SUPPLEMENTARY DATA

Appendix 1 Description and validation of measure of orthogeriatrician involvement

1) Orthogeriatrician hours reported in the NHFD facilities survey

The main measure used in the analysis, orthogeriatrician hours worked in orthopaedic departments per patient admitted with hip fracture, was calculated using two data sources: 1) weekly hours reported for consultant & middle grade orthogeriatricians in the NHFD Facilities Survey; and 2) annual number of patients admitted with hip fracture calculated from Hospital Episode Statistics (HES).

The numerator, weekly hours, was multiplied by 52 and divided by the annual number of patients. The results were robust to denominators calculated from alternative data sources: the NHFD Clinical Audit; and the estimated annual number of hip fracture cases reported in the Facilities Survey. Total weekly hours (numerator) was positively correlated with the annual number of patients admitted with hip fracture (denominator), but the standardised exposure variable (hours per patient) was not.

2) Assessment by an orthogeriatrician documented in NHFD clinical audit

The NHFD is a web-based clinical audit of the process and outcomes of care; using prospectively collected data for all patients presenting with hip fracture in the country. Data on the date and time of assessment by an orthogeriatrician are entered by nurses and audit staff to identify whether individual patient's care meets the criteria for additional Best Practice Tariff. In each hospital, data were aggregated to calculate the annual percentage of patients seen by an orthogeriatrician within 72 hours.

Data fields on the timing of geriatrician assessment and grade of geriatrician were used (Table A1). Patients seen by a geriatrician (consultant, SAS or ST3+ grade) within 72 hours of hospital admission were counted in the numerator. As well as these patients, those not seen by a geriatrician, or seen after 72 hours, were counted in the denominator. Hospital annual rates were set to missing if fewer than 65% of patients within the NHFD had complete data on their time of assessment.

Table A1 Description of NHFD sources used to measure orthogeriatrician involvement

Data source	Field name	Description/Notes	Response format
NHFD Facilities Survey	noofgeriatriconsulthours	Number of hours per week worked by orthogeriatric consultants in the orthopaedic department	Free text
NHFD Facilities Survey	noofgeriatricmghours	Number of hours per week orthogeriatric middle grade doctors work in the orthopaedic department	Free text
NHFD Clinical Audit	4.09 Date & time assessed by geriatrician	Required for BPT	dd/mm/yy hh:mm
NHFD Clinical Audit	4.10 Geriatrician grade	Required for BPT	1. Consultant 2. SAS 3. ST3+ 4. Not seen 5. Unknown

3)   Description of missing data

Missing values of geriatrician hours arose where hospitals did not complete the Facilities Survey. Table A2 shows the number and percentage of hospitals with missing data, which fell from 56 (37.3%) to 10 (6.7%) between 2010 and 2011, and to zero by 2013. The probability of a hospital missing hours data was uncorrelated with hospital-level characteristics including: number of patients admitted with hip fracture; % female, % over 90 years of age; % with comorbidities; and 30-day mortality.

Missing values of annual percentages assessed by geriatricians occurred when the data field for time of assessment was poorly completed (<65% complete), or in a few cases where hospitals were not submitting data to the NHFD. The number (%) of hospitals with missing values fell from 42 (28.0%) to 11 (7.3%) between 2010 and 2011, and to zero by 2013. Rates of missing values were slightly higher in hospitals treating fewer patients with hip fracture (based on HES data).

