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Measurement and evaluation of hip fracture care

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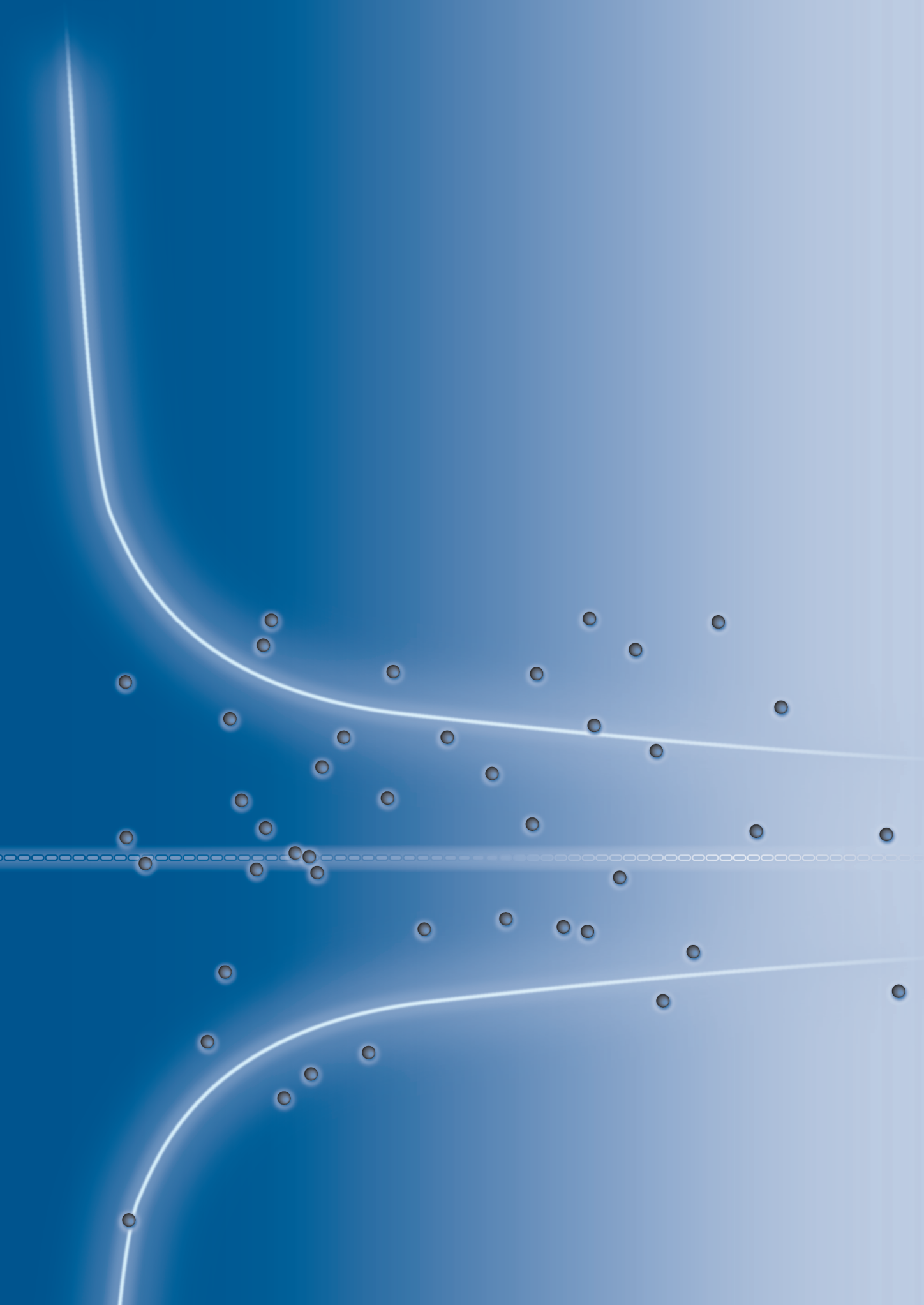
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Part

