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FATAL TRAJECTORIES: IDENTIFYING KEY PREDICTORS OF MORTALITY AFTER FEMORAL FRACTURE

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Abstract

Femur fractures contribute substantially to morbidity and mortality in both the young and elderly populations. The prevalence varies among studies, with the highest prevalence observed in the East Asian region. In order to focus on the prevention of femur fractures, a thorough understanding of the existing evidence is imperative. This scoping review seeks to identify and map the predictors of mortality associated with femur fractures. Our objective is to highlight existing knowledge gaps, support interdisciplinary collaboration, and inform the development of policies aimed at reducing mortality related to these injuries.Original observational studies published in English between January 1983 and April 22, 2025, were included. A comprehensive literature search was conducted using the keywords "Mortality", "Femoral Fractures", and "Prognosis". Search was limited to the PubMed (MEDLINE) database. Identified records were exported and screened independently by two reviewers—the initial screening of titles and abstracts for relevance, followed by full-text review of potentially eligible studies. Any discrepancies in study selection were resolved through discussion or, when necessary, consultation with a third reviewer.Fifty-four (54) eligible studies were included in the final scoping review. The fracture site described mostly was the hip in 23 (42.6%) of articles, followed by the neck of femur (NOF) in 16 (29.6%), and the proximal femur in 13 (24.1%). Shaft and distal femur fractures in only one article (1.9%). Most studies reported mortality outcomes at one year (32 studies; 59.3%). Demographic and patient-related factors, pre- and post-operative management-related factors were presented in the articles and summarised. While we have identified the scope of the factors that would predict the mortality following femur fractures, this scoping review did not include a formal critical appraisal of the included studies to assess the quality or risk of bias in individual studies. We recommend a comprehensive review with a meta-analysis.

***Key words**:* Femur, Fracture, Predictors, Mortality

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Introduction

Femur fractures are a significant global health concern, contributing substantially to morbidity and mortality (Lundin et al., 2021; A. M. Wu et al., 2021). The incidence and prevalence of these fractures have demonstrated rising trends in many countries, with the former particularly noted among the elderly population (Fu et al., 2025; J. Wu et al., 2024) and the latter among the individuals aged 15-49 years (Fu et al., 2025). Reported prevalence rates vary substantially across geographic regions, with some studies citing rates as high as 43 per million (Fu et al., 2025; Lundin et al., 2021). The highest prevalence has been observed in East Asia, while the lowest rates are reported in regions such as Central Latin America (J. Wu et al., 2024).

A one-year mortality rate of approximately 20% has been consistently documented across multiple studies (Lundin et al., 2021), underscoring the urgent need for effective preventive strategies and management protocols. While primary etiological factors include road traffic accidents, physical violence, and other mechanical injuries (Fu et al., 2025), numerous additional factors significantly influence mortality outcomes in patients with femur fractures. These include the anatomical location of the fracture (Mubark et al., 2020), laboratory parameters, timing of intervention, surgical and perioperative variables, and the quality of post-operative care. Importantly, many of these predictors are modifiable and provide potential opportunities for targeted interventions.

Given the multifactorial nature of mortality following femur fractures, a comprehensive understanding of the current evidence is essential. Our scoping review seeks to identify and map the predictors of mortality associated with femur fractures. Our objective is to identify knowledge gaps, inform relevant disciplines, and help the development of health policies aimed at reducing mortality associated with femur fractures.

Methods

This scoping review was conducted following the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) guidelines. A detailed protocol was developed a priori by the research team to guide the review process; however, the protocol was not registered on any public registry.

