Factors Associated With Mortality After Surgical Management of Femoral Neck Fractures

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Background: Hip fractures are recognized as one of the most devastating injuries impacting older adults because of the complications that follow. Mortality rates postsurgery can range from 14% to 58% within one year of fracture. We aimed to identify factors associated with increased risk of mortality within 24 months of a femoral neck fracture in patients aged ≥50 years enrolled in the FAITH and HEALTH trials.

Methods: Two multivariable Cox proportional hazards regressions were used to investigate potential prognostic factors that may be associated with mortality within 90 days and 24 months of hip fracture.

Results: Ninety-one (4.1%) and 304 (13.5%) of 2247 participants died within 90 days and 24 months of suffering a femoral neck fracture, respectively. Older age ($P < 0.001$), lower body mass index ($P = 0.002$), American Society of Anesthesiologists (ASA) class III/IV/V ($P = 0.004$), use of an ambulatory aid before femoral neck fracture ($P < 0.001$), and kidney disease ($P < 0.001$) were associated with a higher risk of mortality within 24 months of femoral neck fracture. Older age ($P = 0.03$), lower body mass index ($P = 0.02$), use of an ambulatory aid before femoral neck fracture ($P < 0.001$), and having a comorbidity ($P = 0.04$) were associated with a higher risk of mortality within 90 days of femoral neck fracture.

Conclusions: Our analysis found that factors that are indicative of a poorer health status were associated with a higher risk of mortality within 24 months of femoral neck fracture. We did not find a difference in treatment methods (internal fixation vs. joint arthroplasty) on the risk of mortality.

Accepted for publication August 11, 2020.
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The HEALTH trial was supported by research grants from the Canadian Institutes of Health Research (CIHR) (MCT-90168), National Institutes of Health (NIH) (1UM1AR063386-01), ZorgOnderzoek Nederland-medische wetensehappen (ZonMw) (17088.2503), Sophies Minde Foundation for Orthopaedic Research, McMaster Surgical Associates, and Stryker Orthopaedics. The funding sources had no role in design or conduct of the study; the collection, management, analysis, or interpretation of the data; or the preparation, review, or approval of the manuscript. The FAITH trial was supported by research grants from the Canadian Institutes of Health Research (MOP-106630 and MCT-87771), National Institutes of Health (1R01AR055267-01A1), Stichting NutsOhra (SNO-T-0602-43), the Netherlands Organisation for Health Research and Development (80-82310-97-11032), and Physicians' Services Incorporated. M. Bhandari was also funded, in part, through the Early Research Award Program which provided funding for the present study as well as by a Canada Research Chair in Musculoskeletal Trauma, which is unrelated to this study (McMaster University, Hamilton, ON, Canada). The FAITH trial was also supported by the National Institute of Arthritis and Musculoskeletal and Skin Diseases of the National Institutes of Health under Award Number R01AR055267-01A1. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. Research reported in this publication was also supported by The County Durham & Tees Valley Comprehensive Local Research Network which operates as part of the National Institute for Health Research Comprehensive Clinical Research Network in England. The funding sources had no role in design or conduct of the study; the collection, management, analysis, or interpretation of the data; or the preparation, review, or approval of the manuscript.
E. H. Schemitsch reports personal fees from Acumed, LLC, personal fees from Amgen Co, research support from Biocomposites, board or committee member for the Canadian Orthopaedic Association, personal fees from DePuy, board or committee member for the Hip Society, board or committee member for the International Society for Fracture Repair, personal fees from ITS, editorial or governing board for the Journal of Orthopaedic Trauma, board or committee member for the Orthopaedic Trauma Association, editorial or governing board for the Orthopaedic Trauma Association International, board or committee member for the Osteosynthesis and Trauma Care Foundation, personal fees from Pentopharm, personal fees from Sanofi-Aventis, personal fees from Saunders/Mosby-Elsevier, personal fees from Smith & Nephew, personal fees from Springer, personal fees from Stryker, personal fees from Swemac, and personal fees from Zimmer, outside the submitted work. M. Swiontkowski reports board or committee member for the American Orthopaedic Association, consultant to the Minnesota Board of Medical Practice, editorial or governing board and publishing royalties, financial or material support for the Journal of Bone and Joint Surgery—American, publishing royalties, financial or material support from Saunders/Mosby-Elsevier, and publishing royalties, financial or material support from Wolters Kluwer Health—Lippincott Williams & Wilkins, outside the submitted work. F. Frihagen reports personal fees from Amgen Co, personal fees from Smith & Nephew, personal fees from Synthes, and personal fees from Zimmer, outside the submitted work. M. Bhandari reports research support from Acumed, LLC, research support from Aphria, research support from Ferring Pharmaceuticals, research support and personal fees from Pendopharma, and research support and personal fees from Sanofi-Aventis, outside the submitted work. S. Sprague reports editorial or governing board for BMS Women's Health, employment from Global Research Solutions Inc, and employment from McMaster University, outside the submitted work. The remaining authors report no conflict of interest.
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DOI: 10.1097/BOT.0000000000001937

