Predictors of short-term outcomes after postoperative periprosthetic femoral fracture

a UK linked data analysis

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Aims
Postoperative periprosthetic femoral fractures (POPFFs) following hip and knee arthroplasty are increasing. They often have poor outcomes. We have limited understanding of the predictors of these outcomes, which this study addresses.

Methods
We extracted administrative hospital data for patients aged 18 years and above with admissions to NHS hospitals in England with a primary diagnosis of POPFF between April 2016 and December 2022, including demographic characteristics, comorbidities, surgery for POPFF, admission source, outpatient department (OPD) appointments, and pre-POPFF admissions. Data were linked to the national death register. The most relevant available hospital-level key performance indicators (KPIs) were taken from the National Hip Fracture Database (NHFD). We used multilevel models with random intercepts for hospitals to predict in-hospital death, 30-day death, length of stay (LOS) above the upper quartile, and 30-day emergency readmission.

Results
A total of 33,728 patients were included, with a median age of 82 years (IQR 73 to 88); 65.9% were female. In total, 1,510 deaths occurred within 30 days of admission. In multiple regression models, age was associated with higher mortality and longer LOS. Females showed lower odds of mortality and 30-day readmission. Congestive heart failure and liver disease were more strongly linked to all adverse outcomes than were other comorbidities. Fixation (odds ratio (OR) 0.72, 95% CI 0.64 to 0.81) and revision (OR 0.78, 95% CI 0.68 to 0.91) were associated with lower 30-day mortality but longer hospital stays than having neither procedure. Previous hip fracture was associated with 30-day readmission and longer LOS but not with mortality. Admission from a care home was associated with higher 30-day mortality (OR 1.70, 95% CI 1.31 to 2.39), but shorter LOS. Previous any-cause emergency admissions and missed outpatient appointments were associated with worse outcomes. Hospital-level NHFD KPIs for POPFF and admission numbers for POPFF were not associated with any outcome.

Conclusion
We identified several patient factors, but no hospital factors, associated with adverse short-term outcomes following POPFF admission.

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Take home message

- Several patient factors, such as age, missed outpatient appointments, and comorbidities, were associated with adverse short-term outcomes following postoperative periprosthetic femoral fracture admission.
- This knowledge may help inform perioperative care strategies and suggests that optimizing patients' medical conditions might have a role in preventing some short-term outcomes, such as 30-day readmission.

Introduction

Improvements in clinical outcomes following hip and knee arthroplasty and a reduction in revisions related to bearing wear and common complications such as implant loosening or dislocation mean that orthopaedic surgeons' focus has shifted more to concerns over postoperative periprosthetic femoral fracture (POPFF).[1,2]

The outcome for patients sustaining POPFF is often poor. A meta-analysis of 35 cohorts, including 4,841 patients, reported a one-year mortality of 13.4%,[1] a figure supported by a more recent analysis of the National Joint Registry linked to Hospital Episodes Statistics (HES) database.[3] Gausden et al[4] showed that 19% of patients with POPFF require reoperation within two years; our team's recent national analysis in England showed a reoperation rate of 6.5% within the first year.[5] Additionally, a multicentre study indicated that 11.8% and 3% of POPFF treated with fixation and revision, respectively, were readmitted within 30 days after surgery;[6] the emergency 30-day readmission rate was 13% in our study for all POPFFs combined.[5] The length of hospital stay is usually prolonged, being 15 days on average[6-8] and thereby associated with high costs and demand on healthcare resources.[9]

Predicting outcomes after POPFF is less frequently documented than for hip fractures.[6,7] Moreover, existing studies are limited to analyzing patient-level data without considering both the patient-level and hospital-level factors, and sample sizes were small, well under 1,000. The evidence base would also benefit from national data to predict post-surgery outcomes. This lack of evidence prevents clinicians from properly informing patients and their families about the potential impact of this injury on their wellbeing and health outcomes.

As part of the PROFOUND study, this paper aims to address this gap, using national administrative patient-level and hospital-level data to predict outcomes after POPFF, including in-hospital death, 30-day total mortality (i.e. in or out of hospital), emergency 30-day readmission, and length of stay (LOS).

