomatology or true positives in those
27
28 457 asymptomatic. Nevertheless, this issue with data has been speculated on in another national
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30 458 study.²³ Data ought to be submitted during the peak of the pandemic as well as at various
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32 459 time intervals as the lockdown measures ease resulting in more freedom of movement while
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34 460 also accounting for the continued risk of subsequent waves and national lockdowns.³⁶ Further
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36 461 studies will also require to compare the impact of the pandemic on the speciality in the UK
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38 462 compared to other countries on other continents.
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3 463 **Conclusion**
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5 464 This was the first, longest and largest British multi-centre representation of the impact of
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7 465 COVID-19 pandemic on acute orthopaedic trauma referrals and mortality between mid-
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9 466 March to end-April, representing the peak of the first wave during the lockdown. The
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11 467 mortality rate for acute referrals, as well as those undergoing operative intervention, more
12
13 468 than doubled in odds when compared to the same time interval one year ago. The majority of
14
15 469 mortalities consisted of the elderly with neck of femur fractures and cardiovascular and/or
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17 470 cerebrovascular diseases. This study will aid clinicians in counselling trauma patients of the
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19 471 increased risk of mortality during the era of COVID-19 and also aid in both healthcare
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21 472 infrastructure, resource allocation, decision-making and policymaking as we continue to
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23 473 battle with the pandemic.
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3 474 **Research Ethics Approval - Human Participants:** This study involves human participants
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5 475 but an Ethics Committee(s) or Institutional Board(s) exempted this study. All data points
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7 476 were utilised for routine auditing purposes to reflect departmental activity and service
8
9 477 provision without altering clinical care pathways. Each centre contributing data to this study
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11 478 registered their interests with local authority and the auditing or clinical governance
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13 479 departments. No informed consent was required as there was no identifiable data. All data
14
15 480 were anonymised at the time of collection and submission. Each patient was assigned a
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17 481 unique identification number which was cross-referenced with the patients' individual
18
19 482 hospital identification or medical record numbers. This cross-referenced list remained
20
21 483 internally within the hospital trust computer server handled by the contributing team from
22
23 484 each trust. The data was transferred and stored using the NHS.net email server which has
24
25 485 been approved for transfer of patient data. Data protection compliance was abided by at all
26
27 486 times. The lead centre was Imperial College Healthcare NHS Trust where this study was first
28
29 487 approved as a clinical audit prior to expanding onto a national scale. All centres gave
30
31 488 permission for the use of their data. This study was assessed using the UKRI/MRC/NHS
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33 489 Health Research Authority Ethics Decision Tool and was considered an 'audit/not research';
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35 490 and therefore it was not subject to further ethical review by the NHS Research Ethics
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37 491 Committee (NHS REC).
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47 493 **Competing Interests:** None declared

48 494 **Funding:** Nil

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54 496 **Data availability statement:** Underlying data, code and supporting documentation may be
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56 497 made available as a redacted version to interested parties, subject to the completion of a
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58 498 protocol and signing of a Data Transfer Agreement.
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4 615 **Contributorship statement according to the ICMJE guidelines**

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7 616 We have read the ICJME guidelines attentively and have outlined the collaborative
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10 617 contributors below who have all satisfied the criteria to be recognised as a collaborative co-
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13 618 author if this study is published. The core committee of the collaborative consists of KS, AA,
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16 619 CP and KMS who all conceptualised the study, led the
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18
19 620 planning/investigation/methodology/design, supervised the collaborative contributors' roles,
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21
22 621 as well as the initial and final version of the manuscript. Additionally, KS (primary author)
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24
25 622 was also leading data curation, project administration and resource allocation with KMS. KS
26
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28 623 was also leading on validation. KS, CP and AA led the data analysis and the reporting of the
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31 624 results. All other collaborative members, from the seven centres and outside the core
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34 625 committee, were involved in data curation, formal analysis and in resource allocation
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36
37 626 internally under consultant supervision (i.e. those with FRCS). Individual contributions from
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40 627 the core committee and every collaborative member has been outlined below:
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50 629 **COVERT Collaborative members, their affiliations and extent of contribution**

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53 630 **Core Committee**

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Name	Qualifi- cation	Contribution	E-mail
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Figure 2: Types and mechanisms of injuries for operative cases