Key Words: femoral neck fracture, mortality, internal fixation, arthroplasty

Level of Evidence: Therapeutic Level II. See Instructions for Authors for a complete description of levels of evidence.

(*J Orthop Trauma* 2020;34:S15–S21)

INTRODUCTION

Hip fractures have become a major public health problem and are recognized as one of the most devastating injuries impacting older adults because of the complications that follow, which include chronic pain, diminished physical health, quality of life, and premature death.[1] As the global population continues to age, the yearly incidence of hip fractures has been projected to reach 6.26 million by 2050, as compared to 1.66 million in 1990.[1,2] Despite fractures of the femoral neck typically being managed surgically, with either internal fixation or arthroplasty methods, morbidity and mortality rates remain high postsurgery.[3–5] A systematic review of 70 trials, published between 1981 and 2012, found that mortality rates for femoral neck fracture patients were similar over a 31-year period (~20%), whereas another review reported that mortality rates can range from 14% to 58% within one year of fracture.[3,6] In addition, the Fixation using Alternative Implants for the Treatment of Hip fractures (FAITH) and Hip fracture Evaluation with ALternatives of Total hip arthroplasty versus Hemiarthroplasty (HEALTH) trials have found similar high mortality rates of 14.5% and 13.7%, respectively, within 24 months of hip fracture.[7,8]

Although the high mortality rate of hip fracture patients is well documented, factors associated with mortality after hip fracture have not been thoroughly examined in a large, global patient population. Identifying which factors are associated with mortality may assist surgeons in their treatment decisions and, ultimately, enhance the care of hip fracture patients. The objectives of this analysis were to identify factors associated with an increased risk of mortality within 90 days and 24 months of a femoral neck fracture in patients aged 50 years or older enrolled in the FAITH and HEALTH trials.

METHODS

Selection of Factors

With a binary outcome, having fewer than 10 events for each predictor variable can result in overfitted, unstable models.[9] Given that mortality was experienced within 24 months of femoral neck fracture in a total of 304 participants from the FAITH (150 participants) and HEALTH (154 participants) trials, the number of predictor variables included in the first model was limited to 30 parameters. Because mortality was experienced within 90 days of femoral neck fracture in a total of 91 participants from the FAITH (40 participants) and HEALTH (51 participants) trials, the number of predictor variables included in the second model was limited to 10 parameters. Based on biologic rationale, previous reports in the literature, and discussion with 2 orthopaedic surgeons, potential prognostic factors were selected a priori from the study case report forms. Study (FAITH vs. HEALTH) was included as one of the potential prognostic factors to account for difference in intervention status (surgical method of fracture management) between the 2 studies. Because similar eligibility criteria were used to enroll participants into the FAITH and HEALTH trials and given that the survival experience was similar in both trials, it was deemed appropriate to combine data from both trials to evaluate our research questions.

Statistical Analyses

Complete-case analyses using multivariable Cox proportional hazards regressions were used to investigate the association between the selected baseline, fracture characteristic, and surgical prognostic factors and the risk of mortality within 90 days and 24 months of hip fracture in separate models. Mortality of the FAITH and HEALTH trial participants within 90 days and 24 months of hip fracture was chosen as the dependent variable in each model, with continent entered into the model as a stratification variable. Participants who did not experience the event of mortality were censored at 24 months (730 days) or time of last visit. The analyses included continent to account for potential differences in treatment practices between the geographic locations that participants were recruited from. Selected independent variables were entered into the multivariable Cox proportional hazards regression models simultaneously. Results were reported as adjusted hazard ratios (HR), 95% confidence intervals (CIs), and *P*-values. All tests were 2-tailed with alpha = 0.05.[10] All analyses were performed with SPSS version 25.

