Organisational factors associated with hospital costs and patient mortality in the 365 days following hip fracture in England and Wales (REDUCE): a record-linkage cohort study

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Summary

Background Hip fracture care delivery varies between hospitals, which might explain variations in patient outcomes and health costs. The aim of this study was to identify hospital-level organisational factors associated with long-term patient outcomes and costs after hip fracture.

Methods REDUCE was a record-linkage cohort study in which national databases for all patients aged 60 years and older who sustained a hip fracture in England and Wales were linked with hospital metrics from 18 organisational data sources. Multilevel models identified organisational factors associated with the case-mix adjusted primary outcomes: cumulative all-cause mortality, days spent in hospital, and inpatient costs over 365 days after hip fracture.

Findings Between April 1, 2016, and March 31, 2019, 178 757 patients with an index hip fracture were identified from 172 hospitals in England and Wales. 126 278 (70·6%) were female, 52 479 (29·4%) were male, and median age was 84 years (IQR 77–89) in England and 83 years (77–89) in Wales. 365 days after hip fracture, 50 354 (28·2%) patients had died. Patients spent a median 21 days (IQR 11–41) in hospital, incurring costs of £14 642 (95% CI 14 600–14 683) per patient, ranging from £10 867 (SD 5880) to £23 188 (17 223) between hospitals. 11 organisational factors were independently associated with mortality, 24 with number of days in hospital, and 25 with inpatient costs. Having all patients assessed by an orthogeriatrician within 72 h of admission was associated with a mean cost saving of £529 (95% CI 148–910) per patient and a lower 365-day mortality (odds ratio 0·85 [95% CI 0·76–0·94]). Consultant orthogeriatrician attendance at clinical governance meetings was associated with cost savings of £356 (95% CI 188–525) and 1·47 fewer days (95% CI 0·89–2·05) in the hospital in the 365 days after hip fracture per patient. The provision of physiotherapy to patients on weekends was associated with a cost saving of £676 (95% CI 67–1285) per patient and with 2·32 fewer days (0·35–4·29) in hospital in the 365 days after hip fracture.

Interpretation Multiple, potentially modifiable hospital-level organisational factors associated with important clinical outcomes and inpatient costs were identified that should inform initiatives to improve the effectiveness and efficiency of hip fracture services.

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Introduction

Hip fractures are among the most frequent and serious traumatic injuries sustained by adults over the age of 60 years. Each year, more than 70 000 older adults in the UK,[1] 610 000 in Europe,[2] and 200 000 in the USA[3] sustain a hip fracture, which equates to age-standardised hip fracture rates of 250 per 100 000 people in the UK, 157–439 per 100 000 in Europe, and 195 per 100 000 in the USA.[4] Hip fractures lead to increased mortality, lengthy hospital stays, and substantial reductions in quality of life.[1,5] These injuries place a large financial burden on health-care services, with inpatient costs from the past 10 years estimated to exceed £869 million in the UK[6] and US$5·96 billion in the USA.[7] The financial burden of hip fractures, driven by high secondary health-care use and long hospital stays,[6] are similar to the costs incurred in the year after a stroke[8] and exceed those of various common cancers.[9]

Hip fracture services are provided by complex multidisciplinary organisational structures. Hospitals report stark differences in patient outcomes such as mortality, functional recovery, and length of hospital stay,[1] all of which have cost implications. Although these differences are partly explained by patient-level variables, much of the remaining variation in hip fracture care delivery is hypothesised to be explained by organisational factors—ie, the set-up and organisation of health services, which can affect delivery of patient care and patient outcomes. Understanding predictors of variation in care delivery, effects on patient outcomes, and the drivers of health costs will inform service-level interventions to reduce unwarranted variations (ie, in

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Research in context

Evidence before this study

Hip fracture is an important cause of hospitalisation, disability, and death, and represents an indicator of the quality of delivery of complex care to older people. Despite established standards and guidelines, substantial variation in hip fracture care in the UK and worldwide persists. We searched MEDLINE using the keywords "hip fracture", "health service", "improvement", "quality", "length of stay", "mortality", "death", "bed days", or "costs" for articles in any language, published from database inception to Dec 31, 2022. Few studies assessed the multiple components of the hip fracture care pathway; most focused on single organisational factors or small composites across hospitals, and usually did not account for patients clustering. Most studies focused on short-term outcomes, such as 30-day mortality and length of stay. We have recently shown that several potentially modifiable organisational factors, such as prompt surgery, orthogeriatrician assessment, and postoperative physiotherapy, are associated with these short-term patient outcomes after hip fracture. A few studies examining the determinants of hip fracture care costs included hospital-specific factors (eg, patient volume), but we did not identify any study that focused specifically on the role of hospital-level organisational factors on long-term patient outcomes (eg, 1-year mortality and days spent in hospital over 1 year) or these associated health-care costs.

Added value of this study

We identify multiple organisational factors that can potentially be modified to increase the effectiveness and efficiency of hip fracture services to improve patient outcomes. Namely, prompt admission to a hip fracture ward, assessment by an orthogeriatrician, prompt postoperative mobilisation, 7-day physiotherapy provision, effective delirium avoidance, and clinical governance within a hospital equipped with a fracture liaison service were identified as characteristics of services with lower costs and better patient outcomes.

Implications of all the available evidence

Our data show the high health-care burden that follows hip fracture, with inpatient health costs varying substantially across UK regions and between National Health Service hospitals for no clinical reason. The identified organisational factors should be used to generate evidence-based quality improvement strategies for hip fracture services across the UK, to achieve financial savings and improved patient outcomes.

medical practice unexplained by medical need or evidence-based medicine), maximise value for money, and ultimately improve patient experiences.

This study, linking multiple national-level health-care datasets, aimed to establish which hospital-level organisational factors predicted patient outcomes in the first 365 days after hip fracture across England and Wales. We specifically aimed to assess all-cause mortality, the number of days spent in a National Health Service (NHS) hospital, and total direct inpatient health costs to identify areas on which potential cost-saving and national quality improvement initiatives should be focused.

Methods

Data sources and study population

Reducing Unwarranted Variation in the Delivery of High-Quality Hip Fracture Services in England and Wales (REDUCE)[10] was a record-linkage cohort study that used linked, anonymised patient-level data for index hip fracture cases from the routinely collected Hospital Episodes Statistics (HES) Admitted Patient Care database for NHS hospitals in England[11] and from its counterpart in Wales (the Patient Episode Database for Wales). Data were linked by the executive non-departmental public body NHS Digital to Office for National Statistics Civil Registration Deaths data,[10,12] and then to the National Hip Fracture Database (appendix p 4). The National Hip Fracture Database is a Healthcare Quality Improvement Partnership clinical audit, capturing data on hip fracture care from all NHS hospitals in England, Northern Ireland, and Wales.[13]

See Online for appendix

Ethical approval for this study was obtained from the NHS Health Research Authority, London City and East Research Ethics Committee (reference 20/LO/0101); the Royal College of Physicians Falls and Fragility Fracture Audit Programme (reference FFFAP/2018/003) and the Healthcare Quality Improvement Partnership (reference HQIP330); and the NHS Wales Informatics Service (reference NWIS/30941). We also obtained an NHS Digital Data Sharing Agreement (reference DARS-NIC-334549-B1Y6X-v1.4). The study protocol has been published previously.[10]

The study population consisted of all patients with an index hip fracture (ie, first occurrence of hip fracture for any given patient during the study period), among residents of England and Wales aged 60 years or older and presenting to an English or Welsh hospital between April 1, 2016, and March 31, 2019 (further details on the selection of the study population are in appendix p 2). Patient follow-up was planned for 365 days. This study was exempt from the requirement to obtain patient consent due to its registry data-based nature.