Table A2 Rates of missing data for two measures of orthogeriatrician involvement, annual number (%) out of 150 hospitals

Year	Orthogeriatrician hours per patient reported in annual facilities survey		Annual % of patients assessed within 72 hours calculated from clinical audit data	
	Complete	Missing	Complete	Missing
2010	94 (62.7%)	56 (37.3%)	108 (72.0%)	42 (28.0%)
2011	140 (93.3%)	10 (6.7%)	139 (92.7%)	11 (7.3%)
2012	149 (99.3%)	1 (0.7%)	144 (96.0%)	6 (4.0%)
2013	150 (100.0%)	0 (0.0%)	150 (100.0%)	0 (0.0%)

4) Correlation between alternative measures of orthogeriatrician involvement

We calculated Spearman's rank correlation coefficients to examine associations between pairs of measures of orthogeriatrician involvement, plus their assocaitions with hospital annual rates of prompt surgery (day of, or day after, admission to hospital). Annual hospital-level indicators were calculated directly from hospital-level data collected via the NHFD Facilities Survey, or from aggregated patient-level data from the NHFD Clinical Audit or Hospital Episode Statistics.

The main intervention measure of orthogeriatrician hours per patient was strongly correlated with other measures, including: the annual % of patients assessed by a geriatirican within 72 hours; the number of ward rounds per week (NHFD Facilities Survey), the annual mean number of days on which patients were assessed by a geriatrician each week (NHFD Clinical Audit).

Table A3 Spearman's rank correlation coefficients for associations between pairs of indicators

	a) Hours per patient	b) Annual rate of assessment within 72 hours	c) Number of ward rounds per week	d) Annual mean number of assessment days per week	e) Annual % having prompt surgery
a) Hours per patient	1.00				
b) Annual rate of assessment within 72 hours	0.51***	1.00			
c) Number of ward rounds per week	0.45***	0.45***	1.00		
c) Annual mean number of assessment days per week	0.28***	0.61***	0.45***	1.00	
e) Annual % having prompt surgery	0.24***	0.38***	0.15*	0.17**	1.00

*** p value <0.001 ** p value <0.01 *p value <0.05

Sources of data: a) NHFD Facilities Survey; b) NHFD Clinical Audit; c) NHFD Facillities Survey; d) NHFD Clinical Audit; e) Hospital Episode Statistics.

Appendix 2 Results from different models

In the main paper, we have presented results from conditional Poisson models with mortality (number of deaths per group divided by number of patients per group) as the outcome variable and the average number of orthogeriatrician hours per patient. As described in full in the methods section of the main paper, we included year as a categorical explanatory variable to adjust for time trends; patients' age group, sex and number of comorbidities as potential confounders; and treated hospital as a fixed effect, which is equivalent to including dummy variables for each individual hospital (omitting 1 as a reference).

Table A4 shows the full set of estimated rate ratios from different models including fixed effects and random effects models. The associations of each of the two exposures to mortality were small but statistically significant across all of the models. With orthogeriatrician hours per patient, the estimated association was slightly smaller but more precise for the random effects vs the fixed effects model but each of the estimates lies within the confidence interval of the other estimate. With annual rates of assessment by an orthogeriatrician, the estimated association is unchanged and again slightly more precise for the random effects model.

Table A5 shows results from models exploring the relationships between orthogeriatrician hours, prompt surgery, and 30-day mortality. Table A6 shows results from models with the annual % assessed by a geriatrician within 72 hours as the main intervention variable.

1)   Models with interactions

We estimated models including interaction terms to test for differences in mortality time trends by age and sex, and interaction terms to test for differences in the association between orthogeriatrician involvement and mortality by age and sex. There was no evidence that any individual interaction was significant (based on Wald tests), and no evidence that models including interaction terms fitted the data better (based on likelihood ratio tests).

Table A4 Estimated rate ratios (SEs) from five Poisson regression models with 30-day mortality as the outcome: 1) without adjustment for hospital; 2) hospitals treated as fixed effects; 3) hospitals treated as fixed effects and adjustment for other variables but not comorbidity; 4) hospitals treated as fixed effects and adjustment for other variables including comorbidity (MAIN MODEL); and 5) hospitals treated as random effects and adjustment for other variables

