Pre-operative indicators for mortality following hip fracture surgery: a systematic review and meta-analysis

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Abstract

Objective: hip fracture is a common and serious condition associated with high mortality. This study aimed to identify pre-operative characteristics which are associated with an increased risk of mortality after hip fracture surgery.

Design: systematic search of published and unpublished literature databases, including EMBASE, MEDLINE, AMED, CINAHL, PubMed and the Cochrane Library, was undertaken to identify all clinical studies on pre-operative predictors of mortality after surgery in hip fracture with at least 3-month follow-up. Data pertaining to the study objectives was extracted by two reviewers independently. Where study homogeneity was evidence, a meta-analysis of pooled relative risk and 95% confidence intervals was performed for mortality against pre-admission characteristics.

Results: fifty-three studies including 544,733 participants were included. Thirteen characteristics were identified as possible pre-operative indicators for mortality. Following meta-analysis, the four key characteristics associated with the risk of mortality up to 12 months were abnormal ECG (RR: 2.00; 95% CI: 1.45, 2.76), cognitive impairment (RR: 1.91; 95% CI: 1.35, 2.70), age >85 years (RR: 0.42; 95% CI: 0.20, 0.90) and pre-fracture mobility (RR: 0.13; 95% CI: 0.05, 0.34). Other statistically significant pre-fracture predictors of increased mortality were male gender, being resident in a care institution, intra-capsular fracture type, high ASA grade and high Charlson comorbidity score on admission.

Conclusions: this review has identified the characteristics of patients with a high risk of mortality after a hip fracture surgery beyond the peri-operative period who may benefit from comprehensive assessment and appropriate management.

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Keywords: elderly, femoral fracture, mortality, older people, prognostic indicators, risk factors, systematic review

Introduction

Worldwide, the incidence of hip fracture is high with an estimated annual incidence rate of ~100 per 100,000 people [1, 2]. It is the most common among the elderly, osteoporotic patients [3]. With an ageing population, it is anticipated that this will pose a greater burden on health services in the foreseeable future [4, 5].

Hip fracture is a significant cause of mortality for elderly people [6, 7]. Kannegaard et al. [8] reported a cumulative mortality at 12 months among hip fracture patients are 37.1% in men and 26.4% in women. While this may be contributed at least in part by post-operative complications and medical conditions following fracture such as pulmonary embolism, heart failure or infection [9–11], various studies have suggested a number of factors may be significant predictors of the clinical outcome and mortality following hip fracture. These have included duration between injury and surgery [12], post-operative delirium [13], timing of rehabilitation [14] and surgical technique [15, 16].
In addition, previous attempts have been made to identify pre-operative indicators for the post-operative mortality outcome. Such studies have included the assessment of age [17], gender [18], pre-operative functional capability [19] and presence of various co-morbidities and general health status [20]. While the evidence-base has developed in this area, to date no rigorous systematic reviews, adopting the PRISMA recommendations for systematic review conduct, have been reported [21]. It is, therefore, not possible to make a consensus statement over the evidence in relation to what pre-operative characteristics may predict mortality for this population beyond the peri-operative period.

Identifying and quantifying the impact of pre-operative indicators or predictors of post-operative mortality will allow clinicians to better identify those patients with a high risk of mortality after a hip fracture surgery beyond the peri-operative period who may benefit from comprehensive assessment and appropriate management. Therefore, we conducted a systematic review and quantified the evidence by a meta-analysis technique to identify the pre-operative indicators of mortality after hip fracture surgery.

Search strategy and selection criteria
A PRISMA [21] compliance systematic review was conducted.

Search strategy
Electronic databases: EMBASE, MEDLINE, AMED, CINAHL, Pubmed and the Cochrane Library were searched (for example, see Supplementary data available in Age and Aging online, Table S1). Unpublished literature and trial registry databases were also searched using the databases OpenGrey, WHO International Clinical Trials Registry Platform, Current Controlled Trials, UKCRN Portfolio Database, National Technical Information Service and the UK National Research Register Archive for on-going and recently completed trials. All searches were conducted from inception to Week 1 of October 2013. All reference lists of review papers and potentially eligible studies were reviewed to identify any additional papers.