1

Measurement of the quality of hip fracture care



2

Quality indicators for hip fracture care, a systematic review

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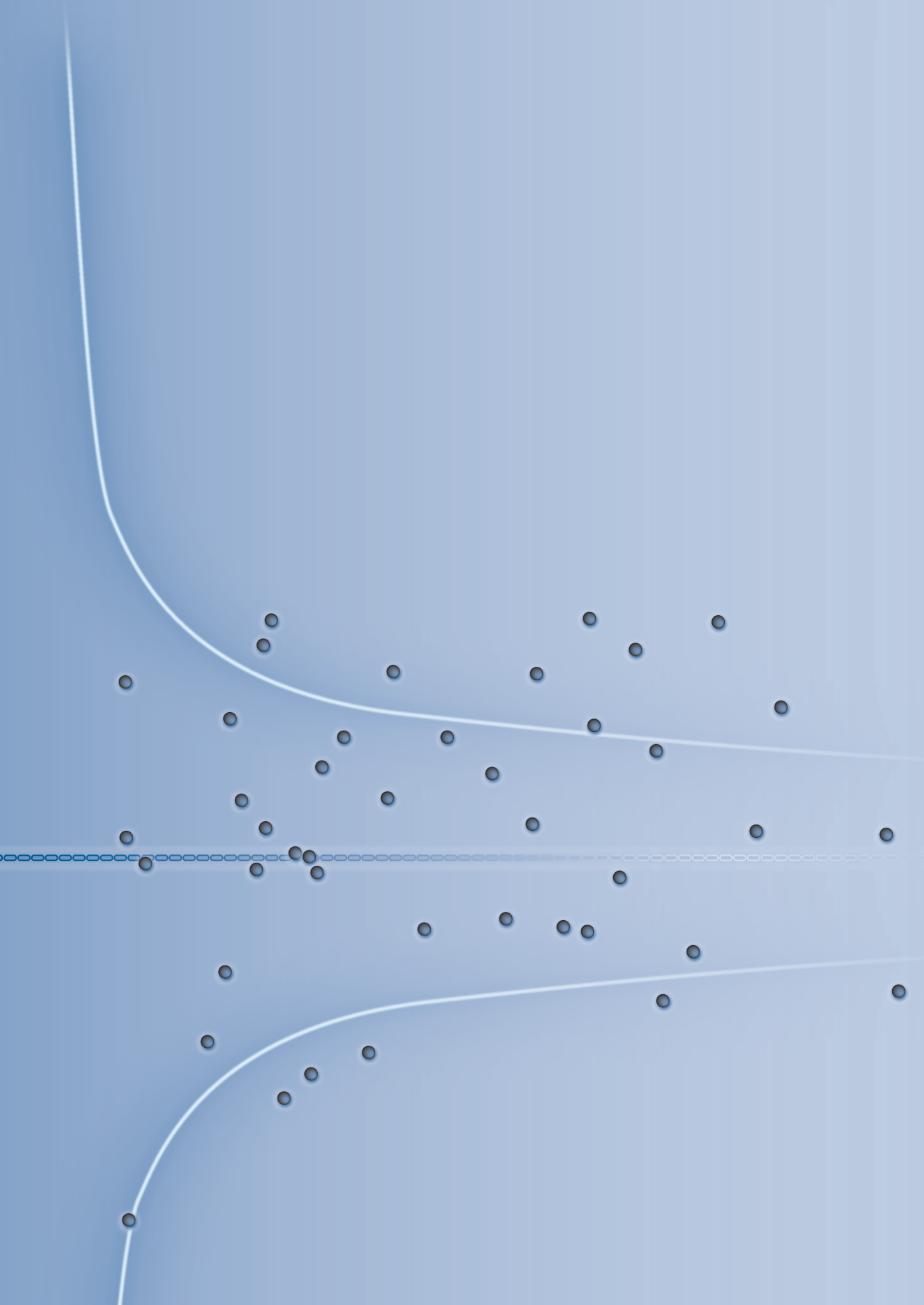
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Abstract

Background

Quality indicators are used to measure quality of care and enable benchmarking. An overview of all existing hip fracture quality indicators is lacking. The primary aim was to identify quality indicators for hip fracture care reported in literature, hip fracture audits, and guidelines. The secondary aim was to compose a set of methodologically sound quality indicators for the evaluation of hip fracture care in clinical practice.

Methods

A literature search according to the PRISMA guidelines and an internet search were performed to identify hip fracture quality indicators. The indicators were subdivided into process, structure and outcome indicators. The methodological quality of the indicators was judged using the AIRE instrument. For structure and process indicators the construct validity was assessed.

Results

Sixteen publications, nine audits and five guidelines were included. In total 97 unique quality indicators were found: 9 structure, 63 process and 25 outcome indicators. Since detailed methodological information about the indicators was lacking, the AIRE instrument could not be applied. Eleven indicators correlated with an outcome measure. A set of nine quality indicators was extracted from the literature, audits and guidelines.