Eligibility criteria were defined using the Population–Concept–Context (PCC) framework. Studies were eligible if they were original observational research—specifically, cohort, case-control, or cross-sectional studies—that reported on adult patients (aged 18 years or older) with femur fractures and investigated predictors, risk factors, or determinants of mortality. Only studies conducted in acute care settings such as trauma units, emergency departments, surgical wards, or inpatient hospital environments were considered. Exclusion criteria included studies focusing on non-femoral fractures (e.g., tibial, fibular, or pelvic fractures), studies limited to rehabilitation or outpatient settings without data on the acute phase, and studies that did not assess mortality outcomes or focused exclusively on non-mortality outcomes such as pain, function, quality of life, or patient satisfaction. In addition, non-original research articles—such as reviews, editorials, commentaries, letters, case reports, and conference abstracts without full-text availability—were excluded. The review was restricted to studies published in English between January 1983 and April 22, 2025.

A comprehensive literature search was conducted using PubMed (MEDLINE). The search strategy incorporated the following MeSH terms: *"Mortality"*, *"Femoral Fractures"*, and *"Prognosis"*, combined using Boolean operators: ("Mortality"[MeSH]) AND ("Femoral Fractures"[MeSH]) AND ("Prognosis"[MeSH]). Filters were applied to restrict the results to clinical studies involving human adults (≥19 years), published in English, and excluding preprints. The final search was executed on April 22, 2025. The complete search strategy is provided in Annexure 1.

Following the search, all identified records were exported and screened independently by two reviewers. The screening process involved two stages: initial screening of titles and abstracts for relevance, followed by full-text review of potentially eligible studies. Any discrepancies in study selection were resolved through discussion or, when necessary, consultation with a third reviewer.

Data from included studies were charted using a standardised extraction form developed and pilot-tested by the research team. Data extraction was conducted independently by two reviewers and cross-checked for accuracy. Extracted data included study characteristics (e.g., author, publication year, country, study design, and setting), population demographics (e.g., age, sex, comorbidities), fracture-specific details (e.g., anatomical site and type), predictors of mortality (e.g., clinical, biochemical, temporal, surgical, and post-operative variables) and mortality outcomes (e.g., in-hospital, 30-day, and one-year mortality). Any assumptions or simplifications made during the data abstraction process were documented and discussed among the team to maintain consistency. Finally, the extracted data were synthesised narratively and presented in tabular format (Tables 1–4), with a focus on identifying patterns, summarising key findings, and categorising predictors of mortality following femur fractures.

This scoping review did not include a formal critical appraisal of the included studies, as the primary objective was to map the available evidence and identify key predictors and knowledge gaps rather than to assess the quality or risk of bias in individual studies.

Results

300 articles, which were screened based on their title and abstract. After full-text assessment for eligibility, 54 articles were included in the final scoping review. The selection process is illustrated in Fig.1, following the PRISMA-ScR flow diagram framework. The included studies varied in design, settings, and focus areas. The hip was the most commonly studied site, appearing in 23 (42.6%) of articles, followed by the neck of femur (NOF) in 16 (29.6%), and the proximal femur in 13 (24.1%). Shaft and distal femur fractures were each reported in only one article (1.9%). Most studies reported mortality outcomes at one year (32 studies; 59.3%). Mortality within less than one year was reported in 15 studies (27.8%), while only two studies (3.7%) addressed in-hospital mortality. A smaller proportion (5 studies; 9.3%) examined longer-term mortality extending beyond one year.

