Between-hospital variability in the management and outcomes of postoperative periprosthetic femoral fractures

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Cite this article:
Bone Jt Open 2025;6(9):
1013–1021.

DOI: 10.1302/2633-1462.69.BJO-2025-0050.R1

Aims

Postoperative periprosthetic femoral fractures (POPFFs) following hip arthroplasty pose complex challenges, with differences in management and outcomes across healthcare facilities. However, there is limited published literature on such variability to inform improvement initiatives. This study aims to quantify the between-hospital variations in surgical management and short-term outcomes.

Methods

Administrative hospitalizations data from all 177 NHS hospital Trusts in England were analyzed for patients aged 18 years and above with a primary diagnosis of POPFF between April 2016 and December 2022. Patient demographic characteristics, comorbidities, procedures, length of stay, in-hospital mortality, 30-day total mortality (in or out of hospital), and emergency 30-day all-cause readmissions were extracted. Multilevel models with random intercepts for hospitals and funnel plots assessed the non-random variations between hospitals in procedures and outcomes.

Results

Among 39,035 hospitalized patients, 66% were female (n = 25,720), with a median age of 82 years (IQR 73 to 88). Hospital variation existed in treatment outcomes, with adjusted intraclass correlation coefficients for fixation without revision, revision, and no surgical procedure of 4.0%, 3.8%, and 2.4%, respectively. Funnel plots revealed hospital outliers for procedure choice after adjusting for age, sex, and number of comorbidities – among 177 hospitals, nine (5.1%) exceeded the upper 95% control limit for fixation and 17 (9.6%) did so for revision; outlier proportions were 14.1% for length of stay, 3.9% for emergency 30-day readmission, and 1.1% for mortality.

Conclusion

Inter-hospital variation exists for the management and short-term outcomes following POPFFs in England. This warrants further explanation to better understand the reasons for this.

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Take home message

- In this analysis of national data, we found notable variation between hospitals in choice of surgery and short-term outcomes for postoperative periprosthetic femoral fractures.
- Efforts to better understand the underlying reasons for these variations, and to achieve more consensus on management, are needed.

Introduction

Over recent years, there has been growing attention on periprosthetic fractures around hip and knee arthroplasties.[1] This is likely to increase in coming years: a recent National Joint Registry (NJR) study predicts a 38% increase in UK total hip arthroplasty (THA) surgeries by 2060.[2] Postoperative periprosthetic femoral fractures (POPFFs), which include other prostheses (e.g. fixation or hemiarthroplasty following hip fracture), are also increasing.[3-5] The reasons for this likely include expanding surgical indications and an ageing, increasingly frail population.[6,7] Our previous study indicated a year-on-year increase of 13% in admissions for periprosthetic fractures in England.[8] Identification of UK patients who have sustained POPFFs has historically been limited to those undergoing revision surgery, due to data capture by the NJR. The NJR started to collect details of patients undergoing fixation surgery for POPFF in June 2023, but these data are likely to take time to mature.

The increasing numbers of POPFFs means that it is crucial for us to understand the complex challenge of managing patients with these fractures, which may have significant clinical and workforce implications. The complexity arises from several factors.[9] These include patient characteristics such as age and comorbidity,[10,11] the choice between conservative management, fixation, and revision ('re-do') joint arthroplasty for optimal treatment,[12] and decision-making complexities related to fracture location and extent, prosthesis stability, and available bone stock.[13] The techniques used for fracture reduction and the specific construct configuration further complicate the management process.[14] Furthermore, the availability of specialized skills in revision joint arthroplasty and orthopaedic trauma,[15] as well as suitable implant options,[16] significantly influence the overall strategy and, ultimately, patient outcome.

