HIP

Baseline quality of life in people with hip fracture: results from the multicentre WHiTE cohort study

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Aims
To assess the variation in pre-fracture quality of life (QoL) within the UK hip fracture population, and quantify the nature and strength of associations between QoL and other routinely collected patient characteristics and treatment choices.

Methods
The World Hip Trauma Evaluation (WHiTE) study, an observational cohort study of UK hip fracture patients, collects a range of routine data and a health-related QoL score (EuroQol five-dimensional questionnaire (EQ-5D)). Pre-fracture QoL data are summarized and statistical models fitted to understand associations between QoL, patient characteristics, fracture types, and operations.

Results
Fitting a multiple linear regression model indicated that 36.5% of the variance in pre-fracture EQ-5D scores was explained by routinely collected patient characteristics: sex (0.14%), age (0.17%), American Society of Anesthesiologists (ASA) score (0.73%), Abbreviated Mental Test Score (AMTS; 1.3%), pre-fracture mobility (11.2%), and EQ-5D respondent (participant, relative, or carer; 23.0%). There was considerable variation in pre-fracture EQ-5D scores between operations within fracture types. Participants with trochanteric fractures reported statistically significant but not clinically relevant lower pre-fracture QoL than those with intracapsular fractures. Participants with intracapsular fractures treated with internal fixation or total hip arthroplasty (THA) reported better QoL than those treated with hemiarthroplasty with the overall fittest group receiving THA.

Conclusion
Pre-fracture QoL varies considerably between hip fracture patients; it is generally higher in younger than older patients, patients with better mobility, and those patients who live more independently. Pre-fracture QoL is significantly associated with a range of patient characteristics (e.g. age, mobility, residency). These data explain ~35% of the variation in QoL.

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Article focus
- This article focuses on the potential variation in pre-fracture quality of life (QoL) within the UK hip fracture population.
- It assesses the associations between QoL and other routinely collected patient characteristics and treatment choices.

Key messages
- Pre-fracture QoL varies considerably between hip fracture patients.
- Patient characteristics such as age and mobility can only partly account for this variation.

Strengths and limitations
- The great strengths of the study were the prospective nature of data collection and the inclusion of patient-reported outcomes for this patient group.
- One potential limitation is the accuracy of the data reporting which is common...
for studies of this size, although this was deemed to be acceptable upon examination of the dataset.

**Introduction**

Health-related quality of life (QoL) is now recognized as the most important measure of patient outcome after hip fracture.1–5 The EuroQol five-dimension questionnaire (EQ-5D)6–7 is the most widely used tool for measuring QoL8–10 and is part of the UK Core Outcome Set for hip fracture studies,10 which has been adopted by the National Institute for Health and Care Excellence in Hip Fracture Guidelines.11 The measurement properties of EQ-5D in the UK hip fracture population have been extensively studied, with previous work describing the characteristics and responsiveness of the measure,1 the post-fracture recovery profile,2 and the merits of death-adjusted and unadjusted scores.12 There has not, however, been such a detailed examination of the variation of EQ-5D at baseline more generally in the population sustaining hip fracture, and particularly the relationship between EQ-5D and other widely reported population characteristics such as pre-fracture mobility and residency.

The World Hip Trauma Evaluation (WHiTE) cohort was established in 2014, with the same inclusion criteria as the UK National Hip Fracture Database13 and recruited participants into the study from a representative sample of hospitals that also reported cases to the registry. WHiTE provides comprehensive follow-up of all participants including QoL,4 fracture classification, operation,15 and medication,16 and has been shown to be representative of the wider UK hip fracture population.17

The aim of this study was to model variation in QoL to determine if baseline QoL can be predicted by baseline characteristics commonly collected in other hip fracture studies, or whether it is an important independent predictor of outcome. Specifically we considered the following objectives: 1) to assess the variation in pre-fracture QoL within the UK hip fracture population; 2) to assess and quantify the nature and strength of associations (correlations) between QoL and other routinely collected baseline (pre-fracture) characteristics of patients sustaining hip fracture; and 3) to assess the extent to which pre-fracture QoL is associated with subsequent choice of treatment.