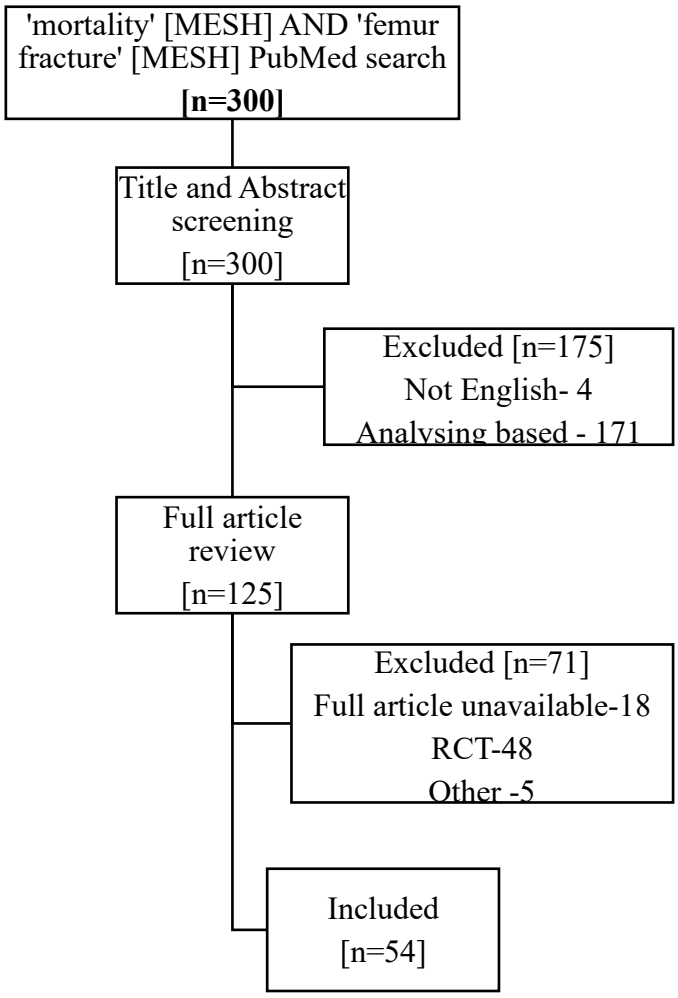

Figure 01: PRISMA-ScR flow diagram indicating the study selection

Demographic and Patient-related Factors

Table 1 summarises the impact of demographic and patient-related factors on mortality associated with femur fractures. Advanced age was consistently identified as a significant risk factor of increased mortality (Barrett-Lee et al., 2021; Bilsel et al., 2013; Delgadillo et al., 2024; Ghouri et al., 2021; Schürch et al., 1996), while male sex was reported to increase mortality (Bilsel et al., 2013; Delgadillo et al., 2024; B.-G. Kim et al., 2016; Schürch et al., 1996), with no studies contradicting these associations.

Six articles examined the impact of fracture type on mortality. Two studies (B.-G. Kim et al., 2016; Sundkvist et al., 2021) found neck of femur (NOF) fractures were linked with higher mortality, with subtrochanteric fractures associated with greater mortality than per-trochanteric fractures (Aguado et al., 2022). Among NOF fractures, displaced femoral neck fractures (dFNF) and basicervical femoral neck fractures (bFNF) were associated with higher mortality compared to undisplaced femoral neck fractures (uFNF) (Sundkvist et al., 2021).

Patient health status and comorbidities emerged as key predictors of mortality. Factors significantly associated with increased mortality included pre-existing comorbidities (Delgadillo et al., 2024; Ishimaru et al., 2012; Schürch et al., 1996), COVID-19 infection (Muñoz Vives et al., 2020; “Outcomes after Perioperative SARS-CoV-2 Infection in Patients with Proximal Femoral Fractures: An International Cohort Study,” 2021), osteoporosis (Schürch et al., 1996), cancer (B.-G. Kim et al., 2016; Meynard et al., 2020), dementia (Delgadillo et al., 2024), and Parkinson’s disease (Karadsheh et al.,

2015). A high Sernbo score (Mellner et al., 2017) also correlated with higher mortality risk. Good nutritional status (Popp et al., 2024) and a high Barthel Index (Delgadillo et al., 2024) were protective. Additionally, ASA (American Society of Anesthesiologists) score of 3–4 prior to surgery was associated with significantly increased mortality (Bilsel et al., 2013; Ishimaru et al., 2012); B.-G. (Kim et al., 2016; Meynard et al., 2020; Muñoz Vives et al., 2020).