Methods

We analyzed administrative HES data, which capture all admissions to NHS Trusts in England (a Trust can comprise multiple hospital sites), for patients aged 18 years and above with the primary diagnosis (i.e. the main problem treated) of POPFF via the International Classification of Diseases of the World Health Organization (ICD)-10 code M96.6,[10] irrespective of the previous hip or knee procedure. We included records with discharge dates falling between April 2016 and December 2022. For patients with more than one fracture, we took their first according to the admission date. As M96.6 is not specific to the femur, we excluded records where any secondary procedure code indicated another bone.

We merged the HES data with hospital-level information from the National Hip Fracture Database (NHFD)[11] to obtain the key performance indicators (KPIs) (Table I). Such KPIs are not yet defined specifically for POPFFs, but we included them due to some similarities in the case-mix, treatment aims, and perioperative challenges faced by both sets of patients. The NHFD publishes KPI data at hospital site level, so we included the name of the trust for each site in the NHFD file, and then we merged POPFF records with HES by the site where possible and by the Trust where not. If a trust had multiple sites and only one was in the NHFD file, we excluded other sites of the same trust. Non-NHS (i.e. private sector) healthcare organizations in the HES dataset were excluded as they are not in the NHFD.

Patient characteristics

We extracted each patient's age, sex, ethnicity, urban or rural dwelling, comorbidities, admission source, outpatient department (OPD) appointments, emergency admissions within 12 months prior to the POPFF admission, day of the week of the POPFF admission date, and treatment for POPFF (fixation alone, revision with or without fixation, or neither) as patient-level predictors. We also flagged prior admissions for hip fracture since April 2000 (the first HES year for which we had access). The hospital-level predictors were KPIs from the NHFD files (reported as percentages) and hospital POPFF volume.

We included a total of 33,728 admissions that were present in both the HES and the NHFD datasets, out of 39,035 patients in the HES dataset. The median age was 82 years (IQR 73 to 88), 65.9% were female, and comorbidity and prior hospitalization were common (Table II). Most patients had attended at least one OPD appointment for any reason in the previous 12 months, but nearly one in four had missed at least one appointment – these patients were, on average, older (median age 81 years vs 77 years) and with more comorbidities, but not dementia. There was a slight reduction in the proportion of fixations between 2016 and 2022, while the proportion of revisions increased (Supplementary Material).

Outcomes

The outcomes were in-hospital death, 30-day total mortality, emergency 30-day all-cause readmission, and length of stay in the acute hospital before any subsequent transfers ('pretransfer LOS'); note that if the patient was admitted to Hospital A but was transferred to Hospital B to undergo a procedure there, the procedure was captured, though only the stay at Hospital A was counted in the pretransfer LOS outcome. We dichotomized LOS to facilitate modelling given its skew (logarithm and other transformations did not allow linear regression). The threshold was the upper quartile (23 nights). The 30-day total mortality was derived using the date of death from the national death registry.

Statistical analysis

To predict outcomes, we ran two multilevel logistic regression models with random intercepts for hospitals, one with just patient factors and the second with both patient and hospital

Table I. National Hip Fracture Database key performance indicators for postoperative periprosthetic femoral fracture.

National Hip Fracture Database key performance indicators
Received a nerve block and admitted to a specialist ward within four hours of presentation
Reviewed by a senior orthogeriatric physician within 72 hours of presentation
Surgery on the day of or the day following presentation with hip fracture
Got out of bed by the day after surgery
Not delirious when assessed using the 4A test within 72 hours of surgery
Return to original residence by four months after hip fracture
Known to still be on bone protection medication four months after hip fracture

factors. Variables were all entered together, with no variable selection. The area under the receiver operating characteristic curve (AUC) values measured discrimination, while Brier scores assessed overall model fit. All analyses used R software (R Project for Statistical Computing, Austria). Statistical significance was set at $p < 0.05$.

Results

There were 15,700 deaths in total, 1,373 of which occurred in hospital, and 1,510 occurred within 30 days of POPFF in or out of hospital; 1,059 (77.1%) of in-hospital deaths also occurred within 30 days.