Unlike primary hip fractures, which are typically managed according to relatively standardized pathways based on clinical evidence, patients sustaining POPFFs do not have recognized pathways, leading to uncertainty about the optimal approach. About one in four do not undergo surgery, and it is sometimes less clear what happens to these patients in terms of pain relief, care, and complications.[9] There can be differences in management by type of hospital: major trauma centres,[17] despite offering a wide range of surgical expertise for severely injured patients, may encounter priority conflicts, potentially causing delays for other patients as well as those with POPFFs. On the other hand, less specialized trauma units may have easier access to operating lists but may lack specific surgical skills. There are also differences in orthogeriatric care between hospitals; transfer between these centres is feasible after stabilization and adequate analgesia (e.g. peripheral nerve block), but this approach may be complicated by the facilities and multidisciplinary care required for individuals with multiple comorbidities and frailty. While hospitalization for POPFF is generally an emergency, leaving patients with limited time for decision-making, these factors may contribute to variability in the management between hospitals, resulting in different outcomes.

To our knowledge, no previous study has examined the variability in the management and outcomes of POPFFs across different healthcare facilities. This study aims to address the current research gap by quantifying the existing variability in the management and short-term outcomes of POPFFs across different hospitals.

Methods

We analyzed administrative Hospital Episode Statistics (HES) data, which capture all admissions to NHS hospital Trusts in England (a Trust can comprise multiple hospital sites). We included patients aged 18 years and above with via the International Classification of Diseases of the World Health Organization, 10th revision (ICD-10) code M96.6 ('Fracture of bone following insertion of orthopaedic implant, joint prosthesis, or bone plate') as the primary diagnosis, representing the main problem treated.[18] We included records with discharge dates falling between April 2016 and December 2022. For the 3,321 (7.7%) patients with more than one fracture, we took their first according to the date of admission. As M96.6 is not specific to the femur, we excluded records where any secondary procedure code indicated another joint or bone.

We extracted details on patient factors, procedures, and short-term outcomes. Patient demographics encompassed sex, age, ethnicity, and type of geographical location (urban, town, or rural). Secondary diagnosis fields were used to identify the Elixhauser comorbidity index,[19] dementia, and delirium. Details on the procedure performed for POPFF are recorded in HES using the UK's Office of Population Censuses and Surveys (OPCS) classification.[20] We sought primary or secondary procedure codes for fixation without revision, revision with or without fixation, other orthopaedic procedure, and no major procedure. The outcomes were in-hospital mortality, 30-day total mortality (in or out of hospital, captured via linkage to the national death register), hospital length of stay (LOS) in nights, and emergency 30-day all-cause readmission to any hospital in England.

Patient characteristics

We included a total of 39,035 hospitalization patients. Approximately 66% (25,720) were female. The median age was 82 years (IQR 73 to 88). Nearly half had one or two comorbidities, while one in six had none (Table I).

Statistical analysis

Using multilevel models with random intercepts for hospitals, and funnel plots, we examined variations between hospitals in procedures and outcomes. The models were adjusted for patient demographic characteristics and comorbidities with no selection of variables. The variations were quantified using the intraclass correlation coefficient (ICC) and median odds ratios (MOR) obtained from the multilevel models: the former estimates the variation within a cluster, and the latter estimates the variation between clusters. The MOR is the median of the set of odds ratios between two randomly chosen POPFF patients with the same characteristics but

Table I. Patient characteristics.

