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Indirect effect of the COVID-19 pandemic on hospital mortality in patients with hip fracture: a competing risk survival analysis using linked administrative data

Fiona Grimm ,[1] Antony Johansen,[2,3] Hannah Knight ,[1] Richard Brine ,[1] Sarah R Deeny [1]

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[1]The Health Foundation, London, UK
[2]University Hospital of Wales and Cardiff University School of Medicine, Cardiff, UK
[3]National Hip Fracture Database, Royal College of Physicians, London, UK

Correspondence to
Dr Fiona Grimm, The Health Foundation, London, London, UK; fiona.grimm@health.org.uk

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ABSTRACT

Background Hip fracture is a leading cause of disability and mortality among older people. During the COVID-19 pandemic, orthopaedic care pathways in the National Health Service in England were restructured to manage pressures on hospital capacity. We examined the indirect consequences of the pandemic for hospital mortality among older patients with hip fracture, admitted from care homes or the community.

Methods Retrospective analysis of linked care home and hospital inpatient data for patients with hip fracture aged 65 years and over admitted to hospitals in England during the first year of the pandemic (1 March 2020 to 28 February 2021) or during the previous year. We performed survival analysis, adjusting for case mix and COVID-19 infection, and considered live discharge as a competing risk. We present cause-specific hazard ratios (HR_{CS}) for the effect of admission year on hospital mortality risk.

Results During the first year of the pandemic, there were 55 648 hip fracture admissions: a 5.2% decrease on the previous year. 9.5% of patients had confirmed or suspected COVID-19. Hospital stays were substantially shorter ($p<0.05$), and there was a higher daily chance of discharge (HR_{CS} 1.40, 95% CI 1.38 to 1.41). Overall hip fracture inpatient mortality increased (7.2% in 2020/2021 vs 6.4% in 2019/2020), but patients without concomitant COVID-19 infection had lower mortality rates compared with the year before (5.3%). Admission during the pandemic was associated with a 11% increase in the daily risk of hospital death for patients with hip fracture (HR_{CS} 1.11, 95% CI 1.05 to 1.16).

Conclusions Although COVID-19 infections led to increases in hospital mortality, overall hospital mortality risk for older patients with hip fracture remained largely stable during the first year of the pandemic.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The COVID-19 pandemic led to rapid changes in hip fracture treatment pathways and protocols in the National Health Service in England, particularly during the first months of the outbreak, but the impact of these on quality of care and outcomes for patients is uncertain.

⇒ The indirect effect of the pandemic on hospital mortality is difficult to assess as patients were discharged more quickly, which might have led to displacement of deaths from hospitals to care homes or to people's own homes.

WHAT THIS STUDY ADDS

⇒ Using a competing risk approach, we show that during the first year of the pandemic inpatient mortality risk did not increase substantially for older patients who were admitted with hip fracture.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study provides new evidence regarding the indirect impact of the COVID-19 pandemic, as the effect of rapid changes in treatment pathways and protocols on patient outcomes has not yet been fully understood.

INTRODUCTION

During the COVID-19 pandemic, the number of emergency hospital admissions to the English National Health Service (NHS) decreased substantially.[1 2] An exception were admissions for falls and fragility fractures, which continued to present at similar rates and were managed as a surgical priority.[2–7] Hip fracture is a major cause of accidental disability and death, and the most common traumatic injury for older people requiring hospital admission and emergency surgery.[8] In England alone, approximately 65 000 people suffer this injury each year.[9] While outcomes have gradually improved over the last decade, patients suffering a hip fracture in England continue to have higher mortality rates than in other high-income countries.[10 11]

The COVID-19 pandemic impacted hip fracture care in several ways. There is already ample international evidence on the direct effect of COVID-19 on patients with hip fracture, demonstrating that concurrent COVID-19 infection increases the risk of serious complications and mortality.[12–15] Additionally, the pandemic affected orthopaedic services in England, which underwent rapid restructuring in response to pressures on hospitals, with redeployment of theatre staff, equipment and facilities to critical care and medical wards.[16]

The rapid changes in treatment pathways and protocols and the risk of hospital-acquired COVID-19 infections have led to concerns that some hip fracture quality standards may have slipped.[14] The lack of auditing during this period has added to these concerns, as data submissions to national audits and pay-for-performance initiatives, which link reimbursement to the achievement of quality metrics, were suspended at the onset of the pandemic to free up staff capacity.[17 18] Conversely, pressures on bed availability, recommendations to offer less invasive surgical management and an emphasis on prompt rehabilitation and expedited discharge may have preserved or improved care quality and patient outcomes.[4] Therefore, there is an urgent need to investigate the indirect consequences of the COVID-19 pandemic on mortality outcomes for patients with hip fracture, including patients not directly affected by the infection. Since length of hospital stay for patients with hip fracture fell during the pandemic and there was an overall displacement of deaths from hospitals to private homes and care homes, this analysis necessarily needs to consider earlier hospital discharge as competing event for hospital death.[14 19]

In the UK, 3.4% of the population over 65 live in a residential care setting, but care home residents account for a disproportionate percentage (around 30%) of hip fracture admissions due to their higher risk of falls and resulting fractures due to frailty, osteoporosis and other comorbidities.[20–22] This population is also at high risk of poor outcomes from COVID-19 infection.[23] In England, there are two main types of care homes: residential care homes, which provide accommodation and help with personal care, and nursing homes, which additionally provide 24-hour nursing care. Characteristics of residents differ between the two care home types, and in nursing homes a higher proportion of residents were found to be in their last year of life.[24 25] Both populations have complex healthcare needs due to the high prevalence of multimorbidity, functional dependence and cognitive impairments.[24–27]

This study examines such indirect effects of the pandemic on hip fracture care and in-hospital mortality for older patients admitted for hip fracture from residential care, from nursing homes or from their own home (living in the community). We compared the number of admissions and their outcome with patients with hip fracture admitted during the year before using a competing risk survival analysis approach, taking into account the direct effect of concurrent COVID-19 infections.