**Methods**

**Design, setting, and participants.** The WHiTE study is an observational cohort study that collects information on assessment, treatment, and recovery of patients admitted to participating UK NHS hospitals after hip fracture. Participants were eligible to participate in WHiTE if they were aged 60 years or older and were to be treated operatively for a hip fracture. WHiTE also collected outcome data from a number of embedded randomized controlled trials: WHiTE One,16–18 WHiTE Two,19,20 WHiTE3Hemi,5,21 WHiTE4,22 and WHiTES.23

**Consent.** Participants gave their consent to participate in the WHiTE study or, for those without capacity, agreement was provided by an appropriate consultee. The WHiTE study was approved by research ethics committees (RECs; WHiTE cohort approved by Camberwell St Giles Research Ethics Committee with reference 11/LO/0927).

**Treatment.** Participants enrolled in the WHiTE cohort study only were treated in accordance with local standard care pathways. The National Institute for Clinical Excellence (NICE) have issued standardized care guidelines that are used in the majority of hospitals, and are summarized in the WHiTE cohort study protocol.4 A minority of participants were enrolled in embedded randomized studies and were randomly allocated to a treatment; all treatment options were in routine use in the NHS.5,22

**Sample size and data.** The data reported here are based upon the data extract for the pre-specified analysis of the WHiTE cohort of the first 6,000 complete outcome datasets. Full details are reported in the published protocol.4

**Data collection.** Data were transcribed from clinical reporting forms completed by recruitment centre research teams at baseline, or entered directly during follow-up telephone calls, by the central trial team into the WHiTE database (OpenClinica, V3.7; OpenClinica LLC, Waltham, Massachusetts, USA). Data were extracted from the database and saved to a comma separated (csv) format for analysis.

The main focus of the analysis reported here is QoL assessed by the EuroQol five-dimension five-level questionnaire (EQ-5D-5L);6,7 a generic, validated, cross-disciplinary standardized health utility instrument widely used to assess QoL after hip fracture. EQ-5D has two parts: a visual analogue scale (VAS), which measures self-rated health; and a health status instrument, which is the focus of the analysis reported here, consisting of a five-level response (no problems, slight problems, moderate problems, severe problems, and extreme problems) for five health domains related to daily activities (mobility, self-care, usual activities, pain and discomfort, and anxiety and depression). Each WHiTE participant was asked to indicate their health state by ticking the box next to the most appropriate statement in each of the five dimensions; combining these together provides a five-digit number that describes the individual’s health state. The five-digit responses, from the EQ-5D health classifications, were converted into an overall score using a published utility algorithm for the UK population.24

Participants in WHiTE were asked to provide (retrospective) pre-fracture assessments of QoL, using EQ-5D, at enrolment into the study. In addition to an assessment of pre-fracture EQ-5D, a number of other important participant characteristics were collected at baseline. Foremost among these were the demographic variables of age, sex, alcohol consumption, smoking status, and reported diabetes or renal failure. Additionally participants were asked about their residence and mobility...
Results

Description of the data. Full details of the initial WHITE dataset are reported elsewhere.\textsuperscript{15} However, to aid interpretation of this report the dataset includes data from 8,673 participants recruited between May 2014 and April 2017, of whom 7,391 provided a baseline EQ-5D.

Participant characteristics. The mean age of WHITE cohort participants at recruitment was 83 years (SD 8.5), and the percentage female to male sex split was 72.5:27.5.

Table I shows full details of participant characteristics, together with pre-fracture mean EQ-5D scores by group; the overall mean EQ-5D was 0.65 (SD 0.29; n = 7,391). The majority of participants (83%, n = 7,159) lived in their own home or in sheltered housing, and were either freely mobile without aids (40%, n = 3,498) or mobile outdoors with one aid (24%, n = 2,063).

There were marked and highly clinically and statistically significant\textsuperscript{12} differences in pre-fracture QoL between the groups identified in Table I. QoL reduced with age (< 80 years vs 80+ years: mean difference 0.10 in favour of younger age; 95% CI 0.08 to 0.11; p < 0.001, paired t-test) and ASA score (ASA I vs ASA IV: mean difference 0.34 in favour of ASA I; 95% CI 0.30 to 0.39; p < 0.001, paired t-test), and increased with AMTS score (severe impairment vs no impairment: mean difference 0.34 in favour of no impairment; 95% CI 0.32 to 0.36; p < 0.001, paired t-test). Variation in QoL with pre-fracture mobility followed the pattern one might expect clinically, with significant differences observed for all categories between the extremes of ‘freely mobile without aids’ to ‘no functional mobility’ (mean difference 0.47 in favour of increased mobility; 95% CI 0.43 to 0.52; p < 0.001, paired t-test). For pre-fracture residency, there were similar trends with clinically and statistically significant differences in QoL observed (own home vs nursing care: mean difference 0.33; 95% CI 0.30 to 0.36; p < 0.001, paired t-test). There were statistically significant differences in QoL between sexes, alcohol and smoking groupings, and renal function, although none of these differences reached clinical significance.