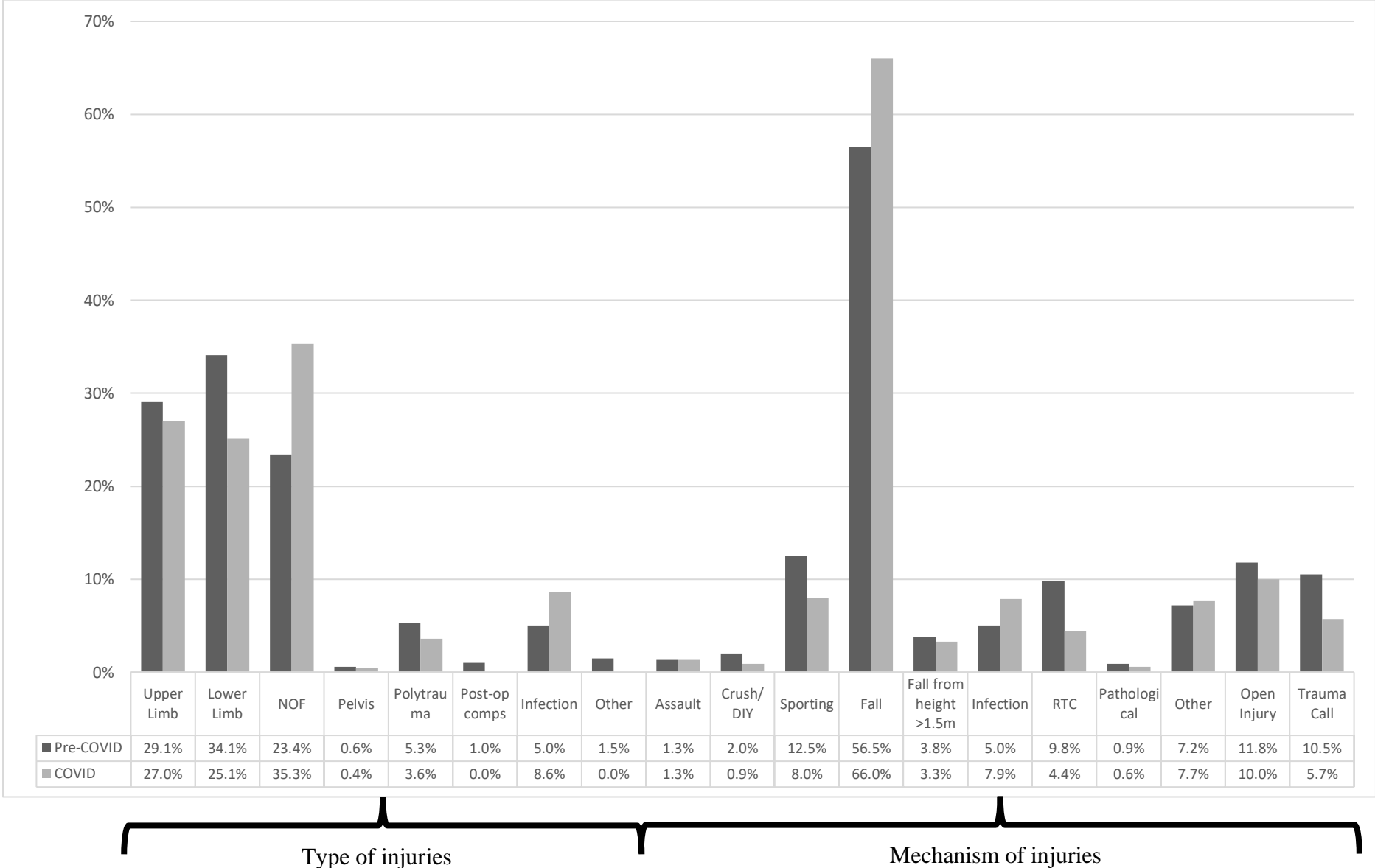
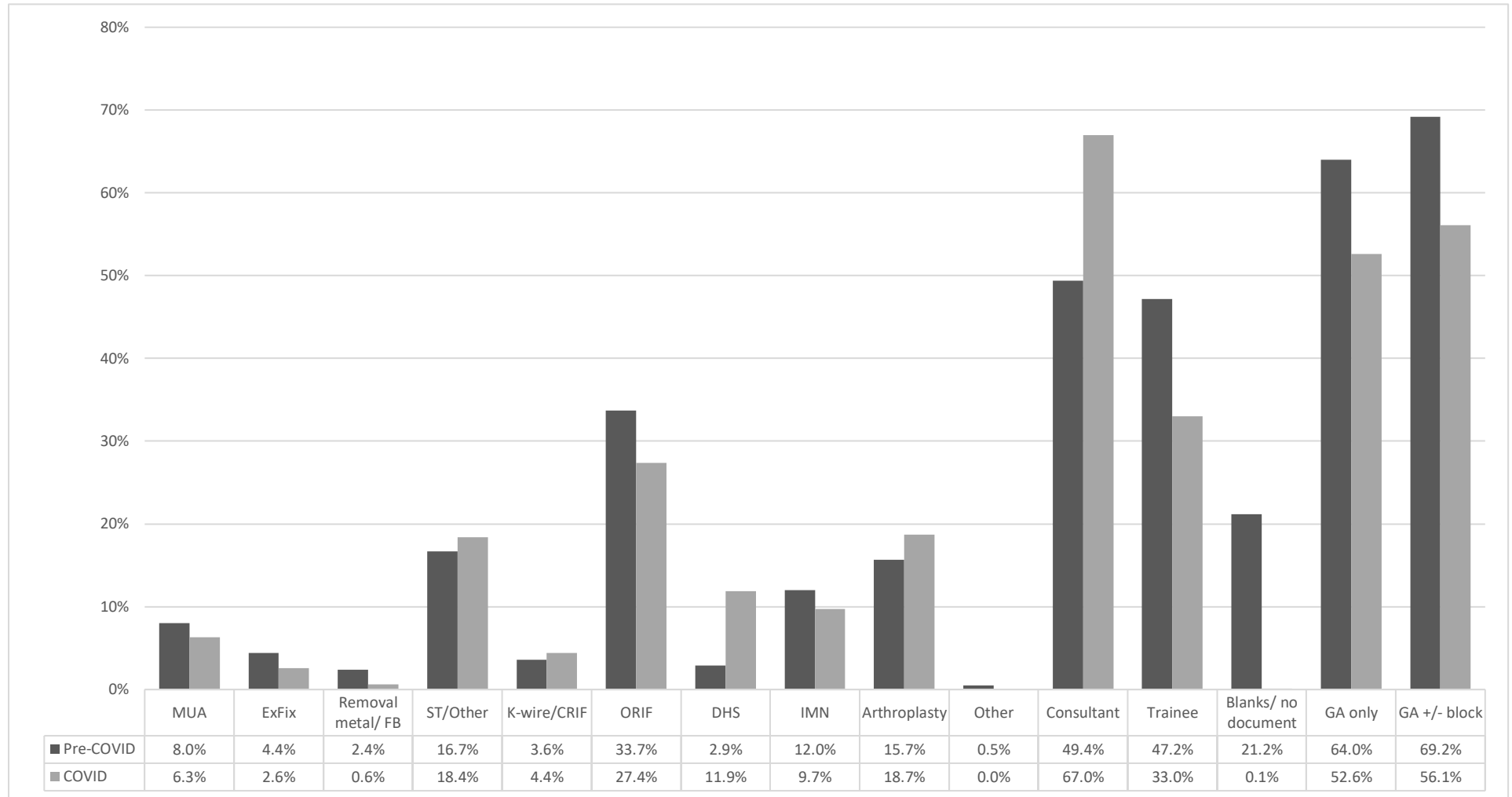


Figure 3: operative and anaesthetic techniques compared between pre- and post-COVID



Type of injuries
Primary surgeon
Anaesthetic technique

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Figure 4: COVID status of both cohorts including positive results in all mortalities (with 5% error bars)