Table III shows the results of the multiple regression model for patient factors. Age was associated with higher odds of mortality and longer pretransfer LOS. Female sex was associated with lower odds of mortality and 30-day readmission. Among the comorbidities, arrhythmias, diabetes, renal failure, cancer, liver disease, and congestive heart failure (CHF) were associated with all outcomes, with the strongest associations observed for liver disease and CHF. Prior hip fracture was associated with higher odds of 30-day readmission, longer pretransfer LOS, and 30-day total mortality. We also found associations between the other patient factors – care home residence, prior emergency admissions, and prior OPD appointments not attended – and several outcomes. There was no significant pattern between the day of the week of admission and surgical procedures, but we observed a higher in-hospital risk of death among patients admitted over the weekend (Supplementary Material).

Patients receiving fixation (OR 0.72, 95% CI 0.64 to 0.81) or revision treatment (OR 0.78, 95% CI 0.68 to 0.91) had lower 30-day mortality than those who received neither fixation nor revision. Fixation was associated with lower odds of 30-day readmission (OR 0.81, 95% CI 0.75 to 0.88), while revision was not. Fixation and revision were associated with longer pretransfer LOS (see also the crude proportion in the Supplementary Material), with a stronger association observed for revision than fixation. In-hospital mortality did not significantly differ by procedure group. Weekend admission was associated with higher in-hospital mortality and longer pretransfer LOS but not with 30-day total mortality or 30-day emergency readmission.

Hospital volume was associated with the proportion of patients having a hip revision (Spearman correlation 0.19, p = 0.04o), but not with the proportion having fixation (Spearman correlation -0.13, p = 0.151, Supplementary Material). In contrast, no hospital factors were associated with our outcomes either before or after adjusting for patient factors (Table IV). Hospital performance as defined by the NHFD POPFF KPIs were not associated with any of our outcomes.

The AUC values for in-hospital death, 30-day mortality, 30-day readmission, and long LOS were 0.81, 0.78, 0.62, and 0.72, respectively (higher values are better). The Brier scores for these outcomes were 0.04, 0.04, 0.11, and 0.17, respectively (lower values are better).

Discussion

Main findings

Our analysis of national data identified several patient factors significantly associated with worse outcomes. Older age, arrhythmia, diabetes, renal failure, cancer, liver disease, and CHF were associated with all outcomes. Fixation or revision treatment had lower 30-day mortality but higher odds of a long pretransfer stay compared with neither. Fixation had lower odds of 30-day readmission, but revision did not.

Prior hip fracture admission was associated with higher odds of 30-day readmission and long LOS, but not mortality. Admissions from care homes were associated with increased 30-day mortality, but shorter LOS. Pre-POPFF emergency admissions were linked with all outcomes except 30-day mortality. Similarly, missing prior OPD appointments was associated with long stays and readmissions, but not mortality. Hospital-level factors, which were hospital volume and NHFD KPIs, were not associated with any outcomes.

The models' predictive performance was moderate and insufficient for patient-level prediction, with mortality and LOS performing much better than readmission, a common finding.

Comparison with the literature

We observed 4.1% and 4.5% in-hospital death and 30-day total mortality, respectively. Jain et al[6] reported 3.2% of deaths within 30 days after admission for POPFF; this was 5.2% and 9.4% in the COMPOSE[7] and Moreta et al[12] studies, respectively. The updated figure has also been presented recently by Lamb et al.[3] This variation could be explained by the difference in the number of hospital sites included as we included all public sites, and in the prevalence of the different types of fractures or depending on the surgical treatments considered. The type of fracture was not recorded in our data, so we included all types.

In our models, comorbidities, particularly CHF and liver disease, were associated with all outcomes. This knowledge may help to inform perioperative care strategies and suggests that optimizing patients' medical conditions might have a role in preventing some short-term outcomes such as 30-day readmission. However, the feasibility of this approach depends on the underlying disease and its current management. Some conditions could already be optimally managed, and others may require advanced interventions for full optimization (e.g. biventricular pacemaker for CHF or transjugular intrahepatic portosystemic shunt for liver disease). Both scenarios would

Table II. Patient characteristics.