Eligibility criteria
The titles and/or abstracts were screened by two reviewers (M.B. and T.O.S.) independently against the following eligibility criteria.

Inclusion criteria
• Studies of adult cohorts who had sustained a proximal femoral fracture (upper third of the femur) who were managed with surgical interventions.
• Randomised controlled trials, cohort studies and observational case series.
• Studies reporting pre-operative variables or characteristics against mortality with a minimum of the 3-month follow-up from the index hospital admission.

Exclusion criteria
• Papers reporting mortality rates of cohorts with acetabulum and fractures of the femoral shaft below the subtrochanteric region. In the case of papers presenting subgroups of proximal femoral fracture and other fracture types, such papers were excluded, but data derived from the proximal femoral fracture cohorts were extracted.
• Studies solely reporting mortality following conservative management of hip fracture or where it was not possible to distinguish between surgical and non-surgical management mortality rates.

Papers reporting mortality rates for pathological proximal femoral fractures, where this accounted for over 5% of the cohort. Where such data are presented separately, the data from the non-pathological cohort were included.

Following this, the full texts of any potentially eligible papers were obtained. The eligibility of these was then re-assessed by the two reviewers independently, before inclusion was finalised and confirmed through consensus. If disagreement arose regarding study eligibility, this was resolved through an adjudicator (A.C.L.O.).

Data extraction
Data extraction was performed independently by two reviewers (K.N.P. and T.O.S.) and adjudicated by one investigator (A.C.L.O.). The data were extracted onto pre-defined data extraction tables.

Outcome measures
The primary outcome of the meta-analysis was the relative risk (RR) of gender on 12-month mortality following hip fracture as prior scoping searches indicated that gender was one of the most investigated characteristics. Anticipated secondary outcomes included the relationship of age, type of hip fracture, presence of co-morbidities, scoring systems such as ASA grade or Charlson co-morbidities index, residential setting and pre-fracture mobility and activities of daily living and function.

Methodological quality
Each included paper was evaluated independently for methodological quality based on the CASP Cohort Appraisal tool [22] by two reviewers (K.N.P. and T.O.S.) and adjudicated by A.C.L.O. The criterion for blinding participants and assessor to the outcome of interest (mortality) was removed from this assessment since it was considered logistically inappropriate to blind for this outcome.

Data analysis
An assessment of study heterogeneity was undertaken by reviewing the data extraction tables. Where substantial heterogeneity in study design and population characteristics
occurred, such data were analysed using a narrative review approach. When no evidence existed of substantial design and study characteristic heterogeneity, a pooled meta-analysis of each of the pre-operative risks was undertaken. For each analysis, statistical heterogeneity was evaluated using the inconsistency-value ($I^2$). In cases where this was 20% or under, a Mantel–Haenszel fixed-effect model meta-analysis was undertaken. When this was over 20%, a Mantel–Haenszel random-effects meta-analysis was performed. In each instance, RR values with 95% confidence intervals (95% CI) were reported to allow for between-study heterogeneity. To ensure independence between variables, tests for interaction were assessed using summary estimates using the method described by Altman and Bland [23]. Small study publication bias was evaluated through interpretation of a funnel plot of the primary outcome (gender). All meta-analyses were undertaken using RevMan Version 5.1 (Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2011).

**Results**

The findings of the search strategy are summarised in Figure 1. A total of 394 papers were identified. Of these, 102 were deemed potentially eligible and full-text papers were reviewed and 53 met the study criteria.