There were also large and statistically significant differences in QoL between EQ-5D respondent groups; participant responders (0.74) reported higher EQ-5D scores than both NOK or relative (0.42) and carer or nursing home (0.55) groups. These differences, in part at least, are explained simply by participants in the latter groups being older and having lower AMTS scores.

Fracture type and operation. Table II shows full details of participant fractures and operations, together with pre-fracture mean EQ-5D scores by group. The simple group means in Table II hide considerable variation in EQ-5D scores between operations within fracture type groups; Figure 1 displays these differences graphically. Participants with trochanteric fractures reported statistically significant but not clinically relevantly lower pre-fracture QoL than those with intracapsular fractures (mean difference EQ-5D in favour intracapsular types 0.04; 95% CI 0.03 to 0.05; p < 0.001, paired t-test).

Participants with intracapsular fractures treated with internal fixation or total hip arthroplasty (THA) reported better QoL than those treated with hemiarthroplasty, with the overall fittest group being those receiving THA. The overwhelming majority of participants with trochanteric fractures were treated with either a sliding hip screw (SHS) or intramedullary nail (IM nail) so that estimates in those treated with arthroplasty are very imprecise. The participants treated with an IM nail reported clinically similar QoL (mean difference EQ-5D in favour of IM nail 0.05; 95% CI 0.01 to 0.08; p = 0.05, paired t-test). Fewer participants had a subtrochanteric fracture and so there was considerable imprecision in the estimates of QoL.

Modelling. In order to fully understand the complexity of the relationships observed between the patient baseline data and QoL, we proceeded to fit linear regression models using all the characteristics reported in Table I as explanatory variables and EQ-5D as the response variable. The best fitting model accounted for 36.5% of the variance in EQ-5D scores, with the following terms proving to be significant: sex (0.14%); age (0.17%); ASA (0.73%); AMTS (1.3%); pre-fracture mobility (11.2%); and EQ-5D respondent (23.0%), where numbers in parentheses are 5% level, adjusted for multiple comparisons using the Holm–Bonferroni method.\textsuperscript{30} In order to model the relationship between baseline patient characteristics and baseline EQ-5D, regression models were fitted with the latter as the response variable and the former as explanatory variables. Model fitting proceeded using a forward selection and backwards elimination algorithm. Due to the size of the dataset available for model development and the risk of overfitting, decisions for inclusion of terms were based on changes in the Bayesian information criterion (BIC).\textsuperscript{31} The effect of recruitment centre on baseline EQ-5D was assessed after conditioning on the important patient characteristics identified during model development. For the purposes of inference, the minimum clinically important difference for EQ-5D was considered to be 0.075.\textsuperscript{32} All analyses were undertaken in the statistical software R (R Foundation for Statistical Computing, Vienna, Austria).
Table I. World Hip Trauma Evaluation cohort participant characteristics at baseline.

