Social deprivation predicts adverse health outcomes after hospital admission with hip fracture in England

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Mini Abstract

Summary

We found social deprivation to be associated with higher mortality in the year following hip fracture among men and women aged 60 years and older in England. In those who did survive, deprivation was associated with longer hospital stays and greater risk of subsequent emergency readmission particularly for patients with dementia.

Abstract

Purpose

Social deprivation predicts a range of adverse health outcomes; however, its impact on outcomes following hip fracture is not established. We examined the effect of area-level social deprivation on outcomes following hospital admission for hip fracture in England.

Methods

We used English Hospital Episodes Statistics linked to the National Hip Fracture Database (04/2011-03/2015) and Office for National Statistics mortality database, to identify patients aged 60+ years admitted with hip fracture. Deprivation was measured using Index of Multiple Deprivation quintiles; Q1-least deprived; Q5-most deprived, and outcomes by mortality over 1-year, length-of-stay in NHS acute and rehabilitation hospitals ('superspell'), and emergency 30-day readmission.

Results

We identified 218,907 admissions with an index hip fracture (mean age 82.8 [SD 8.4]years; 72.6% female). Each quintile of deprivation was associated with greater mortality; age-adjusted 30-day mortality OR 1.30 [95%CI:1.24,1.37], p<0.001, equating to on average 1,038 fewer deaths/year amongst those who are least deprived (Q1 versus 2-5). Similarly, at 365-days, those most deprived had 24% higher mortality (age-sex-comorbidity-adjusted OR:1.24 [1.20,1.28], p<0.001; Q5 *versus* Q1). Among survivors, mean superspell was longer in the most *versus* least deprived (Q5:24.4 [SD 21.7]days, Q1:23.3 [SD 22.1], p<0.001). Readmission was more common in those most *versus* least deprived (age-sex-comorbidity-adjusted OR 1.27 [1.22,1.32],p<0.001).

Conclusion

Greater deprivation is associated with reduced survival at all timepoints in the year following hip fracture. Among survivors, hospital stay is increased as is readmission risk. The extent to which configuration of English hospital services, rather than patient case-mix, explains these apparent health inequalities remains to be determined.

Introduction

Each year, in the UK, approximately 80,000 older adults fracture a hip, incurring £1.2 billion in direct medical costs alone [1]. Outcomes are poor, with a 22% reduction in quality-of-life [2], and a 23.3% one-year mortality reported in a recent European systematic review [3], rising to 45% in patients with diagnosed dementia [4]. Lengths of hospital stay are long, with 'Superspell' length of stay (LOS), defined as the overall time spent in NHS care before discharge (*i.e.* acute care ± rehabilitation), on average 22.7 days for hip fracture patients in England [5]. Of concern, emergency 30-day readmissions following hip fracture have risen progressively over the last 10 years from 8.3% to 12% [6]. Premature discharge may result in a necessity for readmission; hence longer LOS may actually be preferable, although patient-level factors may be more important than hospital-level factors in determining readmission risk [7].

We know deprivation predicts many adverse health outcomes, such as frailty in older adults, mortality from cardiovascular disease, type 2 diabetes, dementia, cancer, and emergency hospital admissions [8-12]. We have previously shown higher rates of hip fracture among those who are most deprived, particularly among men, and that over more than a decade these health inequalities have failed to improve, or in the case of women in England, have even worsened [13]. A recent systematic review has shown that individuals with low socioeconomic position have higher mortality at 30 and 365 days following fragility fracture (mostly of the hip) compared to those with high socioeconomic position, as measured by both individual-level and area-based socioeconomic measures [14]. Specifically, the pooled meta-analysis of seven area-based studies found living in the most deprived areas was associated with 14% greater risk of mortality within 1-year post-hip fracture (95% CI: 9% to 19%), compared to the least deprived areas [14]. Among patients discharged alive following a hip fracture, there is limited evidence that greater deprivation is associated with greater risk of readmission [15,16] and longer hospital stays [17]; however the later has not been consistently demonstrated [18,16]. It therefore seems likely that deprivation predicts outcomes post hip fracture. However, the impact of social deprivation on immediate (within 7-days) and intermediate (120-days) post-fracture mortality and other outcomes such as LOS and readmission is not well established [17,19,15,20,18]. Furthermore, it is not known whether the relationship between deprivation and outcomes such as mortality, LOS and readmission differs according to individual-level risk factors (*i.e.* 'effect modification') by *e.g.* age, sex, comorbidity, particularly dementia.

We hypothesised that following hospital admission for hip fracture, poorer clinical outcomes would be observed among the most deprived compared with the least deprived patients. We aimed to determine the effect of area-level social deprivation on patient-level outcomes following hip fracture including mortality over one year, 'superspell' LOS and emergency readmission to hospital. Furthermore, we aimed to examine whether the relationship between deprivation and these clinical outcomes differs according to patient characteristics such as age, sex and comorbidity, including dementia.

Methods

Data sources

We used anonymised patient-level data from the routinely collected Hospital Episodes Statistics (HES) Admitted Patient Care database that included admissions to all English hospitals within the National Health Service (NHS) (*i.e.* excluding privately financed healthcare). This HES data extract was linked by NHS Digital, the national health and social care data provider, to Office for National Statistics (ONS) mortality data for the same 4-year period. The resulting HES-ONS data extract was then linked to an extract from the UK's National Hip Fracture Database (NHFD) for the period 1st April 2011 to 31st March 2015 [21]. The quality of linkage was assessed, with 'good' linkage defined as having a matching date of admission (within 10 days), age (within 1 year), sex and hospital provider code [22].

Each entry, or episode, in HES relates to a period of care under a single hospital consultant; there are one or more hospital episodes during a hospital admission. Each HES episode includes information on patient demographics and up to 20 clinical diagnoses using International Classification of Diseases, Tenth Revision (ICD-10) disease codes [23]. ONS mortality data are obtained from death certificates of all registered deaths in England and Wales [24], thus capturing deaths that occurred outside of hospital. The NHFD is a national clinical audit of hip fracture care provided by NHS hospitals in England, Wales and Northern Ireland. Each NHFD record includes information on patient demographics, anaesthetic risk grade, type of hip fracture and surgical operation performed.

Study population

We identified hip fracture admissions using ICD-10 codes for fractured neck of femur (S72.0), pertrochanteric fracture (S72.1), and subtrochanteric fracture (S72.2). Our study population consisted of index cases of hip fracture (*i.e.* the first occurrence of hip fracture), among English residents aged 60 years or more, admitted to hospital. We excluded second hip fractures to avoid double-counting, since we were unable to distinguish reliably between two separate hip fracture events in HES.

Exposure: Socioeconomic deprivation

To measure socioeconomic deprivation, we used the Index of Multiple Deprivation (IMD), a relative measure of deprivation for small areas, termed lower super output areas (LSOAs), which are defined as geographical areas of a similar population size with an average of 1,500 residents [25]. The IMD comprises seven measures of deprivation: income deprivation; employment deprivation; education, skills and training deprivation; health deprivation and disability; crime; barriers to housing and services; and living environment deprivation. The IMD was specifically designed to measure deprivation, not affluence, and this is reflected in the indicators used to construct the index [26]. For example, the income domain measures low-income families as determined by receipt of benefits, whilst the housing domain captures poor quality and unaffordable housing. There are 32,482 LSOAs in England, and each LSOA is assigned a score and a national rank for the individual domains of deprivation. A weighted sum of the ranks for each domain is used to calculate an overall IMD score based upon LSOAs which are then ranked nationally. We used the IMD rank for a patient's LSOA and categorised patients into quintiles based upon the national ranking of local areas, with quintile 1 being the least deprived group and quintile 5 being the most deprived group (*i.e.* reordered to aid reporting).

Outcomes

Mortality: Cumulative mortality was determined at 7, 30, 120, and 365 days after hospital admission for hip fracture. It was not possible to obtain the precise date of death from the ONS due to NHS Digital data access restrictions and therefore, NHS Digital generated binary death status variables at these specified time points post admission.

'Superspell' Length of Stay: A hip fracture superspell LOS was defined as the index hip fracture admission, plus if applicable, planned hospital transfers for elective care and/or subsequent unplanned hospital transfers for emergency care. Superspell LOS was calculated as the difference between the date of the index hip fracture admission and the final date of discharge alive from an NHS hospital.