Management-related factors

Management-related predictors of mortality were assessed in 38 studies and classified into three domains: operative, pre-operative, and post-operative factors (Table 2). There was significantly lower mortality following surgical management compared to conservative approaches (Barrett-Lee et al., 2021; Ishimaru et al., 2012; Meynard et al., 2020). Surgical timing was a critical determinant, where delays beyond 48 hours were associated with higher mortality (Barrett-Lee et al., 2021; Caruso et al., 2019; Ghouri et al., 2021; Hapuarachchi et al., 2014; B.-G. (Kim et al., 2016; Lahtinen et al., 2015; Nyholm et al., 2015). Comparisons between cemented and uncemented hemiarthroplasty (HA) (Figved et al., 2009; Gavaskar et al., 2014; Macfie et al., 2012; Vidović et al., 2015), intramedullary nails, hip screws, and plate fixation (Meynard et al., 2020; Pitsaer & Samuel, 1993; Utrilla et al., 2005) did not reveal significant mortality differences. Similarly, unipolar versus bipolar HA showed no notable differences (Kanto et al., 2014). However, total hip arthroplasty (THA) was associated with lower mortality compared to HA (Hansson et al., 2020), while HA was linked to higher mortality than nail or plate fixation in one study (Bilsel et al., 2013). Poor fracture reduction quality was a mortality predictor in one study (Cordero-Ampuero et al., 2021). No associations were found with compression techniques or tip-apex distance. Furthermore, there were no associations between mortality and anaesthesia technique (Bilsel et al., 2013; Häusler et al., 2022; Kaçmaz & Turhan, 2022; MCKENZIE et al., 1984).

Pre-operative management

Biomarkers such as elevated (B.-G. Kim et al., 2016), creatinine (B.-G. Kim et al., 2016), calcium (Kovar et al., 2016), and low haemoglobin (B.-G. Kim et al., 2016), and albumin (Harrison et al., 2017; B.-G. Kim et al., 2016) levels were associated with increased mortality. Warfarin use (Caruso et al., 2019) was linked to high mortality, primarily due to surgical delays, while tranexamic acid (TXA) had no significant impact (Lee et al., 2015). There was no mortality difference between liberal and restrictive blood transfusion strategies (Gillies et al., 2021), but allogenic red blood cell transfusion was associated with increased mortality (Shin et al., 2020). Post-operative thromboprophylaxis also showed an association with higher mortality (Leer-Salvesen et al., 2017). Additionally, one study (Metcalfe et al., 2016)assessing the impact of the place of admission found no significant difference in mortality between low-volume and high-volume hospitals**.**

Post-operative management and rehabilitation

Models of care such as the Integrated Care System, Geriatric Consult Service (Solberg et al., 2023), and multidisciplinary teams showed no significant mortality differences (Macfie et al., 2012; Werner et al., 2020). Similarly, there was no difference between hospital-based and home-based care (O'Cathain, 1994), geriatric fracture centres with usual care, nor with Best Practice Tariff (BPT) (Oakley et al., 2017), or fast-track pathways (Gomez et al., 2019). However, one study reported higher mortality among patients requiring ICU care (B.-G. Kim et al., 2016). Early weight-bearing and participation in physical rehabilitation were associated with lower mortality (Sanchez-Munoz et al., 2020) (Che et al., 2023; Lahtinen et al., 2015). No differences were observed among rehabilitation in orthopaedic, geriatric, or non-rehabilitation wards (MCKENZIE et al., 1984)

Table 01: Articles studying mortality in relation to patient factors and injury factors