| Characteristic                  | Group                | n     | %    | QoL EQ-5D | p-value* |
|---------------------------------|----------------------|-------|------|-----------|----------|
| Sex (n = 8,673; 100%)           | Female               | 6,290 | 72.5 | 0.64      | 0.63 to 0.65 | -       |
|                                 | Male                 | 2,383 | 27.5 | 0.68      | 0.66 to 0.69 | < 0.001 |
| Age (years) (n = 8,673; 100%)   | < 80 (median = 74; IQR = 70 to 78) | 3,095 | 35.7 | 0.71      | 0.70 to 0.72 | -       |
|                                 | 80+ (median = 87; IQR = 84 to 91) | 5,578 | 64.3 | 0.61      | 0.60 to 0.62 | < 0.001 |
| Smoker (n = 7,713; 88.9%)       | No                   | 6,981 | 80.5 | 0.65      | 0.64 to 0.65 | -       |
|                                 | Yes                  | 732   | 8.4  | 0.68      | 0.66 to 0.70 | 0.002   |
| Alcohol (n = 7,685; 88.6%)      | 0 to 7 units         | 6,841 | 78.9 | 0.64      | 0.63 to 0.64 | -       |
|                                 | 8 to 14 units        | 457   | 5.3  | 0.76      | 0.74 to 0.78 | < 0.001 |
|                                 | 15 to 21 units       | 173   | 2.0  | 0.74      | 0.70 to 0.78 | < 0.001 |
|                                 | > 21 units           | 214   | 2.5  | 0.70      | 0.66 to 0.73 | 0.018   |
| Diabetes (n = 7,742; 89.3%)     | No                   | 6,556 | 75.6 | 0.65      | 0.64 to 0.66 | -       |
|                                 | Yes                  | 1,186 | 13.7 | 0.64      | 0.62 to 0.66 | 0.213   |
| Renal failure (n = 7,735; 89.2%)| No                   | 7,244 | 83.5 | 0.65      | 0.64 to 0.66 | -       |
|                                 | Yes                  | 491   | 5.7  | 0.70      | 0.67 to 0.62 | < 0.001 |
| AMTS (n = 8,293; 95.6%)         | 0 to 3: Severe impairment | 1,446 | 16.7 | 0.37      | 0.36 to 0.39 | -       |
|                                 | 4 to 6: Moderate impairment | 728   | 8.4  | 0.52      | 0.50 to 0.55 | < 0.001 |
|                                 | 7 to 10: No impairment | 6,119 | 70.6 | 0.72      | 0.71 to 0.72 | < 0.001 |
| ASA score (n = 8,165; 94.1%)    | I                    | 188   | 2.2  | 0.85      | 0.82 to 0.89 | -       |
|                                 | II                   | 2,307 | 26.6 | 0.76      | 0.75 to 0.77 | < 0.001 |
|                                 | III                  | 4,586 | 52.9 | 0.61      | 0.60 to 0.62 | < 0.001 |
|                                 | IV                   | 1,071 | 12.3 | 0.51      | 0.49 to 0.53 | < 0.001 |
|                                 | V                    | 13    | 0.1  | 0.43      | 0.22 to 0.64 | < 0.001 |
| Pre-fracture mobility (n = 8,570; 98.8%) | No functional mobility | 191   | 2.2  | 0.31      | 0.25 to 0.36 | -       |
|                                 | Freely mobile: without aids | 3,498 | 40.3 | 0.78      | 0.77 to 0.79 | < 0.001 |
|                                 | Mobile outdoors: one aid | 2,063 | 23.8 | 0.64      | 0.63 to 0.66 | < 0.001 |
|                                 | Mobile outdoors: two aids/frame | 1,419 | 16.4 | 0.54      | 0.52 to 0.55 | < 0.001 |
|                                 | Indoor mobility: help outside | 1,325 | 15.3 | 0.44      | 0.42 to 0.45 | < 0.001 |
|                                 | Unknown              | 74    | 0.9  | 0.52      | 0.44 to 0.61 | < 0.001 |
| Pre-fracture residency (n = 8,587; 99.0%) | Own home/Sheltered housing | 7,159 | 82.5 | 0.69      | 0.68 to 0.70 | -       |
|                                 | Residential care     | 778   | 9.0  | 0.40      | 0.38 to 0.42 | < 0.001 |
|                                 | Nursing care         | 525   | 6.1  | 0.36      | 0.33 to 0.39 | < 0.001 |
|                                 | Rehab unit           | 10    | 0.1  | 0.59      | 0.37 to 0.81 | 0.999   |
|                                 | Index hospital       | 76    | 0.9  | 0.52      | 0.45 to 0.60 | < 0.001 |
|                                 | Other hospital in Trust | 25   | 0.3  | 0.58      | 0.46 to 0.70 | 0.333   |
|                                 | Other                | 14    | 0.2  | 0.48      | 0.29 to 0.67 | 0.076   |
| EQ-5D respondent (n = 6,610; 76.2%) | Participant         | 4,720 | 54.4 | 0.74      | 0.73 to 0.74 | -       |
|                                 | NOK/Relative         | 1,703 | 19.6 | 0.42      | 0.41 to 0.43 | < 0.001 |
|                                 | Carer/Nursing home   | 187   | 2.2  | 0.35      | 0.30 to 0.39 | < 0.001 |

*Paired t-tests, with first category as comparator, using Holm’s correction for multiple testing.

AMTS = Abbreviated Mental Test Score, ASA = American Society of Anesthesiologists, CI = confidence interval, NOK = next of kin; IQR, interquartile range; EQ-5D, EuroQol five-dimensional questionnaire; QoL, quality of life.