METHODS

Data sources

We used pseudonymised administrative data on hospital admissions from Secondary Uses Service (SUS), a national database of NHS-funded hospital activity in England. At the time of data extraction, SUS data were available until the end of June 2021. Care homes are not reliably recorded as the source of admission; therefore, we identified residents through linkage to the patient index from the National Health Applications and Infrastructure Services, as previously described.[2 24 28] Patient addresses were matched to Unique Property Reference Numbers, which were cross-referenced to care home addresses and characteristics (up to October 2020) from the Care Quality Commission, the regulator of social care services in England. Linkage to mortality records was not available for this data extract and we were unable to determine if patients died after hospital discharge. Processing of addresses and linkage of patient information was carried out by the National Commissioning Data Repository. Data were anonymised in line with the Information Commissioner's Office's code of practice on anonymisation.

Study populations

For each patient, we linked electronic health records to create continuous inpatient spells (CIPS) from admission to discharge, even when this included transfers between hospitals.[29 30] We included CIPS that started between 1 March 2019 and 28 February 2021 and where the method of admission was an emergency, the age at admission was 65 years or older and the primary diagnosis code was a fracture of the hip joint (International Classification of Diseases, 10th edition or ICD-10 codes S72.0, S72.1 or S72.2). We excluded CIPS where the administrative category was private patient or where admission occurred via a Mental Health Crisis Resolution Team.

Cohorts were divided based on whether the admission occurred in the year before the pandemic (1 March 2019 to 29 February 2020) or the first year of the pandemic (1 March 2020 to 28 February 2021), and whether the patient address matched to a care home on the date of admission. March 2020 was chosen as the start of the period of interest during the pandemic, as this was when NHS providers were advised to reorganise care priorities and free up inpatient capacity, and emergency care attendances among the general public started to decrease.[1 31] Patients with hip fracture from care homes were further split into subgroups based on care home type (residential or nursing), using information provided by the regulator as to whether nursing care was being provided to some residents in the home. If patients matched to multiple care homes, care home opening and closing dates were used to exclude implausible matches. If this was not sufficient to resolve multiple matches (n=22, 0.12% of admissions from care homes), we chose the care home with the earliest opening date, or if they were identical, the nursing home. Online supplementary figure S1 shows a data flow chart with details of inclusion and exclusion criteria.

Hospital mortality

Hospital deaths were identified if the patient died according to either the SUS discharge destination variable (79=not applicable—patient died or stillbirth) or the SUS discharge method variable (4=died). Hospital deaths were indexed to the admission date, and mortality rates were calculated using all hip fracture admissions as denominator.

Covariates

Patient sex and age at admission were taken from the patient index. Hip replacement and repair procedures were categorised into total hip replacement, partial hip replacement or osteosynthesis (placement of a screw, plate, pin or internal fixation) using Office of Population Censuses Surveys Classification of Surgical Operations and Procedures (OPCS4) codes (online supplemental table S1).[11] The date and time of the procedure were not available in the data extract used for this study. The presence of conditions related to the updated Charlson Comorbidity Index (excluding HIV/AIDS) and conditions related to frailty was determined using primary or secondary diagnosis codes of all admissions up to 3 years prior to the index admission.[32–35] Diagnoses of suspected or confirmed COVID-19 were determined using ICD-10 codes U07.1 and U07.2.

Statistical analysis

The similarity between baseline characteristics of cohorts was evaluated using standardised mean differences (R package 'tableone'). These are defined as the difference in means of a given characteristic expressed as a percentage of the pooled SD, with a cut-off value of 10% indicating a negligible imbalance between groups.[36] The measure allows comparisons of the magnitude of difference between groups, rather than of statistical significance, can be used across variables of different scales and is not dependent on sample size. Wilcoxon-Mann-Whitney tests were used to compare the distribution of hospital length of stay between admission years.

We followed a competing risk time-to-event analysis approach to examine the association between the admission period and hospital death, the outcome of interest, with live discharge being a competing risk (R packages 'survival' and 'survminer'). This was necessary since being discharged alive precludes the occurrence of the event of interest. Therefore, simply censoring patients at discharge would violate the assumption of non-informative censoring and lead to incorrect and potentially biased results.[37–39] We used Cox proportional hazard models to estimate multivariable-adjusted cause-specific HRs (HR_{CS}, with 95% CIs) for hospital death and live discharge, comparing admissions during the first year of the pandemic with admissions during the prior 12 months (modelled as a binary variable). Alternative approaches were considered, including Fine-Gray models. These are based on the subdistribution hazard and model the effect of covariates on cumulative incidences rather than risk. However, initial exploration showed that the structure of our dataset was not compatible with the assumption of proportional subdistribution hazards (not shown). In addition, subdistribution HRs do not have a straightforward interpretation relating to the changes of epidemiological risk and are therefore not as well suited for aetiological questions.[38 39]