A summary of the critical appraisal findings is presented in Supplementary data available in *Age and Ageing* online, Table S2. This indicates that the studies were of moderate methodological quality. Recurrent strengths to the evidence-base include clearly stating a focused research question ($n = 52; 98\%$), clearly defining the cohort’s characteristics ($n = 51; 96\%$) and appropriate study design ($n = 49; 93\%$). The majority of the papers had clearly defined outcomes and used appropriate methods to assess the outcome. The follow-up was sufficiently long (i.e. 6 months or longer) to evaluate post-operative mortality following hip fracture in 49 papers (93%), with 85% or more of the recruited cohort completing the final data assessment in 45 papers (85%). Forty-five papers (85%) evaluated outcomes appropriately for mortality differences across important variables with statistical tests.

A number of important limitations are noted. Twenty-two papers (40%) did not control for important confounders such as population heterogeneity (e.g. age, co-morbidities) or intervention heterogeneity (e.g. surgical procedure, time to surgery). Twenty-five studies (45%) did not present the 95% CI of point estimate making analysis of statistical precision impossible.

![Figure 1. PRISMA flow-chart illustrating the results of the search strategy.](image-url)
Characteristics of included studies

A summary of the included study characteristics is presented in Supplementary data available in Age and Ageing online, Table S3. In total, 544,733 participants were included in this systematic review. Six studies accounting for <10% of participants did not specify their gender mix [24, 25, 26, 27, 28, 29]. The remaining studies consisted of 125,559 males and 409,530 females. The mean ages of studies ranged from 72 [30] to 93 years [31]. Study follow-up periods ranged from 3 months [21–23, 25–32, 33, 34] to 25 years [35]. The most common co-morbidities reported (n = 31 studies) included diabetes mellitus [30, 36], ischaemic heart disease [32, 37, 38, 39], hypertension [38, 40, 41], osteoporosis [31], Parkinson’s disease [42] and dementia [23, 31, 43, 44, 45, 46]. Fourteen papers reported the orthopaedic procedure used. The most common surgical procedure undertaken was the hemiarthroplasty, a fixation method, for the largest proportion of participants (12 studies) [32, 36, 42, 43, 44, 45, 47, 48, 49, 50, 51, 52]. Other surgical methods included were dynamic hip screws, cannulated screws or some form of internal fixation (Jones et al. [30], Eisler et al. [53], Grimes et al. [54] Shah et al. [39]). Figure 2 indicates some degree of small study publication bias.

Characteristics in meta-analyses against mortality risk

It was possible to perform a meta-analysis on 13 pre-operative indicators for people with hip fracture from the available literature. A summary of the meta-analysis results is presented in Table 1. The meta-analysis and narrative review findings are synthesised for each individual variable below.

Primary outcome: gender

Data from 18 studies (n = 127,396) formed the analysis of gender [3, 8, 18, 20, 38, 40, 41, 43, 44, 51, 55, 56, 57, 58, 59, 60, 61]. The results indicated that gender was a statistically significant predictor with risk of death, being 32% lower in females compared with males (RR: 0.68; 95% CI: 0.62, 0.76; Figure 2).

Secondary outcomes: age

Age was evaluated in six studies [18, 20, 44, 55, 56, 57], assessing mortality in 51,938 participants. The results indicated that age was a statistically significant indicator for mortality at 6–12 months post-hip fracture surgery, with the risk of death is 68% less in people age under 85 years (RR: 0.42; 95% CI: 0.20, 0.90; Supplementary data available in Age and Ageing online, Figure S1).

Ethnicity

Data on ethnicity were pooled from two studies, assessing 770 participants [40 44]. The analysis indicated no statistical relationship between mortality and different ethnic groups following hip fracture (RR: 1.07, 95% CI: 0.20, 5.81) at 6–12 months post-fracture.

Residence

It was possible to evaluate the difference in mortality risk between people who resided in their own home, compared with a residential or nursing care institution [45, 55, 59, 61, 62]. The data from five studies (n = 25,497) indicated a 43% lower risk of death at 6–12 months following hip fracture surgery for...
those who lived in own homes compared with those who residing in a care setting (RR: 0.57; 95% CI: 0.43, 0.72).