The percentage of the variance accounted for by the individual terms. Excluding EQ-5D respondent yielded an almost equally well fitting model, which accounted for 33.1% of the variance in EQ-5D scores where the following terms proved significant: sex (0.17%); pre-fracture residency (0.63%); ASA (1.1%); AMTS (10.0%); and pre-fracture mobility (21.3%). As a final step in the modelling, the recruitment centre variable was added to the best fitting model, in order to assess whether there were systematic differences in baseline QoL between recruitment centres, which could not be explained by the variation in participant characteristics between recruitment centres. This extended model was no improvement on the best fitting model (change in BIC was negative), indicating that the variation in EQ-5D between recruitment centres was not important after adjusting for the differing participant characteristics between recruitment centres. This is best visualized by plotting adjusted EQ-5D values from the best fitting model by recruitment centre (Figure 2), which shows a consistent distribution of values across sites with no outliers.

Discussion

In this large, multicentre study collecting health-related QoL in people with hip fracture, we found that...
Table II. Fracture and operation details of World Hip Trauma Evaluation cohort study participants.

| Characteristic                  | Group         | n   | %   | EQ-SD mean | 95% CI       | p-value* |
|---------------------------------|---------------|-----|-----|------------|--------------|----------|
| Fracture side                   |               |     |     |            |              |          |
| (n = 8,588; 99.0%)              |               |     |     |            |              |          |
| Left                            |               | 4,469 | 51.5 | 0.65       | 0.64 to 0.66 | -        |
| Right                           |               | 4,119 | 47.5 | 0.65       | 0.64 to 0.66 | 0.414    |
| Fracture type                   |               |     |     |            |              |          |
| (n = 8,580; 98.9%)              |               |     |     |            |              |          |
| Intracapsular                   |               | 5,148 | 59.4 | 0.66       | 0.66 to 0.67 | -        |
| Trochanteric                    |               | 3,030 | 34.9 | 0.62       | 0.61 to 0.64 | < 0.001  |
| Subtrochanteric                 |               | 402  | 4.6  | 0.63       | 0.60 to 0.66 | 0.080    |
| Pathological fracture           |               |     |     |            |              |          |
| (n = 8,351; 96.3%)              |               |     |     |            |              |          |
| No                              |               | 8,235 | 94.9 | 0.65       | 0.64 to 0.65 | -        |
| Atypical                        |               | 33   | 0.4  | 0.63       | 0.51 to 0.74 | 0.999    |
| Malignant                       |               | 83   | 1.0  | 0.64       | 0.56 to 0.72 | 0.999    |
| Operation                       |               |     |     |            |              |          |
| (n = 8,558; 98.7%)              |               |     |     |            |              |          |
| Hemiarthroplasty                |               | 3,710 | 42.8 | 0.62       | 0.61 to 0.63 | < 0.001  |
| Total hip arthroplasty          |               | 814  | 9.4  | 0.83       | 0.81 to 0.84 | < 0.001  |
| Sliding hip screw               |               | 2,941 | 33.9 | 0.63       | 0.62 to 0.64 | < 0.001  |
| Intramedullary nail             |               | 830  | 9.6  | 0.66       | 0.63 to 0.68 | 0.163    |
| Other                           |               | 15   | 0.2  | 0.51       | 0.29 to 0.73 | 0.163    |

*Paired t-tests, with first category as comparator, using Holm’s correction for multiple testing.
CI, confidence interval; EQ-SD, EuroQol five-dimension questionnaire.

Pre-injury, retrospectively reported QoL is strongly associated (correlated) with a range of other routinely reported patient characteristics. Participant age, ASA, AMTS, pre-fracture mobility, and pre-fracture residence were each highly statistically and clinically significantly associated with baseline EQ-SD. A model including these variables accounted for 36.5% of the variability in pre-fracture EQ-SD, which is typical of values for models reported elsewhere in orthopaedic studies more generally. Although the variance accounted for by the model is modest, it is without doubt useful and sufficient for use more generally as a predictive tool. Given the strong associations we know exist between baseline and four-month EQ-SD and death,1,2,12 and given that the models are likely to be improved with the addition of other relevant demographic data, it seems feasible that, in the not too distant future, long-term patient outcomes could be predicted for hip fracture patients after surgery.