Variable	Data
Female sex, n (%)	22,218 (65.9)
Median age, yrs (IQR)	82 (73 to 88)
Age group, yrs, n (%)	
18 to 44	850 (2.5)
45 to 64	2,978 (8.8)
≥ 65	29,900 (88.7)
Ethnic group, n (%)	
White	30,115 (89.3)
Asian	424 (1.2)
Black	168 (0.5)
Other	366 (1.1)
Not known	2,655 (7.9)
Geographical location of residence, n (%)	
Urban	24,458 (72.9)
Town	3,843 (11.5)
Rural	5,224 (15.6)
Admitted from usual residence, n (%)	26,520 (78.6)
Admitted from care home, n (%)	487 (1.4)
Admitted from other location, n (%)	6,721 (20.0)
Emergency admissions for any reason in the previous 12 mnths, n (%)	
0	25,641 (76.0)
1	3,033 (9.0)
2	2,096 (6.2)
3+	2,958 (8.8)
No. of OPD appointments attended for any reason in the previous 12 mnths, n (%)	
0	7,160 (21.6)
1	3,994 (12.0)
2	3,361 (10.1)
3+	18,713 (56.3)
No. of OPD appointments for any speciality not attended in the previous 12 mnths, n (%)	
0	26,068 (78.5)
1	4,434 (13.3)
2	1,450 (4.4)
3+	1,276 (3.8)
Dementia, n (%)	4,697 (13.9)
Delirium, n (%)	2,384 (7.1)
No. of Elixhauser index comorbidities, n (%)	
0	5,210 (15.5)
1 to 2	15,732 (46.6)
3 to 4	9,346 (27.7)
5 to 6	2,855 (8.5)
> 6	585 (1.7)
Elixhauser index comorbidities, n (%)	
Hypertension	17,449 (51.7)
Arrhythmias	8,253 (24.5)
Chronic pulmonary disease	6,141 (18.2)
Diabetes mellitus	5,573 (16.5)
Renal failure	5,266 (15.6)
Fluid and electrolyte disorders	3,912 (11.6)
Hypothyroidism	3,387 (10.0)
Congestive heart failure	3,183 (9.4)
Rheumatoid arthritis/collagen vascular diseases	2,841 (8.4)
Depression	2,684 (8.0)
Valvular disease	2,675 (7.9)
Other neurological disorders	2,345 (7.0)
Obesity	2,122 (6.3)
Deficiency anaemia	1,563 (4.6)
Alcoholism	1,325 (3.9)
Peripheral vascular disorders	1,221(3.6)
Solid tumour without metastasis	1,144 (3.4)
Liver disease	683 (2.0)
Pulmonary circulation disorders	510 (1.5)
Metastatic cancer	427 (1.3)
Paralysis	369 (1.1)
Others*	< 1%
Treated with fixation and not revision, n (%)	14,105 (41.8)
Treated with revision with or without fixation, n (%)	6,721 (19.9)
Treated with other procedure, n (%)	2,437 (7.2)
No surgical procedure recorded, n (%)	9,145 (27.1)
Total	33,728

*Others included coagulopathy, weight loss, peptic ulcer disease, psychosis, lymphoma, drug abuse, and blood loss anaemia; each was less than 1%.
OPD, outpatient department.

leave little scope for improvement given the emergent nature of the presentation and timeframes involved in treatment.

Although treating with fixation or revision was associated with longer LOS than conservative management, it was linked with lower 30-day mortality and 30-day readmission rates, and the effect was more evident for fixation. The shorter LOS in those not managed with fixation or revision

Table III. Regression model results for patient-level variables.