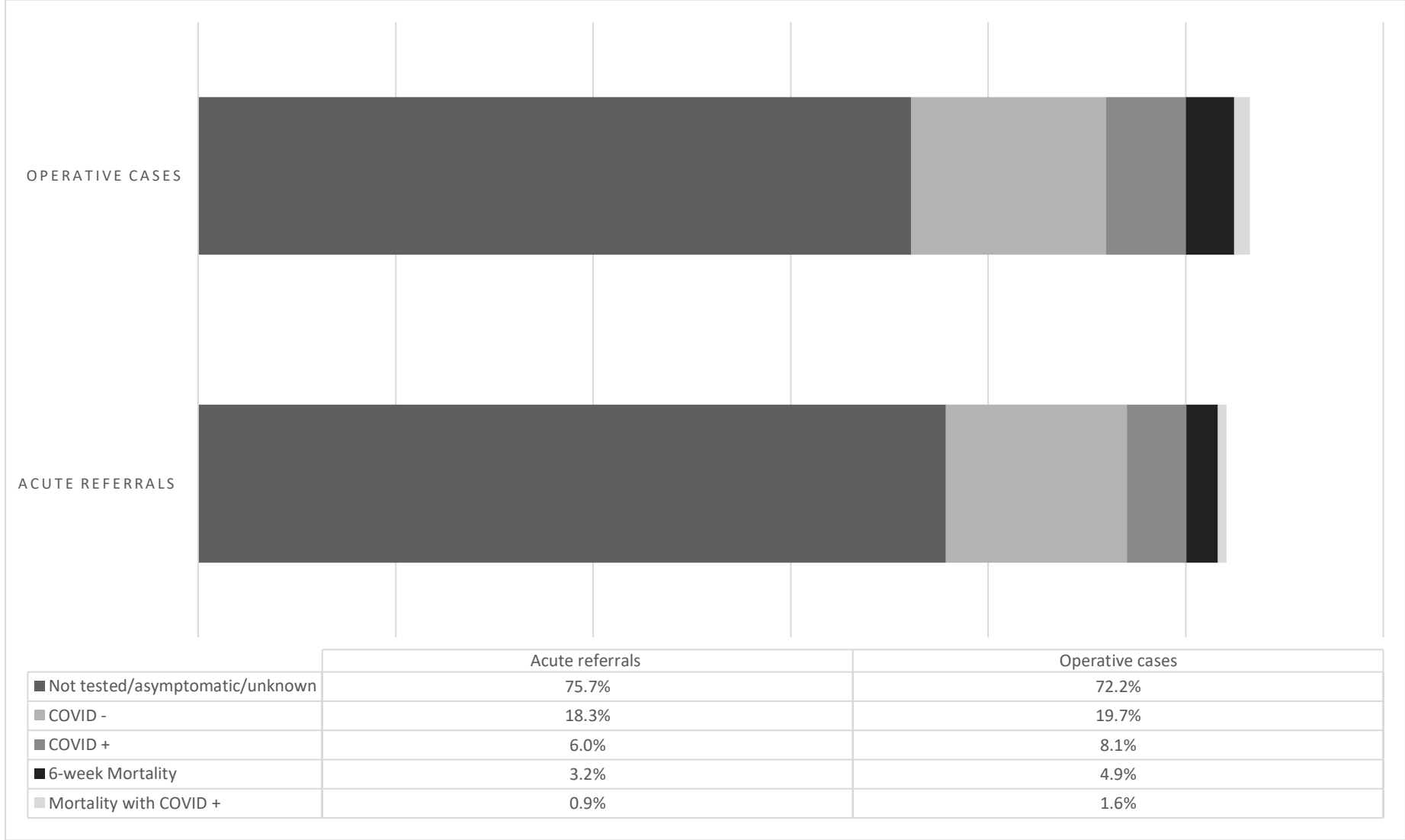
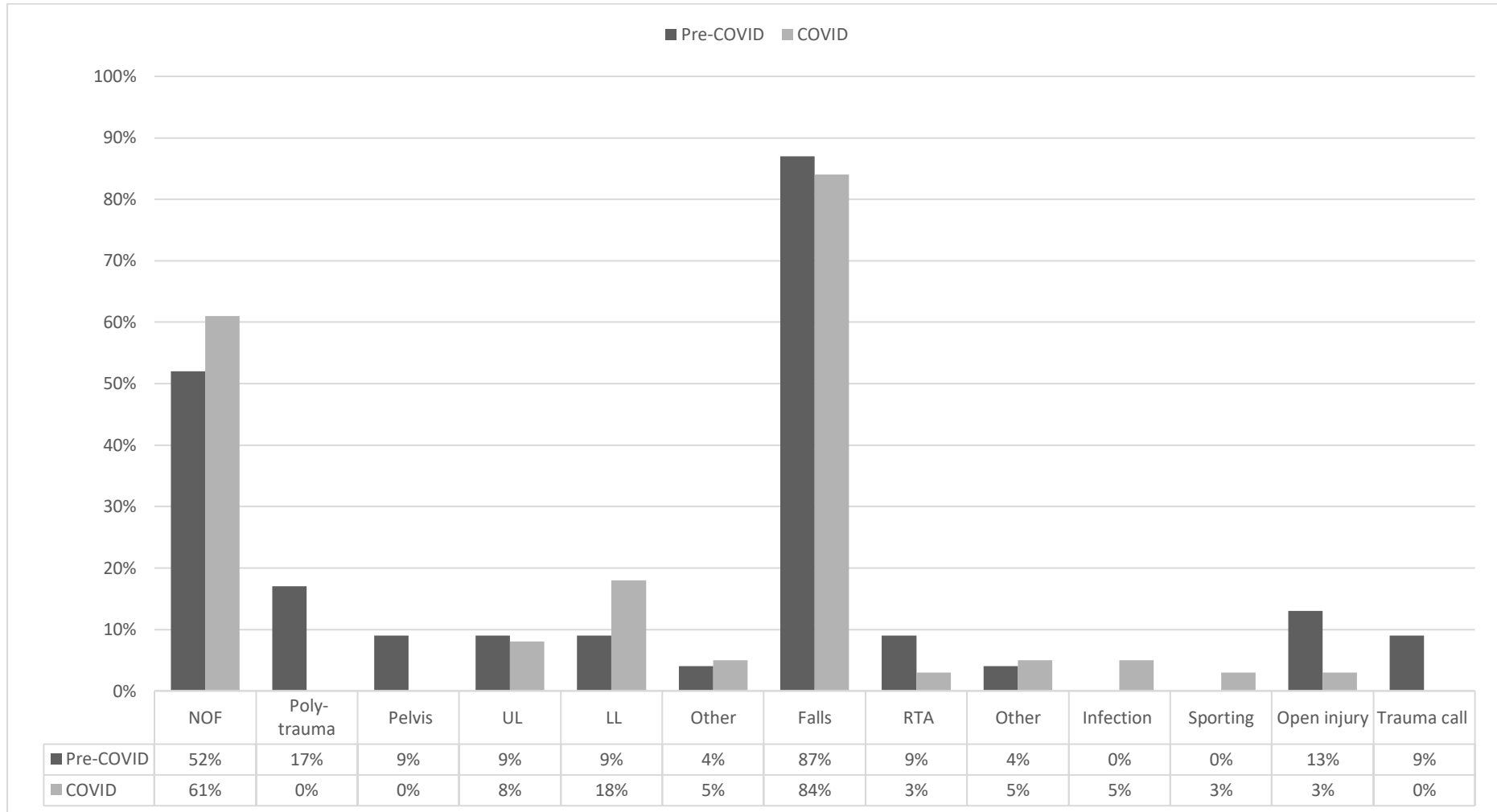