RESULTS

Baseline Participant Characteristics

One thousand six and 1241 participants enrolled in the FAITH and HEALTH trials, respectively, totaling 2247 participants, had complete data for the independent variables included in the mortality models. The majority of participants were female (57.2%), the mean age was 75.3 years (SD 10.8), and the mean body mass index (BMI) was 24.8 (SD 4.7). Before injury, the majority of participants were independent ambulators (77.0%), lived in a noninstitutionalized setting (95.5%), did not use osteoporosis medications (92.6%), and did not have any comorbidities, with the exception of high blood pressure (56.7%). The typical femoral neck fracture was displaced (69.7%), with a fracture line at the subcapital level (59.5%), and assigned a type II Pauwels classification (57.0%).[11,12] Furthermore, the majority of participants had either a Class I or Class II American Society of Anesthesiologists (ASA) classification at baseline (54.4%). The event of mortality was experienced in 304 [13.5% total; 150 (49.3%) from FAITH and 154 (50.7%) from HEALTH] and 91 [4.1% total; 40 (44.0%) from FAITH and 51 (56.0%) from HEALTH] participants within 24 months and 90 days of femoral neck fracture, respectively (Table 1).

TABLE 1. Baseline Participant Characteristics

Variable	Death within 2 Years, N = 304	No Death Within 2 Years, N = 1943	Total, N = 2247
Age, mean (SD) y	80.6 (8.3)	74.5 (10.9)	75.3 (10.8)
Sex, n (%)			
Female	155 (51.0)	1130 (58.2)	1285 (57.2)
Male	149 (49.0)	813 (41.8)	962 (42.8)
BMI, mean (SD) kg/m^2	24.0 (4.9)	25.0 (4.6)	24.8 (4.7)
ASA classification, n (%)			
Class I/II	94 (30.9)	1128 (58.1)	1222 (54.4)
Class III/IV/V	210 (69.1)	815 (41.9)	1025 (45.6)
Prefracture living setting, n (%)			
Not institutionalized	276 (90.8)	1871 (96.3)	2147 (95.5)
Institutionalized	28 (9.2)	72 (3.7)	100 (4.5)
Prefracture functional status, n (%)			
Independent ambulator	158 (52.0)	1572 (80.9)	1730 (77.0)
Using ambulatory aid	146 (48.0)	371 (19.1)	517 (23.0)
Study, n (%)			
FAITH (internal fixation)	150 (49.3)	856 (44.1)	1006 (44.8)
HEALTH (joint replacement)	154 (50.7)	1087 (55.9)	1241 (55.2)
Baseline osteoporosis medication use, n (%)			
Yes	31 (10.2)	136 (7.0)	167 (7.4)
No	273 (89.8)	1807 (93.0)	2080 (92.6)
Heart disease, n (%)			
Yes	149 (49.0)	574 (29.5)	723 (32.2)
No	155 (51.0)	1369 (70.5)	1524 (67.8)
High blood pressure, n (%)			
Yes	209 (68.8)	1066 (54.9)	1275 (56.7)
No	95 (31.3)	877 (45.1)	972 (43.3)
Lung disease, n (%)			
Yes	77 (25.3)	315 (16.2)	392 (17.4)
No	227 (74.7)	1628 (83.8)	1855 (82.6)
Diabetes, n (%)			
Yes	72 (23.7)	323 (16.6)	395 (17.6)
No	232 (76.3)	1620 (83.4)	1852 (82.4)
Kidney disease, n (%)			
Yes	64 (21.1)	140 (7.2)	204 (9.1)
No	240 (78.9)	1803 (92.8)	2043 (90.9)
Depression, n (%)			
Yes	47 (15.5)	242 (12.5)	289 (12.9)
No	257 (84.5)	1701 (87.5)	1958 (87.1)
Fracture displacement, n (%)			
Undisplaced	124 (40.8)	556 (28.6)	680 (30.3)
Displaced	180 (59.2)	1387 (71.4)	1567 (69.7)
Level of the fracture line, n (%)			
Subcapital	212 (69.7)	1126 (58.0)	1338 (59.5)
Midcervical	73 (24.0)	704 (36.2)	777 (34.6)
Basal	19 (6.3)	113 (5.8)	132 (5.9)
Pauwels classification, n (%)			
Type I	50 (16.4)	237 (12.2)	287 (12.8)
Type II	184 (60.5)	1097 (56.5)	1281 (57.0)
Type III	70 (23.0)	609 (31.3)	679 (30.2)
Time from injury to surgery, mean (SD) hours	58.1 (69.7)	50.8 (74.2)	51.8 (73.7)
Length of surgery, mean (SD) minutes	71.1 (40.4)	75.3 (37.8)	74.7 (38.2)