Organisational-level data

Service organisation data at the hospital or trust level included national audits, data series, and ratings, which are largely publicly available.[10] Using data from 18 multidisciplinary reports, an expert consensus review determined that 89 of 231 identified organisational factors (appendix pp 21–24) were relevant to patient stays in hospital and costs, and that 105 (appendix pp 21–24) were relevant to mortality outcomes in the 365 days after hip fracture.[10] Using the previously described systematic approach,[10] we mapped organisational factors that were potentially related to one or more patient outcomes to 14 domains of hip fracture care: emergency department; anaesthetic services; surgical services; orthogeriatric services; admission volume; nutrition assessment; delirium prevention; pain management; ward staffing and care; therapy provision; rehabilitation facilities; inpatient falls; hospital governance; and hip fracture service governance.

Outcomes

Patient outcomes were cumulative all-cause mortality, total number of days spent in an NHS hospital in England or Wales (for acute and post-acute care), and cumulative inpatient NHS costs (elective and non-elective), all measured over 365 days of follow-up from the time of hospital admission for hip fracture. Secondary analyses investigated cumulative inpatient NHS costs at 120 days after admission and cumulative outpatient, and emergency department NHS costs at 120 days and 365 days after hip fracture admission for patients in England only (because no outpatient and emergency department attendance data were available for admissions in Wales). Costs in the 120 days and 365 days before hip fracture were also calculated to adjust for expenditures associated with pre-existing conditions. Costs are presented by different patient subgroups and by government office region in England.

Health costs, cumulative mortality, and length of hospital stay

A consultant episode is defined as the time a patient spends in the continuous care of one consultant (ie, a hospital doctor of senior rank within a specific field) using hospital site or care home beds of one health-care provider or, in the case of shared care, in the care of two or more consultants. All finished consultant episodes in the 365 days before and after the index hip fracture admission were extracted from the HES Admitted Patient Care database for England and from the Patient Episode Database for Wales for each patient. All attended appointments were extracted from the HES Outpatients and Accident and Emergency data for England. All finished consultant episodes and emergency department episodes were assigned to a health-care resource group (groups of clinically similar treatments that consume similar levels of health-care resource) using the 2018–19 HRG4+ Reference Costs Grouper software.[14] Resource use was valued using 2019–20 prices obtained from the national collection of costs for NHS trusts.[15] We took a macro-costing approach to our analysis for generalisability and external validity of findings. The national unit costs applied are the weighted national average costs from all hospital trusts, averaging across low-cost and high-cost areas; London-weighting was not added to London hospitals to avoid over-representing their costs. For episodes for which a health-care resource group code could not be attached, we imputed costs with the weighted average of costs of procedures with missing health-care resource group codes from the 2019–20 cost schedule. For each patient, inpatient costs were aggregated for the 120 days and 365 days before and after the date of hip fracture admission. Outpatient appointments were valued on the basis of their service codes (ie, the specialty in which the attending physician was working during the period of care). We used a simple imputation method for cost of episodes and visits with missing health-care resource group codes or service codes and applied sensitivity analyses to these (appendix p 2).

The total number of days spent in an NHS hospital was derived from the HES Admitted Patient Care database for England and the Patient Episode Database for Wales. All days in hospital during the first 365 days after index hip fracture admission, both elective and non-elective, regardless of admission indication (acute, post-acute, and any NHS rehabilitation bed days), were included. Date of death was obtained from the Office for National Statistics Civil Registration of Deaths.

Statistical analysis

Multilevel regression models (logistic regression for mortality and linear regression for hospital days and health-care costs) were used to estimate associations between organisational-level factors and patient-level outcomes, adjusting for patient case-mix and, in the cost models, pre-fracture costs as well. The hierarchical data structure consisted of patients (level 1) nested within hospitals (level 2). Organisational factors were dichotomised, categorised, or, if continuous, converted to linear splines at quartiles or tertiles. Backward stepwise elimination identified the organisational factors most strongly associated with each outcome. Organisational factors were simplified by expert review (expert reviewers were CLG, JG, MKJ, YB-S, AJo, and TC) and splines were dichotomised, categorised at appropriate thresholds, or converted back to continuous measures on an appropriate scale. Patient case-mix adjustment was the same as that used in the National Hip Fracture Database clinical audit,[16] and included age (10-year age groups), sex, American Society of Anesthesiologists physical status classification of preoperative physical status,[17] hip fracture type, pre-fracture residence, and pre-fracture mobility. Statistical analyses were performed in Stata version 16.1 and MLwiN version 3.01 (Centre for Multilevel Modelling, University of Bristol, Bristol, UK). The significance threshold for p values was set at 0·05. STROBE guidance was followed for this study.[18]

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

Results

172 hospitals across England and Wales were included in this analysis. Between April 1, 2016, and March 31, 2019, 178 757 patients (126 278 [70·6%] women and 52 479 (29·4%) men; 168 359 [94·2%] from England and 10 398 [5·8%] from Wales; appendix p 4; table 1) were identified with an index hip fracture. Median age was 84 years (IQR 77–89) in England and 83 years (77–89) in Wales. During the study period, the 172 hospitals admitted a median of 1026 (IQR 759–1282) patients with hip fractures, with an annual (in 2018–19) mean of 355 (IQR 246–421) admissions for hip fractures (appendix p 5). All patients were followed-up for 365 days, or until death during this period. Median follow-up was 365 days (IQR 274–365).

50 354 (28·2%) of 178 757 patients died within 365 days of an index hip fracture admission (table 1); more than half of these deaths, 31 659 (17·7%), occurred within 120 days. 11 organisational factors were independently associated with mortality at 365 days (figure 1; appendix pp 6–7). Hospitals where all patients were assessed by an orthogeriatrician within 72 h of admission, where the

	Number of patients	Mortality at 365 days after hip fracture	Days spent in hospital over 365 days after hip fracture	Health costs per patient over 365 days after hip fracture, £
Total	178 757	50 354 (28·2%)	21 (11–41)	14 642 (9017)
Country				
England	168 359	47 507 (28·2%)	20 (11–40)	14 443 (8640)
Wales	10 398	2847 (27·4%)	29 (13–61)	17 857 (13 347)
Age, years				
60–69	16 062	2000 (12·5%)	12 (7–26)	13 468 (9924)
70–79	41 096	7556 (18·4%)	16 (9–35)	14 408 (9662)
80–89	80 863	23 149 (28·6%)	23 (12–44)	15 053 (8980)
≥90	40 736	17 649 (43·3%)	25 (13–45)	14 523 (7921)
Sex				
Female	126 278	31 405 (24·9%)	20 (11–39)	14 093 (8458)
Male	52 479	18 949 (36·1%)	23 (11–46)	15 962 (10 115)
American Society of Anesthesiologists physical status classification				
I or II	45 222	4405 (9·7%)	13 (8–27)	12 093 (7182)
III	102 323	29 317 (28·7%)	24 (13–45)	15 248 (9104)
IV or V	31 212	16 632 (53·3%)	25 (13–48)	16 345 (10 280)
Hip fracture type				
Intracapsular	105 082	28 022 (26·7%)	19 (10–38)	14 651 (8939)
Intertrochanteric, subtrochanteric, or other	73 675	22 332 (30·3%)	24 (12–45)	14 628 (9127)
Pre-fracture residence				
Own home or sheltered housing	146 642	34 678 (23·6%)	22 (11–44)	14 964 (9387)
Not own home or sheltered housing	32 115	15 676 (48·8%)	17 (10–31)	13 167 (6895)
Pre-fracture mobility				
Freely mobile without walking aids	66 440	10 625 (16·0%)	15 (8–30)	13 112 (8187)
Mobile outdoors with one or two aids or frame	66 521	19 547 (29·4%)	26 (14–48)	15 750 (9628)
Some indoor mobility or no functional mobility	45 796	20 182 (44·1%)	25 (13–47)	15 252 (8939)
Survival at 365 days after index fracture				
Survived	128 403	0	19 (10–37)	14 056 (8724)
Died	50 354	50 354 (100·0%)	27 (13–49)	16 135 (9563)
Ethnicity				
White	152 932	43 728 (28·6%)	21 (11–41)	14 628 (8864)
Non-Chinese Asian	2074	499 (24·1%)	24 (13–43)	15 806 (10 210)
Other	1206	287 (23·8%)	22 (12–41)	14 997 (9752)
Black	495	149 (30·1%)	26 (14–52)	16 722 (10 552)
Mixed	190	50 (26·3%)	24 (10–47)	15 549 (9763)
Chinese	150	29 (19·3%)	18 (11–39)	13 971 (8644)
Missing data	21 710	5612 (25·8%)	20 (10–42)	14 552 (9828)