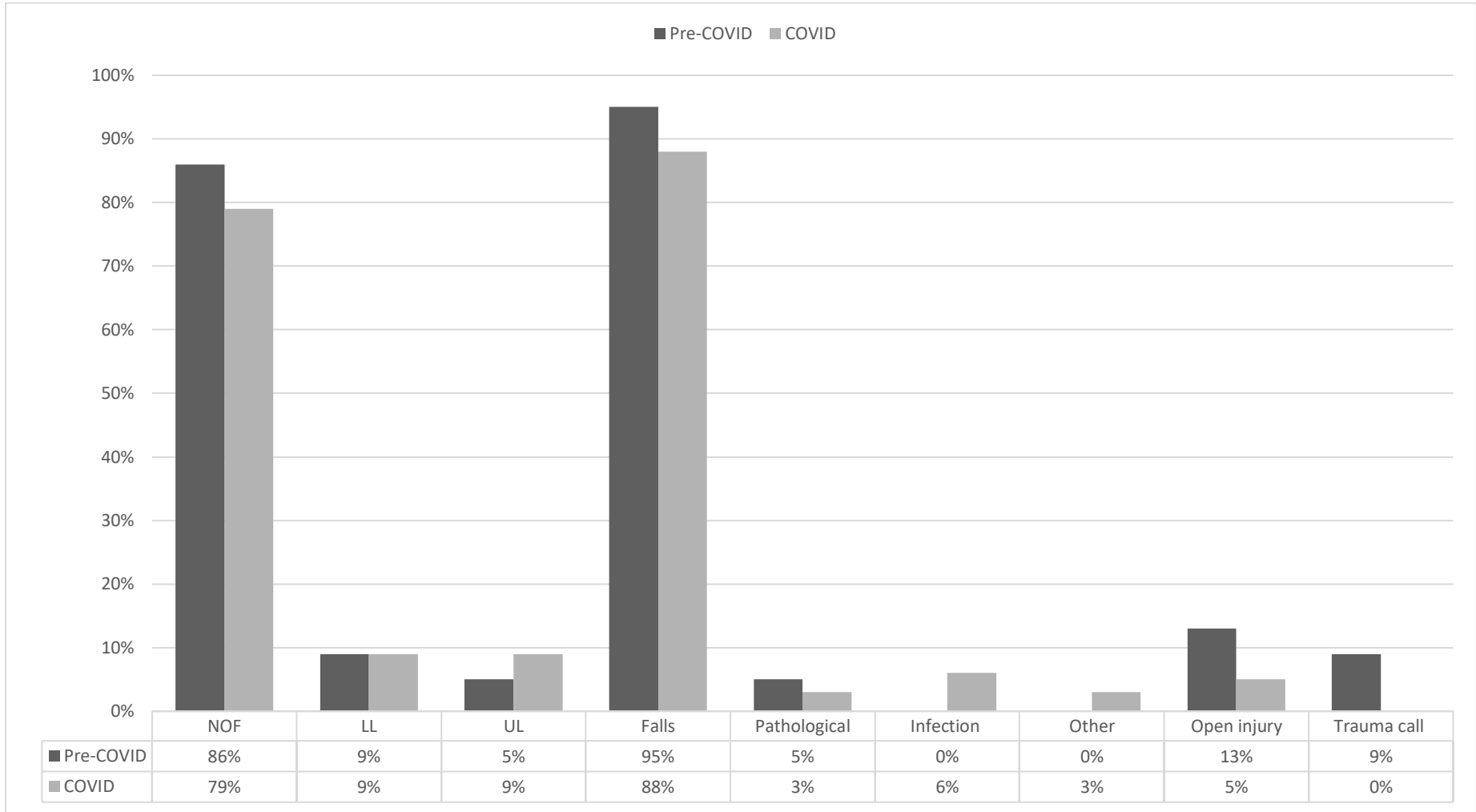