Factors in models	In-hospital death, OR (95% CI)	30-day total mortality, OR (95% CI)	30-day readmission, OR (95% CI)	Long LOS, OR (95% CI)
Age, per yr	1.08 (1.07 to 1.09)	1.08 (1.07 to 1.09)	1.01 (1.01 to 1.02)	1.05 (1.04 to 1.05)
Sex, female	0.73 (0.65 to 0.82)	0.70 (0.63 to 0.79)	0.83 (0.77 to 0.89)	1.03 (0.97 to 1.09)
Geographical location				
Urban	Ref	Ref	Ref	Ref
Town	1.02 (0.85 to 1.22)	0.97 (0.82 to 1.15)	0.89 (0.80 to 0.99)	0.99 (0.91 to 1.08)
Rural	0.94 (0.80 to 1.11)	0.95 (0.82 to 1.12)	0.88 (0.80 to 0.97)	0.88 (0.81 to 0.95)
Treatment				
Revision	1.15 (0.98 to 1.34)	0.78 (0.68 to 0.91)	1.04 (0.96 to 1.14)	2.46 (2.29 to 2.64)
Fixation	0.93 (0.82 to 1.06)	0.72 (0.64 to 0.81)	0.81 (0.75 to 0.88)	1.70 (1.60 to 1.81)
Neither	Ref	Ref	Ref	Ref
Hip fracture prior to POPFF				
None	Ref	Ref	Ref	Ref
1	1.03 (0.90 to 1.18)	1.13 (1.00 to 1.28)	1.09 (1.01 to 1.19)	1.16 (1.09 to 1.24)
2	1.02 (0.75 to 1.38)	1.02 (0.77 to 1.36)	1.36 (1.14 to 1.62)	0.99 (0.85 to 1.15)
Comorbidities				
Arrhythmia	1.48 (1.31 to 1.67)	1.35 (1.20 to 1.52)	1.13 (1.04 to 1.22)	1.23 (1.15 to 1.30)
Diabetes	1.32 (1.15 to 1.52)	1.22 (1.07 to 1.40)	1.08 (0.99 to 1.18)	1.22 (1.14 to 1.31)
Hypertension	0.85 (0.75 to 0.95)	0.87 (0.78 to 0.97)	0.97 (0.91 to 1.04)	1.03 (0.98 to 1.09)
COPD	1.47 (1.28 to 1.68)	1.32 (1.16 to 1.51)	1.25 (1.15 to 1.36)	1.16 (1.08 to 1.23)
Renal failure	1.45 (1.27 to 1.65)	1.35 (1.19 to 1.53)	1.12 (1.02 to 1.23)	1.16 (1.08 to 1.25)
Liver disease	2.07 (1.48 to 2.91)	2.00 (1.44 to 2.79)	1.30 (1.05 to 1.61)	1.35 (1.13 to 1.62)
PVD	1.45 (1.15 to 1.82)	1.31 (1.05 to 1.65)	1.02 (1.86 to 1.21)	1.07 (0.94 to 1.22)
Valvular	1.17 (0.99 to 1.38)	1.03 (0.87 to 1.22)	1.04 (0.92 to 1.17)	1.29 (1.18 to 1.41)
CHF	2.43 (2.11 to 2.80)	1.96 (1.71 to 2.26)	1.17 (1.04 to 1.31)	1.31 (1.20 to 1.43)
Cancer	1.67 (1.34 to 2.07)	1.90 (1.55 to 2.32)	1.15 (0.98 to 1.35)	1.25 (1.10 to 1.42)
Source of admission				
Usual residence	Ref	Ref	Ref	Ref
Care home	1.03 (0.71 to 1.51)	1.77 (1.31 to 2.39)	1.09 (0.84 to 1.41)	0.50 (0.40 to 0.63)
Other locations	0.20 (0.16 to 0.25)	0.35 (0.29 to 0.43)	0.93 (0.85 to 1.01)	0.70 (0.64 to 0.74)
Emergency admissions for any reason in the previous 12 mnths				
0	Ref	Ref	Ref	Ref
1	1.14 (0.93 to 1.39)	1.25 (1.05 to 1.50)	1.22 (1.09 to 1.36)	1.08 (1.00 to 1.19)
2	1.24 (1.01 to 1.53)	1.33 (1.10 to 1.62)	1.32 (1.16 to 1.50)	1.15 (1.04 to 1.28)
3+	1.57 (1.33 to 1.85)	1.53 (1.31 to 1.79)	1.55 (1.39 to 1.72)	1.32 (1.21 to 1.45)
No. of OPD appointments for any speciality not attended in the previous 12 mnths				
0	Ref	Ref	Ref	Ref
1	1.12 (0.95 to 1.32)	1.16 (1.00 to 1.35)	1.24 (1.13 to 1.36)	1.15 (1.07 to 1.25)
2	1.07 (0.82 to 1.39)	0.94 (0.72 to 1.22)	1.51 (1.31 to 1.74)	1.46 (1.29 to 1.66)
3+	1.31 (0.99 to 1.73)	1.14 (0.87 to 1.51)	1.59 (1.37 to 1.86)	1.62 (1.41 to 1.85)
Weekend admission vs weekday	1.14 (1.01 to 1.29)	1.03 (0.91 to 1.16)	0.99 (0.92 to 1.07)	1.09 (1.03 to 1.16)

CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; LOS, length of stay; OPD, outpatient department; OR, odds ratio; POPFF, postoperative periprosthetic femoral fracture; PVD, peripheral vascular disease.