Data are n (%), median (IQR), or mean (SD).

Table 1: **Cumulative mortality, days spent in an NHS hospital, and health costs per patient within the first 365 days after hip fracture admission in England and Wales, 2016–19**

orthogeriatric consultant attended the daily trauma meeting, and with clinical governance meetings attended by the nursing lead were associated with lower mortality (table 2). Mortality was also lower in hospitals with protocols in place for preoperative nutritional supplementation; with fracture liaison services (which systematically identify and assess people who have had a fragility fracture to reduce the risk of refracture); able to report their reoperation rates; and those that routinely reviewed patient experience feedback in hip fracture clinical governance meetings (table 2). By contrast, hospitals reporting 100% compliance with UK Best Practice Tariffs for fragility hip fracture care criteria for nutrition assessment and physiotherapy assessment recorded higher mortality rates, as did hospitals where a consultant surgeon attended clinical governance meetings and where a trauma and orthopaedic manager attended the daily trauma meeting (table 2).

Patients spent a median 21 days (IQR 11–41) in hospital in the first 365 days after hip fracture (20 days [11–40] in England and 29 days [13–61] in Wales; table 1). 24 organisational factors were independently associated with the mean number of days spent in hospital in the 365 days after hip fracture (figure 2; appendix pp 8–10). Provision of physiotherapy on Saturdays or Sundays was associated with fewer days in hospital per patient, as was consultant orthogeriatrician attendance at clinical governance meetings (table 2). Patients spent fewer days in hospitals that performed best in terms of provision of preoperative nerve blocks, use of total hip replacements for eligible patients, use of intramedullary nails for subtrochanteric fracture, prompt postoperative mobilisation (defined as mobilisation out of bed [standing or hoisted] by the day after the hip fracture surgery), and prevention of postoperative delirium, and in hospitals that had a fracture liaison service and where National Hip Fracture Database audit data were regularly disseminated to hip fracture team staff (table 2). Patients also spent fewer days in hospitals with a higher number of emergency admissions, in hospitals where the number of full-time equivalent for trauma and orthopaedic consultant surgeons was more than 17%, or where the number of hip fracture admissions recorded in the National Hip Fracture Database month was more than 27% or where a consultant orthogeriatrician attended the governance meeting (table 2).

Patients had spent more bed days in hospitals using protocols for preoperative fluid management, reporting 100% compliance with the Best Practice Tariff qualifier

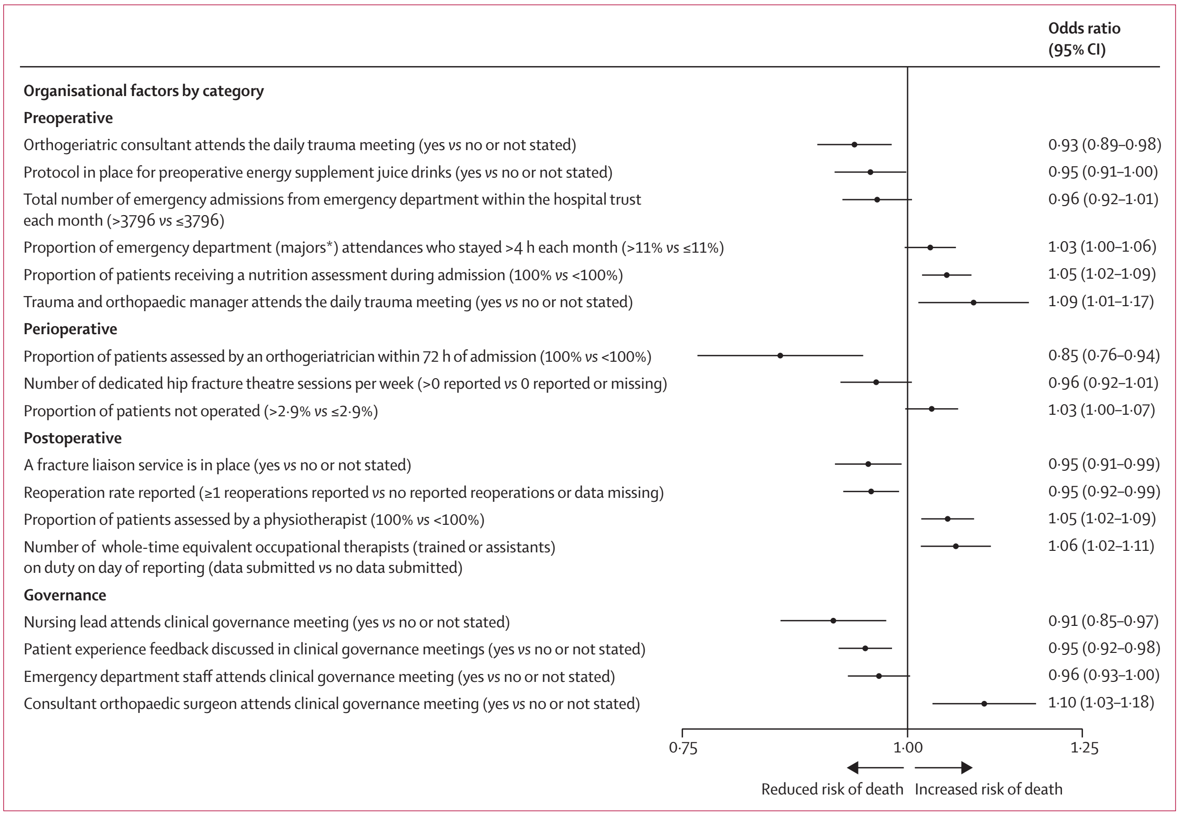

Figure 1: **Associations between organisational factors and mortality in the 365 days after hip fracture, accounting for patient case-mix**
Organisational factors adjusted for case-mix (age, sex, American Society of Anesthesiologists physical status classification, hip fracture type, prefracture residence, and prefracture mobility) and mutually adjusted for all backward-selected factors reported in the appendix (pp 6–7). Only factors with a p value of less than 0·1 are shown. Data are from 178 757 patients across 172 hospitals; intraclass correlation coefficient of the model 0·002 (95% CI 0·001–0·0030). *Patients who exhibit signs of being seriously ill but are not in immediate danger to life are triaged to majors.

