IMPACT-Global Hip Fracture Audit: Nosocomial infection, risk prediction and prognostication, minimum reporting standards and global collaborative audit. Lessons from an international multicentre study of 7,090 patients conducted in 14 nations during the COVID-19 pandemic

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IMPACT-Global Hip Fracture Audit: Nosocomial infection, risk prediction and prognostication, minimum reporting standards and global collaborative audit. *Lessons from an international multicentre study of 7,090 patients conducted in 14 nations during the COVID-19 pandemic.*

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ABSTRACT

Aims

This international study aimed to assess: 1) the prevalence of preoperative and postoperative COVID-19 among patients with hip fracture, 2) the effect on 30-day mortality, and 3) clinical factors associated with the infection and with mortality in COVID-19-positive patients.

Methods

A multicentre collaboration among 112 centres in 14 countries collected data on all patients presenting with a hip fracture between 1st March-31st May 2020. Demographics, residence, place of injury, presentation blood tests, Nottingham Hip Fracture Score, time to surgery, management, ASA grade, length of stay, COVID-19 and 30-day mortality status were recorded.

Results

A total of 7090 patients were included, with a mean age of 82.2 (range 50-104) years and 4959 (70%) being female. Of 651 (9.2%) patients diagnosed with COVID-19, 225 (34.6%) were positive at presentation and 426 (65.4%) became positive postoperatively. Positive COVID-19 status was independently associated with male sex (odds ratio (OR) 1.38, p=0.001), residential care (OR 2.15, p<0.001), inpatient fall (OR 2.23, p=0.003), cancer (OR 0.63, p=0.009), ASA grade 4-5 (OR 1.59, p=0.008; OR 8.28, p<0.001), and longer admission (OR 1.06 for each increasing day, p<0.001). Patients with COVID-19 at any time had a significantly lower chance of 30-day survival versus those without COVID-19 (72.7% versus 92.6%, p<0.001). COVID-19 was independently associated with an increased 30-day mortality risk (hazard ratio (HR) 2.83,

p<0.001). Increasing age (HR 1.03, p=0.028), male sex (HR 2.35, p<0.001), renal disease (HR 1.53, p=0.017), and pulmonary disease (HR 1.45, p=0.039) were independently associated with a higher 30-day mortality risk in patients with COVID-19 when adjusting for confounders.

Conclusion

The prevalence of COVID-19 in hip fracture patients during the first wave of the pandemic was 9%, and was independently associated with a three-fold increased 30-day mortality risk. Among COVID-19-positive patients, those who were older, male, with renal or pulmonary disease had a significantly higher mortality risk.

HIGHLIGHTS

- IMPACT-Global is the largest multicentre observational study undertaken solely in T&O
- Prevalence of COVID-19 in hip fracture patients was ten times higher than background
- COVID-19 was independently associated with a 3x increased 30-day mortality risk
- Nosocomial transmission likely had significant role in COVID-19 prevalence & mortality
- Lessons applicable to audit and practice in future communicable disease outbreaks

INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic disrupted the delivery of Trauma and Orthopaedic (T&O) services, but despite a reduction in the incidence of activity-related trauma the incidence of fragility-related trauma was unchanged.(1–3) Developing COVID-19 in the perioperative period has been reported to double the background mortality risk following orthopaedic surgery, and the patients at greatest risk of mortality from COVID-19 are those who are older, comorbid and presenting with a fragility fracture.(3) It is essential to have an understanding of the prevalence and patterns of SARS-CoV-2 infection within the hip fracture population, and to analyse the effects of the COVID-19 pandemic on this large and vulnerable patient group.

A recent systematic review and meta-analysis found that hip fracture patients with COVID-19 had a crude 30-day mortality of 35% and was seven times the risk of patients without COVID-19.(4) However, in this same review less than half of the included studies reported patient age and sex and only two adjusted for confounding factors in their analysis.(3,5) Two multicentre cohort studies by the International Multicentre Project Auditing COVID-19 in Trauma & Orthopaedics in Scotland (IMPACT-Scot) Group have reported that after adjusting for confounding factors the 30-day mortality risk in COVID-19-positive hip fracture patients was three times greater than in COVID-19-negative patients. Furthermore, the reports are from a single nation with a relatively homogenous population and a standardised approach to hip fracture services.(4,6)

77 The IMPACT Global Hip Fracture Audit aimed to determine factors associated with a positive
78 COVID-19 diagnosis and the influence this has on outcome, with the inclusion of international
79 data from a wider range of patients and healthcare providers from across the globe. The aims
80 of this international multicentre audit were to examine the hip fracture population and assess
81 the: 1) prevalence and clinical factors associated with a diagnosis of COVID-19 in the
82 preoperative and postoperative periods; 2) the independent effect of COVID-19 on 30-day
83 mortality, and 3) factors associated with mortality in COVID-19-positive patients.
84

PATIENTS AND METHODS

In March 2020 the International Multicentre Project Auditing COVID-19 in Trauma & Orthopaedics (IMPACT) was established in order to provide an emergency clinical audit response to the COVID-19 pandemic.(8,9) It was recognised that investigation into the effects of COVID-19 on hip fracture patients and services was necessary and urgent. The IMPACT collaborative network gained support from the Scottish Hip Fracture Audit (SHFA), Scottish Government and the Scottish Committee for Orthopaedics & Trauma (SCOT). An international multicentre observational cohort study was subsequently established with data collected retrospectively from 112 hospitals in 14 nations, including: Australia, Argentina, Chile, Cyprus, England, India, Italy, Greece, Mexico, Northern Ireland, Scotland, Spain, Sudan, Wales. Centres were invited to participate through a recruitment process delivered through existing hospital networks and audit programmes, the Fragility Fracture Network (FFN) and the Royal College of Surgeons of England.

Data were collected in accordance with UK Caldicott guidance and equivalent principles in each nation, and no patient-identifiable information was transferred outside of local units or accessed by the IMPACT research team.(8)

Inclusion and exclusion criteria

All patients who were over 50 years of age and presenting with a hip fracture to any participating hospital in the study period (1st March 2020 to 31st May 2020) were included. The inclusion criteria were that of the SHFA and previous IMPACT reports: all intracapsular or extracapsular fractures of the femur proximal to and including the distal limit of the

subtrochanteric region (defined as a point five centimetres distal to the lesser trochanter).(9) Periprosthetic femur fractures and isolated fractures of the pubic rami, acetabulum, and greater trochanter were excluded.

Baseline data collection

Data collection was defined prior to the commencement of the audit, which was delivered by a team of data collectors (comprised of clinicians and trained auditors) who were local to each hospital. Patients were identified through retrospective review of local admission data throughout the study period, and these data were cross-referenced with patients' medical records, surgical operating lists and discharge letters. Data were input into the IMPACT Hip Fracture Audit data collection tool, a database constructed with data-validated fields and automatically computed variable calculation mechanisms to ensure transcription accuracy, consistency, and completion, as well as to ensure intra- and inter-observer reliability.

Data on demographics, injury details, and surgical management were recorded and included: age; sex; pre-fracture residence (coded as: Home/Sheltered Housing; Care/Nursing Home, or 'Hospital'); injury date; location where injury was sustained (coded as: Home/Indoor; Outdoor, or Hospital); admission date; date of surgery; surgical procedure; surgical delay status (defined as being surgery out with 36 hours of admission), and reason for nonoperative management (if applicable).

Data concerning clinical patient factors were recorded and included: American Society of Anesthesiologists (ASA) classification, presence of major comorbidity (cardiovascular disease,

renal disease, pulmonary disease, dementia, active cancer, or diabetes mellitus) and laboratory blood tests taken on admission (haemoglobin concentration, lymphocyte count, platelet count, serum sodium concentration, and serum albumin concentration).(12) These laboratory blood tests were included on the basis of existing evidence that they may correlate with either disease severity in COVID-19 specifically, or with outcomes in hip fracture patients.(11–15) The Nottingham Hip Fracture Score (NHFS) was calculated from the variables included in the dataset.(16)

COVID-19 Diagnosis

Data in relation to COVID-19 status in the preoperative and postoperative periods were collected independently and included whether patients demonstrated clinical features of COVID-19 infection, as well as any SARS-CoV-2 rt-PCR test result (positive or negative) obtained via the standard oropharyngeal and nasopharyngeal swab technique as part of the routine clinical management.

Outcomes

Data relevant to early patient outcome measures were collected and included: date and destination of discharge from acute admission (defined as the acute orthopaedic trauma admission, or the total acute hospital admission if a patient was transferred from an acute centre to another acute centre of comparable care level), date of death, and whether death occurred during the acute admission. Patients were followed up for a minimum of 30 days following presentation with hip fracture.