Figure 5: types and mechanism of injury for mortalities in acute referral cohorts



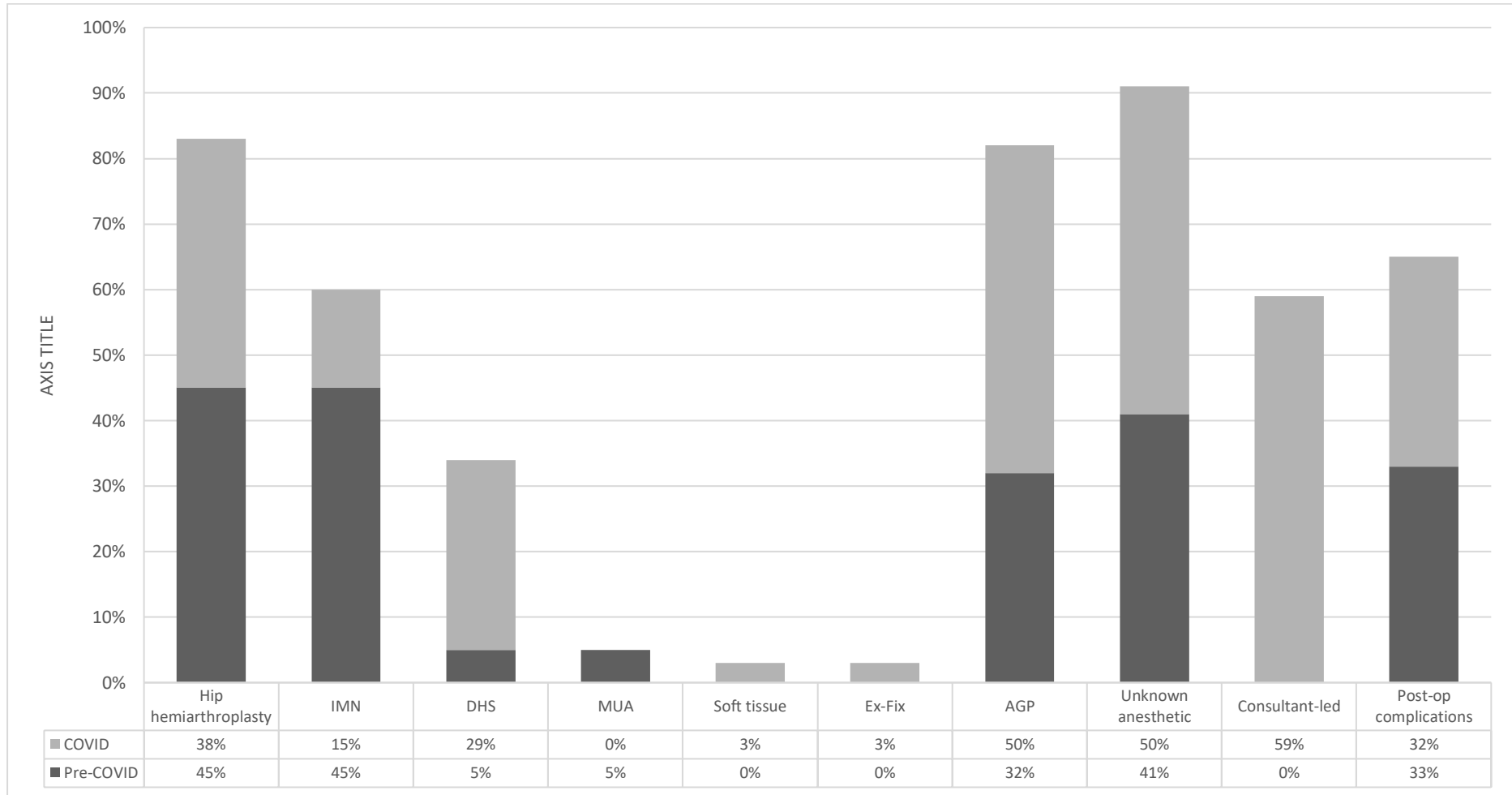
Key: UL: upper limb / LL: lower limb / RTA: road traffic accidents

Figure 6: types and mechanism of injury for mortalities in operative casemix cohorts



Key: NOF: neck of femur fracture / UL: upper limb / LL: lower limb

Figure 7: Surgical and anaesthetic techniques utilised in mortalities as a means of proportions



Key: IMN: intramedullary nailing / DHS: dynamic hip screw / MUA: manipulation under anaesthesia / Ex-Fix: external fixation / AGP: aerosolizing-generating procedures

Figure 8: Six-week Kaplan-Meier survival probability analysis for mortalities between pre- and post-COVID for acutely referred from the Emergency Department