	365-day mortality		Days spent in hospital		Health costs per patient, £	
	OR (95% CI)	p value	Days (95% CI)	p value	Cost per patient, £ (95% CI)	p value
Preoperative factors						
Orthogeriatric consultant attends daily trauma meeting (yes *vs* no or not stated)	0·93 (0·89–0·98)	0·0052	..	..	..	..
Protocol in place for preoperative energy supplement juice drinks (yes *vs* no or not stated)	0·95 (0·91–1·00)	0·042	..	..	..	..
Total number of emergency admissions from emergency department within the hospital trust each month (for mortality: >3796 *vs* ≤3796; for days: continuous, for every 100 emergency department admissions; for costs: >2970 *vs* ≤2970)	0·96 (0·92–1·01)	0·087	–0·09 (–0·11 to –0·07)	<0·0001	121 (–69 to 310)	0·21
Proportion of emergency department (majors*) attendances who stayed >4 h each month (for mortality: >11% *vs* ≤11%; for costs: >17% *vs* ≤17%)	1·03 (1·00–1·06)	0·082	..	..	–265 (–374 to –156)	<0·0001
Proportion of patients receiving a nutrition assessment during admission (100% *vs* <100%)	1·05 (1·02–1·09)	0·0019	..	..	–332 (–454 to –211)	<0·0001
Trauma and orthopaedic manager attends the daily trauma meeting (yes *vs* no or not stated)	1·09 (1·01–1·17)	0·019	..	..	..	..
Dedicated hip fracture ward to which patients can be admitted direct from emergency department (yes *vs* no or not stated)	..	..	–3·35 (–7·07 to 0·36)	0·077	..	..
Proportion of patients given a nerve block before surgery (>70% *vs* ≤70%)	..	..	–0·72 (–1·20 to –0·24)	0·0034	–37 (–172 to 97)	0·59
Protocol in place for preoperative fluid management (protocol reported *vs* no protocol reported)	..	..	2·65 (0·11 to 5·19)	0·041	..	..
Proportion of patients admitted to orthopaedic ward within 4 h of presentation to the emergency department (>23% *vs* ≤23%)	..	..	..	..	–339 (–498 to –181)	<0·0001
Consultant orthopaedic surgeon attends the daily trauma meeting (yes *vs* no or not stated)	..	..	1·41 (–2·12 to 4·94)	0·43	972 (–122 to 2065)	0·082
Perioperative factors						
Proportion of patients assessed by an orthogeriatrician within 72 h of admission (100% *vs* <100%)	0·85 (0·76–0·94)	0·0026	..	..	–529 (–910 to –148)	0·0066
Number of dedicated hip fracture theatre sessions per week (>0 reported *vs* 0 reported or missing)	0·96 (0·92–1·01)	0·085	..	..	..	..
Proportion of patients not operated (>2·9% *vs* ≤2·9%)	1·03 (1·00–1·07)	0·074	..	..	–203 (–337 to –68)	0·0032
Total full-time equivalent for trauma and orthopaedic consultant surgeons at the trust (for mortality and days: >17 *vs* ≤17; for costs: >25 *vs* ≤25)	1·00 (0·96–1·05)	0·84	–1·02 (–1·76 to –0·28)	0·0068	397 (143 to 651)	0·0022
Proportion of eligible patients receiving a total hip replacement (>40% *vs* ≤40%)	..	..	–0·67 (–1·19 to –0·16)	0·011	..	..
Proportion of subtrochanteric fractures receiving an intramedullary nail (>80% *vs* ≤80%)	..	..	–0·56 (–1·03 to –0·10)	0·016	..	..
Proportion of spinal anaesthetics accompanied by a nerve block (>19% *vs* ≤19%)	..	..	..	..	–126 (–256 to 5)	0·059
Proportion of arthroplasties cemented (100% *vs* <100%)	..	..	..	..	207 (27 to 388)	0·025
Orthopaedic NHFD lead has role reflected in their job plan (yes *vs* no or unknown)	..	..	..	..	209 (66 to 353)	0·0041
Total full-time equivalent for consultant anaesthetists at the trust (for days: >63 *vs* ≤63; for costs: >43 *vs* ≤43)	..	..	–0·18 (–1·21 to 0·86)	0·74	375 (138 to 611)	0·0019
Postoperative factors						
A fracture liaison service is in place (yes *vs* no or not stated)	0·95 (0·91–0·99)	0·021	–1·08 (–1·98 to –0·17)	0·020	..	..
Reoperation rate reported (one or more reoperations reported *vs* no reported reoperations or data missing)	0·95 (0·92–0·99)	0·011	..	..	..	..
Proportion of patients assessed by a physiotherapist (100% *vs* <100%)	1·05 (1·02–1·09)	0·0029	1·03 (0·61 to 1·45)	<0·0001	..	..
Number of whole-time equivalent occupational therapists (trained or assistants) on duty on day of reporting (data submitted *vs* no data submitted)	1·06 (1·02–1·11)	0·0069	–2·58 (–6·14 to 0·98)	0·16	..	..
Patients in hospital receive physiotherapy on Saturday, Sunday, or both (yes *vs* no weekend physiotherapy)	..	..	–2·32 (–4·29 to –0·35)	0·021	–676 (–1285 to –67)	0·030
Proportion of patients not delirious after surgery (>64% *vs* ≤64%)	..	..	–1·19 (–1·81 to –0·57)	0·0002	–258 (–431 to –85)	0·0008
Proportion of patients promptly mobilised (>71% *vs* ≤71%)	1·00 (0·96–1·05)	0·82	–1·07 (–1·80 to –0·34)	0·0040	–346 (–550 to –142)	0·0009
Hours of orthogeriatric support time by specialist nurse (≥1 h *vs* none or missing)	..	..	0·73 (0·11 to 1·35)	0·022	..	..
Hospital reports patients followed up at 120 days (at least some follow-up *vs* no follow-up or missing)	..	..	0·89 (0·20 to 1·57)	0·011	299 (109 to 490)	0·0020
Proportion of patients returning to original residence† (for mortality: >76% *vs* ≤76%; for costs: >65% *vs* ≤65%)	1·01 (0·96–1·05)	0·77	1·01 (0·30 to 1·71)	0·0050	105 (–86 to 297)	0·28
Number of days between discharge and start of community therapy reported (any data *vs* no data)	0·98 (0·93–1·04)	0·57	3·15 (1·12 to 5·19)	0·0024	615 (–12 to 1242)	0·054

(Table 2 continues on next page)