**Educational attainment**

Two studies provided data for meta-analysis on education level on mortality following hip fracture [40, 43]. The meta-analysis indicated no statistically significant difference in the risk of mortality between those classified as illiterate compared with literate (RR: 1.09; 95% CI: 0.45, 2.62).

**Fracture type**

A comparison of mortality risk was possible between people who sustained an intra-capsular compared with an extra-capsular hip fracture from seven studies [31, 42–44, 47, 60, 61]. From a cohort of 1,805 participants, people with an intra-capsular fracture demonstrated 77% greater risk of mortality compared with extra-capsular fracture (RR: 0.77; 95% CI: 0.63, 0.95).

**BMI**

The body mass index was evaluated in two studies [40, 43]. On meta-analysis of 370 participants, there was no statistical relationship between participants with a BMI of <0 kg/m² compared with those with a BMI of ≥30 kg/m² for risk of mortality post-hip fracture surgery. However, people with a BMI >30 kg/m² were reported to have a higher risk of mortality at 12 months compared with those under 30 kg/m² ($P < 0.01$).

**Mobility**

There was a statistically significant relationship between pre-operative mobility, independent mobilisation with or without a walking aid compared with requiring personal assistance to mobilise and mortality 12-month post-hip fracture surgery. The meta-analysis of two studies [19, 44] of 916 participants, indicated that those who required personal assistance pre-fracture had an 87% lesser risk of mortality at 6–12-month post-hip fracture compared with those who could mobilise independently pre-fracture (RR: 0.13; 95% CI: 0.05, 0.34).

**Co-morbidities**

**Depression.** Two studies [40, 46] presented data on the influence of pre-operative depression on mortality following hip fracture surgery. There was no statistically significant relationship on meta-analysis between the diagnosis of depression prior to hip fracture and mortality at 12 months.

**Cognitive impairment.** The impact of cognitive impairment on mortality following hip fracture was evaluated in six studies with 1,525 participants [40, 43, 44, 46, 49, 58]. People with cognitive impairment presented with a 91% greater risk of death compared with those without cognitive impairment on admission following a hip fracture (RR: 1.91; 95% CI: 1.35, 2.70).

**Abnormal ECG.** The presence of an abnormal ECG was demonstrated to be a statistically significant indicator of mortality at 12 months following hip fracture in two studies [47, 63]. People with an abnormal ECG on admission were twice as likely to die compared with those without abnormal ECG following hip fracture (RR: 2.00, 95% CI: 1.45, 2.76).

**ASA grade and Charlson comorbidity score.** Both higher ASA grade and higher Charlson comorbidity score were demonstrated to be statistically significant indicators of mortality at 12 months following hip fracture. Four studies [18, 26, 40, 61] of 1,559 participants assessed the risk of death based on