The recruitment centre was not significantly associated with baseline QoL, after adjusting for differences in participant characteristics. The same recruitment and data collection processes were used at all WHiTE recruitment centres, so we would not expect to see unexplained systematic differences in EQ-SD between recruitment centres. This result is important for future analyses, as it establishes a single (homogeneous) baseline population, against which differences in QoL outcomes can be assessed. It is similarly reassuring that the variation in baseline QoL with fracture type and surgical treatment is clinically plausible; for example, pre-fracture QoL being higher in patients treated with THA rather than hemiarthroplasty.

Although the EQ-SD respondent, that is the person reporting the pre-fracture QoL, was the single most important predictor of baseline EQ-SD, this is misleading. Clearly the very fact that it was necessary for a proxy to complete EQ-SD tells us a lot about the likely EQ-SD score; EQ-SD being considerably lower than if the participant had been able to complete the score themselves. Repeating the statistical model, without including EQ-SD respondent variable, gave a very similar model to that with the variable included. This suggests that although EQ-SD respondent is a good predictor of EQ-SD score, it provides only a small amount of information additional to that obtained from the other participant baseline characteristics. The model excluding the EQ-SD respondent variable, which is not routinely reported outside of the WHiTE cohort study, is more widely applicable and general, so will be the preferred option for future adjusted analyses.

It is informative to compare the measured EQ-SD responses of the WHiTE hip fracture population to other reference populations. Useful comparator data, from 3,691 people with a variety of health conditions (in six countries) who completed the EQ-5D questionnaire, were reported in 2012 by van Hout et al.33 They identified a number of condition-specific health groups and reported mean (SD) EQ-5D index values (using the UK value set);34 the most comparable groups were those identified as orthopaedic accident and arthritis from Denmark and England, respectively. Although the mean ages of these populations were markedly younger than the WHiTE population (38 years and 58 years vs 83 years), the reported mean EQ-5D scores were similar: 0.63 (0.42) and 0.64 (0.23) vs 0.65 (0.29) for WHiTE. Although such crude comparisons are useful, they do not convey the true variability in responses found in the WHiTE hip fracture population. At one extreme, those WHiTE participants...
Fig. 1

Mean EuroQol five-dimension questionnaire (EQ-5D) (•), 95% confidence interval (–), and comparator group mean (---) by operation group for a) intracapsular, b) trochanteric, and c) subtrochanteric fractures. Individual EQ-5D group means were compared to all other data with significance assessed using Holm’s correction for multiple testing, with p-values reported as: *p < 0.05; †p < 0.001. QoL, quality of life.
with no functional mobility or severe cognitive impairment (Table I) had very low EQ-SD scores (0.31 and 0.37) that were comparable with stroke or Parkinson’s disease populations. However, WHiTE participants who were freely mobile without aids or had a low ASA score (Table I) had high EQ-SD scores (0.78 and 0.76 to 0.85) that were comparable with mild health conditions such as diabetes or the wider population. A direct comparison of the WHiTE EQ-SD scores to age-matched population norms is complicated to some extent by the lack of good data for older people (> 80 years), who form the larger part of the hip fracture population. The WHiTE EQ-SD scores for the 65 to 74 years age group (n = 1,258) of 0.73 (95% CI 0.71 to 0.75) are significantly lower than the comparable data for age group matched UK population norms of 0.78 (95% CI 0.76 to 0.80)\textsuperscript{33}. The age group matched UK population norms for the 75 years and over group are considerably higher than the comparable data for WHiTE (0.73 vs 0.63 for UK population and WHiTE, respectively); without more detailed analysis it is difficult to assess whether this difference in QoL is due (in totality or in part only) to health status differences or to possible age differences between the populations. However it seems clear from the 65 to 74 years age group data alone that the WHiTE population has lower QoL (as measured by EQ-SD) than the wider UK population.

The principal limitations of this study are those common to all large cohort studies – principally the accuracy of the data reporting. There were some examples in the dataset of what seems to be most likely coding errors, for example highly unlikely fracture type and treatment combinations. However, a more wide-ranging examination of the dataset reported elsewhere\textsuperscript{15} suggested that...
accuracy was good. There is also the possibility of error in the reporting of pre-fracture EQ-5D retrospectively, for example due to recall or response shift. However, in this trauma setting there is no alternative and we have previously shown that this process yields plausible estimates of QoL. The great strengths of the study that distinguish it from other large registry studies are firstly that it was collected prospectively, for the explicit research questions reported in the protocol,9 and secondly it included patient-reported outcomes. In conclusion, we have confirmed that pre-fracture QoL helps describe patients with hip fracture beyond what is possible using other commonly collected demographic data. This is intuitive - we did not collect sufficient demographic information to explain all the variation in patients’ QoL. However, with an ever-improving research infrastructure, increasing sophistication in the methods we use to capture data, and the increased availability of routine data from multiple sources (the internet of things), it seems likely that the modest amount of the variability in QoL attributable to the model will be increased substantially in the future. Collecting pre-fracture QoL will greatly strengthen our ability to control for confounding when reporting future studies of patients with hip fracture.