Statistical methods

Statistical analyses were performed using Statistical Product and Service Solutions version 17.0 (SPSS Inc. Released 2008. SPSS Statistics for Windows, Version 17.0. Chicago: SPSS Inc.). Parametric and non-parametric tests were used as appropriate to analyse continuous variables for significant differences between groups. Unpaired t-tests were used to compare values between groups for numerical variables that demonstrated a normal distribution. A Chi square test was used to assess dichotomous variables for differences between groups (Fisher's exact test was used if the frequency was 5 or less in any one cell). Kaplan-Meier methodology was used to investigate 30-day survival after hip fracture and Log rank was used to compare survival between patients who had a positive COVID-19 diagnosis with those with a negative COVID-19 diagnosis. Cox regression analysis was used to assess the independent association of (1) COVID-19 status on 30-day mortality and (2) factors associated with 30 day mortality in patients with COVID-19. Logistic regression analysis was used to assess the independence of predictors associated with a positive COVID-19 diagnosis. Receiver operating characteristic (ROC) curve analysis was used to identify a threshold values in the scalar variables that were identified as predictors associated with a positive COVID-19 diagnosis: i) on admission; ii) after admission, and iii) at any time. The area under the ROC curve (AUC) ranges from 0.5 (which indicates a test with no accuracy in distinguishing whether a patient is COVID-19-positive), to 1.0 (where the test accurately identifies all COVID-19-positive patients). The threshold value was defined as the point at which the sensitivity and specificity were maximal in predicting a COVID-19-positive patient. A p-value of <0.05 was defined as statistically significant.

RESULTS

During the audit period data for 7387 patients with a hip fracture from 14 different countries were submitted. Data were excluded for 104 patients (1.4%) who were younger than 50 years of age or who presented outside the audit period. Another 193 patients (2.6%) did not have a COVID-19 status recorded and were excluded from further analysis. The final cohort consisted of 7090 patients of whom 4959 (69.9%) were female and 2130 (30.0%) male (one patient did not have sex recorded). Mean age was 82.2 years (standard deviation (SD) 10.6, range 50 to 104) (Figure 1).

The independent influence of COVID-19 on patient mortality

There were 651 (9.2%) patients who were assigned a diagnosis of COVID-19, of whom 225 (34.6%) were positive preoperatively and 426 (65.4%) positive postoperatively. In total 652 (9.2%) patients died within and including 30 days of presentation with a hip fracture, of whom 178/652 (27.3%) had been diagnosed with COVID-19. Patients diagnosed with COVID-19 at any timepoint had a significantly lower 30-day survival rate when compared to those without COVID-19 (72.7%, 95% Confidence Interval (CI) 69.4 to 76.0% versus 92.6%, 95% CI 92.4 to 92.8, Log rank p<0.001, Figure 2). There was no significant difference in 30-day survival (Log rank p=0.661) when comparing those diagnosed with COVID-19 preoperatively (75.1%, 95% CI 69.4 to 80.8) and those diagnosed postoperatively (71.4%, 95% CI 67.1 to 75.7); survival was significantly lower for both groups (Log rank p<0.001) than for patients without COVID-19 (Figure 3).

Unadjusted analysis of factors associated with increased 30-day mortality were older age (p<0.001), male sex (p<0.001), a higher Nottingham Hip Fracture Score (p<0.001),

care/nursing home (p<0.001) or hospital (p<0.001) residence, hip fracture sustained indoors or in hospital (p<0.001), cardiovascular disease (<0.001), renal disease (p<0.001), pulmonary disease (p=0.012), dementia (p=0.004), active cancer (p=0.039), higher ASA grades (4 and 5) (p<0.001), and a positive COVID-19 status (p<0.001) (Table I). The significant influence of non-operative management (p<0.001) and consequent 'not applicable' classification regarding surgery within 36 hours of admission (p<0.001) on mortality (Table I) was thought to be a secondary marker of increased mortality risk due to frailty and was thus not included in the regression models. Cox regression analysis (Table II) identified that a diagnosis of COVID-19 was associated with a significantly increased mortality rate in the 30-days following admission for a hip fracture after adjusting for confounding factors (Hazard ratio (HR) 2.83, 95% CI 2.33 to 3.42, p<0.001). The associated HR was higher if COVID-19 was diagnosed after admission (3.09, 95% CI 2.48 to 3.85) compared to those diagnosed on admission (2.36, 95% 1.73 to 3.21), but this was not statistically different.

Predictors associated with having COVID-19 at any time

Factors associated with a positive COVID-19 status on unadjusted analysis were older age (p<0.001), male sex (p=0.012), a higher Nottingham Hip Fracture score (p=0.001), place of residence (p=0.001), place of injury (p=0.001), cardiovascular disease (p=0.001), renal disease (p=0.039), pulmonary disease (p=0.013), dementia (p=0.001), active cancer (p=0.046), increasing ASA grade (p<0.001), lower lymphocyte count (p<0.001), lower serum albumin concentration (p<0.001) increased length of hospital stay (p<0.001) (Table III). Regression analysis demonstrated male sex, residence in a care/nursing home, place of injury, active cancer, ASA grade 4 and 5, and increased length of stay were independently associated with positive COVID-19 status (Table IV).

227

228 *Predictors associated with having COVID-19 on admission*

229 There were 225 patients who had COVID-19 at the time of presentation with hip fracture.
230 Regression analysis demonstrated residence in a care/nursing home, in hospital fracture, ASA
231 grade 5, lower lymphocyte count and albumin were all independently associated with a
232 positive COVID-19 diagnosis on admission (Table V). ROC curve analysis illustrated that a
233 lymphocyte count at time of presentation of ≤0.93 and an albumin level of ≤36g/dL were
234 predictors of COVID-19 on admission (Figure 4), but were poorly predictive, with an AUC of
235 60%.

236

237 *Predictors associated with having COVID-19 after admission*

238 There were 426 patients diagnosed with positive COVID-19 after admission to hospital.
239 Regression analysis demonstrated male sex, a fall indoor, cardiovascular disease, ASA grade
240 4 or 5, and longer duration of hospital stay were independently associated with a positive
241 COVID-19 diagnosis on admission (Table V). ROC curve analysis illustrated that length of stay
242 of 10 or more days was a moderately reliable predictor of COVID-19 following admission
243 (Figure 5), with an AUC of 71.6%.

244

245 *Predictors associated with increased mortality in patients with COVID-19*

246 Factors associated with increased risk of 30-day mortality on unadjusted analysis were older
247 age, male sex, higher NHFS, injury sustained outdoors, renal disease, pulmonary disease,
248 dementia, increasing ASA grade, nonoperative management, lower lymphocyte count, lower
249 platelet count, and lower serum albumin concentration (Table VII). Regression analysis
250 demonstrated that increasing age (HR 1.03, 95% CI 1.01-1.05, p=0.028), male sex (HR 2.35,

95% CI 1.66-3.34, p<0.001), renal disease (HR 1.53, 95% CI 1.08-2.18, p=0.017), and pulmonary disease (HR 1.45, 95% CI 1.02-2.06, p=0.039) were independently associated with an increased risk of 30-day mortality (Table VIII).

DISCUSSION

This global multicentre audit reports the findings from 112 hospitals in 14 countries. A positive diagnosis of COVID-19 during an acute admission for hip fracture was independently associated with an approximate three-fold increase in 30-day mortality risk compared to patients without COVID-19, and it is likely that hip fracture patients are the single group of surgical admissions that account for the largest number of COVID-19-related deaths. Approximately two thirds of COVID-19 cases were diagnosed postoperatively, which supports findings from a previous study suggesting the major role of nosocomial transmission among this vulnerable patient group.(19) For the first time, clinical factors that are associated with increased risk of death in hip fracture patients who have COVID-19 are reported and this may help to identify fragility trauma patients that could benefit from isolating or shielding. This study, which is understood to be the largest multicentre orthopaedic collaborative audit delivered, offers the only global data into hip fracture and COVID-19 from the pre-vaccination era and could be used to ensure better preparedness for future disease outbreaks, from seasonal influenza to emerging diseases.

The prevalence of COVID-19 in this study cohort was 9.2%. This is consistent with the existing literature from single-centre or regional studies, but was many times higher than the mean background prevalence in any of the participating nations throughout the study period (range 0·0-0·5%).(5) The extreme vulnerability of this patient group may be under-recognised among healthcare professionals, and the major disruption to fragility trauma services experienced globally is likely to contribute to an enduring public health crisis. Although the study

investigated only patients with hip fracture, these findings are likely to be generalisable to frail trauma patients, as well as to the wider frail inpatient population.(20)

The current data suggests that two-thirds of COVID-19 cases were diagnosed postoperatively, and IMPACT-Scot 2 demonstrated that approximately 60% of COVID-19 cases were likely to be hospital-acquired, with the majority of these nosocomial infections occurring in acute orthopaedic wards or following discharge to inpatient orthopaedic rehabilitation facilities.(20) Nosocomial infection may be an important factor in the high rates of COVID-19 observed among vulnerable inpatients and this problem has significant implications for the spread of COVID-19 between hospitals, downstream bed facilities, residential care settings and the community. There remains little published evidence that demonstrates successful strategies for the mitigation of this phenomenon among frail orthogeriatric trauma patients.