Table IV. Regression model results for hospital-level variables only.

Factor in model	In-hospital death, OR (95% CI)	30-day total mortality, OR (95% CI)	30-day readmission, OR (95% CI)	LOS, OR (95% CI)
Admission to specialist ward	1.01 (0.91 to 1.13)	1.03 (0.95 to 1.12)	0.98 (0.90 to 1.06)	1.10 (0.98 to 1.25)
Prompt orthogeriatric review	0.96 (0.94 to 0.99)	0.98 (0.97 to 1.00)	1.02 (1.00 to 1.04)	0.99 (0.97 to 1.02)
Prompt surgery	0.99 (0.95 to 1.03)	1.01 (0.99 to 1.04)	1.00 (0.97 to 1.03)	0.97 (0.93 to 1.01)
Prompt mobilization	0.99 (0.96 to 1.02)	1.01 (0.99 to 1.04)	1.01 (0.99 to 1.03)	0.98 (0.95 to 1.02)
Not delirious postoperatively	1.01 (0.99 to 1.04)	1.01 (0.99 to 1.03)	0.98 (0.97 to 1.00)	1.01 (0.98 to 1.04)
Return to original residence	1.00 (0.96 to 1.05)	1.00 (0.97 to 1.04)	1.02 (0.99 to 1.06)	1.00 (0.95 to 1.06)
Bone medication	1.01 (0.98 to 1.04)	0.99 (0.97 to 1.01)	1.01 (0.99 to 1.03)	1.01 (0.98 to 1.04)
Hospital volume per 10 admissions pear year	0.99 (0.99 to 1.00)	1.00 (0.99 to 1.00)	1.00 (1.00 to 1.00)	0.99 (0.99 to 1.00)

LOS, length of stay; OR, odds ratio.

may reflect selection, with those with stable fracture patterns not requiring surgery to mobilize selected for conservative management. One possible explanation that 30-day total mortality, but not in-hospital mortality, varied by the type of surgery is that some patients who were managed nonoperatively might be transferred to rehabilitation facilities not contributing records to HES (e.g. local authority or privately owned intermediate care). This would have the effect of reducing the nonoperative group's in-hospital deaths but not its total 30-day deaths. A recent study[13] shows that treatment mode is not associated with in-hospital mortality. This aligns with our research; however, our analysis shows that patients treated with fixation or revision had better 30-day survival than those who received neither fixation nor revision. This may reflect some patients being selected for nonoperative treatment as they are perceived to be too unwell for a big operation. The COMPOSE study showed that LOS differs by type of treatment, in which patients with a revision had the longest stays, followed by those with a fixation, and lastly nonoperative management, which was associated with higher mortality but not with 30-day readmission.[7] However, that study did not adjust the models for comorbidities; the conservative treatment management was associated with higher mortality compared with fixation in Moreta et al[12] study, who did adjust the model for comorbidities, though the 95% CI was extremely wide, ranging between 3.7 and 366.1 and 1.7 and 47.3, for 30-day and one-year mortality, respectively, indicating small numbers and biased estimates; there was no significant difference between revision and fixation in mortality rates.

We found that older age and comorbidities increase the risk of all mentioned outcomes; prior fracture was associated with longer LOS and higher odds of 30-day readmission but not with mortality. While Finlayson et al[14] reported that American Society of Anesthesiologists physical status grade 3 and 4 and additionally active neoplasia are major predictors for one-year mortality, Gitajn et al[15] identified the number of comorbidities (Charlson Comorbidity Index) as the main risk factor. Older age is also a known risk factor in several studies.[16–18]

Our finding that missed outpatient appointments prior to POPFF were associated with higher odds of long stays and unplanned readmission (though not with short-term mortality) warrants some discussion. Few databases capture missed appointments, but HES is one that does. In other patient groups, such as those with chronic obstructive pulmonary disease or heart failure, missing appointments is associated with worse outcomes.[19] Non-attendance has been shown to be due to forgetfulness (cognitive impairment is common in POPFF patients), apathy, medical issues, clerical or transport problems, among other factors.[20] We adjusted for HES-recorded dementia and other comorbidities, so missed appointments probably captures other unrecorded medical and psychosocial issues that lead to longer stays and more readmissions.