	365-day mortality		Days spent in hospital		Health costs per patient, £	
	OR (95% CI)	p value	Days (95% CI)	p value	Cost per patient, £ (95% CI)	p value
(Continued from previous page)						
Proportion of patients receiving an inpatient delirium assessment (100% *vs* <100%)	..	..	..	..	–275 (–412 to –138)	<0·0001
Proportion of patients receiving a bone health assessment during admission (100% *vs* <100%)	..	..	..	..	–157 (–301 to –12)	0·034
Proportion of patients receiving a falls assessment during admission (100% *vs* <100%)	..	..	..	..	184 (43 to 326)	0·011
Data submitted for average physiotherapy time (minutes) received in first week after surgery (any data *vs* no data)	..	..	..	..	654 (9 to 1299)	0·047
Governance factors						
Nursing lead attends clinical governance meeting (yes *vs* no or not stated)	0·91 (0·85–0·97)	0·0059	..	..	..	..
Patient experience feedback discussed in clinical governance meetings (yes *vs* no or not stated)	0·95 (0·92–0·98)	0·0019	..	..	258 (107 to 409)	0·0008
Emergency department staff attends clinical governance meeting (yes *vs* no or not stated)	0·96 (0·93–1·00)	0·072	..	..	..	..
Consultant orthopaedic surgeon attends clinical governance meeting (yes *vs* no or not stated)	1·10 (1·03–1·18)	0·0037	0·96 (0·25 to 1·66)	0·0078	–185 (–391 to 21)	0·078
Consultant orthogeriatrician attends clinical governance meeting (yes *vs* no or not stated)	..	..	–1·47 (–2·05 to –0·89)	<0·0001	–356 (–525 to –188)	<0·0001
NHFD data regularly disseminated to hip fracture ward staff (yes *vs* no or not stated)	..	..	–0·85 (–1·39 to –0·30)	0·0023	..	..
Community rehabilitation team attends clinical governance meeting (yes *vs* no or not stated)	..	..	0·81 (–0·12 to 1·74)	0·088	..	..
Clinical governance meetings are established (yes *vs* no or not stated)	..	..	1·52 (0·52 to 2·53)	0·0030	347 (82 to 611)	0·010
Teaching hospital (yes *vs* no)	..	..	2·14 (0·12 to 4·15)	0·038	..	..
Plans in place to reconfigure the local hip fracture service (yes *vs* no or not stated)	0·97 (0·92–1·03)	0·33	3·44 (1·13 to 5·75)	0·0035	1235 (519 to 1950)	0·0007
Physiotherapist attends clinical governance meeting (yes *vs* no or not stated)	0·97 (0·93–1·01)	0·18	..	..	289 (134 to 444)	0·0003
Workload factors						
Number of hip fracture admissions recorded in NHFD per month (for days: >27 *vs* ≤27; for costs: >45 *vs* ≤45)	..	..	–0·76 (–1·22 to –0·29)	0·0015	48 (–94 to 191)	0·51
Proportion of hip fractures occurring in inpatients (>5·1% *vs* ≤5·1%)	..	..	0·43 (–0·02 to 0·89)	0·061	180 (55 to 306)	0·0049
Mean number of trauma and orthopaedic beds occupied per day (per 10 beds)	..	..	0·93 (0·78 to 1·09)	<0·0001	–39 (–77 to –1)	0·046
Hours of orthogeriatric consultant direct clinical care per week (for days: >12 *vs* ≤12; for costs: >30 *vs* ≤30)	1·02 (0·98–1·07)	0·29	0·99 (0·25 to 1·72)	0·0086	985 (758 to 1212)	<0·0001

Data are shown for those factors included in the model for each outcome. Organisational factors adjusted for case-mix (age, sex, American Society of Anesthesiologists physical status classification, hip fracture type, prefracture residence, and prefracture mobility) and mutually adjusted for all backward-selected factors are reported in the appendix (pp 6–9, 14–16). NHFD=National Hip Fracture Database. OR=odds ratio. *Patients who exhibit signs of being seriously ill but are not in immediate danger to life are triaged to majors. †Return to original residence was defined as hospital discharge directly to the patient's original residence, or patient being at that residence at the 120-day follow-up.

***Table 2:* Summary of associations between organisational factors with mortality, days in hospital, and health costs per patient in the 365 days after hip fracture, accounting for patient case-mix (n=178 757)**

for physiotherapy assessment, with higher daily trauma and orthopaedic bed occupancies, and those reporting plans to reconfigure their local hip fracture service (table 2). Hospitals able to follow-up with patients at 120 days, that discharge a greater proportion of patients home (*vs* moving to an institution), and those that had local data to understand delays between discharge and the start of community rehabilitation also had a greater average number of hospital bed days (table 2). Patients also spent more days in teaching hospitals, in hospitals where governance meetings were established, or where hours of orthogeriatric consultant direct clinical care per week exceeded 12%. Many of these factors were common to the factors associated with costs.

Mean inpatient costs in the 365 days after index hip fracture admission were £14 443 (95% CI 14 233–14 314) in England and £17 602 (17 350–17 853) in Wales. 86·3% (£12 467 [95% CI 12 436–12 497]) of these costs in England and 90·1% (£16 083 [15 863–16 302]) of these costs in Wales occurred within the first 120 days (appendix p 11). Patients who died in the first 365 days after hip fracture incurred higher costs than those who survived (table 1).

Mean 365-day costs varied by government office region in England, ranging from £13 777 (95% CI 13 636–13 918) in the East Midlands to £16 128 (15 976–16 280) in London (figure 3). Furthermore, 365-day costs varied between the 172 hospitals in England and Wales, ranging from a mean per-patient cost of £10 867 (SD 5880) to £23 188 (17 223). Sensitivity analyses for the imputation of missing costs and outpatient and emergency department costs are described in the appendix (pp 3, 12–13).

25 organisational factors were independently associated with hospital inpatient costs in the 365 days following hip fracture (figure 4; appendix pp 14–16). In the preoperative factors category, hospitals admitting more than 23% (defined by the model spline) of patients with hip fracture to an orthopaedic ward within 4 h of presentation to the emergency department and hospitals recording higher proportions of stays longer than 4 h for all-cause emergency department attendances had lower costs per patient (table 2). In the preoperative and perioperative factors categories, hospitals providing orthogeriatrician assessment to all patients with hip fracture within 72 h of admission and hospitals providing nutritional assessment to all patients had lower costs per patient. Foregoing surgery (patients not operated) was uncommon but was associated with cost savings, whereas cementing of all arthroplasties was associated with greater costs. Costs were higher in hospitals with larger numbers of orthopaedic and anaesthetic consultants, and if an orthopaedic surgeon was scheduled to lead hip fracture care (table 2).

In the postoperative factors category, provision of physiotherapy on Saturdays or Sundays was associated with lower costs per patient (table 2). Hospitals able to promptly mobilise more than 71% of patients by the end of the first day after surgery also had lower costs per patient. Lower delirium rates and provision of delirium screening and bone health assessment to all patients were associated with lower inpatient costs (table 2; appendix pp 14–16). Hospitals with data available for the 120-day follow-up and for average physiotherapy time in the first week after surgery had higher costs.