(*continued on next page*)

TABLE 1. (*Continued*) Baseline Participant Characteristics

Variable	Death within 2 Years, N = 304	No Death Within 2 Years, N = 1943	Total, N = 2247
Type of anesthesia, n (%)			
General	139 (45.7)	1042 (53.6)	1181 (52.6)
Regional	165 (54.3)	901 (46.4)	1066 (47.4)
Intraoperative blood loss, mean (SD), mL	203.0 (200.5)	207.4 (180.4)	206.8 (183.2)
Postoperative thromboprophylaxis, n (%)			
Yes	301 (99.0)	1932 (99.4)	2233 (99.4)
No	3 (1.0)	11 (0.6)	14 (0.6)
Majority of procedure performed by, n (%)			
Surgeon	187 (61.5)	1188 (61.1)	1375 (61.2)
Resident	99 (32.6)	641 (33.0)	740 (32.9)
Fellow	18 (5.9)	114 (5.9)	132 (5.9)

ASA, American Society of Anesthesiologists; BMI, body mass index; SD, standard devation.

Predictors of 24-Month Mortality

Older age (HR 1.42 for every 10-year increase, 95% CI 1.22–1.65; $P < 0.001$), lower BMI (HR 1.23 for every 5-point decrease, 95% CI 1.08–1.39; $P = 0.002$), American Society of Anesthesiologists (ASA) class III/IV/V (HR 1.53 vs. class I/II, 95% CI 1.14–2.04; $P = 0.004$), use of an ambulatory aid before femoral neck fracture (HR 2.10 vs. ambulating independently, 95% CI 1.63–2.71; $P < 0.001$), and kidney disease (HR 2.14, 95% CI 1.60–2.86; $P < 0.001$) were associated with a higher risk of mortality within 24 months of femoral neck fracture (Table 2). We did not find a difference in treatment methods (internal fixation vs. joint arthroplasty) in the risk of mortality. In addition, no other factors were significantly associated with mortality ($P > 0.05$).

Predictors of 90-Day Mortality

Ninety-nine (4.1%) of 2247 participants died within 90 days of femoral neck fracture. Older age (HR 1.34 for every 10-year increase, 95% CI 1.04–1.73; $P = 0.03$), lower BMI (HR 1.33 for every 5-point decrease, 95% CI 1.04–1.70; $P = 0.02$), use of an ambulatory aid before femoral neck fracture (HR 4.39 vs. ambulating independently, 95% CI 2.74–7.02; $P < 0.001$), and having a comorbidity (HR 2.27, 95% CI 1.02–5.04; $P = 0.04$) were associated with a higher risk of mortality within 90 days of femoral neck fracture (Table 3). No other factors were significantly associated with mortality ($P > 0.05$).

DISCUSSSION

Using data from the FAITH and HEALTH trials, we investigated which factors are associated with mortality within 90 days and 24 months of femoral neck fracture. Older age, lower BMI, ASA class III/IV/V, use of an ambulatory aid before femoral neck fracture, and kidney disease were factors found to be associated with a higher risk of mortality within 24 months of femoral neck fracture in this analysis. Older age, lower BMI, use of an ambulatory aid before femoral neck fracture, and having a comorbidity were factors found to be associated with a higher risk of mortality within 90 days of femoral neck fracture in this analysis. Overall, the majority of the findings from our analysis support the existing literature concerning predictive variables of mortality after hip fracture.[6,13–18]

Increasing age was a factor found to be associated with a higher risk of 1-, 2-, 3-, 5-, and 10-year mortality across several previously completed studies.[6,13–22] Other studies have identified kidney disease, including renal failure, which is the final stage of chronic kidney disease, to be an essential predictor of mortality following hip fracture.[14,20,23,24] Although we did control for ASA grade in our analysis, patients with chronic kidney disease usually have more comorbidities and more postoperative complications, which are highly likely to contribute to mortality within 90 days of hip fracture surgery.[23,24]

Lower BMI being predictive of mortality within 24 months of hip fracture was another finding from our analysis that supports the current published literature.[18,25,26] In particular, one study reported that patients with a BMI >26 had a lower mortality rate than those with BMI <22 (odds ratio 2.6 for the 1-year survival, 95% CI 1.20–5.50; $P = 0.006$).[25] Similarly, another study found that compared to participants of normal weight, mortality in overweight (HR 0.74, 95% CI 0.62–0.88; $P = 0.001$) and obese (HR 0.74, 95% CI 0.60–0.91; $P = 0.004$) participants was significantly lower after sustaining a hip fracture.[26] Although the observation of higher mortality in individuals with a lower BMI is consistent among the published literature, further research is still required to understand the reasons for reduced mortality in obese and overweight participants when compared to those of normal weight.[26] There is evidence suggesting that poor nutritional status is linked to increased mortality in hip fracture patients, which may explain why underweight participants with a lower BMI are at a higher risk of mortality.[22,27]