Emergency 30-day readmission: An emergency 30-day readmission was defined as an emergency all-cause admission to any English NHS hospital that occurred within 30-days of hospital discharge following a hip fracture superspell.

Further variables: We derived patient characteristics, including 5-yearly age groupings from 60 years to 90+ years, sex and comorbidity. To measure comorbidity we used the Royal College of Surgeon's (RCS) Charlson Score, which is calculated based on the presence of several chronic conditions, identified using ICD-10 codes, within the index hip fracture admission and all admissions in the proceeding 5 years [27]. This comorbidity score was then categorised into a three-level ordinal variable (no comorbid condition; ≥1 comorbid condition that excluded dementia; and dementia with or without other comorbidities [referred to henceforth as dementia]). The American Society of Anesthesiologists' (ASA) classification of physical status is an assessment of a patient's preoperative health status based on five classes (I-A normal healthy patient; II-A patient with mild systemic disease; III-A patient with severe systemic disease, IV-A patient with severe systemic disease that is a constant threat to life; V-A moribund patient who is not expected to survive without the operation) [28]. The ASA grade is a predictor of poor outcomes after hip fracture, including increased mortality risk, and the NHFD routinely collects it for hip fracture patients who have undergone surgery [29].

Research approvals

Research approvals were obtained from: NHS Research Ethics Committee (15/LO/1056), the Falls and Fragility Fracture Audit Programme from the Healthcare Quality Improvement

Partnership (FFFAP/2015/001), and an NHS Digital Data Sharing Agreement (DARS-NIC-30645-Z2Z2K-v2.22).

Statistical analyses

We summarised key demographic statistics and used chi-squared (χ^2) tests to assess associations between categorical variables. We calculated the proportion of hip fracture patients who (i) had died at 7, 30, 120 and 365 days after hip fracture, and (ii) were readmitted within 30-days of discharge, for each quintile of deprivation stratified by age, sex and comorbidity. Crude odds ratios were used to calculate the absolute number of excess deaths, occurring amongst those who are deprived (Quintiles 2-5 versus 1), which were then averaged per year. Mean (standard deviation, SD) superspell LOS was calculated according to deprivation quintiles. The distribution of superspell LOS was positively skewed. Although skewed data are conventionally summarised by medians and IQRs, and log-transformed to satisfy the assumption of normality for linear regression, superspell LOS was summarised using arithmetic means to capture the effect of outliers. Linear regression models provide efficient estimates of the mean for skewed data when the sample size is large, as in this case.

We used logistic regression to determine the association between deprivation and mortality and emergency 30-day readmission, and calculated odds ratios (ORs), using quintile 1, the least deprived quintile, as the reference category and adjusting for age group (in 5-yearly intervals), sex and comorbidity score. Logistic regression was used to assess trends in the odds of death by deprivation quintiles, including deprivation as a linear term. Linear regression was used to determine the association between deprivation and superspell LOS. We conducted formal tests for interaction to determine whether the relationship between deprivation and outcomes (*i.e*. mortality, superspell LOS, 30-day readmission) differed according to age, sex and comorbidity (with and without dementia); deprivation was modelled as a linear term for these analyses. All statistical analyses were conducted using Stata, version 14 IC (StataCorp, College Station, TX, USA).

Results

Description of the study population

There were 220,567 hospital admissions with an index hip fracture among English residents aged 60 years and older between 2011 and 2014 with good data linkage, of which 1,660 (0.8%) patients were excluded due to missing data for IMD and/or geographic region of residence. Of the remaining 218,907 admissions, 72.6% occurred in women, 75.9% had 1 or more coded comorbid conditions and 97.9% were patients of White ethnic origin (Table 1). The mean [SD] age of this population was 82.8 [8.4] years; men were a little younger (81.5 [8.6] years) than women (83.3 [8.3] years). 20.0% of hip fracture admissions occurred among individuals in the least deprived quintile and 17.6% in the most deprived quintile. Hip fracture patients in the most deprived quintile were more likely to be younger, male and, have a higher burden of comorbidity and higher anaesthetic risk (ASA grade) when compared to patients in the least deprived quintile. Fewer displaced intracapsular fractures and correspondingly fewer hemi and total hip arthroplasties were performed among more deprived patients (Table 1). Whereas more intertrochanteric fractures and correspondingly more internal fixation screw operations were performed among those living in more deprived areas.

Cumulative mortality

Cumulative mortality rates at 7-days, 30-days, 120-days and 365-days were 2.9%, 7.8%, 18.1% and 28.1%, respectively (Figure 1a). Men had higher mortality than women at all time points. Among men, mortality at 7-days after hip fracture was 2.6% and 5.7% in patients aged 60-84 and 85+ years respectively, increasing to 27.2% and 47.9% at 365-days after hip fracture. In comparison, 7-day mortality was 1.5% and 3.5% in women aged 60-84 and 85+ years, respectively, and 16.8% and 33.9% at 365-days post-hip fracture. Mortality rates were highest in men aged 85+ years at all time points up.

Cumulative mortality by levels of deprivation

Overall, greater deprivation was associated with higher mortality and the strength of the association was similar at all time points up to 365-days post-hip fracture. Mortality at 7-days after hip fracture was 2.6% and 3.1% among patients in the least deprived and most deprived quintiles, increasing to 26.3% and 29.8% at 365-days after hip fracture (Figure 1b).

The odds of death at 7-days after hip fracture were 17% higher among patients in the most deprived compared with the least deprived quintile (unadjusted OR 1.17 [1.08,1.27], p<0.001) (Table 2). The relationship between deprivation and 7-day mortality was augmented following adjustment for age and sex (adjusted OR 1.29 [1.19,1.41], p<0.001); however, additional adjustment for comorbidity partially attenuated this relationship (adjusted OR 1.23 [1.13,1.34], p<0.001). In terms of number of deaths, greater deprivation was associated with higher 30-day mortality, with age-adjusted OR 1.30 [1.24,1.37] (p<0.001) equating to on average 1,038 fewer deaths per year occurring amongst those who are least deprived (Quintile 1 versus 2-5). By 120-days post-hip fracture, mortality remained 21% higher among patients in the most deprived versus the least deprived quintile, despite adjustment for age, sex and comorbidity (age-sex-comorbidity-adjusted OR 1.21 [1.17,1.26], p<0.001). This difference was sustained to 365-days post fracture, when a 24% higher mortality was seen in those in the most deprived versus least deprived quintile (age-sex-comorbidity-adjusted OR:1.24 [95%CI:1.20,1.28], p<0.001).

Modification of the effect of deprivation on mortality, by age, sex and comorbidity

The effect of deprivation on mortality at all time points up to 365-days after hip fracture was similar in men and women, as it was among patients aged 60-84 years and 85+ years. In contrast, the relationship between deprivation and mortality at 30-days, 120-days and 365-days post-hip fracture was found to differ according to levels of comorbidity (p<0.001 for interaction). For men and women combined, the effect of deprivation on mortality was similar in patients with no comorbidity and with comorbidity that excluded dementia but was weaker among patients with dementia compared to those with no comorbidity (negative interaction). Following adjustment for age and sex, the odds of death by 365-days among patients with either no comorbidity or comorbidity that excluded dementia were 40% (OR 1.40 [1.27,1.54], p<0.001) and 32% (OR 1.32 [1.26,1.38], p<0.001) higher in the most deprived compared with the least deprived quintile, respectively. This contrasts with an OR of 1.06 ([1.01,1.13], p=0.001) for the most deprived versus the least deprived patients with dementia (Supplementary Tables 1 & 2). Hence, cumulative mortality rates up to 365-days post-hip fracture were calculated for each quintile of deprivation stratified by age, sex and comorbidity as a prognostic tool for use in clinical settings (Supplementary Tables 3 & 4).

Superspell LOS

Among the 91.2% patients discharged alive from hospital following their hip fracture superspell, the overall mean and median superspell LOS were 23.6 [SD:21.5] days and 17 [IQR:10-30] days respectively. Mean superspell LOS was longer in men than women, among older individuals, and in patients with dementia (Supplementary Table 5). Mean superspell

LOS was 21.3 [21.0] days in patients aged 60-84 years, and on average 5.1 days longer in those aged 85+ years (p<0.001), whilst in women, mean superspell LOS was 23.0 [SD:20.9] days, and on average 2.5 days longer in men (p<0.001). When analyses were stratified by comorbidity, mean superspell LOS was 18.9 days in patients with no recorded comorbidity, and 24.7 days and 26.2 days in patients with comorbidity excluding and including dementia respectively (p<0.001).