### Table 1. Summary of meta-analysis results

<table>
<thead>
<tr>
<th>Outcome</th>
<th>N</th>
<th>Participants Studies</th>
<th>Relative risk (95% CI)</th>
<th>P-value</th>
<th>$I^2$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (versus ≥85 years)</td>
<td>127,396</td>
<td>18</td>
<td>0.68 (0.62, 0.76)</td>
<td>&lt;0.0001</td>
<td>95</td>
</tr>
<tr>
<td>Age (&lt; versus ≥85 years)</td>
<td>51,938</td>
<td>6</td>
<td>0.42 (0.20, 0.90)</td>
<td>0.0099</td>
<td>97</td>
</tr>
<tr>
<td>Charlson comorbidity score (0 versus 1+)</td>
<td>28,614</td>
<td>2</td>
<td>0.59 (0.56, 0.61)</td>
<td>&lt;0.0001</td>
<td>0</td>
</tr>
<tr>
<td>Residence (home versus institution)</td>
<td>25,497</td>
<td>5</td>
<td>0.57 (0.43, 0.72)</td>
<td>&lt;0.0001</td>
<td>73</td>
</tr>
<tr>
<td>Fracture type (intra- versus extra-capsular)</td>
<td>1,805</td>
<td>7</td>
<td>0.77 (0.63, 0.95)</td>
<td>0.01</td>
<td>45</td>
</tr>
<tr>
<td>ASA grade (1/2 versus 3/4)</td>
<td>1,559</td>
<td>4</td>
<td>0.44 (0.35, 0.56)</td>
<td>&lt;0.0001</td>
<td>0</td>
</tr>
<tr>
<td>Cognitive impairment</td>
<td>1,525</td>
<td>6</td>
<td>1.91 (1.35, 2.70)</td>
<td>0.0002</td>
<td>70</td>
</tr>
<tr>
<td>Mobility (independent versus require assistance)</td>
<td>916</td>
<td>2</td>
<td>0.13 (0.05, 0.34)</td>
<td>&lt;0.0001</td>
<td>57</td>
</tr>
<tr>
<td>Ethnicity (Caucasian versus non-Caucasian)</td>
<td>770</td>
<td>2</td>
<td>1.07 (0.20, 5.81)</td>
<td>0.95</td>
<td>80</td>
</tr>
<tr>
<td>Education level (literate versus illiterate)</td>
<td>422</td>
<td>2</td>
<td>1.09 (0.45, 2.62)</td>
<td>0.85</td>
<td>92</td>
</tr>
<tr>
<td>BMI (≤20 versus ≥30)</td>
<td>370</td>
<td>3</td>
<td>0.67 (0.33, 1.35)</td>
<td>0.25</td>
<td>81</td>
</tr>
<tr>
<td>Abnormal ECG</td>
<td>334</td>
<td>3</td>
<td>2.00 (1.45, 2.76)</td>
<td>&lt;0.001</td>
<td>0</td>
</tr>
<tr>
<td>Depression</td>
<td>308</td>
<td>2</td>
<td>1.27 (0.36, 4.54)</td>
<td>0.71</td>
<td>61</td>
</tr>
</tbody>
</table>
pre-operative ASA grade, reporting those with an ASA grade of 3 or 4 were at 44% higher risk of death compared with those with an ASA grade of 1 or 2 (RR: 0.44; 95% CI: 0.35, 0.56; Supplementary data available in Age and Ageing online, Figure S2). Similarly, based on two studies [20, 54] analysing 28,614 participants, people with a Charlson comorbidity index score of 0 were at 41% lower risk of death compared with those with a Charlson comorbidity index of 1 or greater (RR: 0.59; 95% CI: 0.56, 0.61).

**Narrative review findings**

A summary of the narrative review findings is presented in Table 2. These findings support the overall results presented in the meta-analyses.

**Discussion**

This review has identified nine statistically significant pre-admission characteristics which predicted a greater risk of mortality at 12 month following hip fracture. This included male gender, age ≥85 years, residents of institutional care homes, the presence of an intra-capsular fracture, requiring assistance of a second person to mobilise, cognitive impairment, an abnormal ECG on admission and poor general health (ASA grade or Charlson comorbidity index). The four characteristics indicating the highest risk of mortality at 12 months were pre-fracture mobility, age, abnormal ECG and cognitive impairment. Some caution should be made to the interpretation of all meta-analysis findings given high $I^2$ values for all analyses except assessment of the Charlson comorbidity score, ASA grade and abnormal ECG.

The evidence-base presented with moderate quality as assessed through a modified CASP cohort tool. Recurrent limitations within the literature included not controlling for important confounding variables such as population heterogeneity or intervention heterogeneity. Thirty-three per cent of papers did not clearly provide sufficient information on their cohort or the clinical placement. Consequently, the external validity of these findings may be questioned, limiting study generalisability.