The factors identified in the current study that were independently associated with a positive COVID-19 diagnosis (at any time) were consistent with the existing literature, although the current data identified differences depending on whether COVID-19 was identified at initial presentation or following admission, which is of particular relevance to clinical risk stratification and the isolation of at-risk patients.(20,21) Factors predictive of having COVID-19 at admission were certain admission laboratory blood tests (lower blood albumin level and lymphocyte count), higher pre-fracture care demands (residential or inpatient care) and a high ASA grade. Male sex, pre-existing cardiovascular disease, high ASA grade, and a longer length of stay were predictive of COVID-19 diagnoses made postoperatively. Most of these factors are indicators of increasing frailty and may indicate vulnerability to infection. These findings may assist stratification of patients according to their risk of transmitting or acquiring

315 COVID-19 in hospital, and facilitate deployment of clinical patient pathways for isolating,
316 shielding, or 'cohorting' patients in COVID and non-COVID circuits – an approach which has
317 been found to be effective in the management of hip fracture patients during the
318 pandemic.(21) The key modifiable risk factor identified was length of stay, which supports
319 previous work in this area that underlines that safeguarding and prioritisation of fragility
320 fracture services as essential to help protect this vulnerable patient group through early
321 treatment and discharge planning.(23,24) However, the causal relationship of increased
322 length of stay on the likelihood of contracting COVID-19 is difficult to determine, since
323 patients with COVID-19 are likely to require a longer hospital admission, and frailer patients
324 (who are more vulnerable to acquiring COVID-19) typically require longer inpatient
325 management prior to discharge.
326
327 Male sex was associated with a two-fold increased risk of 30-day mortality among patients
328 diagnosed with COVID-19. This supports existing evidence from the general population that
329 males with COVID-19 have a higher mortality rate than females.(25) Various explanatory
330 mechanisms have been suggested and include differences in expression of angiotensin-
331 converting enzyme II, smoking status, obesity, and behavioural factors.(25–27) The existence
332 of underlying pulmonary disease was independently associated with a higher 30-day
333 mortality risk, which is consistent with the known pathophysiology of COVID-19.(26) The
334 influence of renal disease on mortality is of particular importance in hip fracture patients
335 given the relatively high prevalence of chronic kidney disease, acute kidney injury, or mixed
336 acute kidney injury and chronic kidney disease, all of which have been shown to be associated
337 with poorer outcomes in non-hip fracture groups with COVID-19.(27) The identification of

these clinical predictors in the hip fracture population is original and could guide clinical decision-making and prognosis.

The COVID-19 pandemic remains a dynamic situation subject to: further increases in the incidence of SARS-CoV-2 infection; new viral strains with higher transmissibility, mortality risk, and resistance to vaccinations; the need to reduce restrictions in order to meet the needs of the population, and challenges associated with achieving widespread and effective vaccination across the globe.(26,29–31) This study will provide an important baseline against which to measure factors such as vaccine efficacy, strategies for the mitigation of viral transmission, and the effects of different viral strains on this vulnerable population.

Evidence from the IMPACT collaborative has demonstrated widespread disruption to orthopaedic services, with resources and staff being repurposed for non-orthopaedic patients and standard operating procedures being overhauled in favour of other services.(20) Hip fracture patients were managed on open generalist wards by non-specialised staff, experienced delays to surgery and appropriate care, received less specialist multidisciplinary management, and were exposed to an increase in inter-departmental transit. These issues are known to increased risk of nosocomial infection, delirium, and longer duration of hospital stay.(19,22,32) In future communicable disease outbreaks it would be prudent to ensure the protection of specialist multidisciplinary teams, clinical areas, and access to prompt surgical management in line with existing standards of care for this most vulnerable patient group, as well as robust strategies to minimise in-hospital transmission through the use of clinical pathways and closed circuits that have previously been described.(19,21,33–35)

Early in the pandemic there was uncertainty about the infection prevention and control precautions required in the management of patients at risk of contracting SARS-CoV-2 infection. This caused disparities and frequent amendments to guidance about personal protective equipment, testing of patients and staff, the acceptability of risk relating to aerosol generating procedures such as cardiopulmonary resuscitation and anaesthetic procedures, and surgery.(36) This led to confusion and delays to appropriate patient management and care ought to be taken to design procedures for the continuation of orthopaedic services in the context of future disease outbreaks. This is of relevance to unscheduled care and to urgent planned care, since the disruption has been to the detriment of patients attempting to access urgent elective care.(37–39)

The concerning finding of a high proportion of patients acquiring COVID-19 in the inpatient and downstream hospital settings raises questions regarding the efficacy of existing pathways and strategies for the prevention of infection transmission between healthcare services. The establishment of a robust and effective inpatient and post-discharge track and trace system could identify patients at risk of acquiring or transmitting infection, which has the potential to limit the harm from outbreaks and reduce the burden on rehabilitation and community health services.

This international study was conducted within the context of a rapidly-developing global pandemic. As a result, there are limitations inherent in the natural variation between nations relating to the background COVID-19 prevalence, which ranged from 0.003-0.294% during the study period. There was no standardised diagnostic protocol, such as routine regular testing of all patients, and the availability of laboratory testing may have varied between regions; the

prevalence of COVID-19 may therefore have been underestimated. Furthermore, as routine clinical testing was not in place in most countries during the first wave of the pandemic, the mortality associated with undiagnosed COVID-19 was not quantifiable, and because the precise dates of COVID-19 diagnoses are not known the distinction between community- and hospital-acquired SARS-CoV-2 infections cannot be determined with certainty. This reflects real-world uncertainty around clinical criteria for diagnosing COVID-19 and variation in the approaches to population screening and symptomatic testing, and highlights the need to establish early consensus on these matters early in an outbreak in order to facilitate effective research and audit. There was variation in the approach to the provision of hip fracture services, though this could be considered a strength due to increased generalisability across the range of nations affected by the disease. Clinical audit in future outbreaks should strive for even greater coverage of geographical and health-economic context.(40) Follow-up period was limited to 30 days post-presentation with hip fracture, which may underestimate mortality especially in patients who developed COVID-19 later in the admission. This limited follow-up is common amongst studies reporting the mortality associated with COVID-19.(4) However, the current study controlled for this issue by reporting subgroups of patients with COVID-19 confirmed at initial presentation in the preoperative period versus later in the admission following surgical management. Variation in the systems available to clinicians to follow up patients after discharge may underestimate mortality rates in regions that don't have, for example, a unified healthcare system with patients linked by a universally-applied unique community identifier. This ought to be considered in the methodology of future studies. There remains a lack of evidence pertaining to the indirect effects of the pandemic on COVID-19-negative hip fracture, or the effect that mass population vaccination will have on prevalence, transmissibility, and mortality. There was heterogeneity in the literature

reporting investigations in COVID-19 in hip fracture, with many studies being limited by a lack of robust diagnostic criteria, insufficient follow-up durations, unadjusted mortality analyses, and a lack of relevant information pertaining to background prevalence, pathogen variant profiles, and infection prevention and control measures in the catchment population.(5) Adoption of shared reporting standards may improve the quality of evidence available to clinicians and researchers (Figure 6).

The strengths of the study include the large number of patients and the unique international nature that has provided an analysis across a range of hospitals, hip fracture services, healthcare systems, ethnicities and reporting processes. This diversity would suggest that the findings are generalisable globally. The findings pertaining to COVID-19 prevalence, mortality risk, and predictors of infection support existing evidence and provide insight into clinical factors associated with COVID-19 and outcome. The high levels of participation in the UK and Spain in particular, ensured extensive coverage across these geographical areas, which may have helped account for regional variations in clinical practice, patient demographics and COVID-19 prevalence. Furthermore, the size of the COVID-19 positive cohort was large and afforded the first opportunity to perform subgroup regression analyses to identify factors associated with acquiring the infection and the mortality associated with it. The lessons learned from this study of the COVID-19 pandemic are applicable to future disease outbreaks and may facilitate better preparedness for other transmissible diseases such as seasonal influenza, emerging strains of existing pathogens, or novel communicable diseases.

CONCLUSION

The prevalence of COVID-19 in the hip fracture population was at least ten times higher than the background prevalence and was independently associated with a three-fold increase in 30-day mortality. Thus, hip fracture patients may be the cohort of hospital admissions that account for the largest number of COVID-19-related deaths. It is likely that nosocomial transmission of this disease was responsible for a significant proportion of infections, and the development of robust infection prevention and control strategies are likely to improve the management of future outbreaks. The IMPACT collaborative has demonstrated important lessons in the conduct of rapid clinical audit in order to guide the evidence-based response to emerging diseases, and a number of strategies are suggested that can be applied prospectively to ensure better preparedness for future health crises.