Superspell LOS by levels of deprivation

Superspell LOS increased marginally with greater deprivation. Mean superspell LOS was 23.3 [22.1] days among the least deprived patients, and on average 1.1 days longer among those in the most deprived quintile (Table 3). Similarly, the difference between median superspell LOS for patients in the least deprived and most deprived quintile was 1 day, increasing from 16 to 17 days.

Modification of the effect of deprivation on superspell LOS, by age, sex and comorbidity

The effect of deprivation on superspell LOS was similar in men and women but differed among individuals aged 60-84 years and 85+ years (IMD*age interaction 0.20 days [(0.06, 0.34) p=0.004] indicating a shorter superspell LOS for those who were older, for each increasing quintile of deprivation), and according to the presence of dementia (IMD*dementia interaction 0.38 days [(0.19, 0.56) p<0.001] indicating a shorter superspell LOS for those with dementia, for each increasing quintile of deprivation). Mean superspell LOS increased with greater deprivation for all strata of comorbidity, and hospital stays were longer in men than women (Figure 2a). Mean superspell LOS was approximately 1.5 days longer among both men and women in the most deprived compared with the least deprived quintile, irrespective of comorbidity status. For both men and women, mean superspell LOS was similar among those with comorbidity that both included and excluded dementia. However, individuals with comorbidity spent on average an extra 6 days in hospital after hip fracture compared to those with no recorded comorbidity.

Emergency 30-day readmission

Among the 91.2% patients discharged alive from hospital following their hip fracture superspell, 15.6% were readmitted as an emergency within 30-days of discharge. Emergency 30-day readmission rates were higher in men than women, among individuals aged 85+ years, and in patients with dementia. Emergency 30-day readmission rates were 18.5% in men and 14.5% in women, and 14.0% and 17.4% in individuals aged 60-84 years and 85+ years respectively. The highest rates of emergency 30-day readmission were among older men; 16.9% and 20.9% of men aged 60-84 and 85+ years, respectively were readmitted within 30-days of hospital discharge compared with 12.8% and 16.4% of women aged 60-84 years and 85+ years. When stratified by comorbidity, 30-day readmission rates were 10.4%, 16.8% and 18.4% in patients with no recorded comorbidity, comorbidity that excluded dementia and that included dementia respectively ($p<0.001$ for all).

Emergency 30-day readmission by levels of deprivation

Emergency 30-day readmission rates increased with greater levels of deprivation (figure 2B); 14.2% and 17.5% of patients in the least deprived and most deprived quintile were readmitted within 30-days of discharge (Table 4), with odds of readmission 28% higher among individuals in the most deprived compared with the least deprived quintile (unadjusted OR 1.28 [1.23,1.33], $p<0.001$). The association between deprivation and 30-day readmission was marginally strengthened by adjustment for age and sex (adjusted OR 1.32 [1.27,1.38], p<0.001). However, additional adjustment for comorbidity then partially attenuated this relationship (OR 1.27 [1.22,1.32], p<0.001).

Modification of the effect of deprivation on 30-day readmission, by age, sex and comorbidity

There was no evidence of effect modification for deprivation and 30-day readmission post-hip fracture either by sex or age groups but it differed according to levels of comorbidity (p=0.009 for interaction), and therefore further analyses were stratified by comorbidity, adjusted for age and sex (Supplementary Table 6). For all strata of comorbidity, greater deprivation was associated with higher odds of emergency 30-day readmission post-hip fracture; however, the magnitude of this association was strongest among hip fracture patients with dementia in whom the odds of 30-day readmission were 34% higher (OR 1.34 [1.25,1.44], p<0.001) among the most deprived versus the least deprived individuals (Figure 2b & Supplementary Table 6). In contrast, the probability of being readmitted within 30-days of discharge was 14% and 18% higher for the most deprived compared to the least deprived patients with no recorded comorbidity (OR 1.14 [1.03,1.25], p=0.001) and comorbidity that excluded dementia (OR 1.18 [1.12,1.25], p<0.001). Age and sex adjustment did not explain the association between deprivation and emergency 30-day readmission in patients with dementia.

Discussion

Summary of research findings

We examined the effect of area-level social deprivation on outcomes following hospital admission for hip fracture among men and women aged 60 years and older in England.

Greater deprivation was associated with higher mortality at all time points up to 365-days post fracture, *e.g.* 30-day age-adjusted mortality equated to on average 2,697 fewer deaths per year occurring amongst those who were least deprived (Quintile 1 versus 2-5). Among those who did survive, deprivation was associated with longer mean 'superspell' LOS, equating to 19,133 excess bed days each year (Quintiles 2-5 *versus* 1), with those most deprived staying on average 1.1 days longer in hospital compared with those least deprived. Once discharged, patients living in deprived areas had a 28% greater need to be readmitted to hospital, compared with those in the least deprived quintile. These finding are consistent with our hypothesis that poorer clinical outcomes would be observed among the most deprived compared with the least deprived patients following hospital admission for hip fracture. The relationship between deprivation and these outcomes did not vary according to patient characteristics of age and sex (other than superspell LOS which, as expected, lengthened with age). However, the association between deprivation and 30-, 120- and 365-day post-hip fracture mortality, superspell LOS and 30-day emergency readmission all differed by levels of comorbidity, especially dementia.

Mortality

Our findings are consistent with most, largely population-based, studies examining the effect of deprivation on mortality after hip fracture, which have reported an increasing mortality rate with greater deprivation [16,30-35], further supported by a recent systematic review [14]. We found, after accounting for age and sex, relative inequalities in post-hip fracture mortality were greatest among patients with no recorded comorbidity, and were more similar to those with comorbidity excluding dementia, and least apparent in patients with dementia. This finding may be explained by undiagnosed (and therefore unrecorded) comorbidity in those who are most deprived, rather than a true absence of illness, potentially reflecting inequalities in healthcare access in earlier stages of disease [36]. Inequalities in survival were least apparent for those with a diagnosis of dementia, particularly by 120- and 365-days, which may reflect equity in community dementia services implemented following the 2009 National Dementia Strategy for England, or that dementia outcomes are so poor regardless of deprivation that this attenuates any effect of deprivation, or misclassification of historic deprivation. In support of our findings, Thorne *et al*, using English HES data from 2004-14, found no association between deprivation and 365-day mortality in hip fracture patients with dementia, whilst reporting a positive association among those without dementia; 30-day mortality was not assessed due to small numbers [31]. Pre-fracture residential status may explain, in part, the lack of association between deprivation and mortality in those with dementia. Deprivation status, assigned based on current residential postcode, may not accurately capture earlier life exposures that predispose to morbidity and mortality in later life in patients with dementia, 39% of whom reside in care homes [37]. Cross-sectional analysis of English HES data (2011-2012) has shown that, among patients aged 75+ years, those admitted from a care home postcode are much more likely to have dementia compared to patients admitted from a non-care home postcodes (39.3% *versus* 5.5%) [38]. Furthermore, analysis of 2011 census data has shown that coastal areas in the South and East of England, and areas in Yorkshire and the Humber, have among the highest proportion of the resident population living in care homes [39]. It can be extrapolated, using a map of geographic variation in deprivation across England (IMD 2015 version) [40], that, in general, areas with the highest proportion of care homes, are those with lower levels of deprivation. We were unable to take account of pre-fracture residential status (due to missing data) and therefore, owing to differential misclassification of exposure status, may not have estimated the true association between (historical) deprivation and mortality risk in hip fracture patients with dementia.