The impact of time from injury to hip surgery has been a topic of discussion among orthopaedic surgeons. In our

TABLE 2. Factors Associated With 24-Month Mortality (n = 2247; 304 Events)

Independent Variable	HR (95% CI)	*P*
Age (10-y increase)	1.42 (1.22–1.65)	<0.001
BMI (5-point decrease)	1.23 (1.08–1.39)	0.002
ASA classification		
Class III/IV/V vs. Class I/II	1.53 (1.14–2.04)	0.004
Prefracture functional status		
Using ambulatory aid vs. independent ambulator	2.10 (1.63–2.71)	<0.001
Kidney disease		
Yes vs. no	2.14 (1.60–2.86)	<0.001
Sex		
Male vs. female	1.03 (0.80–1.32)	0.84
Prefracture living setting		
Institutionalized vs. not institutionalized	1.40 (0.93–2.11)	0.11
Study		
FAITH (internal fixation) vs. HEALTH (joint replacement)	0.79 (0.48–1.31)	0.36
Baseline osteoporosis medication use		
Yes vs. no	1.02 (0.69–1.52)	0.91
Heart disease		
Yes vs. no	1.14 (0.88–1.47)	0.33
High blood pressure		
Yes vs. no	1.02 (0.79–1.33)	0.86
Lung disease		
Yes vs. no	1.26 (0.96–1.66)	0.10
Diabetes		
Yes vs. no	1.22 (0.92–1.62)	0.17
Depression		
Yes vs. no	0.98 (0.70–1.36)	0.89
Fracture displacement		
Displaced vs. undisplaced	0.75 (0.48–1.18)	0.21
Level of the fracture line		
Midcervical vs. subcapital	0.85 (0.64–1.12)	
Basal vs. subcapital	1.48 (0.90–2.41)	Overall: 0.10
Pauwels classification		
Type I vs. type III	1.15 (0.77–1.72)	
Type II vs. type III	1.08 (0.80–1.46)	Overall: 0.79
Time from injury to surgery (h)	1.001 (0.99–1.002)	0.33
Length of surgery (mins)	1.001 (0.99–1.004)	0.67
Type of anesthesia		
General vs. Regional	1.04 (0.79–1.36)	0.79
Intraoperative blood loss (mL)	1.00 (1.00–1.001)	0.21
Postoperative thromboprophylaxis		
Yes vs. no	0.58 (0.14–2.40)	0.45
Majority of procedure performed by		
Resident vs. surgeon	0.98 (0.76–1.27)	
Fellow vs. surgeon	1.05 (0.64–1.72)	Overall: 0.97

ASA, American Society of Anesthesiologists; BMI, body mass index.

analysis, the mean time from injury to surgery was 57.9 hours (SD 215.4 hours) and not found to be significantly associated with mortality within 24 months (HR 1.00, 95% CI 1.00–1.00; $P = 0.86$) nor within 90 days (HR 1.00, 95% CI 0.998–1.003; $P = 0.69$) of fracture. The recently completed

TABLE 3. Factors Associated With 90-Day Mortality (n = 2247; 91 Events)

Independent Variable	HR (95% CI)	*P*
Age (10-y increase)	1.34 (1.04–1.73)	0.03
BMI (5-point decrease)	1.33 (1.04–1.70)	0.02
Prefracture functional status		
Using ambulatory aid vs. independent ambulator	4.39 (2.74–7.02)	<0.001
Comorbidities		
Yes vs. No	2.27 (1.02–5.04)	0.04
ASA classification		
Class III/IV/V vs. Class I/II	1.44 (0.87–2.38)	0.15
Study		
FAITH (internal fixation) vs. HEALTH (joint replacement)	0.88 (0.53–1.46)	0.62
Time from injury to surgery (hours)	1.00 (0.998–1.003)	0.69
Length of surgery (minutes)	0.99 (0.992–1.004)	0.51
Type of anesthesia		
General vs. Regional	0.88 (0.55–1.41)	0.58

ASA, American Society of Anesthesiologists; BMI, body mass index.