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TABLES

Table I. Patient demographics, Nottingham hip fracture score, residence, place of injury, comorbidity, surgery within 36 hours, ASA grade, surgical management, admission blood test and COVID status according to 30-day mortality.

Demographic	**Descriptive**	**30-day Mortality**		**Difference / Odds Ratio (95% CI)**	**p-value***
		Alive (n=6438)	**Dead** (n=652)		
Age (years: mean, SD)		81.8 (10.7)	86.0 (9.0)	Diff 4.2 (3.3 to 5.0)	<0.001
Sex (n, % of group)	Female	4602 (71.48)	357 (54.75)	Reference	
	Male	1836 (28.52)	294 (45.10)	2.06 (1.75 to 2.43)	<0.001
	Missing	0	1 (0.15)	N/A	-
Nottingham Hip Score (mean, SD)		4.8 (2.4)	6.0 (3.9)	Diff 1.2 (1.0 to 1.4)	<0.001

Residence (n, % of group)	Home/Sheltered	4975 (77.27)	390 (59.82)	Reference	
	Care/Nursing home	1166 (18.11)	221 (56.67)	2.42 (1.03 to 2.89)	<0.001
	Hospital	81 (1.26)	22 (3.37)	3.46 (2.14 to 5.61)	<0.001
	Missing	216 (3.34)	19 (2.91)	1.12 (0.69 to 1.81)	0.639
Place of injury (n, % of group)	Home / Indoor	5082 (78.94)	552 (84.66)	Reference	
	Outdoor	919 (14.27)	40 (6.13)	0.40 (0.29 to 0.56)	<0.001
	Hospital	154 (2.39)	37 (5.67)	2.21 (1.53 to 3.20)	<0.001
	Missing	283 (4.40)	23 (3.53)	0.75 (0.48 to 1.15)	0.188
Comorbidity* (n, % of group)	Not present	Reference			
	CVD	4115 (63.92)	486 (74.54)	1.67 (1.39 to 2.01)	<0.001
	Renal Disease	1281 (19.90)	209 (3.25)	1.91 (1.60 to 2.27)	<0.001
	Pulmonary Disease	1362 (21.16)	216 (3.36)	1.85 (1.56 to 2.20)	<0.001
	Dementia	1868 (29.02)	284 (4.41)	1.90 (1.61 to 2.24)	<0.001
	Cancer	630 (9.79)	109 (1.69)	1.86 (1.49 to 2.32)	<0.001

	Diabetes Mellitus	1289 (20.02)	126 (1.96)	0.96 (0.78 to 1.18)	0.696
Surgery <36 hours	Yes	4043 (62.80)	338 (5.25)	Reference	
(n, % of group)	No	2253 (35.00)	214 (3.32)	1.14 (0.95 to 1.36)	0.162
	N/A	110 (1.71)	94 (1.46)	10.22 (7.60 to 13.75)	<0.001
	Missing	32 (0.50)	6 (0.09)	2.24 (0.93 to 5.40)	0.381
ASA grade	1	118 (0.02)	4 (0.06)	1.48 (0.52 to 4.26)	
(n, % of group)	2	1400 (21.75)	32 (0.50)	Reference	
	3	3720 (57.78)	354 (5.50)	4.15 (2.88 to 5.99)	<0.001
	4	945 (14.68)	219 (33.59)	10.14 (6.93 to 14.8)	<0.001
	5	5 (0.08)	16 (2.45)	13.67 (4.72 to 39.60)	<0.001
	Missing or N/A	250 (3.88)	27 (4.14)	4.73 (2.78 to 8.02)	<0.001
Management	Fixation	3199 (49.69)	292 (44.78)	Reference	
(n, % of group)	Arthroplasty	3049 (47.36)	255 (39.11)	0.92 (0.77 to 1.09)	0.327

	Non-operative	104 (1.62)	91 (13.96)	9.59 (7.06 to 13.01)	<0.001
	Other	35 (0.54)	8 (1.23)	2.50 (1.15 to 5.45)	
	Missing	51 (0.79)	6 (0.92)	1.29 (0.55 to 3.03)	
Admission Blood Tests (mean, SD)					
Haemoglobin Concentration (g / L)	n=6435 vs 650	122.9 (18.0)	118.9 (19.8)	3.9 (2.5 to 5.4)	<0.001
Lymphocyte Count (x 10^9 / L)	n=6430 vs 650	1.21 (0.73)	1.09 (0.62)	0.12 (0.06 to 0.18)	<0.001
Platelet Count (x 10^9 / L)	n=6430 vs 648	245.8 (89.1)	243.8 (98.6)	2.0 (-5.2 to 9.3)	0.582
Sodium Concentration (mmol / L)	n=6414 vs 648	137.6 (1.4)	137.6 (4.8)	0.0 (-0.3 to 0.4)	0.879

Albumin Concentration (g / L)	n=6256 vs 641	36.6 (5.9)	33.8 (6.2)	2.8 (0.3 to 1.7)	0.006
COVID-19 status (n, % of group)	No	5965 (92.65)	474 (72.70)	Reference	
	Yes	473 (7.35)	178 (27.30)	4.74 (3.89 to 5.76)	<0.001
	No	5965 (92.65)	474 (72.70)	Reference	
	On admission	169 (2.62)	56 (8.59)	4.17 (3.04 to 5.72)	<0.001
	Postoperative	304 (4.72)	122 (18.71)	5.05 (4.01 to 6.36)	<0.001

*Data not available for four patients: two died within the 30 day follow up period.

Table II. Cox regression model identifying patient related factors associated with 30-day mortality following a hip fracture.

Demographic	**Descriptive**	**Hazard Ratio (95% CI)**	**p-value***

Age (for each increasing year)		1.04 (1.03 to 1.05)	<0.001
Sex	Female	Reference	
	Male	1.93 (1.63 to 2.30)	<0.001
Nottingham Hip Score (for each increasing point)		0.99 (0.96 to 1.01)	0.331
Residence	Home/Sheltered	Reference	
	Care/Nursing home	1.44 (1.17 to 1.77)	0.001
	Hospital	1.23 (0.67 to 2.26)	0.507
	Missing	0.85 (0.52 to 1.40)	0.854
Place of injury	Home / Indoor	Reference	
	Outdoor	0.65 (0.45 to 0.94)	0.022
	Hospital	1.20 (0.75 to 1.91)	0.452

	Missing	0.69 (0.40 to 1.18)	0.174
Comorbidity*	Not present		
	CVD	1.17 (0.96 to 1.42)	0.129
	Renal Disease	1.23 (1.02 to 1.48)	0.028
	Pulmonary Disease	1.45 (1.21 to 1.73)	<0.001
	Dementia	1.11 (0.91 to 1.35)	0.299
	Cancer	1.46 (1.16 to 1.85)	0.001
ASA grade	1	3.06 (1.06 to 8.78)	0.038
	2	Reference	
	3	2.31 (1.55 to 3.45)	<0.001
	4	3.50 (2.30 to 5.32)	<0.001
	5	7.43 (3.65 to 15.12)	<0.001
	Missing or N/A	2.76 (1.58 to 4.81)	<0.001

Admission Blood Tests (for each increasing point)	Haemoglobin Concentration(g / L)	1.00 (0.99 to 1.01)	0.443
	Lymphocyte Count (x 10^9 / L)	0.94 (0.83 to 1.07)	0.321
	Albumin Concentration (g / L)	0.96 (0.94 to 0.97)	<0.001
COVID-19 status	No	Reference	
	Yes	2.83 (2.33 to 3.42)	<0.001
	Substituted in the model		
	No	Reference	
	On admission	2.36 (1.73 to 3.21)	<0.001
	Postoperative	3.09 (2.48 to 3.85)	<0.001

Table III. Patient demographics, Nottingham hip fracture score, admission blood results, residence, place of injury, comorbidity, time to surgery, ASA grade, management, admission blood tests, length of stay, and mortality according to COVID status.