We fitted a single Cox model for each outcome, which included a variable for patient residence (community, residential care home or nursing home). Models with and without an interaction term for admission year and patient residence were tested. The interaction term did not significantly improve model fit for the mortality outcome (likelihood ratio test: $p>0.05$) and no significant interaction was found; therefore, it was not included in the final models. To select the relevant variable set for case mix adjustment between admission periods, known causes of confounding were conceptualised using causal diagrams (directed acyclic graphs or DAGs; online supplementary figure S2) and the minimal sufficient adjustment set was determined (R package 'ggdag').[40] Patient age and sex, individual comorbidities relating to frailty and the Charlson Comorbidity Index (but not the score itself), COVID-19 infection and procedure type were included as covariates in the final models.[41] Patient age was modelled as 10-year age bands (as shown in table 1), after examining graphs of the continuous variable against the martingale residuals of the null model (R function 'ggcoxfunctional'). The proportional hazards assumption was checked using Schoenfeld residuals (online supplementary figure S3). To test whether the model was able to fully account for the direct impact of COVID-19 infection, a sensitivity analysis was conducted where patients with a record of confirmed or suspected COVID-19 were excluded

Table 1 Characteristics of people aged 65 and over who were admitted to National Health Service hospitals in England with hip fracture before the pandemic (March 2019–February 2020) and during the COVID-19 pandemic (March 2020–February 2021), by patient residence

Residence	Community		Residential care home		Nursing home	
Admission year	**2019/2020**	**2020/2021**	**2019/2020**	**2020/2021**	**2019/2020**	**2020/2021**
n	48 934	46 663	5689	5132	4105	3853
Female (%)	34 476 (70.5)	32 571 (69.8)	4457 (78.3)	4041 (78.7)	2913 (71.0)	2783 (72.2)
Age (%)						
65–69	2998 (6.1)	2645 (5.7)	74 (1.3)	61 (1.2)	70 (1.7)	81 (2.1)
70–74	5392 (11.0)	5019 (10.8)	172 (3.0)	171 (3.3)	219 (5.3)	189 (4.9)
75–79	7420 (15.2)	7224 (15.5)	439 (7.7)	433 (8.4)	445 (10.8)	399 (10.4)
80–84	10 808 (22.1)	10 156 (21.8)	971 (17.1)	896 (17.5)	796 (19.4)	751 (19.5)
85–89	12 009 (24.5)	11 350 (24.3)	1614 (28.4)	1415 (27.6)	1158 (28.2)	1011 (26.2)
90–95	7736 (15.8)	7654 (16.4)	1588 (27.9)	1402 (27.3)	964 (23.5)	976 (25.3)
95+	2571 (5.3)	2615 (5.6)	831 (14.6)	754 (14.7)	453 (11.0)	446 (11.6)
Mean age in years*	83 (8)	83 (8)	88 (7)	87 (7)	86 (7)	86 (7)
Charlson Comorbidity Index (%)						
0	27 894 (57.0)	26 399 (56.6)	1764 (31.0)	1612 (31.4)	1199 (29.2)	1141 (29.6)
1	6480 (13.2)	6168 (13.2)	312 (5.5)	314 (6.1)	194 (4.7)	245 (6.4)
2	6168 (12.6)	5915 (12.7)	1743 (30.6)	1521 (29.6)	1268 (30.9)	1131 (29.4)
3	3789 (7.7)	3657 (7.8)	931 (16.4)	871 (17.0)	681 (16.6)	590 (15.3)
4+	4603 (9.4)	4524 (9.7)	939 (16.5)	814 (15.9)	763 (18.6)	746 (19.4)
Mean Charlson Comorbidity Index*	1.11 (1.70)	1.13 (1.72)	1.98 (1.79)	1.95 (1.76)	2.11 (1.87)	2.09 (1.89)
Metastatic cancer with solid tumour	872 (1.8)	841 (1.8)	45 (0.8)	39 (0.8)	60 (1.5)	70 (1.8)
Other malignant cancer	2977 (6.1)	2976 (6.4)	272 (4.8)	213 (4.2)	265 (6.5)	253 (6.6)
Chronic pulmonary disease	8918 (18.2)	8472 (18.2)	895 (15.7)	862 (16.8)	717 (17.5)	655 (17.0)
Congestive heart failure	4976 (10.2)	4820 (10.3)	700 (12.3)	591 (11.5)	522 (12.7)	500 (13.0)
Dementia	4782 (9.8)	4543 (9.7)	3152 (55.4)	2761 (53.8)	2266 (55.2)	2013 (52.2)
Diabetes with chronic complications	1078 (2.2)	1064 (2.3)	86 (1.5)	87 (1.7)	77 (1.9)	106 (2.8)
Hemiplegia or paraplegia	792 (1.6)	769 (1.6)	98 (1.7)	102 (2.0)	98 (2.4)	95 (2.5)
Moderate or severe liver disease	264 (0.5)	245 (0.5)	<10 (<0.2)	<10 (<0.2)	15 (0.4)	10 (0.3)
Mild liver disease	863 (1.8)	943 (2.0)	93 (1.6)	83 (1.6)	79 (1.9)	77 (2.0)
Rheumatological disease	2407 (4.9)	2335 (5.0)	260 (4.6)	220 (4.3)	163 (4.0)	165 (4.3)
Renal disease	6765 (13.8)	6747 (14.5)	1 097 (19.3)	1 057 (20.6)	810 (19.7)	796 (20.7)
Frailty						
Number of conditions*	0.71 (1.11)	0.73 (1.13)	1.72 (1.39)	1.75 (1.43)	1.85 (1.47)	1.85 (1.48)
Anxiety or depression	4771 (9.7)	4631 (9.9)	914 (16.1)	889 (17.3)	706 (17.2)	670 (17.4)
Cognitive impairment	9385 (19.2)	9372 (20.1)	3729 (65.5)	3341 (65.1)	2734 (66.6)	2540 (65.9)
Dependence	1726 (3.5)	1508 (3.2)	653 (11.5)	601 (11.7)	612 (14.9)	580 (15.1)
Falls and fractures	11 205 (22.9)	10 916 (23.4)	2541 (44.7)	2297 (44.8)	1901 (46.3)	1772 (46.0)
Incontinence	1724 (3.5)	1732 (3.7)	531 (9.3)	558 (10.9)	503 (12.3)	496 (12.9)
Mobility problems	4580 (9.4)	4560 (9.8)	1031 (18.1)	951 (18.5)	817 (19.9)	794 (20.6)
Pressure ulcers	1485 (3.0)	1556 (3.3)	360 (6.3)	336 (6.5)	321 (7.8)	293 (7.6)
COVID-19 infection						
Confirmed or suspected	94 (0.2)	4293 (9.2)	<10 (0.2)	554 (10.8)	<10 (0.2)	417 (10.8)
Procedure (%)						
None	3381 (6.9)	3220 (6.9)	421 (7.4)	384 (7.5)	332 (8.1)	304 (7.9)
Osteosynthesis	21 102 (43.1)	19 818 (42.5)	2488 (43.7)	2297 (44.8)	1833 (44.7)	1744 (45.3)
Partial replacement	19 776 (40.4)	20 397 (43.7)	2735 (48.1)	2419 (47.1)	1896 (46.2)	1773 (46.0)
Total replacement	4675 (9.6)	3228 (6.9)	45 (0.8)	32 (0.6)	44 (1.1)	32 (0.8)
Length of stay in days†	15 (18)	13 (14)	13 (13)	11 (10)	11 (9)	10 (8)