Variable	Value
Total number of patients	39,035
Female sex, n (%)	25,720 (65.9)
Median age, yrs (IQR)	82 (73 to 88)
Age group, n (%)	
18 to 44 yrs	995 (2.5)
45 to 64 yrs	3,450 (8.8)
≥ 65 yrs	34,590 (88.6)
Ethnic group, n (%)	
White	34,986 (89.6)
Asian	472 (1.2)
Black	188 (0.5)
Other	402 (1.0)
Not known	2,987 (7.7)
Geographical location, n (%)	
Urban	28,420 (73.2)
Town	4,397 (11.3)
Other (mostly rural)	5,990 (15.4)
Dementia, n (%)	5,366 (13.7)
Delirium, n (%)	2,725 (7.0)
Number of Elixhauser comorbidities, n (%)	
0	6,085 (15.6)
1 to 2	18,161 (46.5)
3 to 4	10,846 (27.8)
5 to 6	3,278 (8.4)
> 6	665 (1.7)
Elixhauser comorbidity index, specific conditions, n (%)	
Hypertension	20,189 (51.7)
Arrhythmias	9,491 (24.3)
Chronic pulmonary disease	7,098 (18.2)
Diabetes mellitus	6,472 (16.6)
Renal failure	6,096 (15.6)
Fluid and electrolyte disorders	4,496 (11.5)
Hypothyroidism	3,882 (9.9)
Congestive heart failure	3,668 (9.4)
Rheumatoid arthritis/collagen vascular diseases	3,300 (8.5)
Depression	3,112 (8.0)
Valvular disease	3,111 (8.0)
Other neurological disorders	2,642 (6.8)
Obesity	2,516 (6.4)
Deficiency anaemia	1,767 (4.5)
Alcoholism	1,511 (3.9)
Peripheral vascular disorders	1425 (3.7)
Solid tumour without metastasis	1311 (3.4)
Liver disease	781 (2.0)
Pulmonary circulation disorders	586 (1.5)
Metastatic cancer	490 (1.3)
Paralysis	432 (1.1)
Coagulopathy	360 (0.9)
Weight loss	299 (0.8)
Peptic ulcer disease	210 (0.5)
Psychoses	192 (0.5)
Lymphoma	163 (0.4)
Drug abuse	140 (0.4)
Blood loss anaemia	102 (0.3)

admitted to different hospitals (clusters), so higher MORs imply more variation between hospitals in outcomes. Due to its skew, even after log-transformation, LOS was categorized into a binary variable based on the upper quartile (< 23 nights vs ≥ 23 nights). From the funnel plots, we assessed the variation as the number of outliers at 95% and 99% control limits without adjustment for overdispersion, employing Poisson limits. Not adjusting for overdispersion allows us to show the variation only above that due to randomness (sampling error) and makes no assumptions about the causes of any non-random variation found. We also calculated the ratio of observed to expected outcomes and procedures to count risk-adjusted outliers (adjusting for age, sex, and number of comorbidities). A p-value < 0.05 was considered statistically significant throughout.

Results

The variation in outcomes between hospitals is presented in Table II. The adjusted ICCs for treatment, when calculated separately as proportions receiving revision, fixation, and no surgical procedure, were small, as were the ICCs for the outcomes. The adjusted MORs were moderate, ranging between 1.15 and 1.43 for the procedures and outcomes.

The unadjusted variations between hospitals in fixation, revision, no surgical procedure, in-hospital death, emergency 30-day readmission, and LOS are illustrated in Figures 1 to 6. Among the 177 hospitals, 29 (16.3%) exceeded the upper 95% control limit for fixation, and 32 (18%) did so for revision. After adjusting for age, sex, and number of comorbidities, this fell to nine (5.1%) and 17 (9.6%) for fixation and revision, respectively, and considerably reduced the number of both low and high outliers in general. Details are shown in Table III.

Table II. Summary of between-hospital variations in outcomes.

Outcome	Median hospital-level value (IQR)	Unadjusted ICC, %	Adjusted ICC, %	Unadjusted MOR (95% CI)	Adjusted MOR (95% CI)
Revision, %	20.1 (19.7 to 20.5)	4.2	3.8	1.43 (1.39 to 1.47)	1.41 (1.38 to 1.45)
Fixation, %	41.4 (40.9 to 41.9)	3.9	4.0	1.41 (1.38 to 1.45)	1.42 (1.38 to 1.46)
No surgical procedure, %	27.2 (26.7 to 27.6)	2.7	2.4	1.34 (1.31 to 1.37)	1.31 (1.31 to 1.33)
In-hospital death, %	4.1 (3.9 to 4.3)	1.1	1.6	1.20 (1.18 to 1.21)	1.25 (1.23 to 1.27)
Length of stay, no. nights	14 (7 to 23)	5.1	5.2	1.49 (1.45 to 1.54)	1.50 (1.46 to 1.55)
Emergency 30-day readmission, %	13.0 (12.7 to 13.3)	1.7	1.5	1.25 (1.23 to 1.27)	1.23 (1.21 to 1.25)
30-day total mortality, %	4.5 (4.3 to 4.7)	0.7	1.0	1.15 (1.14 to 1.16)	1.19 (1.17 to 1.20)

ICC, intraclass correlation coefficient; MOR, median odds ratio.