Superspell length of stay and hospital readmissions

Those with comorbidities, and particularly those with dementia, had the longest superspell LOS. Similarly, emergency 30-day readmission rates were highest among those with dementia (compared with other comorbidities), and furthermore, the odds were 34% higher in those in the most deprived compared to the least deprived quintile. A handful of population-based studies conducted in England have shown that 28-day readmission rates are higher and acute hospital LOS longer following a hip fracture for patients residing in more deprived compared with less deprived areas (measured using the IMD) [17,19,35]. Discharge is often dependent upon social care, to which access can vary by deprivation level, with those most deprived more like to rely on social services funded care, whilst those least deprived may promptly access care via self-funded routes; during the study period some social care providers moved to only accept self-funded service users [20]. A large, register-based study conducted in Denmark found that 30-day readmission risk was higher among the most deprived compared with the least deprived individuals, whereas hospital LOS was similar which may reflect more equitable social care provision in Denmark [16]. Quah *et al* similarly reported no difference in acute hospital LOS according to IMD quintiles; however, they studied a smaller and potentially more homogeneous population with hip fractures admitted to a single urban hospital in England [41]. We found men stayed on average 2.5 days longer than women irrespective of IMD quintile, even though men are reported to be more likely to be discharged home to a spouse, and women to a long term care home (altered discharge destination lengthens hospital LOS) [42,17]. Consistent with our findings, studies conducted among patients with hip fracture in England, Denmark and the USA have reported higher hospital readmission rates in men than women [43-46], and among older individuals [19,47].

Study strengths and limitations

We were able to use a large national dataset, comprehensively linking hip fractures treated in the NHS to follow-up outcomes over one-year post hip fracture. These data provide descriptive statistics which are valuable and pertinent to clinicians caring for patients with hip fracture. We calculated hip fracture outcomes limited to the first occurrence of hip fracture, which likely underestimates hip fracture severity: 8.7% of hip fractures are thought to be second hip fractures [48] and they have been shown to have poorer survival [49]. In the UK almost all hip fractures are managed by NHS hospitals, however, a small proportion may have been admitted to privately financed healthcare facilities and hence were not captured in HES, thus under-representing outcomes among those least deprived.

The RCS Charlson score, used to identify comorbidity, may not have captured all comorbid conditions prevalent among hip fracture patients, plus HES records may not include all comorbidities, risking misclassifying comorbid individuals as having no comorbidities, for example smoking behaviours and body mass index are not routinely captured by HES or the NHFD. Misclassification of comorbidity status may have differentially affected individuals residing in more deprived areas, in whom the burden of comorbidity is higher, but who may be less likely to engage health services for diagnosis [36]. Unmeasured smoking and obesity, both associated with deprivation, may contribute to inequalities in post hip fracture outcomes among those individuals with no recorded comorbidity. Therefore, we may have overestimated the strength of the association between deprivation and mortality in hip fracture patients with no ‘apparent’ comorbidity. We used an area-based measure of deprivation as a proxy for an individual’s level of deprivation, so this ecological measure will in some cases misclassify individuals. Finally, these analyses apply to admissions from 2011 to 2014, with follow-up to 2015; substantial delays in regulatory approvals to access linked national datasets, as used here, mean up-to-date analyses of this type are not currently possible in England.

Implications for policy

Our findings that patients from the most deprived areas have poorer clinical outcomes compared with those from least deprived areas admitted to hospital admission for hip fracture, demonstrates the inequalities that exist for patients with this marker condition. Area-level deprivation likely reflects, at least in part, an individual's cumulative exposure to deprivation throughout a lifetime. Those with dementia who fracture a hip, have a particularly high risk of death. We did not find evidence that this risk is modified by deprivation; however, we did find evidence that those with dementia residing in an area of deprivation, stay in hospital longer and are more likely to be readmitted to hospital following discharge. Taken together, these results may indicate equity in inpatient clinical care, but inequity in provision of social care.

The association between deprivation and outcomes may in part be explained by delays in transfer to hospital and/or delays in surgery as poor pre-fracture health status conveys a greater need for preoperative medical optimisation prior to operation [46]. Operation type may influence superspell length of stay and potentially readmission rates, which requires further investigation. Furthermore, health service provision may vary geographically, such that communities with high levels of deprivation may have greater or lesser access to fracture services. The relative inequality in post-hip fracture mortality identified in patients with no apparent record of comorbidity suggests the possibility of undiagnosed disease in those who are most deprived and may reflect inequalities in access to healthcare systems aimed at disease identification and prevention. Yet, disease prevention to reduce health inequalities has been a key public health policy objective for more than a decade [50].

Conclusion

Despite UK Government and public health initiatives to address health inequalities and improve hip fracture care, it is concerning that the findings of this study suggest that social inequalities in hip fracture outcomes continue to exist in England. These findings stress the need for reassessment of current national public health strategies to prevent hip fractures and improve hip fracture care, with particular emphasis placed on the development of health policies that address persisting social inequalities. The extent to which the configuration of English hospital services, rather than patient case-mix, explains these apparent health inequalities remains to be determined. Established policy initiatives such as the Royal College of Physician's NHFD and Fracture Liaison Service Database (FLS-DB), within the Falls and Fragility Fracture Audit Programme (FFFAP), provide a mechanism by which socioeconomic differences and regional variation in hip fracture care can be audited and interventions to improve services and reduce health inequalities can be evaluated.

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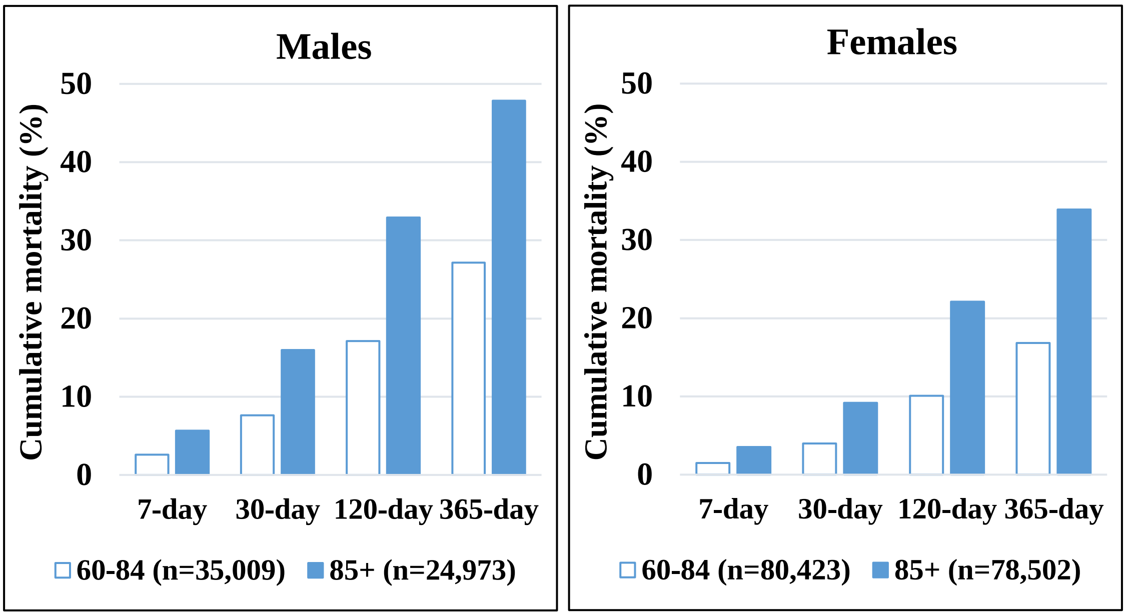
A