Demographic	**Descriptive**	**COVID-19 Status**		**Difference / Odds Ratio (95% CI)**	**p-value***
		Negative (n=6439)	**Positive** (n=651)		
Age (years: mean, SD)		82.0 (10.7)	84.3 (9.0)	Diff 2.3 (1.5 to 3.2)	<0.001
Sex (n, % of group)	Female	4550 (70.66)	409 (0.15)	Reference	
	Male	1888 (29.32)	242 (37.17)	1.43 (1.21 to 1.69)	<0.001
	Missing	1 (0.01)	0 (0.00)	N/A	
Nottingham Hip Score (mean, SD)		4.8 (2.4)	5.6 (4.0)	Diff 0.8 (0.6 to 1.0)	<0.001
Residence	Home/Sheltered	5004 (77.71)	361 (55.45)	Reference	

(n, % of group)	Care/Nursing home	1160 (18.01)	227 (34.87)	2.71 (2.27 to 3.24)	<0.001
	Hospital	83 (1.29)	20 (3.07)	3.34 (2.03 to 5.51)	<0.001
	Missing	192 (2.98)	43 (6.60)	3.10 (2.19 to 4.39)	<0.001
Place of injury (n, % of group)	Home / Indoor	5090 (79.05)	544 (83.56)	Reference	
	Outdoor	916 (14.22)	43 (6.60)	0.44 (0.32 to 0.60)	<0.001
	Hospital	152 (2.36)	39 (5.99)	2.40 (1.67 to 3.45)	<0.001
	Missing	281 (4.36)	25 3.84)	0.83 (0.55 to 1.27)	0.390
Comorbidity* (n, % of group)	Not present				
	CVD	4130 (64.14)	471 (72.35)	1.47 (1.23 to 1.76)	<0.001
	Renal Disease	1333 (20.70)	157 (24.12)	1.22 (1.01 to 1.48)	0.039
	Pulmonary Disease	1408 (21.87)	170 (26.11)	1.26 (1.05 to 1.52)	0.013
	Dementia	1865 (28.96)	287 (44.09)	1.94 (1.64 to 2.28)	<0.001
	Cancer	686 (10.65)	53 (8.14)	0.74 (0.56 to 1.0)	0.046

	Diabetes Mellitus	1277 (19.83)	138 (21.20)	1.09 (0.89 to 1.33)	0.398
Surgery <36 hours	Yes	3991 (61.98)	390 (59.91)	Reference	
(n, % of group)	No	2246 (34.88)	221 (33.95)	1.01 (0.85 to 1.20)	0.920
	N/A	167 (2.59)	37 (5.68)	2.27 (1.56 to 3.29)	<0.001
	Missing	35 (0.54)	3 (0.46)	0.88 (0.27 to 2.87)	
ASA grade	1	119 (1.85)	3 (0.46)	0.50 (0.15 to 1.61)	0.233
(n, % of group)	2	1363 (21.17)	69 (10.60)	Reference	
	3	3705 (57.55)	369 (56.68)	1.97 (1.51 to 2.56)	<0.001
	4	983 (15.27)	181 (27.80)	3.64 (2.72 to 4.85)	<0.001
	5	12 (0.19)	9 (1.38)	14.82 (6.04 to 36.35)	<0.001
	Missing or N/A	257 (3.99)	20 (3.07)	1.54 (0.92 to 2.57)	0.100
Management	Fixation	3181 (49.40)	310 (47.62)	Reference	
(n, % of group)	Arthroplasty	3010 (46.75)	294 (45.16)	1.00 (0.86 to 1.16)	0.999

	Non-operative	160 (2.48)	35 (5.38)	2.24 (1.52 to 3.29)	<0.001
	Other	37 (0.57)	6 (0.92)	1.66 (0.69 to 3.97)	
	Missing	51 (0.79s)	6 (0.92)	1.20 (0.51 to 2.83)	0.671
Admission Blood Tests (mean, SD)					
Haemoglobin Concentration (g / L)	n=6434 vs 651	122.6 (18.3)	121.5 (17.7)	1.1 (-0.3 to 2.6)	0.132
Lymphocyte Count (x 10^9 / L)	n=6425 vs 651	1.21 (0.72)	1.07 (0.68)	0.14 (0.08 to 0.19)	<0.001
Platelet Count (x 10^9 / L)	n=6427 vs 651	246.0 (90.0)	241.8 (89.8)	4.3 (-3.0 to 11.5)	0.250
Sodium Concentration (mmol / L)	n=6411 vs 651	137.6 (4.4)	137.6 (4.7)	0.0 (-0.4 to 0.4)	0.919
Albumin Concentration (g / L)	n=5546 vs 576	36.4 (6.0)	35.3 (5.8)	1.2 (0.7 to 1.7)	<0.001

LOS (days: mean, SD)		10.4 (7.7)	17.2 (13.1)	6.7 (6.0 to 7.4)	<0.001
30-day mortality (n, % of group)	No	5965 (92.64)	473 (72.66)	Reference	
	Yes	474 (7.36)	178 (27.34)	4.74 (3.89 to 5.76)	<0.001

*unpaired Students t-test unless otherwise stated, **chi square test

Table IV. Logistic regression model identifying patient related factors associated with COVID-19 positive patients and a hip fracture.

Demographic	**Descriptive**	**Odds Ratio (95% CI)**	**p-value***
Age (for each increasing year)		1.00 (0.99 to 1.02)	0.428
Sex	Female	Reference	
	Male	1.38 (1.13 to 1.69)	0.001
Nottingham Hip Score (for each increasing point)		1.03 (0.99 to 1.06)	0.129
Residence	Home/Sheltered	Reference	
	Care/Nursing home	2.15 (1.69 to 2.73)	<0.001
	Hospital	1.31 (0.63 to 2.72)	0.467
	Missing	2.57 (1.73 to 3.83)	<0.001
Place of injury	Home / Indoor	Reference	
	Outdoor	0.58 (0.40 to 0.84)	0.004
	Hospital	2.23 (1.31 to 3.79)	0.003
	Missing	1.22 (0.74 to 2.01)	0.436
Comorbidity*	Not present		
	CVD	1.24 (0.99 to 1.53)	0.051

	Renal Disease	0.85 (0.68 to 1.07)	0.165
	Pulmonary Disease	0.99 (0.79 to 1.23)	0.917
	Dementia	1.18 (0.94 to 1.48)	0.164
	Cancer	0.63 (0.44 to 0.89)	0.009
ASA grade	1	0.69 (0.21 to 2.31)	0.548
	2	Reference	
	3	1.16 (0.85 to 1.57)	0.352
	4	1.59 (1.13 to 2.25)	0.008
	5	8.28 (2.81 to 24.42)	<0.001
	Missing or N/A	0.68 (0.36 to 1.30)	0.246
Admission Blood tests (for each point)	Lymphocyte Count (x 10^9 / L)	0.83 (0.71 to 0.98)	0.023
	Albumin Concentration (g / L)	0.99 (0.97 to 1.00)	0.102
Length of stay (for each increasing day)		1.06 (1.05 to 1.07)	<0.001

Table V. Logistic regression model identifying patient related factors associated with COVID-19 positive patients on admission and a hip fracture.

Demographic	**Descriptive**	**Odds Ratio (95% CI)**	**p-value***
Age (for each increasing year)		1.00 (0.99 to 1.02	0.843
Sex	Female	Reference	
	Male	1.01 (0.71 to 1.50)	0.941
Nottingham Hip Score (for each increasing point)		0.98 (0.82 to 1.19)	0.862
Residence	Home/Sheltered	Reference	
	Care/Nursing home	4.13 (2.78 to 6.13)	<0.001
	Hospital	0.85 (0.31 to 2.35)	0.851
	Missing	0.54 (0.13 to 1.26)	0.400
Place of injury	Home / Indoor	Reference	
	Outdoor	0.52 (0.25 to 1.09)	0.085
	Hospital	4.98 (2.64 to 9.38)	<0.001
	Missing	0.71 (0.22 to 2.28)	0.561
Comorbidity*	Not present	Reference	
	CVD	0.96 (0.69 to 1.33)	0.800

	Renal Disease	0.78 (0.54 to 1.14)	0.202
	Pulmonary Disease	0.87 (0.61 to 1.26)	0.471
	Dementia	1.24 (0.81 to 1.92)	0.324
	Cancer	0.61 (0.33 to 1.13)	0.117
ASA grade	1	1.43 (0.32 to 6.34)	0.636
	2	Reference	
	3	0.97 (0.60 to 1.57)	0.902
	4	1.47 (0.86 to 2.51)	0.159
	5	5.25 (1.30 to 21.31)	0.020
	Missing or N/A	0.58 (0.23 to 1.49)	0.258
Admission Blood Tests (for each point)	Lymphocyte Count (x 10^9 / L)	0.62 (0.46 to 0.83)	0.001
	Albumin (g / L)	0.95 (0.93 0.98)	<0.001

Table VI. Logistic regression model identifying patient related factors associated with developing COVID-19 in hip fracture patients following admission.