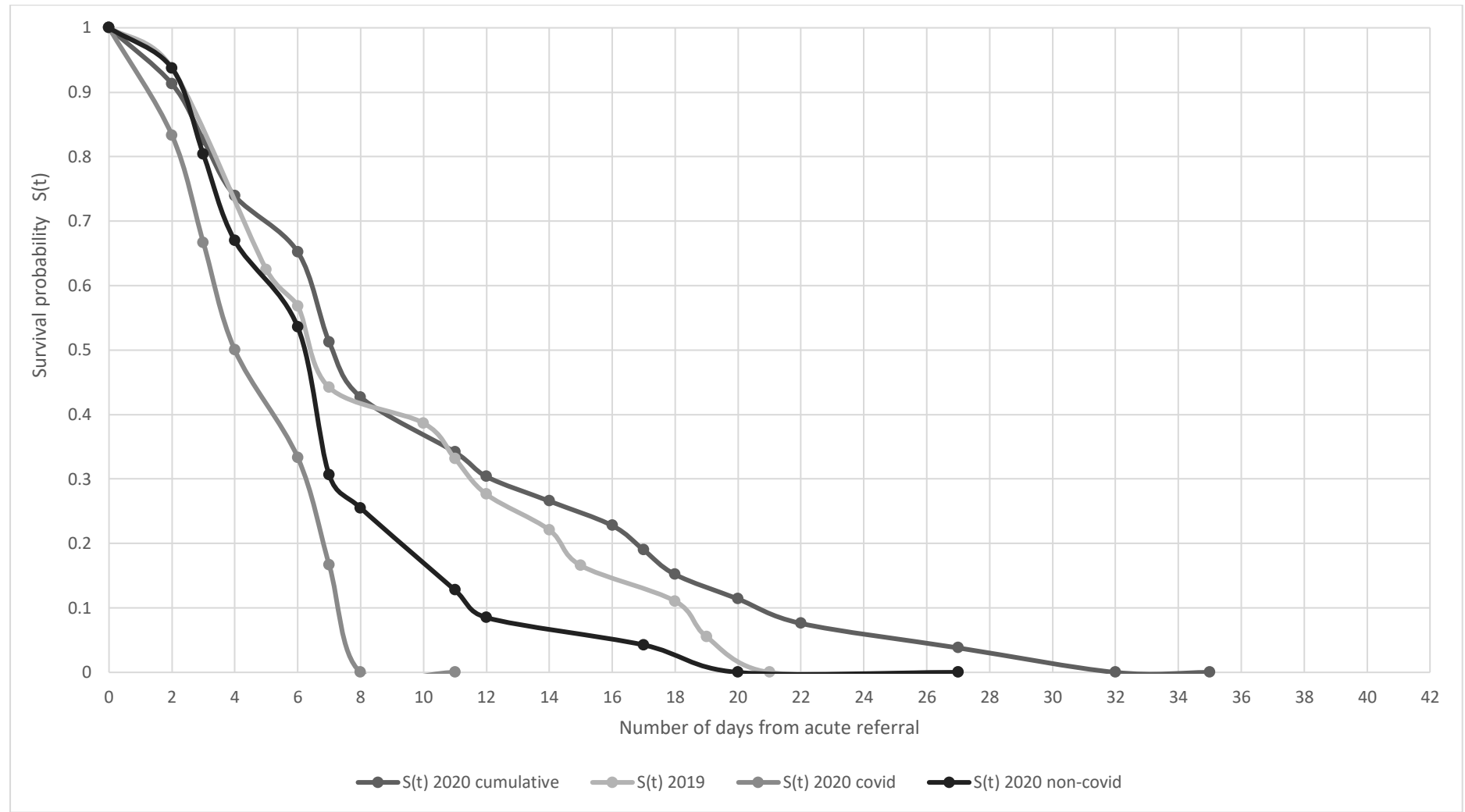
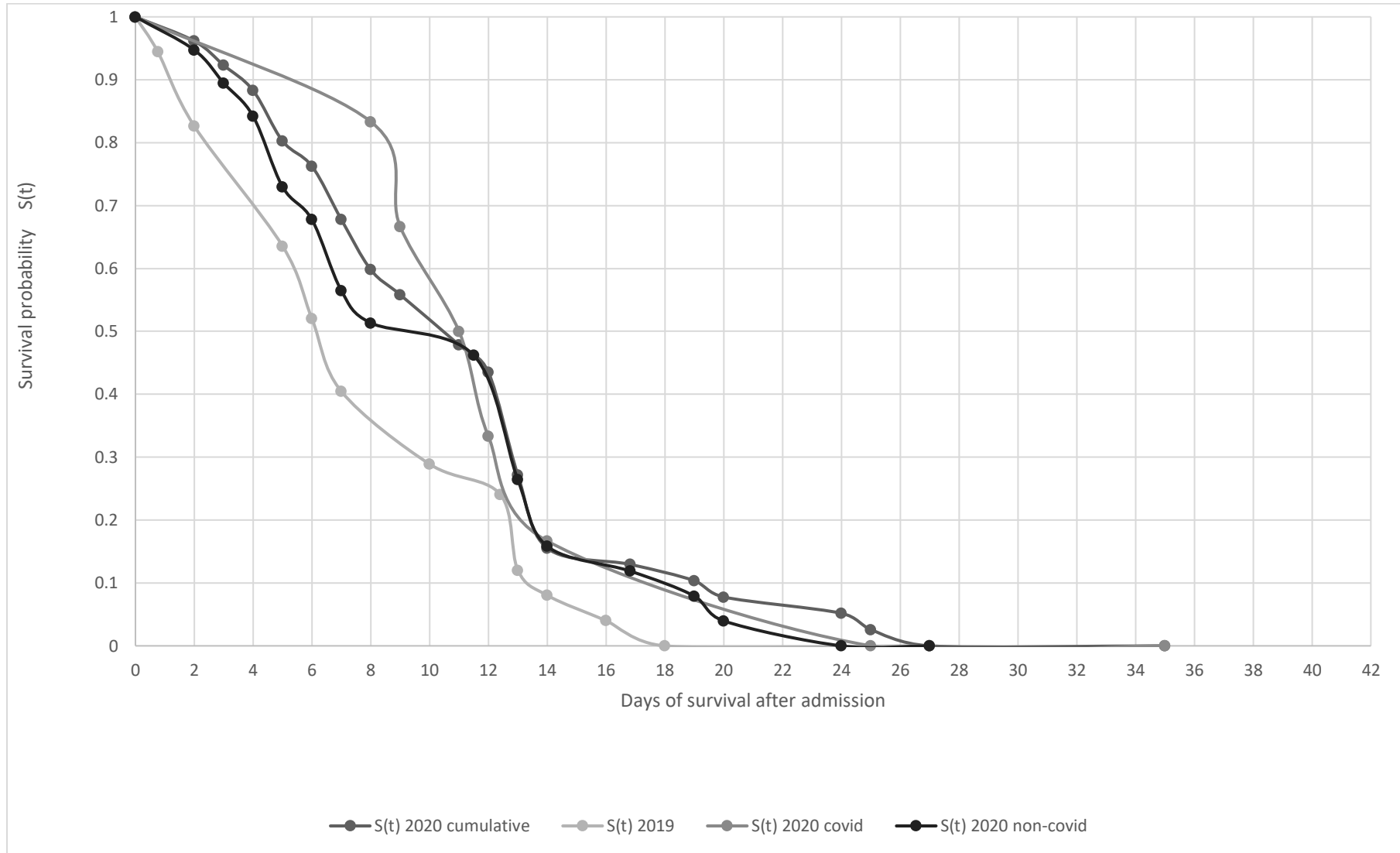