Patients admitted in 2019/2020 can have a record of COVID-19 if they were still in hospital in 2019/2020.
*Mean (SD).
†Median (IQR).

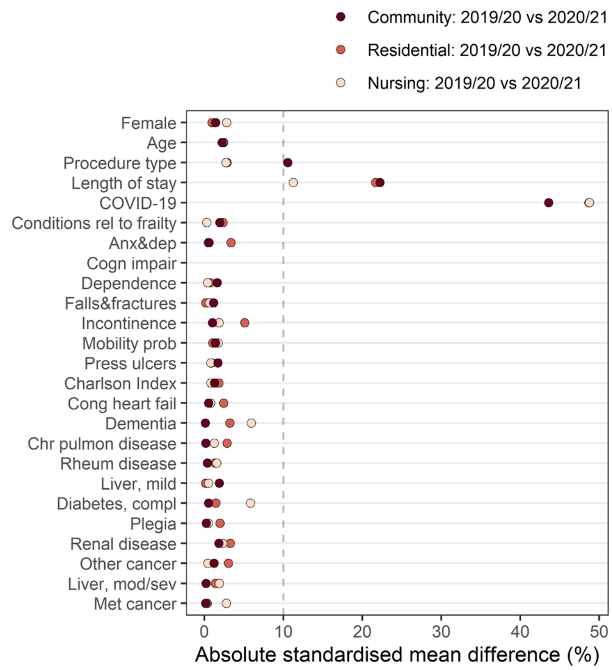

Figure 1 Assessment of similarity of the characteristics between people aged 65 or over (with or without a diagnosis of confirmed or suspected COVID-19) who were admitted to National Health Service hospitals in England for hip fracture before the pandemic (March 2019 - February 2020) or during the COVID-19 pandemic (March 2020 - February 2021), by patient residence. Age and Charlson Comorbidity Index were included as continuous variables. Rel = related, Anx&Dep = anxiety and depression, Cogn Impair = cognitive impairment, Mobility prob = mobility problems, Press ulcers = pressure ulcers, Cong heart fail = congestive heart failure, chr pulmon disease = chronic pulmonary disease, Rheum disease = rheumatological disease, Liver, mild = mild liver disease, Diabetes compl = diabetes with chronic complications, Plegia = hemiplegia or paraplegia, Liver mod/severe = moderate or severe liver disease, Met cancer = Metastatic cancer with solid tumour.

and resulting cause-specific HRs were compared with the initial model. We used R (V.4.0.3) for data processing and statistical analysis and SAS (V.7.12) for data cleaning and analysis of comorbidities.[42]

RESULTS

Study populations

During the pandemic, there were 5132 hip fracture admissions for people from residential care, 3853 for nursing home residents and 46 663 for people living in the community who met the inclusion criteria (table 1), respective decreases of 9.8%, 6.1% and 4.6% compared with the year before. The decrease in monthly admissions from care homes was more pronounced during the last months of the study period (from November 2020, see online supplementary figure S4), which could be related to declining care home occupancies between March 2020 and February 2021.[43]

The demographic characteristics and comorbidity burden of patients admitted with hip fracture during the pandemic were broadly similar to the previous year (figure 1). The median length of hospital stays during the pandemic decreased by 2 days for people from residential care ($p<0.001$) or from the community ($p<0.001$), and by 1 day for people from nursing homes ($p=0.013$). Between March 2020 and February 2021, 10.8% of patients with hip fracture from residential care and from nursing homes had confirmed or suspected COVID-19, compared with 9.2% of patients from the community. Patients with hip fracture with COVID-19 infections stayed in hospital for longer on average (online supplementary figure S5 and online supplementary table S2). For patients with hip fracture from the community, those with COVID-19 infections were slightly older, were less likely to be female and had a higher number of comorbidities. Patients with hip fracture without COVID-19 infections who were admitted during the pandemic were similar to patients with hip fracture admitted during the year before.

There was a slight increase in the proportion of patients with hip fracture from care homes who underwent fracture fixation during the pandemic (table 1). Partial hip replacement remained the most common procedure for patients from residential and nursing homes. People admitted from the community showed a clear shift from total to partial hip replacement during the pandemic, but few care home residents received a total hip replacement in either year. Patients from the community with a record of COVID-19 were less likely to receive total hip replacements (online supplementary figure S5 and online supplemental table S2). The proportion of patients from care homes who were managed non-surgically was broadly unchanged.