Hospital volume was not associated with any outcomes in our study, despite the 'volume-outcome relation' having been demonstrated in many other areas of surgery.[21] This might be due to selection effects and the fact that we combined patients with revision, fixation, and neither into the same analysis rather than stratifying by treatment as is done in procedure-specific studies focusing on the volume-outcome relation. However, as a sensitivity analysis for this specific relation, we stratified by procedure type and again saw no volume-outcome relations.

We did not observe any relation between the type of surgical procedure and day of the week of admission. However, admission at the weekend was associated with increased odds of in-hospital death, consistent with the findings of a systematic review and meta-analysis for emergency admissions for other patient groups.[22] Aylin et al[23] have shown that odds of 30-day mortality are also higher for elective surgical procedures implemented during the weekend or later in the working week.

To our knowledge, no published studies have predicted post-POPFF outcomes using hospital factors. However, much work has been done on hip fractures. While many hospital factors are associated with outcomes in patients with hip fractures, some factors available for predicting POPFF outcomes were not found to be associated in our study. The REDUCE study[24] showed that orthogeriatric and physiotherapy factors reduce the risk of death and are associated with shorter LOS in patients with hip fractures. The REDUCE record-linkage study[25] also indicated that prompt mobilization predicts two days shorter LOS, and many organizational factors, such as prompt surgery and community therapy, soon after discharge, reduce the risk of death and the 30-day readmission, respectively. Additionally, geriatric assessment within 72 hours of admission and timely operations within 36 hours was strongly associated with mortality following hip fractures.[25,26] However, many of these organizational factors were unavailable in the NHFD files in our study.

This is the first study to investigate predicting POPFF results using patient-level and hospital-level factors. It benefits from uniform national data collection and a healthcare system that provides free access at the point of service, with minimal private emergency care. It is by far the largest study on POPFFs examining predictors of patient outcomes. Linkage of HES with the national death registry captured post-discharge deaths.

A limitation is that, if the patient had no procedure, some non-femoral fractures would be classified as ICD-10 M96.6 because no related anatomical diagnosis codes define the bone and/or joint involved. In addition, as is familiar with administrative data, some comorbidities are likely under-recorded, and disease severity is limited. Furthermore, because we rely on Office of Population Censuses and Surveys (OPCS) operation codes, we need more surgical details, such as the Vancouver categorization[27] or Unified Classification System[28] for Periprosthetic Fractures and the use of screws or nails. Most patients who were managed conservatively would either have had a minor fracture (Vancouver A), typically with a short stay, or have been too frail to be considered for surgery, typically with a much longer stay. We do not believe that HES can be used to distinguish reliably between these two groups. Length of stay calculations may also vary between hospitals. We have assumed that the first hospital a patient is admitted to is where they have received their definitive treatment. This will not be the case if a patient is transferred for surgery (giving a falsely low LOS) and in cases where patients are discharged to community hospitals for rehabilitation, which will also give a falsely low LOS figure. Lastly, we used NHFD hospital-level data as we did not have access to patient-level NHFD records, and the NHFD KPIs are designed for patients with hip fractures, not POPFF, so may be of limited relevance despite the similarities between these patient groups.

In conclusion, we identified several patient-level but not hospital-level factors associated with poorer short-term outcomes. Patients treated with either fixation or revision had better outcomes than those managed nonoperatively. Being older, frail, and having comorbidities makes managing POPFF more complex.

Supplementary material

Time trends, length of stay, and other information for fixations and revisions and by day of the week.

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Data sharing

The datasets generated and analyzed in the current study are not publicly available due to data protection regulations. Access to data is limited to the researchers who have obtained permission for data processing. Further inquiries can be made to the corresponding author.

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Ethical review statement

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