	Age	Sex	Fracture type/site	Comorbidities	Cancer	Osteoporosis	Parkinson	Cognitive function	Nutritional status	ADL	ASA
(Delgadillo et al., 2024)	+	+	0	+				+		+	
(Barrett-Lee et al., 2021)	+										
(Ghouri et al., 2021)	+		+								
(Bilsel et al., 2013)	+	+	0								+
(Schürch et al., 1996)	+	+		+		+					
(B.-G. Kim et al., 2016)		+	+		+				+		+
(Sundkvist et al., 2021)			+								
(Aguado et al., 2022)			+								
(Ishimaru et al., 2012)				+							+
("Outcomes after Perioperative SARS-CoV-2 Infection in Patients				+							

with Proximal Femoral Fractures: An International Cohort Study," 2021)											
(Muñoz Vives et al., 2020)				+							+
(Meynard et al., 2020)					+						+
(Karadsheh et al., 2015)							+				
(Mellner et al., 2017)				+							
(Popp et al., 2024)									+		
(Zhang et al., 2018)									+		

+ have an association

0- No association

Table 2: Articles assessing mortality in relation to Management factors

	Treatment type	Surgery timing, quality	Anesthesia	Hemorrhage control	Screening tests	Post-operative care	Rehabilitation	Admission factors

(Delgadillo et al., 2024)		0						
(Barrett-Lee et al., 2021)	+	+						
(Ghouri et al., 2021)		+						
(Bilsel et al., 2013)	+	0						
(Ishimaru et al., 2012)	+							
(Meynard et al., 2020)	0							
(Lahtinen et al., 2015)							+	
(Caruso et al., 2019)		+		+				
(Nyholm et al., 2015)		+						
(Hapuarachchi et al., 2014)		+						
(Vidović et al., 2015)	0							
(Gavaskar et al., 2014)	0							
(Macfie et al., 2012)						0		
(Figved et al., 2009)	0							

(Utrilla et al., 2005)	0							
(Pitsaer & Samuel, 1993)	0							
(Kanto et al., 2014)	0							
(Hansson et al., 2020)	+							
(Cordero-Ampuero et al., 2021)		0						
(Kaçmaz & Turhan, 2022)			0					
(Häusler et al., 2022)			0					
(MCKENZIE et al., 1984)			0					
(Kovar et al., 2016)					+			
(Harrison et al., 2017)					+			
(Lee et al., 2015)				0				
(Gillies et al., 2021)				0				

	Treatment type	Surgery timing, quality	Anesthesia	Hemorrhage control	Screening tests	Post-operative care	Rehabilitation	Admission factors
(Shin et al., 2020)				+				
(Leer-Salvesen et al., 2017)				+				
(Metcalfe et al., 2016)								0
(Solberg et al., 2023)						0		
(O'Cathain, 1994)						0		
(Werner et al., 2020)						0		
(Blauth et al., 2021)						0		
(Oakley et al., 2017)						0		
(Gomez et al., 2019)						0		
(Sanchez-Munoz et al., 2020)							+	
(Che et al., 2023)							+	

(Pérez-Moro et al., 2019)	+							
(Y. T. Kim et al., 2018)	+							
(Pincus et al., 2017)		0						
(Skála-Rosenbaum et al., 2015)						+		
(Vidovic et al., 2013)	0							
(Leonardsson et al., 2010)	+							
(Roder, 2003)							0	

Discussion

This scoping review identified several critical factors influencing mortality following femur fractures, categorising them into demographic, patient-related, and management-related domains. Understanding these variables is essential for improving patient outcomes, particularly among the elderly and those with comorbidities. These findings hold particular relevance for countries where healthcare resources may be limited, making efficient, evidence-based interventions crucial.

Advanced age emerged as a consistent predictor of increased mortality. This is supported by evidence from a meta-analysis (Bui et al., 2024) indicating that each additional year of age increases the odds of 30-day mortality by 6% (OR: 1.06). With a growing elderly population in Sri Lanka, implementing targeted interventions, such as frailty screening and rigorous pre-operative assessments, is imperative. In line with our findings, a randomised controlled trial (RCT) (Afaq et al., 2020) identified higher mortality rates among males. This may reflect differences in occupational hazards or health-seeking behaviours, suggesting the need for public health initiatives aimed at male populations, especially in high-risk occupational sectors.