HIP ATTACK (The Hip Fracture Accelerated Surgical Treatment and Care Track) trial aimed to definitively answer this particular question by examining whether accelerated care (surgery within 6 hours of hip fracture diagnosis) versus standard care (surgery within 24 hours) could reduce mortality and major complications in hip fracture patients aged 45 years or older.[28] The trial did not find a reduction in mortality at 30 and 90 days when surgery was conducted within 6 hours, as well as found no difference between the surgery groups on major complications occurring within 90 days.[28] However, it has been proposed that earlier surgery may shorten the period of immobility, which may improve functional outcomes, lessen costs and, ultimately, reduce morbidity and mortality in the long run.

Several studies found that a high ASA classification as well as ambulating with an assistive device before hip fracture was predictive of mortality.[13,18,21,22,27] It has been hypothesized that the use of an ambulatory aid may lead to higher mortality rates because it delays the patient's ability to immediately bear weight after hip fracture surgery or may be a surrogate for frailty.[29]

Despite our findings indicating otherwise, there have been studies published reporting that being institutionalized before femoral neck fracture is associated with a higher risk of mortality.[20,30] In a retrospective cohort study of 3992 patients older than 45 years having an osteoporotic hip fracture, institutionalization before injury occurrence (incidence rate ratio 1.48, 95% CI 1.36–1.60; $P < 0.05$) was associated with a higher risk of mortality within 5 years of injury.[20]

In our analysis, we found that treatment method (internal fixation in the FAITH trial vs. joint arthroplasty in the HEALTH trial) was not significantly associated with mortality ($P = 0.36$) overall within 24 months nor within 90 days ($P = 0.62$) of fracture. Numerous published studies support our finding that there is no overall difference in mortality between patients treated with arthroplasty versus internal fixation.[27,31–34] However, some published literature has suggested trends of internal fixation favoring mortality reduction.[27,34,35] A prospective multicenter study of 697 patients aged over 80 years, presenting with a fracture of the upper femur, treated with either internal fixation or arthroplasty found that in their univariate analysis, mortality was higher with arthroplasty (25%) than with internal fixation (17%; $P = 0.002$), but that the effect no longer existed in their multivariate analysis ($P > 0.05$).[27] Bhandari et al[35] conducted a meta-analysis to determine the effect of arthroplasty (hemiarthroplasty, bipolar arthroplasty, and total hip arthroplasty) versus internal fixation (with a fixed-angle screw and plate or with multiple screws) on rate of mortality in patients aged 65 years or older with a displaced femoral neck fracture. The authors found a trend toward an increase in the relative risk of death in the first 4 months and at one year after arthroplasty compared with internal fixation. Another meta-analysis of elderly patients with displaced femoral neck fractures compared the effect of arthroplasty versus internal fixation on various clinical outcomes and found that, overall, there was increased postoperative risk for mortality with arthroplasty as compared to internal fixation, but that there was no statistically significant difference between the 2 groups at the different follow-up times.[34]

The primary strength of this analysis is the preplanned analysis of a large number of well characterized patients from over 130 clinical sites across 12 countries that were included when examining the research questions. Such a large and diverse sample size increases the external validity and generalizability of the research findings from this analysis. Another strength is that we focused on femoral neck fractures, whereas most published studies on this topic have combined all hip fracture types together. However, not being able to include all participants from the FAITH and HEALTH trials in this analysis as a result of missing data was a limitation. In addition, because only those variables that were collected as part of the FAITH and HEALTH trials could be used in the analysis, it may be possible that not all factors associated with mortality were captured. Both trials also had strict exclusion criteria that may have resulted in healthier patients being enrolled. For example, patients must have been ambulatory before the fracture (although they may have used an aid such as a cane or walker) and had no history of frank dementia to be included. Given the possibility that healthier patients were enrolled in both trials, this may explain, in part, a lower 24-month mortality rate of 13.5%, as compared to higher rates in the literature.

In conclusion, given the major public health problem surrounding femoral neck fractures in older adults, it is necessary to gain a further understanding of which patients are at risk for mortality in order for surgeons to be able to provide their patients with an accurate prognosis following injury and to develop intervention strategies. Our analysis found that factors that are indicative of a poorer health status, such as older age, lower BMI, worse ASA class, use of an ambulatory aid, and kidney disease, were associated with a higher risk of mortality. We did not find treatment methods (internal fixation vs. joint arthroplasty) to be overall significantly associated with mortality.

ACKNOWLEDGMENTS

The authors thank the HEALTH and FAITH Investigators (http://links.lww.com/JOT/B226).

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