Hospital mortality

Inpatient mortality rates peaked around the beginning of April 2020 and between November 2020 and January 2021 (figure 2), which coincided with periods of high COVID-19 community prevalence and COVID-19-related mortality in the UK.[44 45]

Compared with the year before, mortality was higher during the first year of the pandemic for all groups (table 2). Mortality rates were highest in the subgroup of patients with hip fracture with confirmed or suspected COVID-19, but mortality rates among patients with hip fracture without COVID-19 who were admitted during the pandemic were lower compared with overall mortality in the previous year (table 2).

Cause-specific risks for hospital death and discharge

Models with and without an interaction term for admission year and patient residence were tested. The interaction term did not significantly improve model fit for the mortality outcome (likelihood ratio test: $p>0.05$) and no significant interaction was found, most likely due to the limited sample size in the care home groups (online supplemental table S3). The interaction term was therefore not included in the final

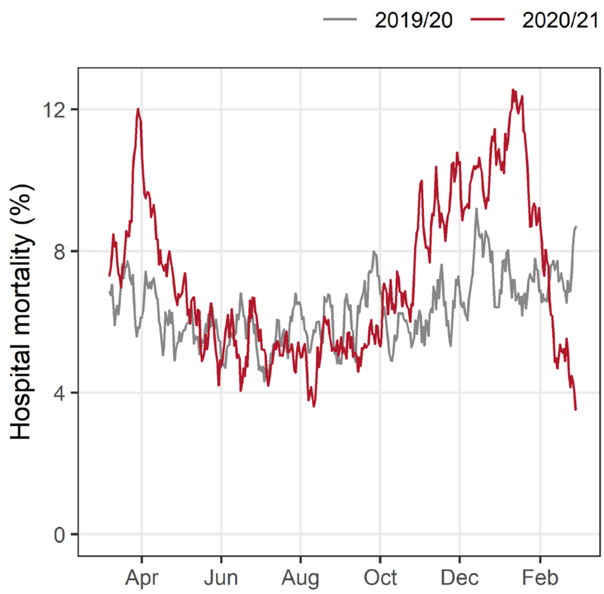

Figure 2 Seven-day rolling average of daily inpatient mortality rate for patients admitted for hip fracture before the pandemic (March 2019–February 2020) and during the COVID-19 pandemic (March 2020–February 2021), by admission date.

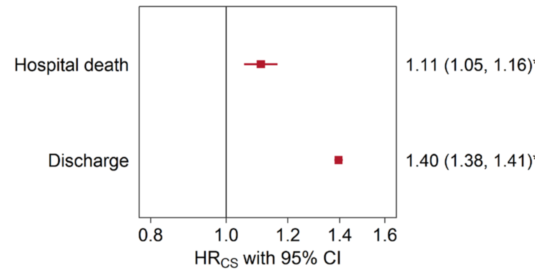

Figure 3 Multivariable-adjusted cause-specific HRs (HR_{CS}) and 95% CIs for the association between admission period (March 2019–February 2020 or March 2020–February 2021) and hospital death or live discharge among patients with hip fracture aged 65 years and over. HRs are shown on a log scale. See online supplemental table S4 for effect estimates of all covariates. *p<0.05.

model. Being admitted during the pandemic was associated with a 11% increase in the daily risk of hospital death for patients with hip fracture (HR_{CS} 1.11, 95% CI 1.05, 1.16; figure 3 and online supplemental table S4). Compared with 2019/2020, the daily chances of discharge for patients with hip fracture increased by 40% (HR_{CS} 1.40, 95% CI 1.38 to 1.41). These findings were broadly unchanged when only patients with hip fracture without a record of confirmed or suspected COVID-19 were included in the regression analysis (online supplementary figure S6).

DISCUSSION

Principal findings

While the COVID-19 pandemic was associated with significant excess mortality due to the virus in the population, the same period was not associated with a substantial change in hospital mortality risk for older patients with hip fracture. The daily chance of being discharged alive from hospital for patients with hip fracture was substantially higher during the first year of the pandemic, so that length of hospital stay fell markedly. This raises the question of whether earlier discharge from hospital during the pandemic led to a shift in place of death, with more deaths occurring outside of hospital. As we did not have access to linked mortality records, we were unable to determine whether this was the case. However, the national clinical audit of hip fracture recorded that 30-day mortality rose from 6.5% in 2019 to 8.3% in

Table 2 Crude hospital mortality for patients aged 65 and over who were admitted for hip fractures before the pandemic (March 2019–February 2020) and during the COVID-19 pandemic (March 2020–February 2021), by patient residence and COVID-19 status

	Admission year	COVID-19 status	Admissions	Hospital deaths (%)
Community				
	2019/2020	All	48 934	3003 (6.1)
	2020/2021	All	46 663	3253 (7.0)
		No record	42 370	2194 (5.2)
		COVID-19*	4 293	1059 (24.7)
Residential care home				
	2019/2020	All	5689	460 (8.1)
	2020/2021	All	5132	443 (8.6)
		No record	4578	295 (6.4)
		COVID-19*	554	148 (26.7)
Nursing home				
	2019/2020	All	4105	289 (7.0)
	2020/2021	All	3853	296 (7.7)
		No record	3436	182 (5.3)
		COVID-19*	417	114 (27.3)

*Confirmed or suspected.

2020. In comparison, this study found that hospital mortality rose from 6.4% to 7.2% (although measured between March and February, rather than across a calendar year). The difference in mortality rates observed during 2020 suggests that some deaths might have been displaced from hospitals to care homes or people's own homes.