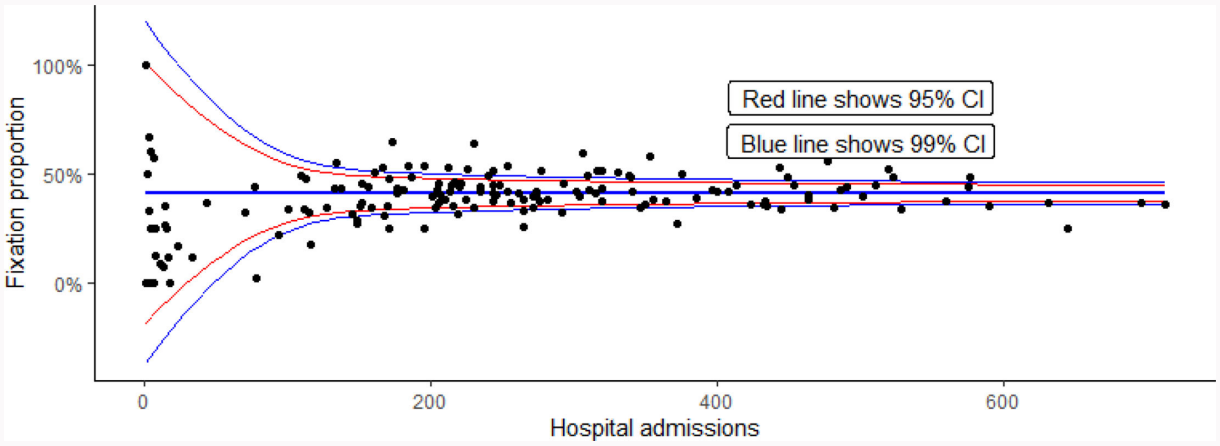


Fig. 1
Funnel plot of fixation proportion of postoperative periprosthetic femoral fractures in England, unadjusted.

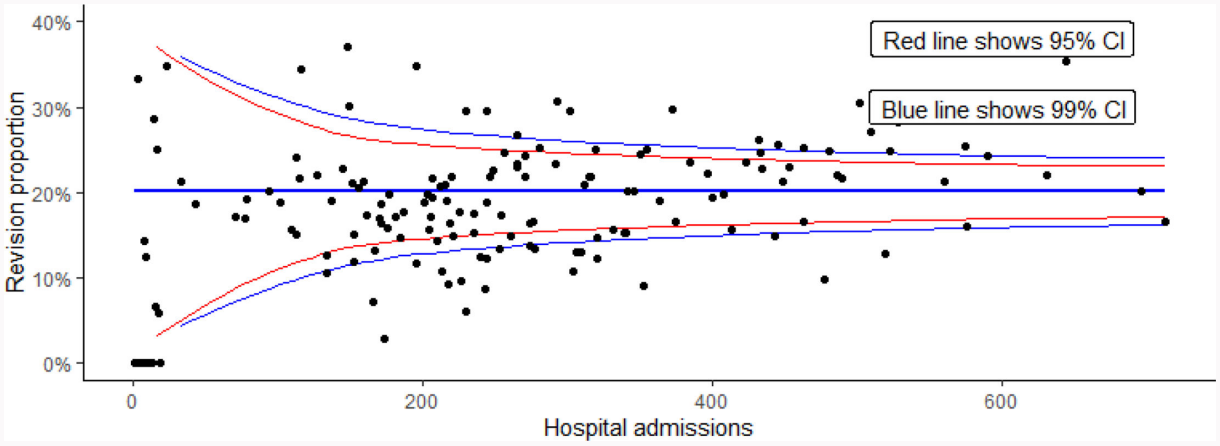


Fig. 2
Funnel plot of revision proportion of postoperative periprosthetic femoral fractures in England, unadjusted.