In conclusion, pre-fracture QoL varies considerably between hip fracture patients; it is generally higher in younger than older patients, patients with better mobility, and those patients who live more independently (i.e. in their own home). A comparison of data summaries suggests that the WHiTE hip fracture population has lower QoL (as measured by EQ-5D) than previously reported data for an age-matched UK population. The pre-fracture QoL is significantly associated with a range of routinely collected patient characteristics (e.g. age, mobility, residency); the model explains a moderate 35% of the variation in the observed baseline QoL data. Therefore, collecting pre-fracture QoL is crucial as it captures important information on the patient population immediately prior to hip fracture that we have no other means of assessing.

References

1. Parsons N, Griffin XL, Achten J, Costa ML. Outcome assessment after hip fracture: is EQ-5D the answer? Bone Joint Res. 2014;3(3)69–75.
2. Griffin XL, Parsons N, Achten J, Fernandez M, Costa ML. Recovery of health-related quality of life in a United Kingdom hip fracture population. The Warwick Hip Trauma Evaluation-a prospective cohort study. Bone Joint J. 2015;97-B(3):372–382.
3. Haywood KL, Brett J, Tutton E, Staniszewska S. Patient-Reported outcome measures in older people with hip fracture: a systematic review of quality and acceptability. Qual Life Res. 2017;26(4):799–812.
4. Costa ML, Griffin XL, Achten J, et al. World hip trauma evaluation (white): framework for embedded comprehensive cohort studies. BMJ Open. 2016;6(10):e1016.
5. Sims AL, Parsons N, Achten J, et al. The World Hip Trauma Evaluation Study 3: Hemiarthroplasty Evaluation by Multicentre Investigation - WHiTE 3: HEMI - An Abridged Protocol. Bone Joint Res. 2016;5(1):18–25.
6. Brooks R. EuroQol: the current state of play. Health Policy. 1996;37(1):53–72.
7. EuroQol G. EuroQol—a new facility for the measurement of health-related quality of life. Health Policy. 1990;16(3):198–208.
8. Marques A, Laurencete O, da Silva JA. Portuguese Working Group for the Study of the Burden of Hip Fractures in Portugal. The burden of osteoporotic hip fractures in Portugal, costs, health related quality of life and mortality. Osteoporos Int. 2015;26(11):2623–2630.
9. Honkavaara N, Al-Ani AN, Campfenfeldt P, Ekström W, Hedström M. Good responsiveness with EuroQol 5-Dimension questionnaire and short form (36) health survey in 20-69 years old patients with a femoral neck fracture: a 2-year prospective follow-up study in 182 patients. Injury. 2016;47(B):1692–1697.
10. Haywood KL, Griffin XL, Achten J, Costa ML. Developing a core outcome set for hip fracture trials. Bone Joint J. 2014;96-B(8):1016–1023.
11. No authors listed. Hip Fracture management. National Institute for Health and Care Excellence (NICE). 2011. https://www.nice.org.uk/guidance/cg124 (date last accessed 24 July 2020).
12. Parsons N, Griffin XL, Achten J, et al. Modelling and estimation of health-related quality of life after hip fracture: a re-analysis of data from a prospective cohort study. Bone Joint Res. 2018;7(1):1–5.
13. No authors listed. Royal College of Physicians. The National Hip Fracture Database: Part of the Falls and Frailty Fracture Audit Programme. 2020. https://www.nhfd.co.uk/ (date last accessed 13 July 2020).
14. Celic M, Lerner RG, Achten J, et al. Prescribing and adherence to bone protection medications following hip fracture in the United Kingdom: results from the World Hip Trauma Evaluation (WHiTE) cohort study. Bone Joint J. 2019;101-B(11):1402–1407.
15. Metcalfe D, Costa ML, Parsons NR, et al. Validation of a prospective cohort study of older adults with hip fractures. Bone Joint J. 2019;101-B(6):708–714.
16. Fernandez MA, Aquilina A, Achten J, et al. The tip-apex distance in the X-Bolt dynamic plating system. Bone Joint Res. 2017;6(4):204–207.