We also saw signs that recommendations on hip fracture management during the pandemic were being implemented, as evidenced by a shift towards partial hip replacements and shorter inpatient stays.[4] This shift away from total hip replacements continued an existing trend that started after the publication of the HEALTH trial in 2019, which found no clinically relevant improvement in function and quality of life after total hip replacement, compared with partial hip replacement.[46] However, this trend accelerated during the COVID-19 outbreak when theatre and staff availability was limited and when procedures that involved less drilling and reduced aerosol generation were preferable.

Comparison with other studies

Our study cohort was similar to other large UK hip fracture cohorts in terms of sociodemographic, clinical and treatment-based characteristics.[17 47 48] Similar trends in hip fracture surgery towards more conservative management, reductions in length of stay and COVID-19 infection rates were observed by others.[6 49 50] The national clinical audit of hip fracture showed that 30-day mortality was three times higher for patients with COVID-19 than for those without the infection.[50] We found that hip fracture inpatient mortality was 4.7 times higher, reflecting how some COVID-19-positive patients remained in hospital for prolonged periods of treatment and end-of-life care. There is also some international evidence that outcomes for patients with hip fracture did not deteriorate during the pandemic, even though length of stay decreased.[15]

Strengths and limitations

This study is the first national analysis of the indirect effect of the COVID-19 pandemic on mortality risk for older people and care home residents admitted with hip fracture. Unlike previous studies, it captures all hip fracture admissions to NHS hospitals in England and covers both the first and second wave of the COVID-19 outbreak. The analysis is based on a novel linkage methodology that enabled us to identify care home residents in routinely collected healthcare data with high specificity, since this is not reliably recorded in administrative records.[28] However, a validation study showed that linkage methodology misses around 22% of care home residents and, although the address matching approach has since improved, our cohort of patients with hip fracture from the community might include some care home residents. As the method relies on addresses held by general practitioner practices, we may not correctly identify residents who moved into a care home shortly before hospital admission, or who moved into a care home temporarily. This is more likely to affect records from the period prior to the pandemic, as fewer people moved into care homes during the pandemic.[43]

As hospital length of stay decreased during the pandemic, we chose a cause-specific survival analysis approach. For a more complete understanding, we report the effect of the exposure, the admission year, on both the event of interest, hospital death, and the competing event, live discharge. As the outcomes are mutually exclusive, this method estimates the instantaneous (in our case, daily) risk among the group of patients with hip fracture who have not yet experienced the competing event, with other patients being censored.[51] However, if exposure disproportionately increases the chances of the competing event, as was the case during the pandemic when patients with hip fracture were discharged more quickly, this could lead to an overestimation (upwards bias) of the mortality risk. Another key assumption is that the competing events occur independently of each other, which cannot be tested using the observed data.[51]

The multivariate regression models used in this study include an adjustment for COVID-19 infection, but during the first months of the pandemic some infections might not have been detected due to the limited availability of testing. Previous studies also found that inpatient mortality was higher among patients with hip fracture who developed COVID-19 after surgery, but we were not able to determine whether the infection was acquired before or during the hospital stay.[14] In addition, we were unable to determine whether patients had symptomatic disease and its level of severity. We did not have information on other established hip fracture care quality markers, such as time to theatre or early mobilisation, but changes in these could have confounded the observed changes in hospital mortality. The pressure of COVID-19 on hospitals, and any potential effects on care quality, likely fluctuated between the first wave of the pandemic in Spring 2020, the summer period and the second wave through Autumn and Winter 2020/2021. However, to maximise the available sample size, we included all hip fracture admissions from the 12-month period covering the first and second waves of the pandemic. The uneven impact of COVID-19 mortality on care homes, in combination with changes in care home occupancy and the influx of new residents, may have led to systematic changes in the risk of residents to experience hip fracture.[43 52 53] While the study cohorts of patients were comparable in observed characteristics across years, unobserved differences may have confounded the estimates.

Implications

This study addresses a major concern regarding the management of frail older people with hip fracture during the COVID-19 pandemic—namely whether the rapid changes in treatment pathways and protocols had negative consequences for patient outcomes. Despite complex pressures on staff and hospitals, our study appears to show that hip fracture inpatient mortality among older people remained largely stable.

However, the observed reduction in length of stay requires urgent further exploration, in particular the impact this may have had on patient outcomes after discharge and whether this led to displacement of deaths from hospitals. To free up capacity for patients critically ill with COVID-19 and to avoid hospital-acquired infections, hospitals were advised at the start of the pandemic to urgently discharge all patients who were medically fit to leave, many of which were discharged to care homes.[31 54] Additional funding was made available to enable patients to leave hospital through 'discharge to assess' types of pathways.[54]

CONCLUSION

The COVID-19 pandemic led to rapid changes in hip fracture treatment pathways and protocols in the NHS in England. Our findings suggest that mortality outcomes for this frail group of patients did not deteriorate, while hospitals were under enormous pressure from COVID-19. Recent work comparing the care offered to patients with hip fracture in 11 different countries has shown that England has the longest length of stay in hospital after hip fracture; nearly three times the average in the USA and the Netherlands.[48] The pandemic may, therefore, provide valuable lessons on how hip fracture care could be delivered more efficiently, which will be relevant at a time when orthopaedic units are facing major elective care backlogs. However, further research is needed to determine the impact of expedited hospital discharges on patient outcomes.