Demographic	**Descriptive**	**Odds Ratio (95% CI)**	**p-value***
Age (for each increasing year)		1.01 (0.99 to 1.02)	0.480
Sex	Female	Reference	
	Male	1.56 (1.23 to 1.97)	<0.001
Nottingham Hip Score (for each increasing point)		1.03 (0.99 to 1.06)	0.110
Residence	Home/Sheltered	Reference	
	Care/Nursing home	1.22 (0.89 to 1.67)	0.218
	Hospital	2.03 (0.81 to 5.11)	0.133
	Missing	3.14 (2.07 to 4.77)	<0.001
Place of injury	Home / Indoor	Reference	
	Outdoor	0.56 (0.36 to 0.87)	0.009
	Hospital	1.03 (0.79 to 2.36)	0.942
	Missing	1.37 (0.79 to 2.36)	0.263
Comorbidity*	Not present		
	CVD	1.43 (1.09 to 1.86)	0.009

	Renal Disease	0.90 (0.69 to 1.18)	0.433
	Pulmonary	1.03 (0.79 to 1.34)	0.850
	Dementia	1.18 (0.89 to 1.55)	0.254
	Cancer	0.65 (0.43 to 0.98)	0.041
ASA grade	1	0.36 (0.05 to 2.69)	0.317
	2	Reference	
	3	1.35 (0.92 to 1.97)	0.123
	4	1.79 (1.16 to 2.75)	0.008
	5	10.84 (3.09 to 38.00)	<0.001
	Missing or N/A	0.69 (0.29 to 1.62)	0.394
Admission Blood Tests (for each point)	Lymphocyte Count (x 10^9 / L)	0.92 (0.77 to 1.10)	0.383
	Albumin (g / L)	1.00 (0.99 to 1.08)	0.681
Length of stay (for each increasing day)		1.07 (1.06 to 1.08)	<0.001

Table VII. Patient demographics, Nottingham hip fracture score, residence, place of injury, comorbidity, surgery within 36 hours, ASA grade, surgical management, admission blood test according to 30-day mortality for COVID-19 positive patients only.

Demographic	**Descriptive**	**30-day Mortality**		**Difference / Odds Ratio (95% CI)**	**p-value***
		Alive (n=473)	**Dead** (n=178)		
Age (years: mean, SD)		83.7 (9.5)	85.8 (7.5)	Diff 2.1 (0.5 to 3.7)	0.008
Sex (n, % of group)	Female	326	83	Reference	
	Male	147	95	OR 2.54 (1.78 to 3.61)	<0.001
	Missing	0	0		
Nottingham Hip Score (mean, SD)		5.3 (1.6)	6.5 (7.1)	Diff 1.2 (0.6 to 1.9)	<0.001
Residence (n, % of group)	Home/Sheltered	270	91	Reference	
	Care/Nursing home	154	73	OR 1.41 (0.98 to 2.03)	0.067
	Hospital	15	5	OR 0.99 (0.45 to 2.16)	0.999
	Missing	34	9	OR 0.83 (0.45 to 1.52)	0.537
Place of injury (n, % of group)	Home / Indoor	385	159	Reference	
	Outdoor	38	5	OR 0.32 (0.12 to 0.82)	0.013
	Hospital	30	9	OR 0.73 (0.34 to 1.56)	0.413
	Missing	20	5	OR 0.61 (0.22 to 1.64)	0.375

Comorbidity* (n, % of group)	Not present	Reference		Reference	
	CVD Disease	335	136	OR 1.33 (0.90 to 1.99)	0.156
	Renal Disease	96	61	OR 2.04 (1.39 to 2.99)	<0.001
	Pulmonary Disease	109	61	OR 1.74 (1.20 to 2.54)	0.004
	Dementia	196	91	OR 1.48 (1.05 to 2.09)	0.027
	Cancer	37	16	OR 1.16 (0.63 to 2.15)	0.628
	Diabetes Mellitus	104	34	OR 0.83 (0.54 to 1.29)	0.645
Surgery <36 hours (n, % of group)	Yes	288	102	Reference	
	No	173	48	OR 0.78 (0.53 to 1.16)	0.221
	N/A	10	27	OR 7.62 (3.57 to 16.30)	<0.001
	Missing	2	1	OR 1.41 (0.13 to 15.74)	0.999
ASA grade (n, % of group)	1	2	1	OR 6.40 (0.49 to 83.39)	0.233
	2	64	5	Reference	
	3	271	98	OR 4.63 (1.81 to 11.84)	<0.001
	4	120	61	OR 6.51 (2.49 to 17.01)	<0.001
	5	1	8	OR 102.40 (10.59 to 990.6)	<0.001

	Missing or N/A	15	2	OR (1.71 90.30 to 9.66)	0.621
Management (n, % of group)	Fixation	225	85	Reference	
	Arthroplasty	227	67	0.78 (0.54 to 1.13)	0.190
	Non-operative	10	25	6.62 (3.05 to 14.36)	<0.001
	Other	6	0	-	0.197
	Missing	5	1	0.53 (0.06 to 4.60)	0.685
Admission Blood Tests (mean, SD)					
Haemoglobin	n=473 vs 178	121.7 (17.4)	120.8 (18.4)	0.9 (-2.1 to 4.0)	0.558
Lymphocyte	n=473 vs 178	1.11 (0.67)	0.98 (0.70)	0.13 (0.01 to 0.25)	0.030
Platelet	n=473 vs 178	245.7 (91.5)	231.3 (84.7)	14.5 (-1.0 to 29.9)	0.067
Sodium	n=473 vs 178	137.5 (4.7)	138.0 (4.7)	0.6 (-0.3 to 1.4)	0.180
Albumin	n=419 vs 157	34.4 (5.7)	35.6 (5.8)	1.2 (0.1 to 2.3)	0.027
Time of COVID-19 Diagnosis (n, % of group)	Admission	169	56	Reference	
	Following admission	304	122	1.21 (0.84 to 1.75)	0.307

*Data not available for four patients: two died within the 30 day follow up period.

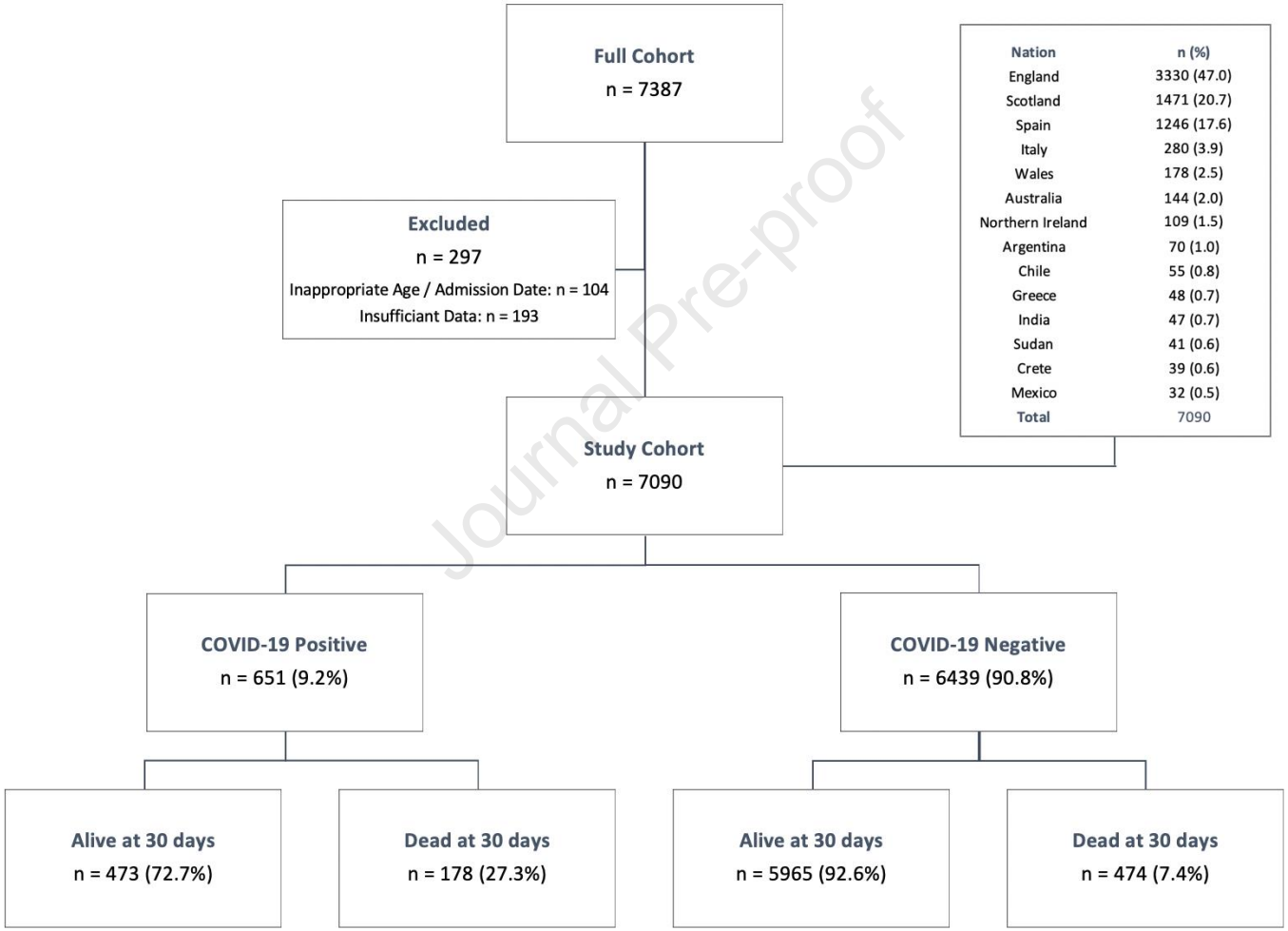
Table VIII. Cox regression model identifying patient related factors associated with 30-day mortality following a hip fracture in patients for patients with COVID-19.