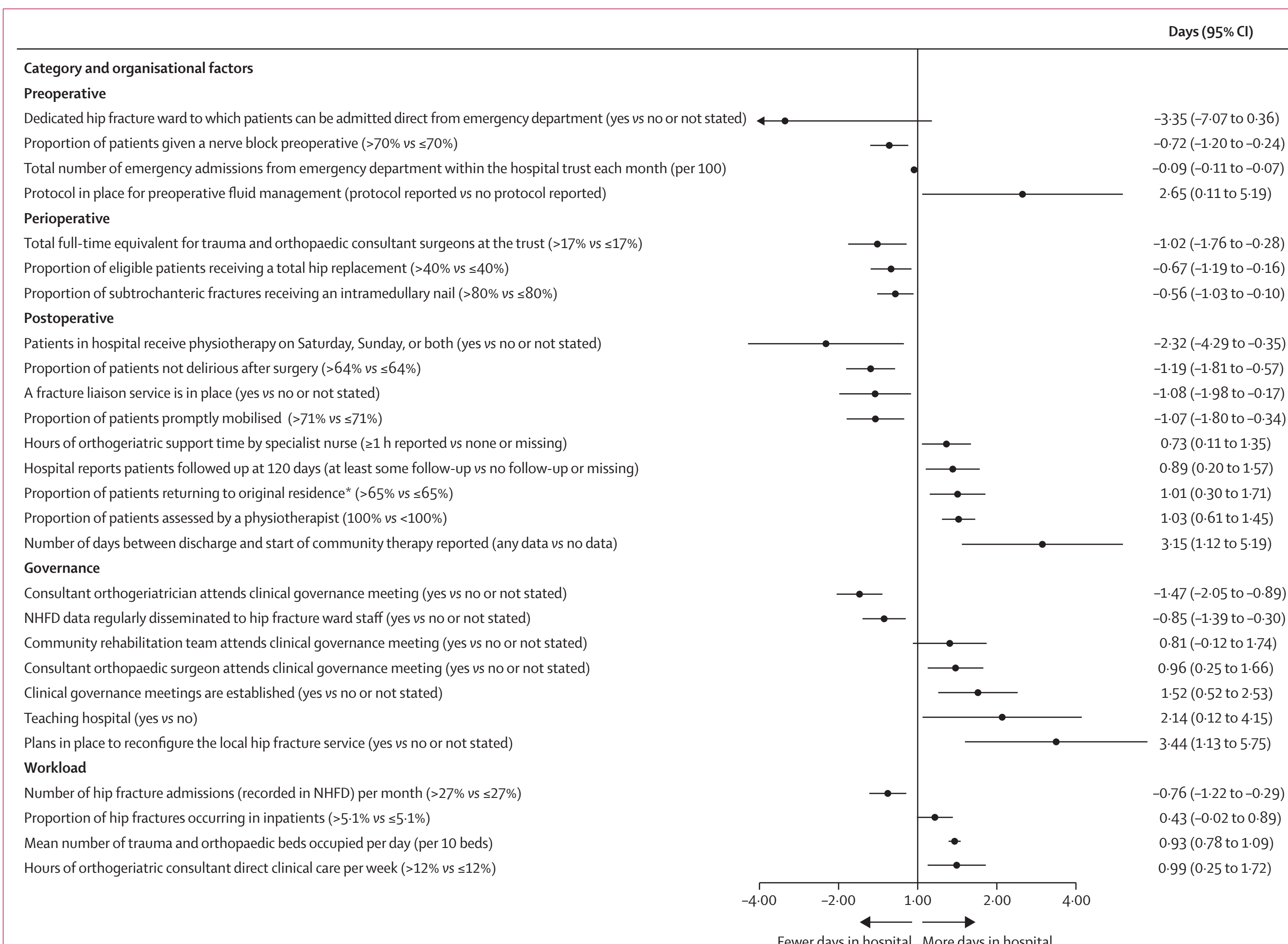

Figure 2: **Associations between organisational factors and days spent in an NHS hospital in the 365 days after hip fracture, accounting for patient case-mix**
Organisational factors adjusted for case-mix (age, sex, American Society of Anesthesiologists physical status classification, hip fracture type, prefracture residence, and prefracture mobility) and mutually adjusted for all backward-selected factors reported in the appendix (pp 8–9). Only factors with a p value of less than 0·1 are shown. Data from 178 757 patients across 172 hospitals; intraclass correlation coefficient of the model 0·032 (95% CI 0·026–0·040). NHFD=National Hip Fracture Database. *Return to original residence was defined as hospital discharge directly to the patient's original residence, or patient being at that residence at the 120-day follow-up.

Clinical governance meeting attendance by a consultant orthogeriatrician was associated with cost savings, whereas attendance by a physiotherapist was associated with higher costs (table 2). Having established clinical governance meetings and discussing patient experience feedback at these meetings was associated with higher costs. Having plans in place to reconfigure the local hip fracture service was associated with substantially higher mean per patient costs. Costs were lower in hospitals with higher daily trauma and orthopaedic bed occupancy and in those where fewer hip fractures (≤5·1%) were sustained by inpatients. Costs were higher in hospitals recording more than 30 sessions per week of direct clinical care by orthogeriatric consultants. Associations between organisational factors and 120-day costs were consistent with the associations observed for 365-day costs, although with some smaller effect sizes (appendix pp 17–20).

Discussion

Multiple organisational-level factors throughout the hip fracture care pathway, many of which are potentially modifiable, are associated with important clinical and financial outcomes. Our findings suggest that a hospital's ability to provide orthogeriatrician assessment to all patients within 72 h of admission was associated with potential cost savings of £529 per patient and with a lower odds ratio of 0·85 (0·76–0·94) for mortality at 365 days. Weekend physiotherapy provision was associated with an average of 2·32 fewer days in hospital and potential cost savings of £676 per patient. Prompt postoperative mobilisation and lower levels of delirium were both associated with cost and bed-day savings. Prompt admission to an orthopaedic ward within 4 h of hospital presentation was associated with cost savings and with bed-day savings if admission was directly to a dedicated hip fracture ward. Clinical governance metrics were associated with all outcomes, with consultant orthogeriatrician attendance associated with both cost savings (£356 per patient) and 1·47 fewer days in hospital in the 365 days after hip fracture. However, although discussing patient experience feedback at clinical governance meetings was associated with 5% lower mortality, it was also associated with higher costs (£258 per patient). Overall, all but two organisational factors listed in table 2 found to be associated with outcomes are potentially modifiable, with the exceptions being whether a hospital is a teaching hospital and the number of hip fracture admissions each month. We acknowledge that some modifications would be easier than others requiring substantial investments.

This study has shown the high health-care burden that follows a hip fracture: a 28·2% mortality at 365 days and the need to spend a median of 21 days in hospital during the first 365 days after fracture, accruing mean inpatient costs of £14 642 per patient—the majority (87·6%) of which were incurred within the first 120 days. We identified variations of twice as high costs between hospitals, and substantial variation between regions and countries, which is difficult to justify on clinical grounds and suggests that the role of organisational factors was not captured within this data-linkage. The differences between England and Wales in both inpatient bed-days and costs, although novel in the context of hip fracture, are consistent with those previously reported at a system level.[19] In England, emergency department and outpatient costs contributed to less than 7% of total costs, highlighting inpatient activity as the major cost driver. Notably, health-care costs for patients who died during the 365 days of follow-up were, on average, higher than for patients who survived.

The expense estimates in our study are slightly higher than in previous comparable UK studies,[6,20–23] probably reflecting more up-to-date costs. A recent international comparison across 11 countries identified substantial variation in health-care spending in the year after hip fracture, with the longest hospital stays seen in England. Our finding of mortality 365 days after hip fracture of 28·2% is consistent with rates reported as of 2011.[24] Since then, 30-day mortality has declined,[1,25] suggesting that short-term mortality has been reduced, potentially with concomitant higher inpatient costs. The findings extend a recent analysis of short-term hip fracture outcomes, which identified the importance of timely orthogeriatrician assessment and clinical governance leadership, as well as prompt postoperative mobilisation to reduce 30-day mortality and number of days that patients spend in hospital with the index hip fracture.[10] Our analyses highlight in particular the potential cost savings associated with weekend physiotherapy provision and with delirium prevention.