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ORCID iDs

Fiona Grimm http://orcid.org/0000-0001-5249-619X
Hannah Knight http://orcid.org/0000-0002-6809-2517
Richard Brine http://orcid.org/0000-0003-4271-5488
Sarah R Deeny http://orcid.org/0000-0001-5994-1583

REFERENCES

1 NHS England and Improvement. A&E Attendances and Emergency Admissions 2020-21 [Internet]. Available: https://www.england.nhs.uk/statistics/statistical-work-areas/ae-waiting-times-and-activity/ [Accessed 02 Sep 2021].
2 Grimm F, Hodgson K, Brine R, *et al*. Hospital admissions from care homes in England during the COVID-19 pandemic: a retrospective, cross-sectional analysis using linked administrative data. *Int J Popul Data Sci* 2021;5:1663.
3 Hampton M, Clark M, Baxter I, *et al*. The effects of a UK lockdown on orthopaedic trauma admissions and surgical cases: a multicentre comparative study. *Bone Jt Open* 2020;1:137–43.
4 British Orthopaedic Association. Management of patients with urgent orthopaedic conditions and trauma during the coronavirus pandemic, 2020. Available: https://www.boa.ac.uk/resources/covid-19-boasts-combined1.html
5 NHS England. Clinical guide for the perioperative care of people with fragility fractures during the coronavirus pandemic. version BOA1, 2020. Available: https://www.boa.ac.uk/static/3e2ef4d7-6788-4fcd-8a17196fca00f63e/NHSE-Fragility-Fractures-and-Coronavirus-VBOA10-24032020docx.pdf
6 Malik-Tabassum K, Crooks M, Robertson A, *et al*. Management of hip fractures during the COVID-19 pandemic at a high-volume hip fracture unit in the United Kingdom. *J Orthop* 2020;20:332–7.
7 Arafa M, Nesar S, Abu-Jabeh H, *et al*. COVID-19 pandemic and hip fractures: impact and lessons learned. *Bone Jt Open* 2020;1:530–40.

8 Johnell O, Kanis JA. An estimate of the worldwide prevalence and disability associated with osteoporotic fractures. *Osteoporos Int* 2006;17:1726–33.
9 Royal College of Physicians. The challenge of the next decade: are hip fracture services ready? A review of data from the National Hip Fracture Database (January–December 2019). [Internet], 2021. Available: https://data.gov.uk/dataset/fa2c8bc9-4230-4b8d-8ba9-1d6fc4affb68/national-hip-fracture-database-annual-report-2020
10 Royal College of Physicians. National hip fracture database (NHFD) annual report 2019. data from January to December 2018, 2019. Available: https://www.nhfd.co.uk/20/hipfractureR.nsf/docs/2019Report
11 Papanicolas I, Riley K, Abiona O, *et al*. Differences in health outcomes for high-need high-cost patients across high-income countries. *Health Serv Res* 2021;56 Suppl 3:1347–57.
12 Alcock H, Moppett EA, Moppett IK. Early mortality outcomes of patients with fragility hip fracture and concurrent SARS-CoV-2 infection: a systematic review and meta-analysis. *Bone Jt Open* 2021;2:314–22.
13 Lim MA, Pranata R. Coronavirus disease 2019 (COVID-19) markedly increased mortality in patients with hip fracture - A systematic review and meta-analysis. *J Clin Orthop Trauma* 2021;12:187–93.
14 Johansen A, Inman DS. A view of COVID-19 from the perspective of the National hip fracture database. *Bone Joint J* 2021;103-B:1007–8.
15 Zhong H, Poeran J, Liu J, *et al*. Hip fracture characteristics and outcomes during COVID-19: a large retrospective national database review. *Br J Anaesth* 2021;127:15–22.
16 Flemming S, Hankir M, Ernestus R-I, *et al*. Surgery in times of COVID-19—recommendations for hospital and patient management. *Langenbecks Arch Surg* 2020;405:359–64.
17 Metcalfe D, Zogg CK, Judge A, *et al*. Pay for performance and hip fracture outcomes. *Bone Joint J* 2019;101-B:1015–23.
18 Oakley B, Nightingale J, Moran CG, *et al*. Does achieving the best practice tariff improve outcomes in hip fracture patients? an observational cohort study. *BMJ Open* 2017;7:e014190.
19 Office for National Statistics. Deaths at home increased by a third in 2020, while deaths in hospitals fell except for COVID-19, 2021. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/deathsathomeincreasedbyathirdin2020whiledeathsinhospitalsfellexceptforcovid19/2021-05-07
20 LaingBuisson. *Care Homes for Older People - UK Market Report*, 2019.
21 Office for National Statistics. Population estimates for the UK, England and Wales, Scotland and Northern Ireland: mid-2019, 2020. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationestimates/bulletins/annualmidyearpopulationestimates/mid2019estimates
22 National Institute for Health and Care Excellence. Hip fracture: management - Clinical guideline, 2011. Available: http://www.wnecumbria.nhs.uk/wp-content/uploads/2016/09/Hip-fracture-managemment-guidance-Jun-2011-NICE.pdf
23 Comas-Herrera A, Zalakain J, Lemmon E. Mortality associated with COVID-19 in care homes: international evidence. Available: https://ltccovid.org/2020/04/12/mortality-associated-with-covid-19-outbreaks-in-care-homes-early-international-evidence/
24 Lloyd T, Conti S, Santos F, *et al*. Effect on secondary care of providing enhanced support to residential and nursing home residents: a subgroup analysis of a retrospective matched cohort study. *BMJ Qual Saf* 2019;28:534–46.
25 Gordon AL, Franklin M, Bradshaw L, *et al*. Health status of UK care home residents: a cohort study. *Age Ageing* 2014;43:97–103.
26 Shah SM, Carey IM, Harris T, *et al*. Mortality in older care home residents in England and Wales. *Age Ageing* 2013;42:209–15.
27 Wolters A, Santos F, Lloyd T. Emergency admissions to hospital from care homes: how often and what for? Health Foundation. [Internet], 2019. Available: https://www.health.org.uk/sites/default/files/upload/publications/2019/Emergency-admissions-from-care-homes-IAU-Q02.pdf
28 Oliveira dos Santos F, Conti S, Wolters A. A novel method for identifying care home residents in England: a validation study. *Int J Popul Data Sci* 2021;5:09.
29 Busby J, Purdy S, Hollingworth W. Calculating Hospital length of stay using the hospital episode statistics; a comparison of methodologies. *BMC Health Serv Res* 2017;17:347.
30 The Health and Social Care Information Centre. Methodology to create provider and CIP spells from hES APC data, 2014. Available: https://webarchive.nationalarchives.gov.uk/ukgwa/20180307232845tf_/http://content.digital.nhs.uk/media/11859/Provider-Spells-Methodology/pdf/Spells_Methodology.pdf
31 NHS England and NHS Improvement. Letter to chief executives of all NHS trusts and Foundation trusts, CCG accountable officers, GP practices and primary care networks, and providers of community health services, 2020. Available: https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/03/urgent-next-steps-on-nhs-response-to-covid-19-letter-simon-stevens.pdf [Accessed 07 Aug 2020].
32 Soong J, Poots AJ, Scott S, *et al*. Developing and validating a risk prediction model for acute care based on frailty syndromes. *BMJ Open* 2015;5:e008457.
33 Quan H, Sundararajan V, Halfon P, *et al*. Coding algorithms for defining comorbidities in ICD-9-CM and ICD-10 administrative data. *Med Care* 2005;43:1130–9.
34 Quan H, Li B, Couris CM, *et al*. Updating and validating the Charlson comorbidity index and score for risk adjustment in hospital discharge Abstracts using data from 6 countries. *Am J Epidemiol* 2011;173:676–82.
35 Soong J, Poots AJ, Scott S, *et al*. Quantifying the prevalence of frailty in English hospitals. *BMJ Open* 2015;5:e008456.
36 Flury BK, Riedwyl H. Standard distance in univariate and multivariate analysis. *Am Stat* 1986;40:249–51.
37 Noordzij M, Leffondré K, van Stralen KJ, *et al*. When do we need competing risks methods for survival analysis in nephrology? *Nephrol Dial Transplant* 2013;28:2670–7.
38 Austin PC, Lee DS, Fine JP. Introduction to the analysis of survival data in the presence of competing risks. *Circulation* 2016;133:601–9.
39 Lau B, Cole SR, Gange SJ. Competing risk regression models for epidemiologic data. *Am J Epidemiol* 2009;170:244–56.
40 Williamson EJ, Aitken Z, Lawrie J, *et al*. Introduction to causal diagrams for confounder selection. *Respirology* 2014;19:303–11.
41 Williamson EJ, Walker AJ, Bhaskaran K, *et al*. Factors associated with COVID-19-related death using OpenSAFELY. *Nature* 2020;584:430–6.
42 R Core Team. *R: A Language and Environment for Statistical Computing [Internet*. Vienna, Austria: R Foundation for Statistical Computing, 2020. https://www.r-project.org