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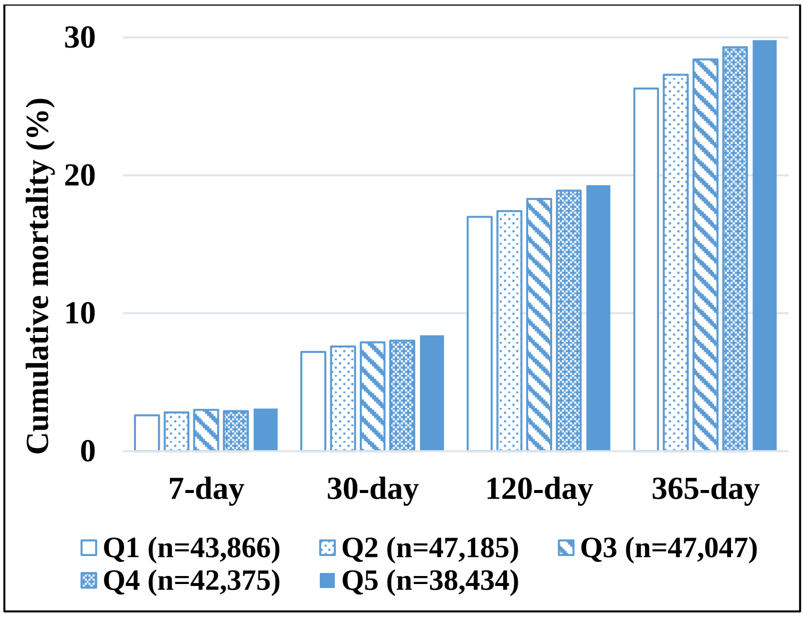
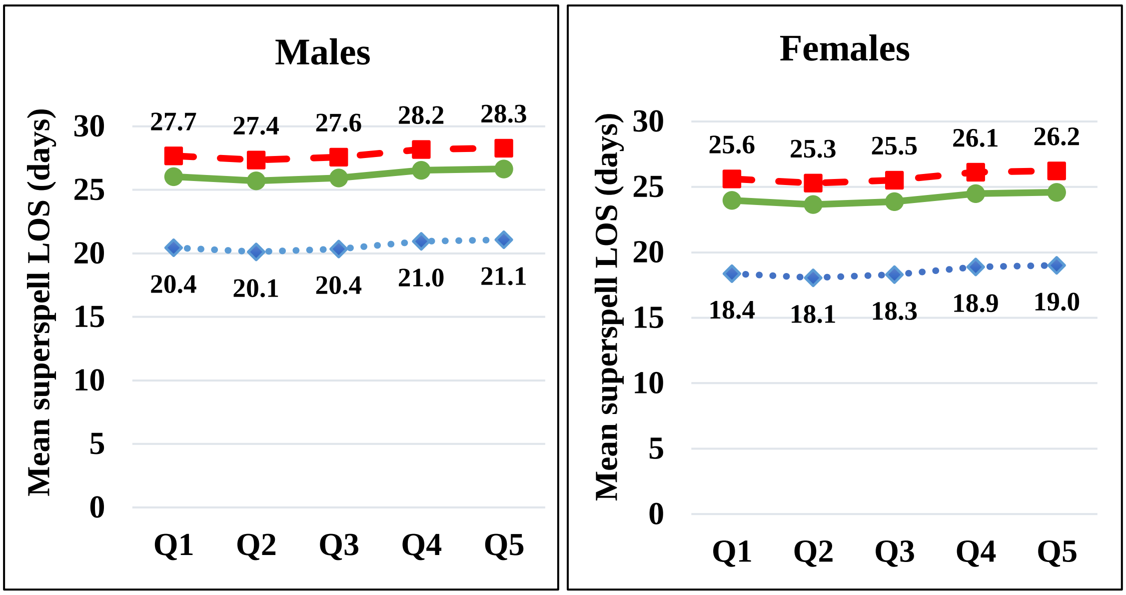


Figure 1 (A): Cumulative mortality rates up to 365-days after hip fracture by age group in men and women, (B): Cumulative mortality rates up to 365-days after hip fracture by quintiles of deprivation in men and women aged 60+ years, 2011–2014

A



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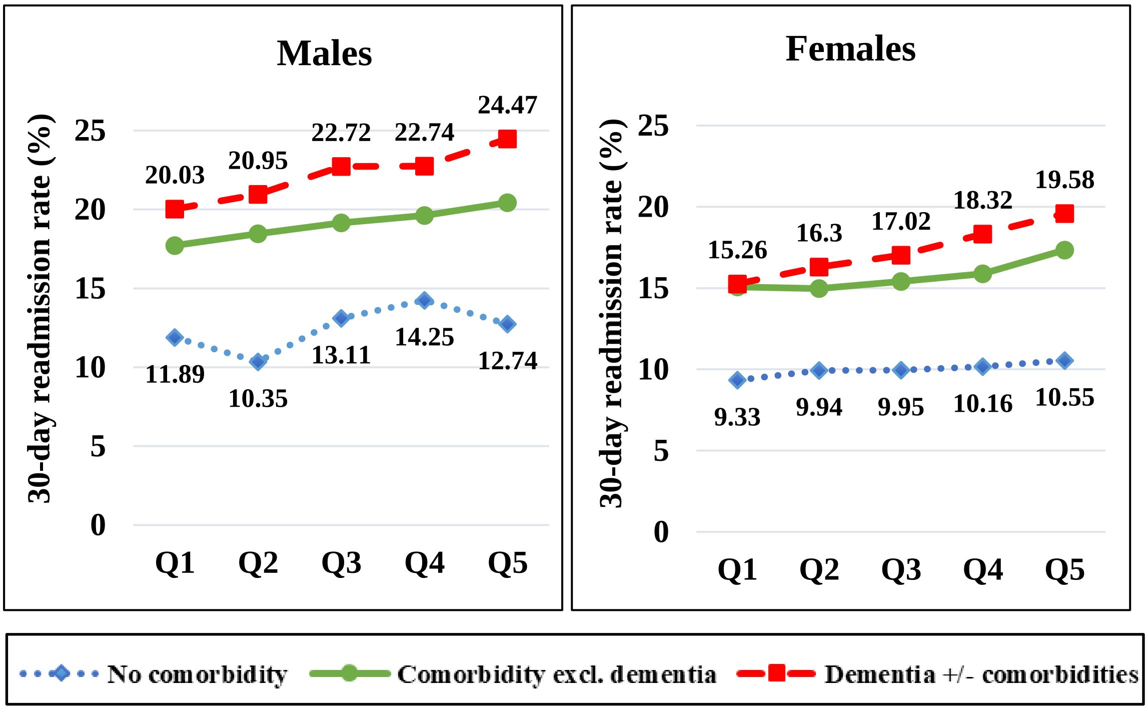

Figure 2 (A): Predicted mean superspell LOS in days by quintiles of deprivation in men and women 2011–2014, (B): Emergency 30-day readmission rates following hospital admission for hip fracture by quintiles of deprivation
(Quintile 1 (Q1) – least deprived quintile, quintile 5 (Q5) – most deprived quintile)
(95% confidence intervals shown but very narrow)

Table 1: Characteristics of patients admitted to hospital with a hip fracture according to quintiles of deprivation, 2011-2014
(Quintile 1 (Q1) – least deprived quintile, quintile 5 (Q5) – most deprived quintile)