17. Griffin XL, Parsons N, McArthur J, Achten J, Costa ML. The Warwick hip trauma evaluation one: a randomised pilot trial comparing the X-Bolt dynamic hip plating system with sliding hip screw fixation in complex extracapsular hip fractures: white (one). Bone Joint J. 2016;88-B(5):686–689.
18. Griffin XL, McArthur J, Achten J, Parsons N, Costa ML. The Warwick hip trauma evaluation one -an abridged protocol for the white one study: an embedded randomised trial comparing the X-bolt with sliding hip screw fixation in extracapsular hip fractures. Bone Joint Res. 2013;2(10):206–209.
19. Griffin XL, McArthur J, Achten J, Parsons N, Costa ML. The Warwick hip trauma evaluation two—an abridged protocol for the white two study: an embedded randomised trial comparing the Dual-Mobility with polyethylene CUPS in hip arthroplasty for fracture. Bone Joint Res. 2013;2(10):210–213.
20. Griffin XL, Parsons N, Achten J, Costa ML. A randomised feasibility study comparing total hip arthroplasty with and without dual mobility acetalubar component in the treatment of displaced intracapsular fractures of the proximal femur: The Warwick Hip Trauma Evaluation Two: WHiTE Two. Bone Joint J. 2016;88-B(1):1431–1435.
21. Sims AL, Parsons N, Achten J, et al. A randomized controlled trial comparing the Thompson hemiarthroplasty with the Exeter polished tapered stem and Unitran modular head in the treatment of displaced intracapsular fractures of the hip: the WHiTE 3: HEMI Trial. Bone Joint J. 2018;100-B(3):352–360.
22. Griffin XL, Achten J, Sones W, Cook J, Costa ML. Randomised controlled trial of the sliding hip screw versus X-Bolt Dynamic Hip Plating System for the fixation of trochanteric fractures of the hip in adults: a protocol study for WHITE 4 (WHITE4). BMJ Open. 2018;8(1):e019944.
23. Fernandez MA, Achten J, Lerner RG, et al. Randomised controlled trial comparing hydroxyapatite coated uncemented hemiarthroplasty with cemented hemiarthroplasty for the treatment of displaced intracapsular hip fractures: a protocol for the WHITE 5 study. BMJ Open. 2019;9(12):e033957.
24. Dolan P. Modeling valuations for EuroQol health states. Med Care. 1997;35(11):1095–1108.
25. Saklad M. Grading of patients for surgical procedures. Anesthesiol. 1941;20(3):281–284.
26. Hodkinson HM. Evaluation of a mental test score for assessment of mental impairment in the elderly. Age Ageing. 1972;1(4):233–238.
27. Devine A, Taylor SJ, Spencer A, et al. The agreement between proxy and self-completed EQ-5D for care home residents was better for index scores than individual domains. J Clin Epidemio. 2014;67(8):1035–1043.
28. Usman A, Lewis S, Hinsliff-Smith K, et al. Measuring health-related quality of life of care home residents: comparison of self-report with staff proxy responses. Age Aging. 2019;48(3):407–413.
29. Parker B, Petrou S, Underwood M, Madan J. Can care staff accurately assess health-related quality of life of care home residents? A secondary analysis of data from the OPERA trial. BMJ Open. 2017;7(4):e012779.
30. Holm S. A simple sequentially Rejective multiple test procedure. Scandinavian Journal of Statistics. 1979;8(2):65–70.
31. Schwarz G. Estimating the dimension of a model. The Annals of Statistics. 1978;6(2):461–464.

32. Walters SJ, Brazier JE. Comparison of the minimally important difference for two health state utility measures: EQ-5D and SF-6D. Qual Life Res. 2005;14(6):1523–1532.

33. van Hout B, Janssen MF, Feng YS, et al. Interim scoring for the EQ-5D-5L: mapping the EQ-5D-5L to EQ-5D-3L value sets. Value Health. 2012;15(5):708–715.

34. Janssen B, Szende A. Population Norms for the EQ-5D. In: Szende A, Janssen B, Cabases J, eds. Self-Reported Population Health: An International Perspective based on EQ-5D. Dordrecht: Springer Open, 2014:19–30.

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