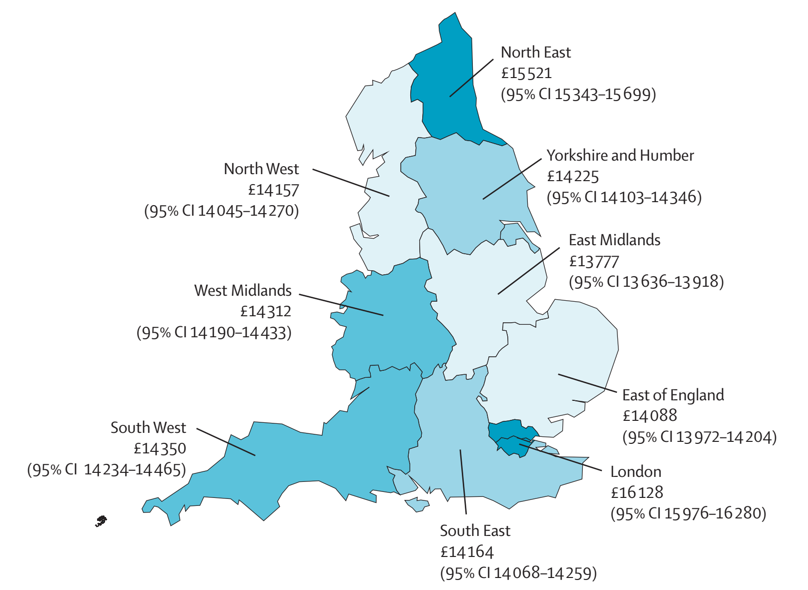

Figure 3: **Mean costs per patient in the 365 days after hip fracture admission in different government office regions within England**
Darker shaded areas correspond to greater average costs.

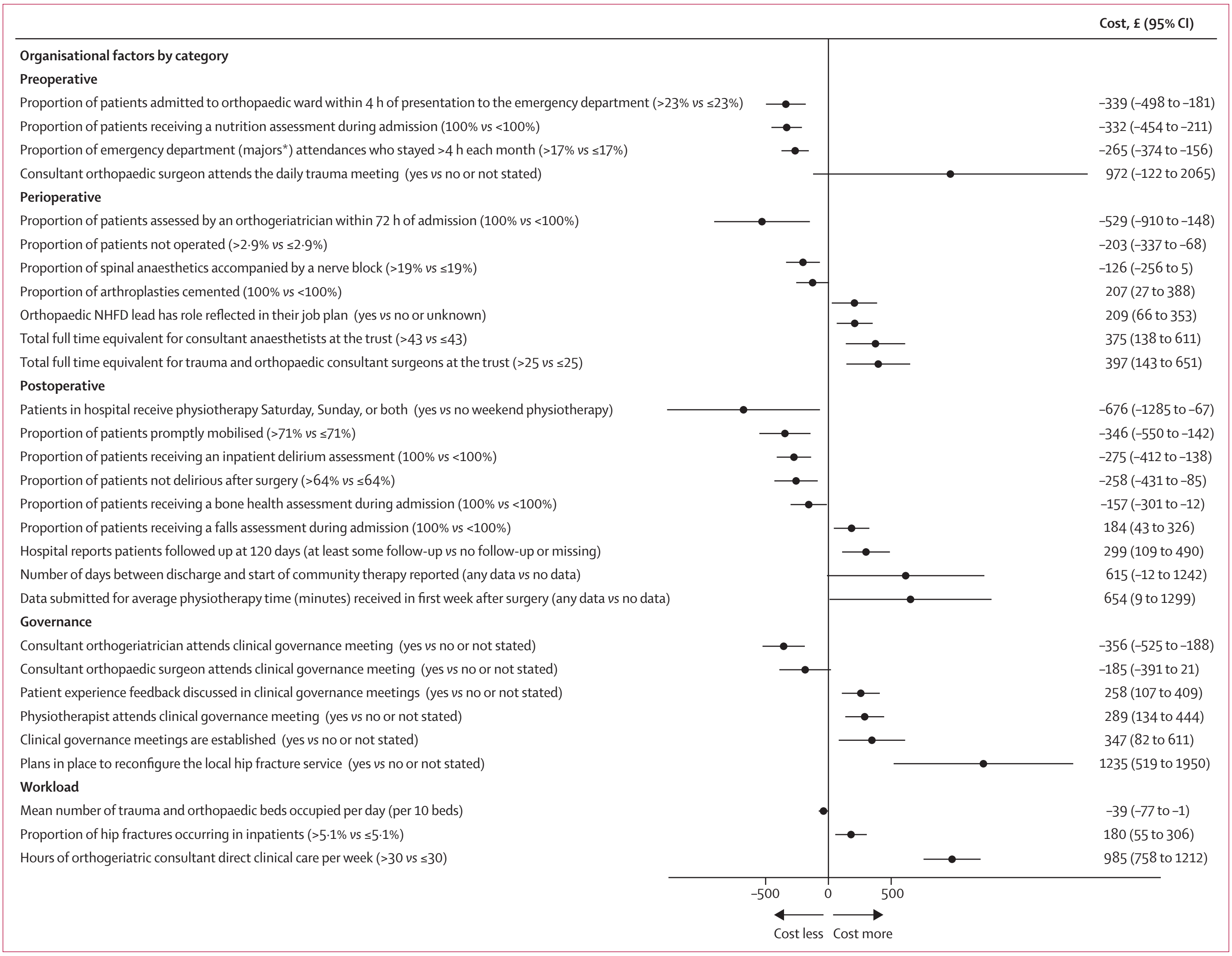

Figure 4: **Associations between organisational factors and hospital inpatient costs in the 365 days after hip fracture, accounting for patient case-mix and hospital costs incurred in the 365 days before hip fracture**

Organisational factors adjusted for case-mix (age, sex, American Society of Anesthesiologists physical status classification, hip fracture type, prefracture residence, and prefracture mobility) and inpatient costs for 365 days pre-index hip fracture and mutually adjusted for all backward-selected factors reported in the appendix (pp 14–16). Only factors with a p value of less than 0·1 are shown. Data are from 178 757 patients across 172 hospitals; intraclass correlation coefficient of the model 0·044 (95% CI 0·036–0·055). *Patients who exhibit signs of being seriously ill but are not in immediate danger to life are triaged to majors.

The Best Practice Tariff guidance for fragility hip fracture care was launched in 2010 to incentivise the delivery of seven important components of hip fracture care; omission of one component forfeits payment from the Integrated Care Systems to the hospital trusts.[26] The results indicate that hospitals reporting 100% compliance with all Best Practice Tariff components had higher mortality, suggesting that hospitals might be simply ticking a Best Practice Tariff box without pursuing assessments as thoroughly as other hospitals that report more realistic figures. A similar trend has been reported for short-term outcomes after hip fracture.[27] Non-operative hip fracture management is uncommon (2·2% of all hip fractures at this time),[28] and is usually only considered when a patient is near the end of life, hence the associated 365-day cost-saving. As for other counter-intuitive findings, higher mortality in hospitals where a consultant orthopaedic surgeon attends clinical governance meetings and a trauma and orthopaedics manager attends the daily trauma meeting might be explained by selective attendance when poor service performance has been identified and might reflect reverse causality. Similarly, hospitals where patients spend a greater number of days in hospital are more likely to have their patients in hospital at, or recently before, 120-day follow-up, aiding access to data. Hospitals with indicators of well developed services saw reduced mortality or fewer days in hospital (eg, where fracture liaison services are established and systems by which re-operation rates are understood, and patient experience feedback is routinely collected and reviewed).