		Total population	IMD Q1	IMD Q2	IMD Q3	IMD Q4	IMD Q5	p value
N (%)		218,907	43,866 (20.0)	47,185 (21.6)	47,047 (21.5)	42,375 (19.4)	38,434 (17.6)	
Age (years)	Mean (SD)	82.8 (8.4)	83.4 (8.1)	83.2 (8.3)	83.1 (8.3)	82.7 (8.5)	81.7 (8.7)	<0.001
Age (years), n (%)	60-69	18,790 (8.6)	3,185 (7.3)	3,695 (7.8)	3,803 (8.1)	3,844 (9.1)	4,263 (11.1)	<0.001
	70-79	47,683 (21.8)	8,873 (20.2)	9,937 (21.1)	10,103 (21.5)	9,293 (21.9)	9,477 (24.7)	
	80-89	103,742 (47.4)	21,409 (48.8)	22,614 (47.9)	22,314 (47.4)	20,032 (47.3)	17,373 (45.2)	
	90+	48,692 (22.2)	10,399 (23.7)	10,939 (23.2)	10,827 (23.0)	9,206 (21.7)	7,321 (19.0)	
Sex, n (%)	Female	158,925 (72.6)	31,913 (72.8)	34,516 (73.2)	34,330 (73.0)	30,809 (72.7)	27,357 (71.2)	<0.001
Ethnicity, n (%)*	White	201,931 (97.9)	40,422 (98.7)	43,596 (98.6)	43,538 (98.1)	39,020 (97.2)	35,355 (96.4)	<0.001
RCS Charlson comorbidity score[a], n (%)	No comorbidity	52,825 (24.1)	12,279 (28.0)	12,299 (26.1)	11,332 (24.1)	9,308 (22.0)	7,607 (19.8)	<0.001
	Comorbidity excl. dementia	104,458 (47.7)	19,890 (45.3)	21,725 (46.0)	22,460 (47.7)	20,669 (48.8)	19,714 (51.3)	
	Dementia	61,624 (28.2)	11,697 (26.7)	13,161 (27.9)	13,255 (28.2)	12,398 (29.3)	11,113 (28.9)	
ASA grade, n (%)	1	4,630 (2.3)	1,185 (2.9)	1,162 (2.6)	1,005 (2.3)	752 (1.9)	526 (1.5)	<0.001
	2	59,919 (29.2)	13,774 (33.5)	13,799 (31.2)	13,096 (29.7)	10,622 (26.7)	8,628 (24.1)	
	3	114,350 (55.7)	21,702 (52.8)	24,096 (54.4)	24,589 (55.7)	22,970 (57.8)	20,993 (58.6)	
	4	25,384 (12.4)	4,314 (10.5)	5,043 (11.4)	5,272 (11.9)	5,257 (13.2)	5,498 (15.3)	
	5	886 (0.4)	156 (0.4)	189 (0.4)	205 (0.5)	156 (0.4)	180 (0.5)	
Hip fracture type, n (%)	IC - displaced	105,749 (48.4)	22,065 (50.4)	23,208 (49.3)	22,742 (48.4)	20,055 (47.4)	17,679 (46.1)	<0.001
	IC - undisplaced	22,385 (10.2)	4,397 (10.0)	4,766 (10.1)	4,838 (10.3)	4,243 (10.0)	4,141 (10.8)	
	Intertrochanteric	75,524 (34.6)	14,394 (32.9)	16,010 (34.0)	16,158 (34.4)	15,045 (35.6)	13,917 (36.3)	
	Subtrochanteric	12,756 (5.8)	2,538 (5.8)	2,662 (5.7)	2,788 (5.9)	2,521 (6.0)	2,247 (5.9)	
	Other	2,032 (0.9)	389 (0.9)	416 (0.9)	441 (0.9)	425 (1.0)	361 (0.9)	
Hip fracture operation, n (%)	No operation	4,824 (2.2)	898 (2.1)	960 (2.0)	1,054 (2.2)	1,001 (2.4)	911 (2.4)	<0.001
	IF - Screws	85,225 (39.0)	16,301 (37.2)	18,193 (38.7)	18,434 (39.3)	16,839 (39.8)	15,458 (40.3)	
	IF - IM nail	19,918 (9.1)	3,983 (9.1)	4,163 (8.8)	4,120 (8.8)	3,949 (9.3)	3,703 (9.7)	
	Hemiarthroplasty	94,492 (43.3)	19,279 (44.0)	20,522 (43.6)	20,355 (43.4)	18,150 (42.9)	16,186 (42.2)	
	THA	12,620 (5.8)	3,089 (7.1)	2,952 (6.3)	2,703 (5.8)	2,093 (5.0)	1,783 (4.7)	
	Other	1,267 (0.6)	218 (0.5)	256 (0.5)	282 (0.6)	237 (0.6)	274 (0.7)	

ASA – American Society of Anaesthesiologists; excl. – excluding; IC – intracapsular; IF – internal fixation; IM – intramedullary; IMD – Index of Multiple Deprivation; RCS – Royal College of Surgeons of England; SD – standard deviation; THA – total hip arthroplasty

*HES recorded ethnicity as specified by the patient, coded according to the 2001 national census [23].

Table 2: Association between quintiles of deprivation and mortality up to 365-days after hip fracture in men and women aged 60+ years, 2011–2014

(Quintile 1 (Q1) – least deprived quintile (reference category), quintile 5 (Q5) – most deprived quintile)

	7-day mortality				**30-day mortality**			
	N (%)	**Crude OR (95% CI)**	**Age-sex adjusted OR[a] (95% CI)**	**Age, sex & comorbidity-adjusted OR[a] (95% CI)**	**N (%)**	**Crude OR (95% CI)**	**Age-sex adjusted OR[a] (95% CI)**	**Age, sex & comorbidity-adjusted OR[a] (95% CI)**
Q1	1,149 (2.6)	Reference category			3,143 (7.2)	Reference category		
Q2	1,328 (2.8)	1.08 (0.99,1.17)	1.10 (1.01,1.19)	1.08 (1.00,1.17)	3,593 (7.6)	1.07 (1.02,1.12)	1.09 (1.04,1.15)	1.07 (1.02,1.13)
Q3	1,396 (3.0)	1.14 (1.05,1.23)	1.16 (1.08,1.26)	1.14 (1.05,1.23)	3,704 (7.9)	1.11 (1.05,1.16)	1.14 (1.08,1.19)	1.10 (1.05,1.16)
Q4	1,240 (2.9)	1.12 (1.03,1.22)	1.18 (1.08,1.28)	1.13 (1.04,1.23)	3,403 (8.0)	1.13 (1.08,1.19)	1.19 (1.13,1.25)	1.13 (1.08,1.19)
Q5	1,173 (3.1)	1.17 (1.08,1.27)	1.29 (1.19,1.41)	1.23 (1.13,1.34)	3,229 (8.4)	1.19 (1.13,1.25)	1.32 (1.25,1.39)	1.23 (1.17,1.30)
p value[b]	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

	120-day mortality				**365-day mortality**			
	N (%)	**Crude OR (95% CI)**	**Age-sex adjusted OR[a] (95% CI)**	**Age, sex & comorbidity-adjusted OR[a] (95% CI)**	**N (%)**	**Crude OR (95% CI)**	**Age-sex adjusted OR[a] (95% CI)**	**Age, sex & comorbidity-adjusted OR[a] (95% CI)**
Q1	7,462 (17.0)	Reference category			11,513 (26.3)	Reference category		
Q2	8,198 (17.4)	1.03 (0.99,1.06)	1.05 (1.01,1.08)	1.02 (0.99,1.06)	12,875 (27.3)	1.05 (1.02,1.09)	1.08 (1.05,1.11)	1.06 (1.02,1.09)
Q3	8,609 (18.3)	1.09 (1.06,1.13)	1.12 (1.09,1.16)	1.08 (1.05,1.12)	13,350 (28.4)	1.11 (1.08,1.15)	1.15 (1.12,1.19)	1.11 (1.07,1.14)
Q4	7,988 (18.9)	1.13 (1.09,1.17)	1.20 (1.16,1.24)	1.13 (1.09,1.17)	12,433 (29.3)	1.17 (1.13,1.20)	1.24 (1.20,1.28)	1.17 (1.13,1.21)
Q5	7,426 (19.3)	1.17 (1.13,1.21)	1.31 (1.26,1.36)	1.21 (1.17,1.26)	11,433 (29.8)	1.19 (1.15,1.23)	1.34 (1.30,1.39)	1.24 (1.20,1.28)
p value[b]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

[a] Age was categorised in 5-yearly age groupings from 60 years to 90+ years; comorbidity was defined as no comorbidity, comorbidity that excluded dementia, and that included dementia

[b] Pearson's chi-squared test was used to assess the association between deprivation quintiles and mortality variables; logistic regression was used to assess trends in mortality variables by deprivation quintiles

Table 3: Mean and median superspell LOS in days by levels of deprivation among men and women aged 60+ years admitted to hospital with a hip fracture, 2011-2015
(Quintile 1 (Q1) -least deprived quintile, quintile 5 (Q5) – most deprived quintile)

IMD quintile	Mean (SD)	Median (IQR)
Q1	23.3 (22.1)	16 (10-29)
Q2	23.1 (21.1)	16 (10-29)
Q3	23.4 (21.2)	16 (10-30)
Q4	24.2 (22.0)	17 (10-31)
Q5	24.4 (21.7)	17 (11-31)

LOS – length of stay; SD – standard deviation; IQR – inter-quartile range

Table 4: Association between quintiles of deprivation and emergency 30-day readmission following hospital admission for hip fracture in men and women aged 60+ years, 2011–2014
(Quintile 1 (Q1) (least deprived quintile) – reference category), quintile 5 (Q5) – most deprived quintile)

IMD quintile	N (%)	Crude OR	Age & sex adjusted OR[a]	Age, sex & comorbidity adjusted OR[a]
Q1	5,744 (14.2)	Reference category		
Q2	6,358 (14.7)	1.04 (1.00,1.08)	1.05 (1.01,1.09)	1.04 (1.00,1.08)
Q3	6,658 (15.5)	1.11 (1.07,1.15)	1.12 (1.08,1.16)	1.10 (1.06,1.14)
Q4	6,250 (16.3)	1.17 (1.13,1.22)	1.19 (1.15,1.24)	1.16 (1.11,1.21)
Q5	6,062 (17.5)	1.28 (1.23,1.33)	1.32 (1.27,1.38)	1.27 (1.22,1.32)
p value[b]	<0.001	<0.001	<0.001	<0.001