While fracture type influences mortality, comparative analyses across all fracture types remain limited. NOF fractures were associated with higher mortality in our review. However, one RCT (Jordan et al., 2014) found distal femur fractures to have higher mortality rates than hip fractures.

Comorbidities such as osteoporosis, cancer, dementia, and Parkinson's disease were consistently associated with increased mortality. These findings align with a systematic review (Bui et al., 2024) that identified chronic renal failure, dementia, diabetes, heart failure and cancer as significant predictors of mortality. In Sri Lanka, integrating routine screening and management of these comorbidities into femur fracture care is vital for reducing mortality.

Timely surgical intervention significantly impacts survival. Delays beyond 48 hours were associated with increased mortality, echoing findings from a meta-analysis involving 190,000 patients, which reported improved survival with early hip surgeries (Moja et al., 2012). Given the common delays in Sri Lanka due to system constraints, implementing fast-track triage protocols and prioritising surgical scheduling for femur fractures are urgent needs. Although no significant mortality differences were observed between various fixation techniques, THA showed lower mortality compared to HA, as demonstrated by a meta-analysis of 10 studies (Peng et al., 2020). In resource-limited settings like Sri Lanka, selectively offering THA to high-risk patients could balance cost with improved outcomes.

Markers such as elevated CRP, high creatinine, low albumin and anaemia were associated with higher mortality. A meta-analysis (Chen et al., 2023) linked elevated pre-operative CRP levels with both short-term (≤30 days) and long-term (≥6 months) mortality, highlighting the need for pre-operative optimisation. Even in rural areas with limited access to advanced testing, basic screening for these biomarkers could guide risk stratification and management.

While no substantial mortality differences were found across various models of post-operative care (e.g., ICS, GCS, hospital vs. home-based), rehabilitation—particularly early weight-bearing and active physical therapy—was strongly associated with lower mortality. In Sri Lanka, where dedicated rehabilitation centres may be scarce, investing in community-level physiotherapy services and caregiver training could offer a cost-effective means of improving recovery and reducing complications.

In summary, the predictors of mortality following femur fractures can be broadly classified into non-modifiable and modifiable factors. Non-modifiable factors include age, sex, fracture type, and pre-existing comorbidities such as dementia, cancer, and cardiovascular disease, which were associated

with increased mortality. Modifiable factors such as timing of surgery, surgical technique, pre-operative optimisation (e.g., correcting low albumin or treating infections), and access to post-operative rehabilitation offer actionable opportunities to reduce mortality. Systematic reviews consistently support interventions such as early surgery (within 48 hours), nutritional and metabolic optimisation, and enhanced rehabilitation as practical strategies to improve outcomes. These targeted, evidence-based approaches have the potential to significantly reduce mortality and enhance recovery in vulnerable patient populations.

Limitations

This review was limited to studies indexed in PubMed, potentially excluding relevant research from other databases. Only observational studies were included, limiting causal inference. Additionally, heterogeneity in study populations and mortality definitions may affect the generalizability of findings. We have presented only the presence and absence of the risk factors. A comprehensive review of each risk factor should be reported using a systematic review and analysed with a meta-analysis, which will give further meaningful evaluation of the content. This scoping review did not include a formal critical appraisal of the included studies to assess the quality or risk of bias in individual studies.

Conclusions and Recommendations

This scoping review highlights the multifactorial nature of mortality following femur fractures, influenced by both modifiable and non-modifiable risk factors such as. Addressing modifiable predictors—such as timely surgery, pre-operative optimisation, and access to rehabilitation—offers tangible opportunities for improving patient outcomes. In settings like Sri Lanka, where resources are limited, implementing targeted, low-cost interventions based on these findings could lead to significant improvements in survival and recovery among patients with femur fractures. Further research is needed to establish the exact effect of the risk factors and how they

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