	1	2	3	4	5
Orthogeriatrician hours (per 2.5-hour increase per patient)	0.976 (0.006)	0.954 (0.012)	0.972 (0.013)	0.966 (0.013)	0.973 (0.009)
Year (reference = 2010/11)					
2011/12	-	-	0.957 (0.025)	0.940 (0.025)	0.934 (0.024)
2012/13	-	-	0.969 (0.026)	0.934 (0.025)	0.928 (0.024)
2013/14	-	-	0.888 (0.025)	0.837 (0.023)	0.831 (0.022)
Female (reference = male)	-	-	0.541 (0.009)	0.614 (0.011)	0.614 (0.011)
Age group (ref = 60-69 years)					
70-79 years	-	-	1.645 (0.081)	1.415 (0.005)	1.416 (0.070)
80-89 years	-	-	2.774 (0.127)	2.270 (0.104)	2.267 (0.104)
90 years and older	-	-	4.870 (0.226)	3.986 (0.185)	3.976 (0.184)
Number of comorbidities (ref = none)					
1 comorbidity	-	-	-	2.150 (0.060)	2.156 (0.061)
2 or more comorbidities	-	-	-	4.000 (0.105)	3.998 (0.105)

Table A5 Estimated rate ratios (SEs) from Poisson regression models exploring relationship between orthogeriatrician hours, prompt surgery and 30-day mortality: a) Prompt surgery as an outcome; b) 30-day mortality as an outcome and prompt surgery as a binary explanatory variable

	Outcome variable	
	a) Prompt surgery	b) 30-day mortality
Orthogeriatrician hours (per 2.5-hour increase per patient)	1.013 (0.007)	0.970 (0.014)
Prompt surgery (reference = no)	N/A	0.871 (0.018)
Year (reference = 2010/11)		
2011/12	1.056 (0.014)	0.954 (0.028)
2012/13	1.110 (0.015)	0.968 (0.029)
2013/14	1.127 (0.016)	0.871 (0.028)
Female (reference = male)	1.062 (0.010)	0.613 (0.011)
Age group (ref = 60-69 years)		
70-79 years	0.990 (0.016)	1.449 (0.086)
80-89 years	1.009 (0.015)	2.516 (0.139)
90 years and older	1.026 (0.017)	4.648 (0.259)
Number of comorbidities (ref = none)		
1 comorbidity	0.974 (0.010)	2.171 (0.067)
2 or more comorbidities	0.901 (0.010)	3.886 (0.114)

Table A6 Estimated rate ratios (SEs) from five Poisson regression models with 30-day mortality as the outcome: 1) without adjustment for hospital; 2) hospitals treated as fixed effects; 3) hospitals treated as fixed effects and adjustment for other variables but not comorbidity; 4) hospitals treated as fixed effects and adjustment for other variables including comorbidity (MAIN MODEL); and 5) hospitals treated as random effects and adjustment for other variables

	1	2	3	4	5
Annual % receiving assessment within 72 hours (per 12.5% increase)	0.974 (0.005)	0.966 (0.009)	0.972 (0.010)	0.973 (0.010)	0.974 (0.008)
Year (reference = 2010/11)					
2011/12	-	-	0.975 (0.239)	0.957 (0.023)	0.955 (0.023)
2012/13	-	-	1.002 (0.026)	0.963 (0.025)	0.960 (0.024)
2013/14	-	-	0.917 (0.026)	0.861 (0.024)	0.856 (0.022)
Female (reference = male)	-	-	0.545 (0.009)	0.617 (0.010)	0.618 (0.010)
Age group (ref = 60-69 years)					
70-79 years	-	-	1.634 (0.080)	1.407 (0.069)	1.409 (0.069)
80-89 years	-	-	2.744 (0.124)	2.247 (0.102)	2.247 (0.102)
90 years and older	-	-	4.867 (0.222)	3.992 (0.183)	3.987 (0.183)
Number of comorbidities (ref = none)					
1 comorbidity	-	-	-	2.179 (0.061)	2.185 (0.061)
2 or more comorbidities	-	-	-	4.010 (0.105)	4.019 (0.105)