Demographic	**Descriptive**	**Hazard Ratio (95% CI)**	**p-value***
Age (for each increasing year)		1.03 (1.01 to 1.05)	**0.028**
Sex	Female	Reference	
	Male	2.35 (1.66 to 3.34)	**<0.001**
Nottingham Hip Score (for each increasing point)		1.00 (0.97 to 1.03	0.825
Residence	Home/Sheltered	Reference	
	Care/Nursing home	1.32 (0.90 to 1.95)	0.155
	Hospital	1.17 (0.30 to 4.45)	0.823
	Missing	0.98 (0.46 to 2.12)	0.982
Place of injury	Home / Indoor	Reference	
	Outdoor	0.35 (0.11 to 1.14)	0.081
	Hospital	0.64 (0.24 to 1.72)	0.374
	Missing	0.32 (0.06 to 1.56)	0.158
Comorbidity	Not present	Reference	

	Renal Disease	1.53 (1.08 to 2.18)	**0.017**
	Pulmonary	1.45 (1.02 to 2.06)	**0.039**
	Dementia	1.24 (0.85 to 1.83)	0.266
ASA grade	1	8.69 (0.96 to 78.75)	0.055
	2	Reference	
	3	2.36 (0.94 to 5.88)	0.066
	4	2.41 (0.94 to 6.14)	0.066
	5	2.66 (0.78 to 9.02)	0.117
	Missing or N/A	1.97 (0.46 to 8.44)	0.358
Management	Fixation	Reference	
	Arthroplasty	0.75 (0.53 to 1.06)	0.103
	Non-operative	2.59 (1.52 to 4.43)	<0.001
	Other	-	
	Missing	1.29 (0.13 to 12.38)	0.824
Blood tests (for each increasing unit)	Lymphocyte	0.83 (0.62 to 1.12)	0.233
	Platelet	1.00 (1.00 to 1.00)	0.085
	Albumin	0.98 (0.95 to 1.01)	0.132

FIGURES

Figure 1. Flow chart showing all patients, included and excluded patients, mortality outcomes according to COVID-19 status, and distribution of patients from participating nations.



Nation	n (%)
England	3330 (47.0)
Scotland	1471 (20.7)
Spain	1246 (17.6)
Italy	280 (3.9)
Wales	178 (2.5)
Australia	144 (2.0)
Northern Ireland	109 (1.5)
Argentina	70 (1.0)
Chile	55 (0.8)
Greece	48 (0.7)
India	47 (0.7)
Sudan	41 (0.6)
Crete	39 (0.6)
Mexico	32 (0.5)
Total	7090

Figure 2. Kaplan Meier curve for 30-day survival according to whether a patient was COVID negative (black) or COVID positive (red) within 30-days of admission. Log rank p<0.001, 92.6% (95% CI 92.4 to 92.8) versus 72.7% (95% CI 69.4 to 76.0) at 30-days.

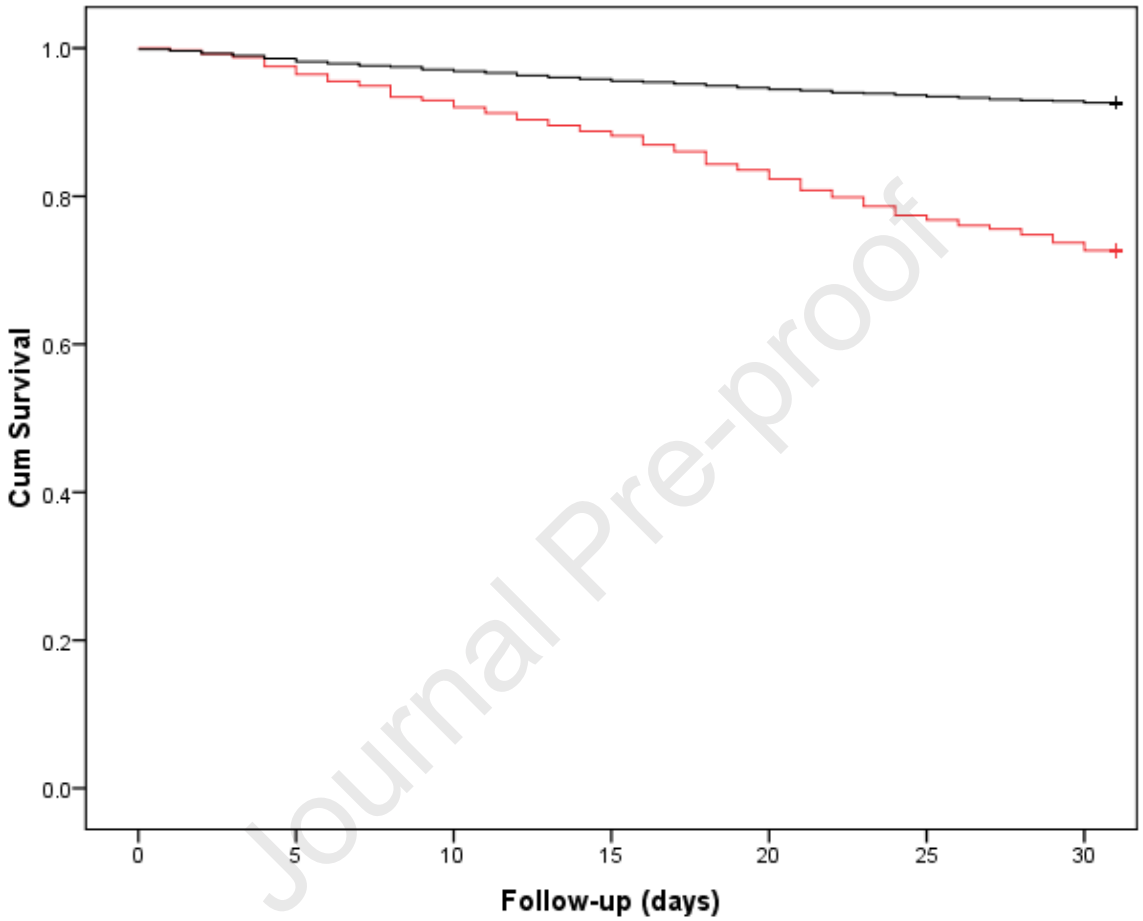


Figure 3. Kaplan Meier curve for 30-day survival according to whether a patient was COVID negative (black), COVID positive at admission (red) or COVID positive after admission (grey). Log rank p=0.661, between COVID positive patients on admission (75.1%, 95% CI 69.4 to 80.8) versus 71.4% (95% CI 67.1 to 75.7) at 30-days.