Discussion

Our analysis of national administrative data showed moderate between-hospital variability in the surgical management and short-term outcomes following POPFFs. However, this variation fell considerably after adjusting for available patient factors and was less pronounced for 30-day readmission and

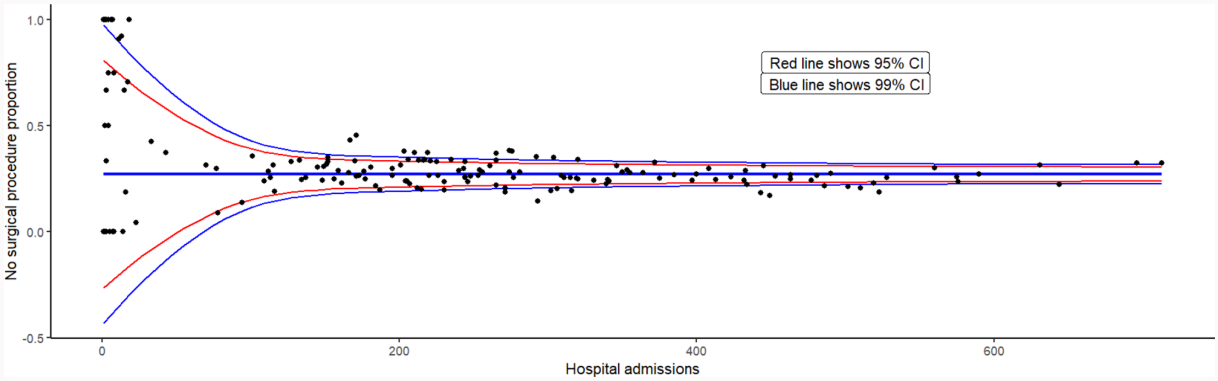


Fig. 3
Funnel plot of no surgical procedure proportion of postoperative periprosthetic femoral fractures in England, unadjusted.

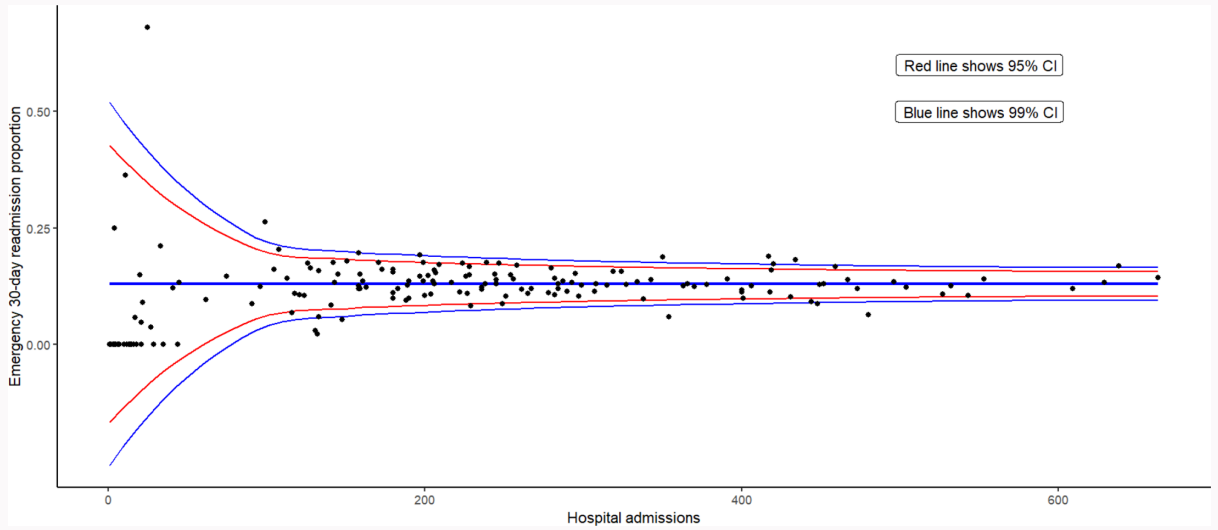


Fig. 4
Funnel plot of proportion of postoperative periprosthetic femoral fractures followed by emergency 30-day readmission in England, unadjusted.