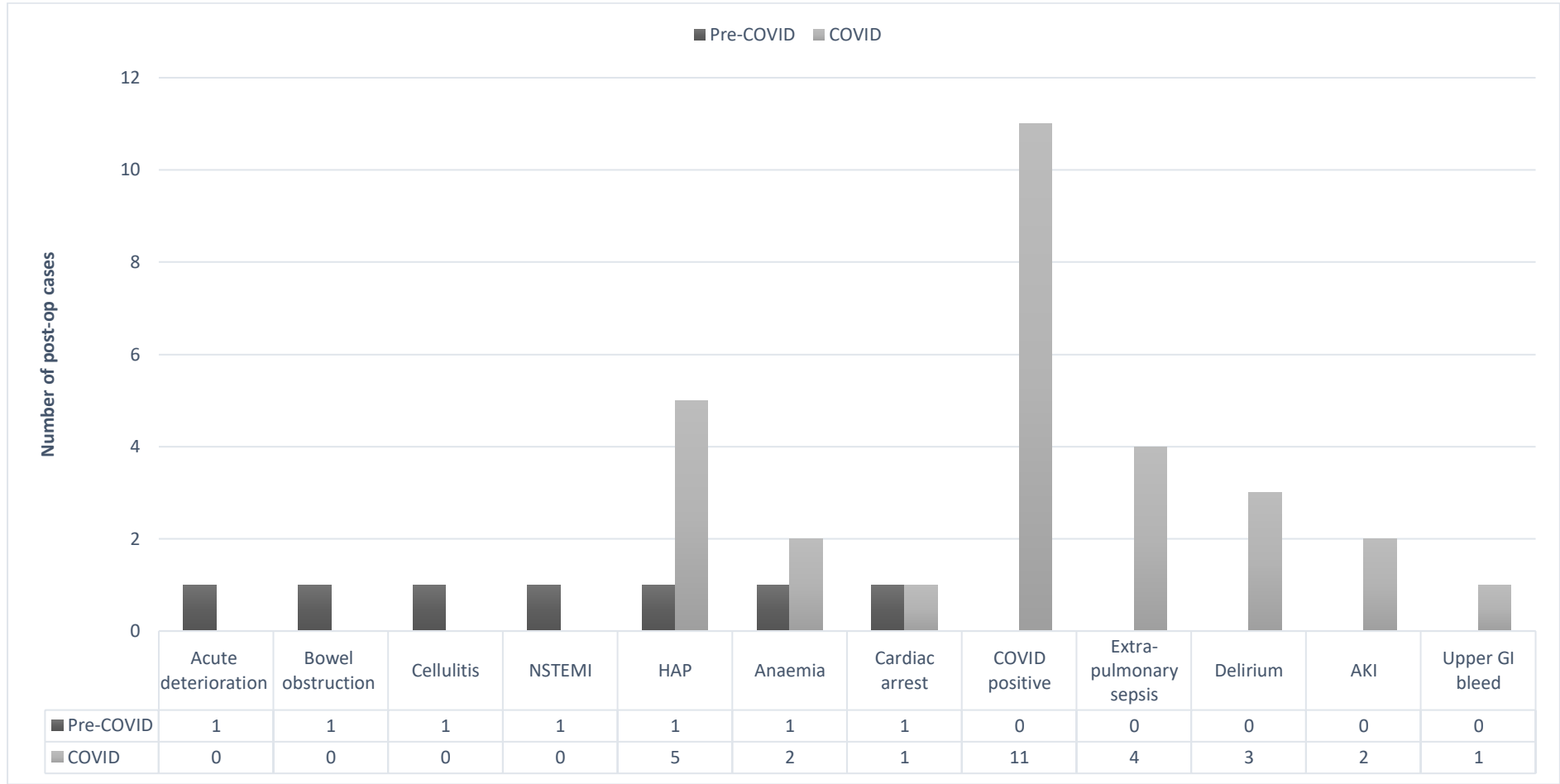