Abnormal ECG on hospital admission and cardiac failure/impairment has been recurrently reported as key predictors to mortality following hip fracture [64]. Findings of this study reiterate these conclusions, reporting this as the highest risk factor for mortality following hip fracture surgery. The finding that cognitive impairment was a significant predictor of mortality following hip fracture surgery may be unsurprising. This may be related to a number of additional factors such as poorer general health, increasing age, difficulties in adhering to rehabilitation pathways either in the short-term with delirium or longer-term with dementia [65]. This population may also have inadequate rehabilitation resources for their specific cognitive capabilities, suggesting that health services are not well designed for this subgroup of the hip fracture population [58].

Pre-fracture mobility was shown to have a significant predictive capability on mortality rates following hip fracture surgery. This may be associated with a lower level of physical capability at baseline, hence rehabilitation taking longer and in some instances, patients not being able to return to previous activity levels due to poor functional capability prior to fracture. As with pre-fracture mobility, a number of authors have suggested that age should not be viewed as an isolated variable for the prediction of mortality [25]. This review’s authors agree that age should be considered in relation to other variables most notably co-morbidities and physical capability, i.e. physical functional health or biological ageing.

Our results also indicate that fracture type was associated with an increased risk of mortality where intra-articular

<table>
<thead>
<tr>
<th>Variable</th>
<th>Outcome</th>
<th>Frequency of studies reporting association</th>
<th>Studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>Male higher mortality</td>
<td>11/13</td>
<td>[3, 17, 19, 27, 29, 41, 50, 57, 58, 74, 79]</td>
</tr>
<tr>
<td></td>
<td>Females higher mortality</td>
<td>2/13</td>
<td>[52, 54]</td>
</tr>
<tr>
<td>Age</td>
<td>Higher age, higher mortality</td>
<td>20/20</td>
<td>[8, 17, 19, 29, 38, 39, 40, 41, 47, 48, 50, 52, 54, 60, 63, 74, 75, 76, 78, 79]</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>No difference in mortality</td>
<td>1/1</td>
<td>[74]</td>
</tr>
<tr>
<td>Pre-fracture residence</td>
<td>Higher mortality in nursing/residential care</td>
<td>4/4</td>
<td>[31, 33, 41, 74]</td>
</tr>
<tr>
<td>Fracture type</td>
<td>Greater mortality in intra-capsular fracture</td>
<td>2/4</td>
<td>[8, 79]</td>
</tr>
<tr>
<td></td>
<td>No difference in mortality</td>
<td>2/4</td>
<td>[3, 61]</td>
</tr>
<tr>
<td>Pre-fracture mobility</td>
<td>Great mortality for those requiring assistance for mobilisation</td>
<td>2/2</td>
<td>[25, 78]</td>
</tr>
<tr>
<td>Depression</td>
<td>Greater mortality with depression</td>
<td>1/1</td>
<td>[23]</td>
</tr>
<tr>
<td>Cognitive impairment</td>
<td>Greater mortality with cognitive impairment</td>
<td>8/8</td>
<td>[23, 25, 31, 45, 50, 52, 75, 78]</td>
</tr>
<tr>
<td>Cardiac disease</td>
<td>Greater mortality with cardiac disease history</td>
<td>3/3</td>
<td>[19, 40, 52]</td>
</tr>
<tr>
<td>Comorbidities (ASA grade/Charlson)</td>
<td>Greater mortality with increased ASA/Charlson scores</td>
<td>3/3</td>
<td>[31, 76, 79]</td>
</tr>
<tr>
<td>Number of comorbidities</td>
<td>Greater mortality in higher incidence of co-morbidities</td>
<td>6/6</td>
<td>[28, 32, 36, 41, 44, 50, 54, 74, 77, 79]</td>
</tr>
<tr>
<td>Number of prescribed medication</td>
<td>Greater mortality if prescribed 4 or more medication</td>
<td>1/1</td>
<td>[45]</td>
</tr>
<tr>
<td>Diabetes</td>
<td>Greater mortality with diabetic patients</td>
<td>1/1</td>
<td>[40]</td>
</tr>
</tbody>
</table>
fractures presented with a higher mortality. This was a surprise finding. It would be expected that the converse would occur since extra-capsular osteosynthesis reported greater pain levels compared with intra-capsular hemiarthroplasty or screw fixation resulting in a slower recovery [66, 67]. Consequently to this, people following extra-articular fracture may expect a longer hospital length of stay thereby increasing their risks of hospital acquired infections to account for higher mortality rates [68, 69]. Secondly, in the case of an unstable extra-capsular fracture, this surgical procedure can be more challenging, requiring longer surgical duration and delayed rehabilitation potential due to pain associated with weight-bearing and mobilisation [43]. It remains unclear why such a difference in mortality has reported in this analysis and should, therefore, be viewed with some caution.