[a] Age was categorised in 5-yearly age groupings from 60 years to 90+ years; comorbidity was defined as no comorbidity, comorbidity that excluded dementia and dementia +/- other comorbidities
[b] Logistic regression was used to assess trends in emergency 30-day readmission by deprivation quintiles

Supplementary tables

Supplementary Table 1: Association between quintiles of deprivation and mortality at 7-days and 30-days after hip fracture by levels of comorbidity in men and women aged 60+ years, 2011–2014

(Quintile 1 (Q1) – least deprived quintile (reference category), quintile 5 (Q5) – most deprived quintile)

	7-day mortality			**30-day mortality**		
	N (%)	**Crude OR (95% CI)**	**Age-sex adjusted OR[a] (95% CI)[a]**	**N (%)**	**Crude OR (95% CI)**	**Age-sex adjusted OR[a] (95% CI)[a]**
No comorbidity						
Q1	110 (0.90)	Reference category		252 (2.1)	Reference category	
Q2	114 (0.93)	1.04 (0.80,1.35)	1.06 (0.81,1.38)	274 (2.2)	1.09 (0.91,1.29)	1.12 (0.94,1.33)
Q3	123 (1.1)	1.21 (0.94,1.57)	1.23 (0.95,1.59)	278 (2.5)	1.20 (1.01,1.43)	1.22 (1.02,1.45)
Q4	110 (1.2)	1.32 (1.01,1.73)	1.34 (1.03,1.75)	244 (2.6)	1.28 (1.08,1.54)	1.31 (1.09,1.57)
Q5	85 (1.1)	1.25 (0.94,1.66)	1.33 (1.00,1.78)	221 (2.9)	1.43 (1.19,1.71)	1.54 (1.28,1.85)
p value[b]	0.17	0.02	0.008	0.001	<0.001	<0.001
Comorbidity that excluded dementia						
Q1	659 (3.3)	Reference category		1,607 (8.1)	Reference category	
Q2	755 (3.5)	1.05 (0.94,1.17)	1.07 (0.96,1.19)	1,835 (8.5)	1.05 (0.98,1.13)	1.07 (1.00,1.15)
Q3	801 (3.6)	1.08 (0.97,1.20)	1.13 (1.01,1.25)	1,915 (8.5)	1.06 (0.99,1.14)	1.11 (1.03,1.19)
Q4	689 (3.3)	1.01 (0.90,1.12)	1.09 (0.97,1.21)	1,803 (8.7)	1.09 (1.01,1.17)	1.17 (1.09,1.26)
Q5	737 (3.7)	1.13 (1.02,1.26)	1.31 (1.17,1.46)	1,798 (9.1)	1.14 (1.06,1.23)	1.31 (1.22,1.40)
p value[b]	0.12	0.09	<0.001	0.005	<0.001	<0.001
Comorbidity that included dementia						
Q1	380 (3.3)	Reference category		1,284 (11.0)	Reference category	
Q2	459 (3.5)	1.08 (0.94,1.24)	1.10 (0.96,1.26)	1,484 (11.3)	1.03 (0.95,1.12)	1.05 (0.97,1.14)
Q3	472 (3.6)	1.10 (0.96,1.26)	1.12 (0.98,1.29)	1,511 (11.4)	1.04 (0.96,1.13)	1.06 (0.98,1.15)
Q4	441 (3.6)	1.10 (0.96,1.26)	1.15 (1.00,1.32)	1,356 (10.9)	1.00 (0.92,1.08)	1.04 (0.96,1.13)
Q5	351 (3.2)	0.97 (0.84,1.13)	1.05 (0.90,1.21)	1,210 (10.9)	0.99 (0.92,1.08)	1.07 (0.98,1.16)
p value[b]	0.29	0.87	0.38	0.62	0.57	0.24

[a] Age was categorised in 5-yearly age groupings from 60 years to 90+ years

[b] Pearson's chi-squared test was used to assess the association between deprivation quintiles and mortality variables; logistic regression was used to assess trends in mortality variables by deprivation quintiles

Supplementary Table 2: Association between quintiles of deprivation and mortality at 120-days and 365-days after hip fracture by levels of comorbidity in men and women aged 60+ years, 2011–2014

(Quintile 1 (Q1) – least deprived quintile (reference category), quintile 5 (Q5) – most deprived quintile)

	120-day mortality			**365-day mortality**		
	N (%)	**Crude OR (95% CI)**	**Age-sex adjusted OR[a] (95% CI)[a]**	**N (%)**	**Crude OR (95% CI)**	**Age-sex adjusted OR[a] (95% CI)[a]**
No comorbidity						
Q1	673 (5.5)	Reference category		1,220 (9.9)	Reference category	
Q2	664 (5.4)	0.98 (0.88,1.10)	1.01 (0.90,1.13)	1,308 (10.6)	1.08 (0.99,1.17)	1.11 (1.02,1.21)
Q3	653 (5.8)	1.05 (0.94,1.18)	1.07 (0.95,1.20)	1,267 (11.2)	1.14 (1.05,1.24)	1.16 (1.07,1.27)
Q4	588 (6.3)	1.16 (1.04,1.30)	1.19 (1.06,1.33)	1,081 (11.6)	1.19 (1.09,1.30)	1.22 (1.12,1.34)
Q5	543 (7.1)	1.33 (1.18,1.49)	1.44 (1.28,1.62)	946 (12.4)	1.29 (1.18,1.41)	1.40 (1.27,1.54)
p value[b]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Comorbidity that excluded dementia						
Q1	3,404 (17.1)	Reference category		5,238 (26.3)	Reference category	
Q2	3,809 (17.5)	1.03 (0.98,1.08)	1.05 (1.00,1.11)	5,914 (27.2)	1.05 (1.00,1.09)	1.07 (1.03,1.12)
Q3	4,055 (18.1)	1.07 1.01,1.12)	1.12 (1.06,1.17)	6,323 (28.2)	1.10 (1.05,1.14)	1.15 (1.10,1.20)
Q4	3,761 (18.2)	1.08 (1.02,1.13)	1.17 (1.11,1.23)	5,873 (28.4)	1.11 (1.06,1.16)	1.21 (1.16,1.26)
Q5	3,677 (18.7)	1.11 (1.05,1.17)	1.28 (1.22,1.35)	5,701 (28.9)	1.14 (1.09,1.19)	1.32 (1.26,1.38)
p value[b]	0.001	<0.001	<0.001	p<0.001	<0.001	<0.001
Comorbidity that included dementia						
Q1	3,385 (28.9)	Reference category		5,055 (43.2)	Reference category	
Q2	3,725 (28.3)	0.97 (0.92,1.02)	0.99 (0.93,1.04)	5,653 (43.0)	0.99 (0.94,1.04)	1.01 (0.96,1.06)
Q3	3,901 (29.4)	1.02 (0.97,1,08)	1.04 (0.99,1.10)	5,760 (43.5)	1.01 (0.96,1.06)	1.03 (0.98,1.08)
Q4	3,639 (29.3)	1.02 (0.97,1.08)	1.06 (1.01,1.13)	5,479 (44.2)	1.04 (0.99,1.09)	1.09 (1.03,1.15)
Q5	3,206 (28.9)	1.00 (0.94,1.05)	1.07 (1.01,1.13)	4,786 (43.1)	0.99 (0.94,1.05)	1.06 (1.01,1.13)
p value[b]	0.27	0.46	0.001	0.30	0.46	0.001

[a] Age was categorised in 5-yearly age groupings from 60 years to 90+ years; comorbidity was defined as no comorbidity,

[b] Pearson's chi-squared test was used to assess the association between deprivation quintiles and mortality variables; logistic regression was used to assess trends in mortality variables by deprivation quintiles

Supplementary Table 3: Cumulative mortality rates up to 365-days after hip fracture by levels of deprivation and comorbidity in men aged 60-84 and 85+ years