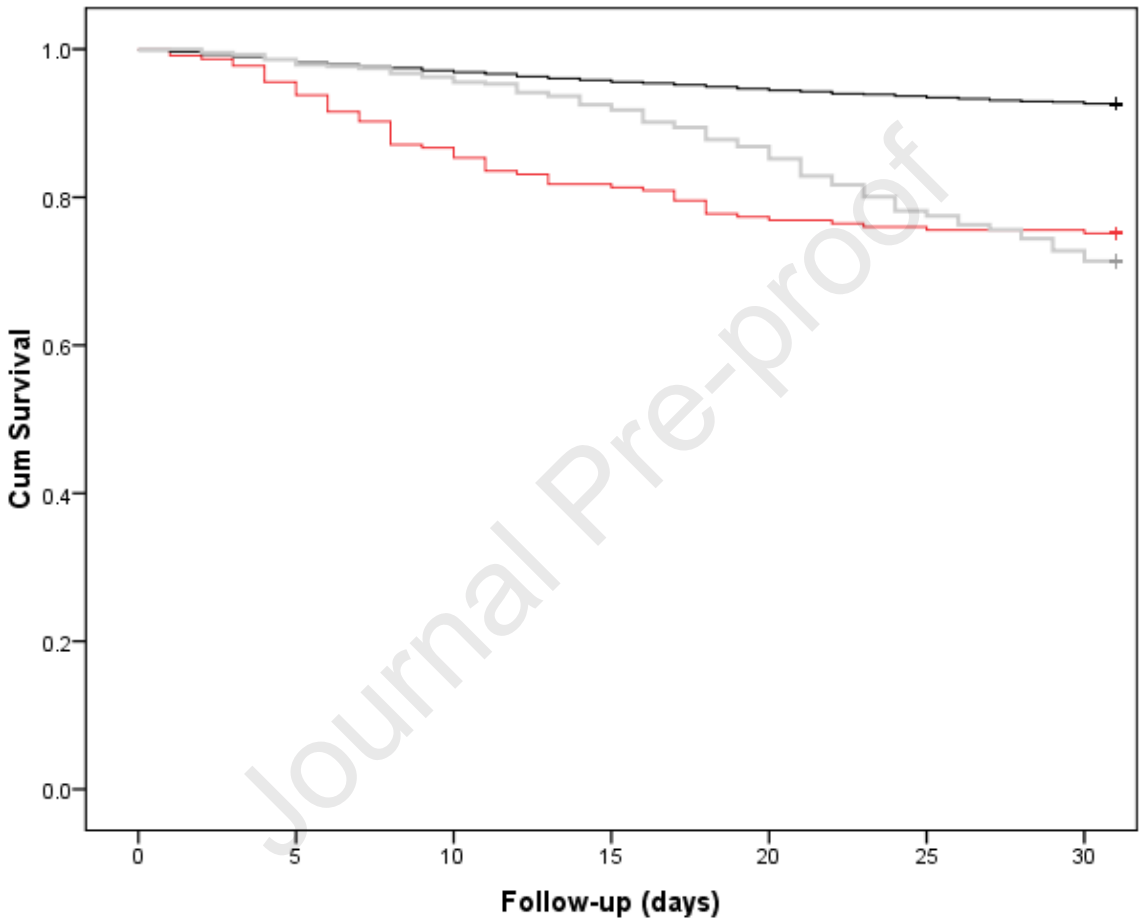


Figure 4. ROC curve for lymphocyte count (grey) and albumin (black dashed) as a predictor of COVID-19 on admission.

Lymphocyte: Area under the curve 60.7% (95% CI 56.7% to 64.6%, p<0.001). Threshold of 0.93 or less has 58.2% specificity and 56.6% sensitivity.

Albumin: Area under the curve 61.3% (95% CI 57.5% to 65.2%, p<0.001). Threshold of 36 g/dL or less has 59.1% specificity and 57.1%sensitivity.

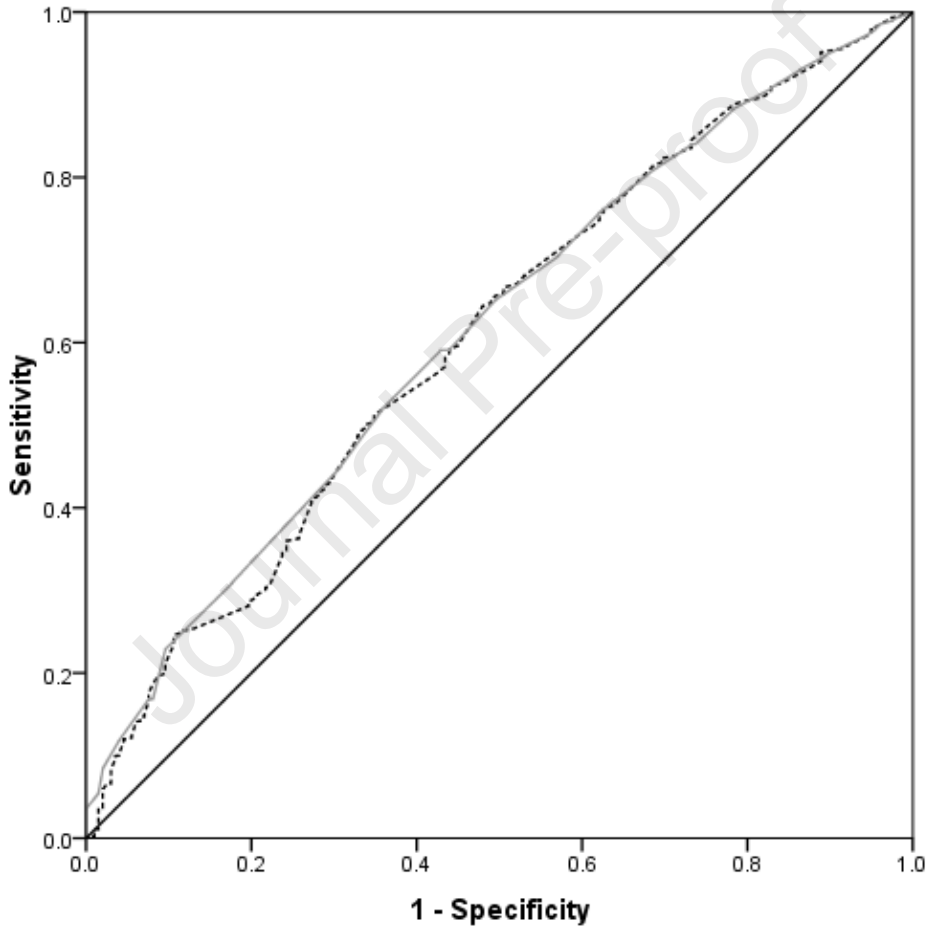


Figure 5. ROC curve for length of hospital stay (dashed line) as a predictor of developing COVID-19 following admission. Area under the curve 71.6% (95% CI 68.8% to 74.4%, p<0.001). Threshold of 10 days or more has 65% specificity and sensitivity.

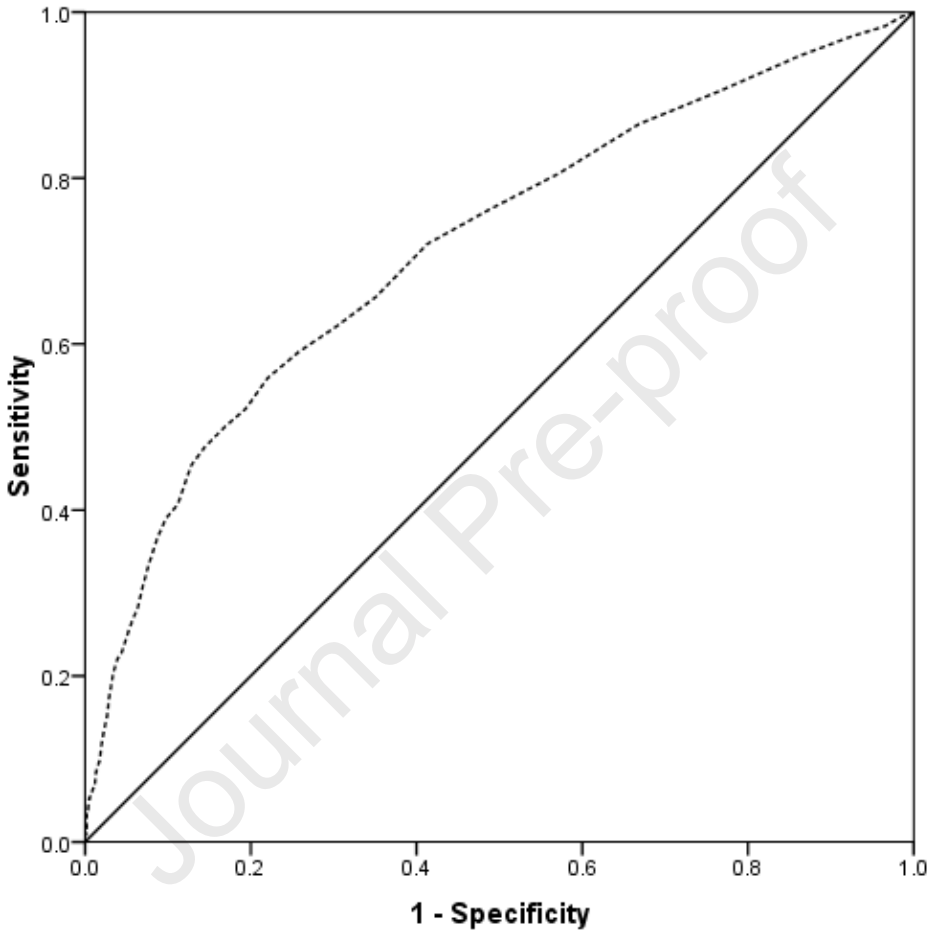


Figure 6. Suggested reporting standards for studies investigating COVID-19 in hip fracture patients.

Suggested reporting standards
Pathogen factors
Contemporary background disease prevalence
Pathogen variant profile (in catchment population)
Pathogen effects on infected host (relevant to study population)
Healthcare factors
Contemporary infection prevention and control strategies
Consistent use of diagnostic criteria and laboratory testing methods
Relevant public health policy factors
Patient factors
Minimum follow-up period of 30 days following date of diagnosis of infection
Patient vaccination status (including type, regimen, and dates administered)
Adjusted mortality analysis (or detailed reporting of patient characteristics and confounding factors)

HIGHLIGHTS

IMPACT-Global is the largest multicentre observational study undertaken solely in T&O

Prevalence of COVID-19 in hip fracture patients was ten times higher than background

COVID-19 was independently associated with a 3x increased 30-day mortality risk

Nosocomial transmission likely had significant role in COVID-19 prevalence & mortality

Lessons applicable to audit and practice in future communicable disease outbreaks