The meta-analysis supports previous findings that males have a higher risk of mortality following hip fracture compared with females [70]. However, a number of researchers have challenged the assumption that gender is an isolated variable, and that mortality is associated with higher ASA grades which are frequently seen as higher in age-matched cohorts, and are less likely to reduce to independent living or mortality compared with age-matched female cohorts [51, 59, 71]. Consequently, the potential for associated confounding variables influencing the findings of this analysis should be considered when interpreting gender.

Through the identification of these variables, clinicians will be better able to identify those at most risk of death on hospital admission. While previous screening tools have provided this information [72, 73], this paper supports the majority of characteristics included within such tools. For example, the Nottingham Hip Fracture Score which is made up of seven independent predictors of mortality including age (66–85 and ≥86 year), sex (male), number of comorbidities (≥2), admission mini-mental test score (≤6 out of 10), admission haemoglobin concentration (≤10 g dl(–1)), living in an institution and the presence of malignancy [74]. However, the current report additionally suggests that fracture type, pre-operative mobility and ECG abnormalities should also be considered as important statistical predictors of mortality. Further consideration on the addition of these parameters may be an important avenue for further studies, to develop better understanding and deeper insight into prognosis after proximal hip fracture surgery to help develop screening tools on the mortality outcome.

**Conclusion**

This study has identified nine pre/on-admission characteristics which statistically predict intermediate to long-term mortality following hip fracture surgery. The results will help develop a prognostic score, which can be used to implement good practice care pathways for those at risk of mortality, and to investigate whether the addition of these new predictors, can better stratify this at-risk population for an appropriate care.

**Key points**

- Hip fracture is a major problem for patients, their families/carers and for health services internationally.
- The strongest pre-operative indicators of post-operative mortality at 12 months are pre-fracture mobility, age, abnormal ECG and cognitive impairment.
- Significant indicators of post-operative mortality at 12 months include male gender, residence in an institutional care home, the presence of an intra-capsular fracture and poor general health.
- The findings of this review will assist in identifying those at the greatest risk of mortality following hip fracture and to more effectively inform planning of their care.

**Acknowledgements**

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**Authors’ contributions**

T.O.S. and P.K.M. conceived the study. T.O.S., P.K.M., A.C. L.O. and M.B. developed the study protocol. M.B. and T.O.S. screened and selected the papers. K.N.P. and T.O.S. extracted the data. All authors drafted the paper. All authors contributed in the writing of the paper and had full access to all of the data in the study with the guarantor taking responsibility for the integrity of the data and the accuracy of the data analysis. T.O.S. is the guarantor.

**Conflicts of interest**

T.S. reports no financial relationships with commercial interests; K.N.P. reports no financial relationships with commercial interests; M.B. reports no financial relationships with commercial interests; A.C.L.O. reports no financial relationships with commercial interests; P.K.M. reports no financial relationships with commercial interests.

**Supplementary data**

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

**References**

The very long list of references supporting this review has meant that only the 30 most important are listed here and are represented by bold type throughout the text. The full list of
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references is available in Supplementary data in Age and Ageing online, Appendix.