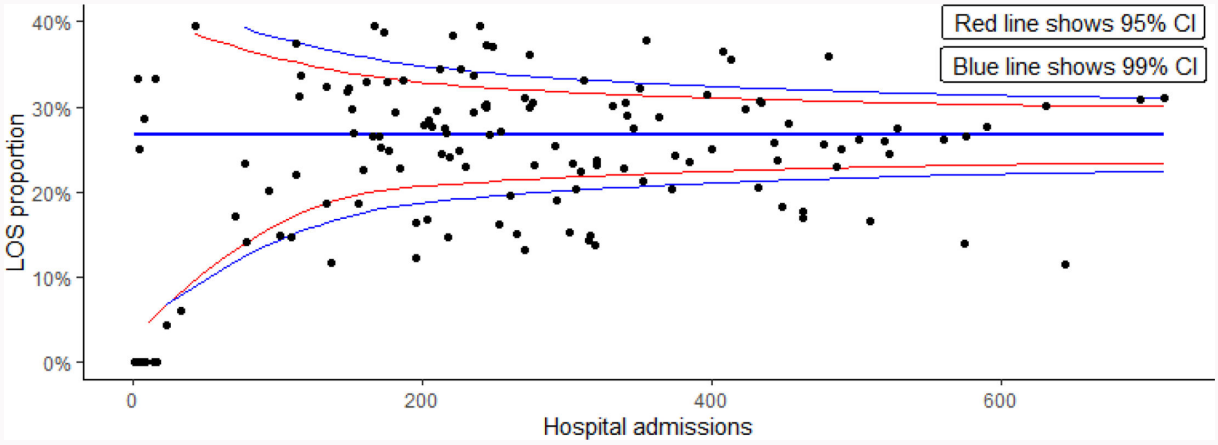


Fig. 5
Funnel plot of long length of stay (LOS) (≥ 23 nights) proportion of postoperative periprosthetic femoral fractures in England, unadjusted.

in-hospital death, although it remained considerably more than what would be expected just by chance.

To our knowledge, there are no published studies of inter-hospital variation in management or outcomes for POPFFs. Work using the National Hip Fracture Database (NHFD), which now includes data on POPFFs, describes how services available to patients with POPFF vary by hospital, though NHFD data for these fractures is still incomplete.[21]

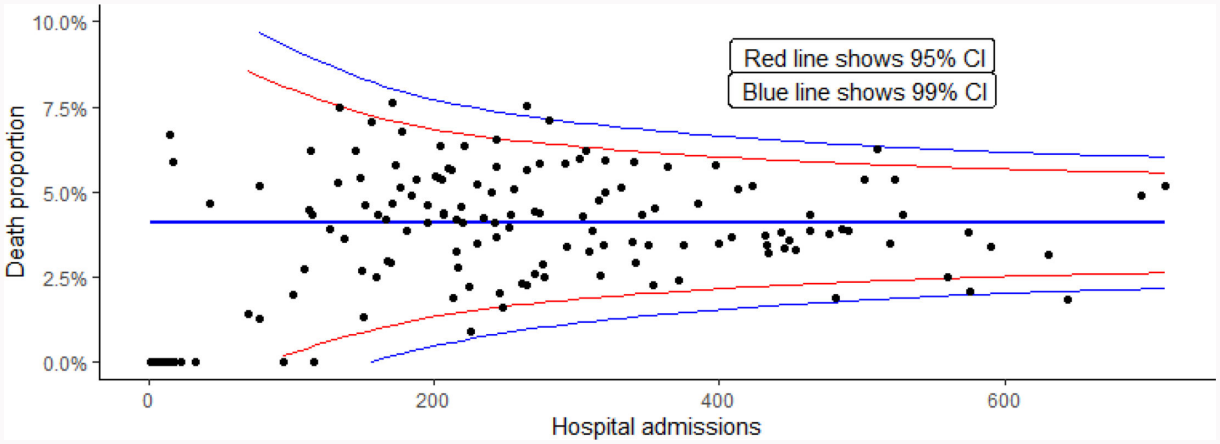


Fig. 6
Funnel plot of proportion of postoperative periprosthetic femoral fractures resulting in in-hospital death in England, unadjusted.