43 National Audit Office. The adult social care market in England, 2021. Available: https://www.nao.org.uk/report/adult-social-care-markets/
44 Office for National Statistics. Coronavirus (COVID-19) infection survey, UK, 2021. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/healthandsocialcare/conditionsanddiseases/bulletins/coronaviruscovid19infectionsurveypilot/27august2021
45 Office for National Statistics. Deaths registered Weekly in England and Wales, provisional: week ending, 2021. Available: https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/deathsregisteredweeklyinenglandandwalesprovisional/weekending20august2021
46 HEALTH Investigators, Bhandari M, Einhorn TA, *et al*. Total hip arthroplasty or hemiarthroplasty for hip fracture. *N Engl J Med* 2019;381:2199–208.
47 Zogg CK, Metcalfe D, Judge A, *et al*. Learning from England's best practice tariff: process measure pay-for-performance can improve hip fracture outcomes. *Ann Surg* 2022;275:506–14.
48 Papanicolas I, Figueroa JF, Schoenfeld AJ, *et al*. Differences in health care spending and utilization among older frail adults in high-income countries: ICCONIC hip fracture persona. *Health Serv Res* 2021;56 Suppl 3:1335–46.
49 Wignall A, Giannoudis V, De C, *et al*. The impact of COVID-19 on the management and outcomes of patients with proximal femoral fractures: a multi-centre study of 580 patients. *J Orthop Surg Res* 2021;16:155.
50 Royal College of Physicians. Facing new challenges: The National Hip Fracture Database report on 2020 [Internet], 2021. Available: https://www.nhfd.co.uk/20/hipfractureR.nsf/docs/2021Report
51 Collett D. Chapter 12 - Competing risks*In: modelling survival data in medical research*. 3rd editio. Chapman and Hall/CRC Press LLC, 2014.
52 Morciano M, Stokes J, Kontopantelis E, *et al*. Excess mortality for care home residents during the first 23 weeks of the COVID-19 pandemic in England: a national cohort study. *BMC Med* 2021;19:71.
53 Burton JK, Bayne G, Evans C, *et al*. Evolution and effects of COVID-19 outbreaks in care homes: a population analysis in 189 care homes in one geographical region of the UK. *Lancet Healthy Longev* 2020;1:e21–31.
54 National Audit Office. Readying the NHS and adult social care in England for COVID-19, 2021. Available: https://www.nao.org.uk/wp-content/uploads/2020/06/Readying-the-NHS-and-adult-social-care-in-England-for-COVID-19.pdf