Figure 9: Six-week Kaplan-Meier survival probability analysis for mortalities between pre- and post-COVID for those undergoing surgery

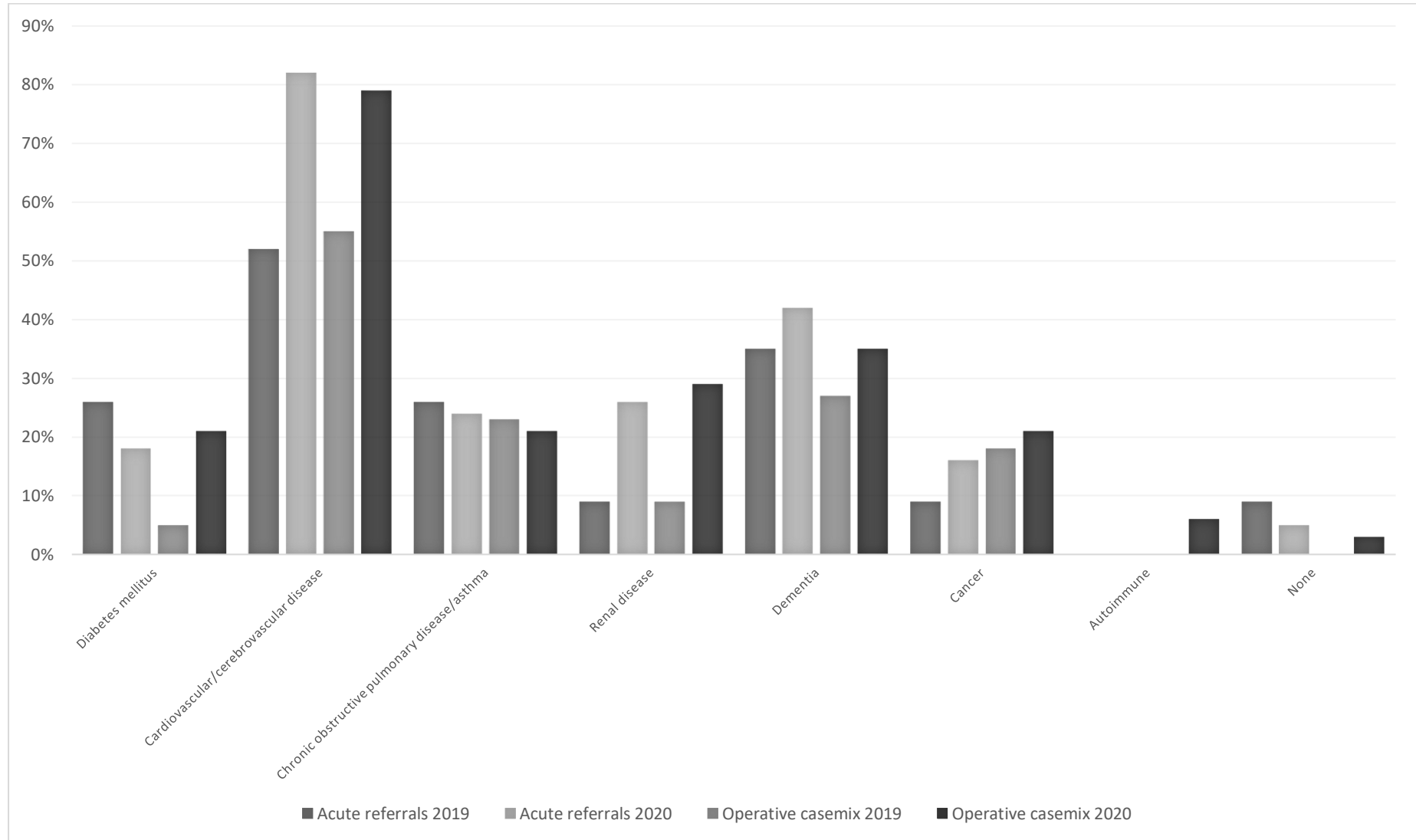


Appendix 1: Post-operative complications for both years



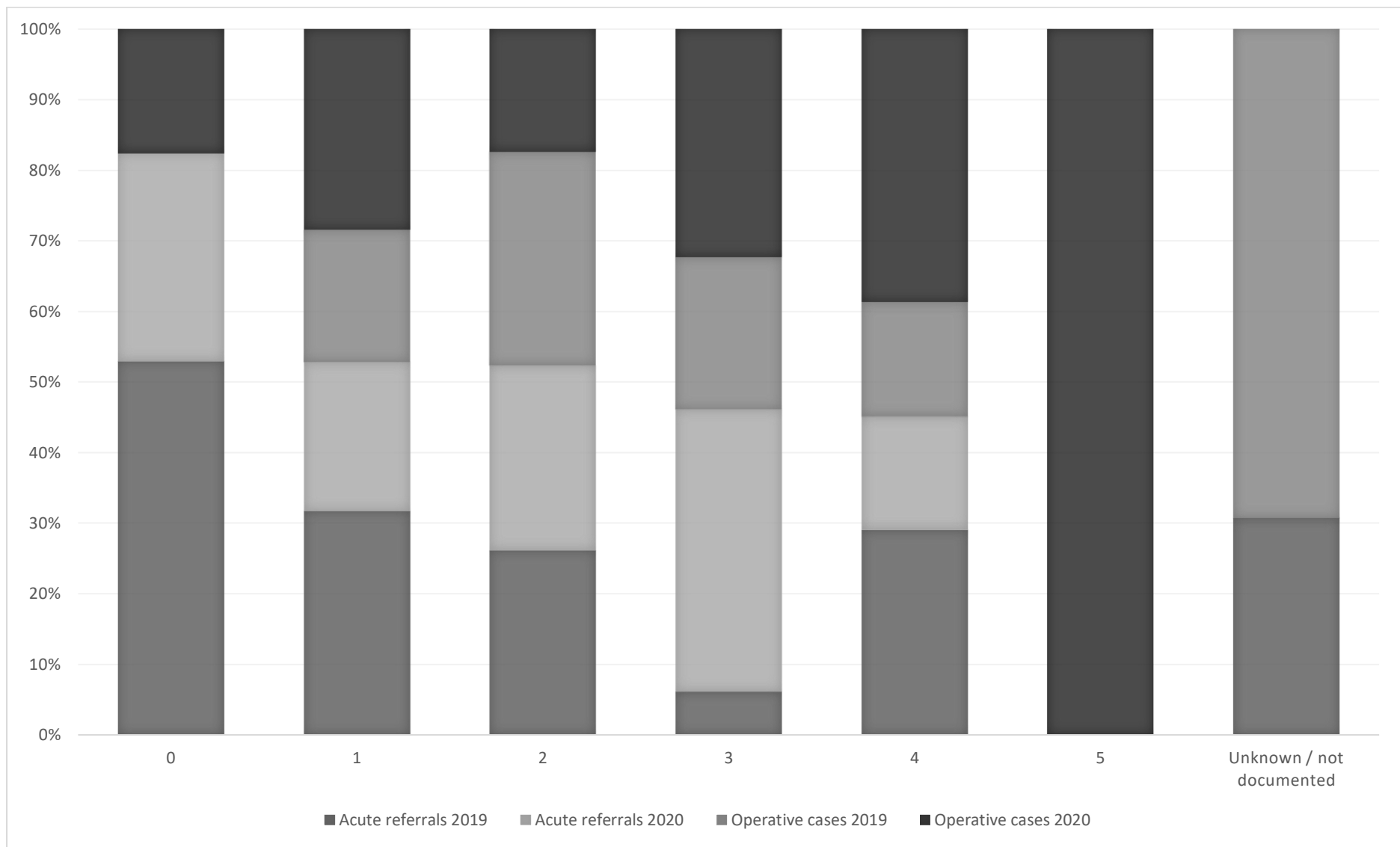
Key: NSTEMI: non-ST elevated myocardial infarction, HAP: hospital-acquired pneumonia, AKI: acute kidney injury, GI: gastrointestinal

Appendix 2: Type of comorbidities for all mortalities relative to both years



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Appendix 3: number of comorbidities for all mortalities relative to both years



STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	1, 7-8 8
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	9-10
Objectives	3	State specific objectives, including any prespecified hypotheses	10
Methods			
Study design	4	Present key elements of study design early in the paper	11
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	11-12
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (b) For matched studies, give matching criteria and number of exposed and unexposed	12 12
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	11-13 Table 1
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	11,14
Bias	9	Describe any efforts to address potential sources of bias	11-12
Study size	10	Explain how the study size was arrived at	11-12
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	11-12, 14
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, explain how loss to follow-up was addressed (e) Describe any sensitivity analyses	14 14 29 n/a n/a
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	16 Table 2, Figs 1-3 16 n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	16 Table 2, Figs 1-3 Figs 1-4 n/a

1	Outcome data	15*	Report numbers of outcome events or summary measures over time	Tables 2-4, Figures 1-12
2				
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6	Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-15, Tables 2-4, Figs 1-12
7			(b) Report category boundaries when continuous variables were categorized	n/a
8			(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Table 3
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15	Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	20-21 Table 4 Figs 8-12
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20	Discussion			
21	Key results	18	Summarise key results with reference to study objectives	22-29
22				
23	Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	29-30
24				
25	Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	22-29
26				
27				
28	Generalisability	21	Discuss the generalisability (external validity) of the study results	22-29
29				
30	Other information			
31	Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15
32				
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34 *Give information separately for exposed and unexposed groups.

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37 **Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. Information on the STROBE Initiative is available at <http://www.strobe-statement.org>.

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