Although hospital provision of orthogeriatrician assessment to all patients with hip fracture within 72 h of admission was associated with substantial potential cost savings, costs were higher if orthogeriatric consultant direct clinical care exceeded 30 sessions a week (equating to more than three full-time consultant orthogeriatricians), presumably reflecting a loss of efficiency in care delivery at this level. The presence of a fracture liaison service was associated with lower mortality and fewer days in hospital in the 365 days after hip fracture, but was not associated with inpatient costs. This effect on mortality is similar to results of previous studies that confirmed a survival benefit from fracture liaison services in patients with a major fracture.[25,29,30]

This study used a unique linkage of national databases for NHS-treated patients across two nations, with 18 different organisational data sources. The 3-year study period allowed for temporal fluctuations, giving representative overall estimates for each hospital. Multilevel analysis, accounting for within-hospital clustering, enabled a true hospital-level assessment of associations. Important limitations to note are that large sample sizes can generate associations that are statistically significant, but might not be clinically meaningful and are prone to type 1 error. Causality cannot be inferred from these observational data and, despite our multivariable models, hospital-level residual confounding might persist. Stepwise selection might detect coincidental associations while missing some causal associations. Multilevel models made bootstrapping too computationally intensive to provide internal validation. A risk of ecological fallacy exists, meaning that some cost-saving factors that operate at a hospital level might not apply at an individual level (eg, receipt of an inpatient delirium assessment). Although organisational factors were derived from high-quality data from the National Hip Fracture Database and publicly available data sources, these could not be independently validated. Some audits had missing data and some components of the care pathway could not be operationalised and remain unmeasured. Other audits with fewer missing data required inclusion of a missing data category or were supplemented with data from available years.[27] The cost analysis was restricted to NHS secondary care costs, with no data available to inform primary or community-based health and social care costs, patient contributions, or indirect costs. Analysis of these costs would require nationally available social care data, as those seen in Scandinavian countries, and the contribution of non-NHS intermediate care providers to the HES database or the Patient Episode Database for Wales.

Hip fractures are a devastating injury for which health care should be reliable and equitable across a country, yet our findings suggest that health-care expenditure on hip fracture care can vary by more than twice as much between hospitals, and that substantial variation exists between regions and between England and Wales. This study has identified several potentially modifiable aspects of hospital organisation that are associated with important clinical outcomes and health costs. These results highlight the importance of orthogeriatrician-led hip fracture care, timely rehabilitation, and well integrated, multidisciplinary clinical governance systems, and can be used to inform quality improvement strategies for hip fracture services to allow both financial savings and improved patient outcomes.

REDUCE Study Group

The REDUCE Study Group is composed of all named authors on this Article and Rachael Gooberman-Hill, Sarah Drew, Katie Whale, and Marianne Bradshaw.

Contributors

CLG, AJo, TC, MKJ, XLG, EMRM, YB-S, and AJu conceived the study and secured funding. CLG, RP, AJo, TC, MKJ, XLG, PB, ECB, EMRM, YB-S, and AJu designed the study. CLG, AJu, and RP were responsible for study management and coordination. RP, PB, EMRM, AJu, and CLG accessed and verified the data, organised the data linkage, and did the statistical analysis. RP verified organisational data. RP, PB, EMRM, and CLG drafted the manuscript. All authors critically revised the manuscript and approved the final version for submission. Datasets were stored on a project specific SafeHaven and access to these datasets was limited to those University of Bristol employed researchers performing the statistical analysis in line with NHS Digital data governance agreements. All authors had access to aggregated data outputs produced during the development of the paper. CLG had final responsibility for the decision to submit for publication.

Declaration of interests

PB reports funding by the European Commission (grant reference H2020-MSCA- ITN-2017 grant agreement identifier 7651141) and from the Hungarian Ministry of Innovation and Technology (grant reference 1783-3/2018/FEKUTSTRAT and TKP2020-IKA-02). AJu reports grants from National Institute for Health and Care Research (NIHR), Health Data Research UK, Versus Arthritis, Healthcare Quality Improvement Partnership, Royal College of Physicians, and Tommy's Health Foundation; chairs a data monitoring committee (NIHR Health Technology Assessment of the DISC trial at the University of Leicester, Leicester, UK) and a trial steering committee (NIHR Health Technology Assessment of the Gentle Years Yoga Trial, Newcastle University, Newcastle, UK); is a member of a steering committee at Nuffield Foundation (Multilevel Integrated Data for musculoskeletal health intelligence and Actions, University of Keele, Keele, UK); is a data monitoring committee member at Robotic Arthroplasty (RACER trial, Clinical Trials Unit, University of Warwick, Warwick, UK); is a sub-panel member of the NIHR Programme Grants for Applied Research programme; is on the Versus Arthritis Health Subcommittee; is co-chair of the Versus Arthritis Research Expert group; and is a member of the Nuffield Foundation Oliver Bird Fund Expert Panel. AJo is the clinical lead for the National Hip Fracture Database at the Royal College of Physicians, London, UK. JG reports an educational contract with Stryker that does not entail any relationships or activities that could have influenced the submitted work. TC is a member of the National Hip Fracture Database Advisory Board; has design and educational contracts with Stryker, Acumed, and Swemac; was a representative of the British Orthopaedic Association; previously sat on the board of the Falls and Fragility Fracture Audit Project (which includes the National Hip Fracture Database); and helped set up and perform British Orthopaedic Association multidisciplinary peer reviews for hip fractures. XLG reports funding from the NIHR Health Technology Assessment Programme;

multiple other grants from NIHR for specific projects unrelated to this work; and consultancy fees from Johnson & Johnson and Stryker. MKJ reports honoraria, unrestricted research grants, and travel or subsistence expenses from Amgen, Consilient Health, Kyowa Kirin Hakin, UCB, AbbVie, Sanofi, and Besin Healthcare; participation in the committees or boards of Regeneron, International Osteoporosis Foundation Capture the Fracture Steering Committee, Fracture Liaison Service Database of England and Wales, and medical advisory board of Brittle Bone Society and Fibrous Dysplasia Support Society UK. ECB reports funding from the UK Prevention Research Partnership (Violence, Health and Society; grant reference MR-VO49879/1), the British Heart Foundation, the Scottish Government Health and Social Care Directorates, Engineering and Physical Sciences Research Council, Economic and Social Research Council, Health and Social Care Research and Development Division (Welsh Government), Medical Research Council, NIHR, Natural Environment Research Council, Public Health Agency (Northern Ireland), the Health Foundation, and the Wellcome Trust. YB-S reports book royalties from Oxford University Press and Wiley; consulting fees from Human Centric Drug Discovery; and is a member of the trial steering committee of the SIMPLIFIED trial. EMRM reports research funding from CeramTec UK, NIHR, Medical Research Council, and the Healthcare Quality Improvement Partnership; is a steering group committee advisor for an NIHR Health Services and Delivery Research grant and an NIHR Health Technology Assessment grant; and a committee member for the NIHR Research for Patient Benefit funding scheme since 2017 and NIHR Programme Grant for Applied Research funding scheme since 2023. CLG reports research grants from Wellcome Trust, Royal Osteoporosis Society, Chan Zuckerberg Donor Advised Fund, and Versus Arthritis; and is a Chair of the National Osteoporosis Guideline Group and a member of the Royal College of Physicians Falls and Fragility Fracture Scientific committee. RP reports funding from CeramTec UK on an unrelated study and after completion of the analyses for the present Article.

Data sharing

The linked dataset containing Hospital Episodes Statistics Admitted Patient Care database for National Health Service (NHS) hospitals in England, Patient Episode Database for Wales, Office for National Statistics Civil Registration Deaths data, and the National Hip Fracture Database cannot be made available in observance of data governance agreements with the respective managing authorities. These data can be obtained only through data applications to the Royal College of Physicians Falls and Fragility Fracture Audit Programme and Healthcare Quality Improvement Partnership, NHS Wales Informatics Service, and NHS Digital.

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