Table III. Frequency of hospitals exceeding and falling below the 95% control limits by procedure and outcome.

	Above the upper 95% control limit, n (%)		Below the lower 95% control limit, n (%)	
Variable	**Crude**	**Adjusted***	**Crude**	**Adjusted***
In-hospital death	5 (2.8)	2 (1.1)	7 (3.9)	0
Fixation	29 (16.3)	9 (5.1)	40 (22.5)	8 (4.5)
Revision	32 (18.0)	17 (9.6)	35 (19.7)	7 (3.9)
LOS, dichotomized at the upper quartile	37 (20.9)	25 (14.1)	33 (18.6)	16 (9.0)
30-day readmission	14 (7.9)	7 (3.9)	14 (7.9)	2 (1.1)
No surgical procedure	42 (23.7)	21 (11.8)	25 (14.1)	5 (2.8)

*Adjusted for age, sex, and number of comorbidities.
LOS, length of hospital stay.

Its 2021 Facilities Survey revealed differences in specialist surgeon numbers, dedicated theatre lists, multidisciplinary team meetings, and transfers to other centres. The management of a given hypothetical clinical scenario also showed differences of opinion, with 75 centres proposing fixation, 35 suggesting revision surgery, and 48 proposing a combination of both revision and fixation. This corresponds with our findings from HES data.

Previous studies have shown variation in management strategies and postoperative outcomes. These studies indicate that treatment with fixation is preferred in roughly 70% to 90% of Vancouver type B1 fracture cases, while revision surgery is favoured in approximately 60% to 80% of type B2/B3 fracture cases.[22–24] Length of hospital stays (LOS) can vary significantly, with the median duration typically falling within the range of 14 to 21 days.[8,23,25,26] The reoperation proportion for periprosthetic fractures overall ranges from around 3% to 30% within a 90-day to two-year timeframe,[23,25] and 30-day post-surgery unplanned readmission proportions range from 1% to 12%.[23,25] Recent studies reveal that for type B periprosthetic fractures, one-year mortality can vary from approximately 6% to 40%, depending on factors such as type of fracture, patient age, and comorbidities.[22,23,25,27–30]

Evaluation of health service variability has previously been undertaken with the hip fracture population, whose characteristics have a lot of overlap with those of POPFF patients. Some studies in England and Wales show that the degree of institutionalized care required and mobility recovery following a hip fracture varies significantly between hospitals.[31–35] In 2020, 70% of the 63,284 patients with hip fractures had returned to their original homes within 120 days. However, this percentage ranged from 41% to 90% in different hospitals.[36] The recent REDUCE record-linkage study showed that factors like direct admission to a specialized ward, discussing treatment plans on admission, and feedback from local hip fracture audits improve outcomes.[37] In other hip fracture initiatives, early orthogeriatrician assessments and fracture liaison services were also associated with reduced mortality,[38] as were meetings discussing patient feedback.[38,39] A systematic review concluded that surgery within 36 hours post-injury, incentivized by tariffs, is strongly correlated with lower 30-day mortality.[40,41]

This study is the first to explore variability in the management and outcomes of POPFF across hospitals in England. It benefits from national data with mandatory, standardized data collection and a healthcare system with free access at the point of care, with negligible private emergency

care. However, it is important to note certain limitations when using administrative data and the ICD-10 code M96.6. If the patient had no procedure, then some non-femoral fractures would be included with M96.6, as there are no associated anatomical diagnosis codes to specify the bone and/or joint involved. Also, as is common with administrative data, there is likely some under-recording of comorbidities and very limited information on disease severity and test results.