	7-day mortality[a] (%)		30-day mortality (%)		120-day mortality (%)		365-day mortality (%)	
	60-84 years	85+ years	60-84 years	85+ years	60-84 years	85+ years	60-84 years	85+ years
No comorbidity								
Total (N (%))	52 (0.7)	102 (2.7)	147 (2.1)	263 (7.0)	321 (4.5)	578 (15.5)	646 (9.1)	975 (26.1)
Q1	0.61	2.6	1.7	6.6	4.8	15.7	8.3	25.2
Q2			2.	6.2	3.7	12.8	8.3	23.9
Q3	<1%	3.1	1.8	7.2	4.2	15.6	8.9	27.2
Q4	0.88	2.7	2.3	7.7	4.9	16.7	9.5	27.5
Q5			2.8	8.5	5.2	18.0	11.0	28.2
p value[b]	0.50	0.69	0.29	0.54	0.33	0.10	0.09	0.30
Comorbidity that excluded dementia								
Total (N (%))	614 (3.0)	802 (6.1)	1,643 (8.0)	2,072 (15.7)	3,387 (16.5)	4,039 (30.5)	5,406 (26.4)	5,977 (45.2)
Q1	2.8	5.8	7.2	14.2	16.0	28.2	24.9	43.0
Q2			7.6	15.4	15.3	30.3	24.7	44.8
Q3	3.1	6.2	7.6	15.4	16.5	30.7	26.8	45.4
Q4	3.1	6.4	8.6	16.2	17.7	31.1	27.8	45.4
Q5			8.8	18.1	17.0	33.7	27.4	48.8
p value[b]	0.36	0.45	0.03	0.007	0.03	0.002	0.002	0.002
Comorbidity that included dementia								
Total (N (%))	240 (3.2)	509 (6.4)	878 (11.8)	1,655 (20.7)	2,282 (30.6)	3,607 (45.0)	3,452 (46.3)	5,003 (62.5)
Q1	3.4	5.8	12.1	20.0	32.1	43.9	46.4	61.2
Q2			11.7	21.1	29.8	43.3	45.8	62.1
Q3	3.4	7.3	12.	22.2	31.6	47.0	47.7	63.1
Q4	3.0	6.5	11.5	18.8	31.0	44.9	47.1	62.7
Q5			10.9	21.0	28.8	46.4	44.7	63.2
p value[b]	0.58	0.11	0.52	0.17	0.28	0.16	0.51	0.78

[a] 7-day mortality data aggregated for Q1/Q2 and Q4/Q5 for suppression of small numbers (N<20)

[b] Pearson's chi-squared test was used to assess the association between deprivation quintiles and mortality variables

Supplementary Table 4: Cumulative mortality rates up to 365-days after hip fracture by levels of deprivation and comorbidity in women aged 60-84 and 85+ years

	7-day mortality[a] (%)		30-day mortality (N (%))		120-day mortality (N (%))		365-day mortality (N (%))	
	60-84 years	85+ years	60-84 years	85+ years	60-84 years	85+ years	60-84 years	85+ years
No comorbidity								
Total (N (%))	82 (0.3)	306 (1.7)	192 (0.8)	667 (3.7)	498 (2.1)	1,724 (9.6)	1,060 (4.4)	3,141 (17.4)
Q1	0.33	1.5	0.6	3.1	1.8	8.4	3.8	15.4
Q2			0.8	3.4	2.0	9.1	4.3	17.3
Q3	<1%	1.9	0.6	4.2	1.5	9.9	3.7	18.6
Q4	0.44	1.9	1.0	3.8	2.4	9.7	5.1	17.6
Q5			1.2	4.2	3.1	11.4	6.0	18.9
p value[b]	0.13	0.07	0.008	0.04	<0.001	0.001	<0.001	0.001
Comorbidity that excluded dementia								
Total (N (%))	812 (2.0)	1,413 (4.6)	2,019 (5.1)	3,224 (10.4)	4,503 (11.3)	6,777 (21.8)	7,333 (18.5)	10,333 (33.3)
Q1	1.9	4.4	4.5	9.6	10.1	20.3	16.1	30.8
Q2			4.7	10.3	10.5	21.5	17.1	33.0
Q3	1.9	4.8	5.0	10.5	10.9	22.4	17.8	34.3
Q4	2.3	4.6	5.3	10.5	11.9	21.8	19.6	34.0
Q5			5.9	11.2	13.1	23.3	21.4	34.8
p value[b]	0.02	0.35	0.001	0.12	<0.001	0.003	<0.001	<0.001
Comorbidity that included dementia								
Total (N (%))	296 (1.8)	1,058 (3.6)	984 (5.9)	3,328 (11.3)	3,096 (18.5)	8,871 (30.1)	5,144 (30.8)	13,134 (44.6)
Q1	2.0	3.4	5.4	11.0	18.0	29.6	30.0	44.2
Q2			5.9	11.4	18.0	29.4	30.2	43.9
Q3	1.6	3.6	5.8	11.0	18.6	29.9	30.4	44.0
Q4	1.7	3.8	6.1	11.6	19.3	30.9	32.2	45.8
Q5			6.1	11.5	18.5	31.2	30.9	45.5
p value[b]	0.29	0.39	0.79	0.79	0.63	0.13	0.29	0.12

[a] 7-day mortality data aggregated for Q1/Q2 and Q4/Q5 for suppression of small numbers (N<20)

[b] Pearson's chi-squared test was used to assess the association between deprivation quintiles and mortality variables

Supplementary Table 5: Mean and median superspell LOS in days by age, sex and comorbidity

	Mean (SD)	Median (IQR)	p value[a]
Age group			
60-84 years	21.3 (21.0)	14 (9-26)	<0.001
85+ years	26.4 (21.9)	20 (12-34)	
Sex			
Males	25.5 (23.3)	18 (10-33)	<0.001
Females	23.0 (20.9)	16 (10-29)	
Comorbidity			
No comorbidity	18.9 (18.2)	13 (8-23)	<0.001
Comorbidity excl. dementia	24.7 (21.8)	18 (11-31)	
Comorbidity incl. dementia	26.2 (23.4)	19 (10-35)	

[a] Linear regression was used to assess trends in superspell LOS by age, sex and comorbidity, with log-transformation of median superspell LOS; p-values presented are for both mean and median values

SD – standard deviation; IQR – inter-quartile range

Supplementary Table 6: Association between quintiles of deprivation and emergency 30-day readmission following hospital admission for hip fracture by levels of comorbidity in men and women aged 60+ years, 2011–2014
(Quintile 1 (Q1) (least deprived quintile) – reference category), quintile 5 (Q5) – most deprived quintile)

IMD quintile	N (%)	Crude ORs	Age & sex adjusted ORs[a]
No comorbidity			
Q1	1,179 (9.8)	Reference category	
Q2	1,203 (10.0)	1.02 (0.94,1.11)	1.03 (0.94,1.12)
Q3	1,166 (10.6)	1.08 (0.99,1.18)	1.09 (1.00,1.19)
Q4	991 (11.0)	1.13 (1.03,1.24)	1.14 (1.04,1.24)
Q5	812 (11.0)	1.14 (1.03,1.25)	1.17 (1.06,1.28)
p value[b]	0.01	0.001	<0.001
Comorbidity excluding dementia			
Q1	2,863 (15.9)	Reference category	
Q2	3,134 (16.1)	1.01 (0.96,1.07)	1.02 (0.97,1.08)
Q3	3,339 (16.6)	1.05 (0.99,1.11)	1.07 (1.01,1.13)
Q4	3,135 (17.0)	1.08 (1.03,1.15)	1.12 (1.06,1.18)
Q5	3,207 (18.3)	1.18 (1.12,1.25)	1.25 (1.18,1.32)
p value[b]	<0.001	<0.001	<0.001
Comorbidity including dementia			
Q1	1,702 (16.4)	Reference category	
Q2	2,021 (17.4)	1.07 (1.00,1.15)	1.08 (1.00,1.16)
Q3	2,153 (18.3)	1.15 (1.07,1.23)	1.15 (1.07,1.23)
Q4	2,124 (19.4)	1.23 (1.14,1.32)	1.23 (1.15,1.32)
Q5	2,043 (20.8)	1.34 (1.25,1.44)	1.34 (1.25,1.44)
p value[b]	<0.001	<0.001	<0.001

[a] Age was categorised in 5-yearly age groupings from 60 years to 90+ years
[b] Logistic regression modelling was used to assess trends in ORs by deprivation quintiles, treating deprivation as a linear term