Additionally, our need to rely on OPCS procedure codes, provided in the Supplementary Material, means that we lack more detailed injury and surgical information such as the Unified Classification System (UCS),[42] now collected by the NJR. We adjusted for age, sex, and comorbidities, which led to a notable reduction in between-hospital variation, and it is likely that further adjustment would lead to further reduction. Our dataset also does not include direct information on functional outcomes, which could significantly enhance discussions between clinicians and patients regarding the most appropriate management strategies.

In conclusion, our work has identified dozens of 'outlier' hospitals with non-random variation in surgical management and short-term outcomes between hospitals. Some of the explanation for such findings will lie in the lack of national guidelines and standards against which practice could be audited. Our work in this and other papers will help to inform understanding of this important condition. We hope to stimulate work to develop guidance so that POPFF care in England can be improved in the way that has been so successful for people with hip fracture.

Supplementary material

Office of Population and Censuses and Surveys code lists for the procedures.

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Funding statement

The author(s) disclose receipt of the following financial or material support for the research, authorship, and/or publication of this article: this study was funded by the National Institute for Health and Care Research (NIHR) Health Services and Delivery Research Programme, grant number NIHR135217 ("Periprosthetic femoral fractures: data, management and outcomes").

ICMJE COI statement

C. Shelton reports three institutional grants from the National Institute for Health and Care Research and three educational institutional grants from NHS England Workforce, Training and Education, all of which are unrelated to this study. C. Shelton also holds unpaid roles as co-chairperson of the Association of Anaesthetists Safety, Standards and Environmental Sustainability Committee, vice chairperson of the World Federation of Societies of Anaesthesiologists Sustainability Committee, and receives an honorarium from the Association of Anaesthesitsts as Editor of the journal Anaesthesia. T. O. Smith's institution has received research grants awarded from the UK NIHR for research in bone, joint and muscle diseases, unrelated to this study. M. R. Reed reports funding from Stryker, Zimmer Biomet, Heraeus, Link, Depuy, Smith & Nephew, Implantcast, Biocomposites, payment from Heraeus fror management time as Chief Investigator for an RCT, an educational grant for a fellow in his team from Zimmer Biomet, machine learning for risk prediction financial support from Microsoft, consulting fees from Heraeus Medical, Pharmacosmos, and Amotio, medical education payments from Zimmer Biomet, Heraeus Medical, Stryker, Pharmacosmos, and Ethicon sutures JNJ, and stock in Openpredictor Holdings Limited, OPCI Limited, Neuranics, and Amotio, all of which are unrelated to this study. M. R. Reed is also an unpaid trustee for OR-UK. M. A. Baxter reports consulting fees from Nuffield Health and textbook royalties from Medicine Publishing, and institutional research funding from Exeter, all of which are unrelated to this study. J. Evans reports grants from Orthopaedic

Research UK and AOUK, unrelated to this study. A. Johansen is Clinical lead for the National Hip Fracture Database (NHFD), the clinical audit of hip fracture in England, Wales and Northern Ireland, at the Royal College of Physicians, London. A. Bottle reports consulting fees from Eli Lilly and AstraZeneca, unrelated to this study. A. Bottle and P. Aylin's Unit is an academic unit in the Department of Primary Care and Public Health, within the School of Public Health, Imperial College London. The Unit is affiliated with the NIHR Imperial Biomedical Research Centre (BRC) and the NIHR Imperial Patient Safety Research Collaboration. The NIHR Imperial Patient Safety Research Collaboration is a partnership between Imperial College Healthcare NHS Trust and Imperial College London.

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.

Acknowledgements

This work is independent research supported by the NIHR Applied Research Collaboration Northwest London. The views expressed in this publication are those of the author(s) and not necessarily those of the National Institute for Health and Care Research or the Department of Health and Social Care.

Ethical review statement

Our unit has HRA approval to use HES data for research and measuring quality of delivery of healthcare, from the London – South East Ethics Committee (REC ref 20/LO/0611). The PROFOUND study has HRA approval for the quantitative analysis from Health and Care Research Wales, REC reference 23/LO/0196.

Open access funding

The open access fee for this article was funded by Imperial College London, UK.

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