Conclusion

Many quality indicators are described and used. Not all of them correlate with outcomes of care and have been assessed methodologically. As methodological evidence is lacking, we recommend the extracted set of nine indicators to be used as the starting point for further clinical research. Future research should focus on assessing the clinimetric properties of the existing quality indicators.

Introduction

Hip fractures (HFs) are one of the most common injuries diagnosed in the emergency department. They are associated with high morbidity and mortality rates in the elderly¹⁻⁴. To optimize care for elderly HF patients, several guidelines for care and management have been developed worldwide⁵⁻⁸.

Also, around the world clinical audits have been started to further improve the quality of the provided HF care. In audits, quality indicators (QIs) are used to measure (outcomes of) care and to enable benchmarking. QIs are measurable aspects of care that reflect the quality of care^{9,10}. They are defined as “measurement tools, screens, or flags that are used as guide to monitor, evaluate, and improve the quality of patient care, clinical support services, and organization functions that affect patient outcomes”¹⁰. Three types of QIs are distinguished: structure, process and outcome indicators¹¹. Structure indicators describe what is needed within a hospital or health care system to provide good care, and reflect the setting of the provided care¹². Process indicators provide information about the appropriateness of the delivered care and can be measured at patient level¹⁰. They are often based on guidelines. Outcome indicators reflect the end results of the provided care.

A good QI must meet four criteria: clinically relevant, scientifically acceptable, feasible and usable^{13,14}. To be scientifically acceptable, a QI has to be reliable and valid⁹. To meet these criteria, a high-quality QI should undergo a well-described methodological development process¹⁵.

The primary aim of this study was to identify quality indicators for HF care that are reported in the literature, ongoing HF audits and national guidelines. The secondary aim was to compose a set of methodologically sound quality indicators for the evaluation of HF care in clinical practice.

Methods

This review was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement¹⁶. The study protocol was registered in PROSPERO, the international prospective database of systematic reviews (registration number CRD42016053425).

Search strategy

The search strategy was developed in collaboration with an experienced medical librarian of the Leiden University Medical Center, to identify all relevant publications in MedLine, Embase, Web of Science, Cochrane Library, Cinahl and Google Scholar. The search strategy

included ‘Hip fracture’ and ‘QIs / benchmarking / audit / medical audit / outcome assessment / process assessment / quality assurance / performance measure’ as Mesh and Tiab terms. The exact search strategy is presented in Appendices 1 to 6. Publications in English from 1990 up to 14 November 2016 were included.

Parallel to the literature search an internet search for HF audits worldwide was performed. These websites and their annual reports were searched to identify the QIs used in these audits. In a second internet search, all national HF guidelines published in English were probed for QIs.

Study selection

The first author (SV) conducted the search and entered the articles identified in EndNote (Endnote X7 Thomson Reuters, Philadelphia, Pennsylvania). After removal of duplicates, the remaining publications were imported into the web-based software platform Covidence (www.covidence.com). Two authors (SV and DV) independently screened the titles and abstracts of the articles for relevance, based on the stated inclusion and exclusion criteria. In case of disagreement a third author (MW) was consulted. The full text of articles found to be relevant on the basis of title and abstract was read by SV and DV who made the final selection following the same procedure. The reference lists of the included articles were screened for relevant studies that had been missed in the literature search.

The inclusion criteria were:

- Studies describing (the development of) QIs / performance measures in HF care
- Studies describing the assessment of the quality of QIs / performance measures in HF care
- Systematic reviews, meta-analyses, randomized-controlled trials, cross-sectional studies, cohort studies, case-control studies, and guidelines on this topic.

Articles were excluded if they described:

- Non-HF care QIs
- QIs for HF patients below 18 years of age
- QIs for HF prevention or prehospital HF care
- Patient reported outcome measures (PROMs) for HF care
- Meeting abstracts.

Data extraction

The definition and operationalization of the reported indicators were extracted from the selected articles. Instead of assessing the quality of the selected articles, the type and quality of the indicators were assessed. The Donabedian quality of care model was used to categorize the QIs as structure, process or outcome indicator¹¹.

All identified articles, audits and guidelines were screened to obtain information about the quality of the QIs. The AIRE instrument (Appraisal of Indicators through Research and Evaluation) is an assessment tool for the methodological quality of QIs. In order to use the AIRE instrument, information on clinical relevancy, scientific acceptability, feasibility and usability of the QIs has to be described¹⁷. If the articles did not provide the information needed for the application of the AIRE instrument, the construct validity of the QIs was assessed using the correlation of the structure and process QIs with one or more outcome measures¹⁸.

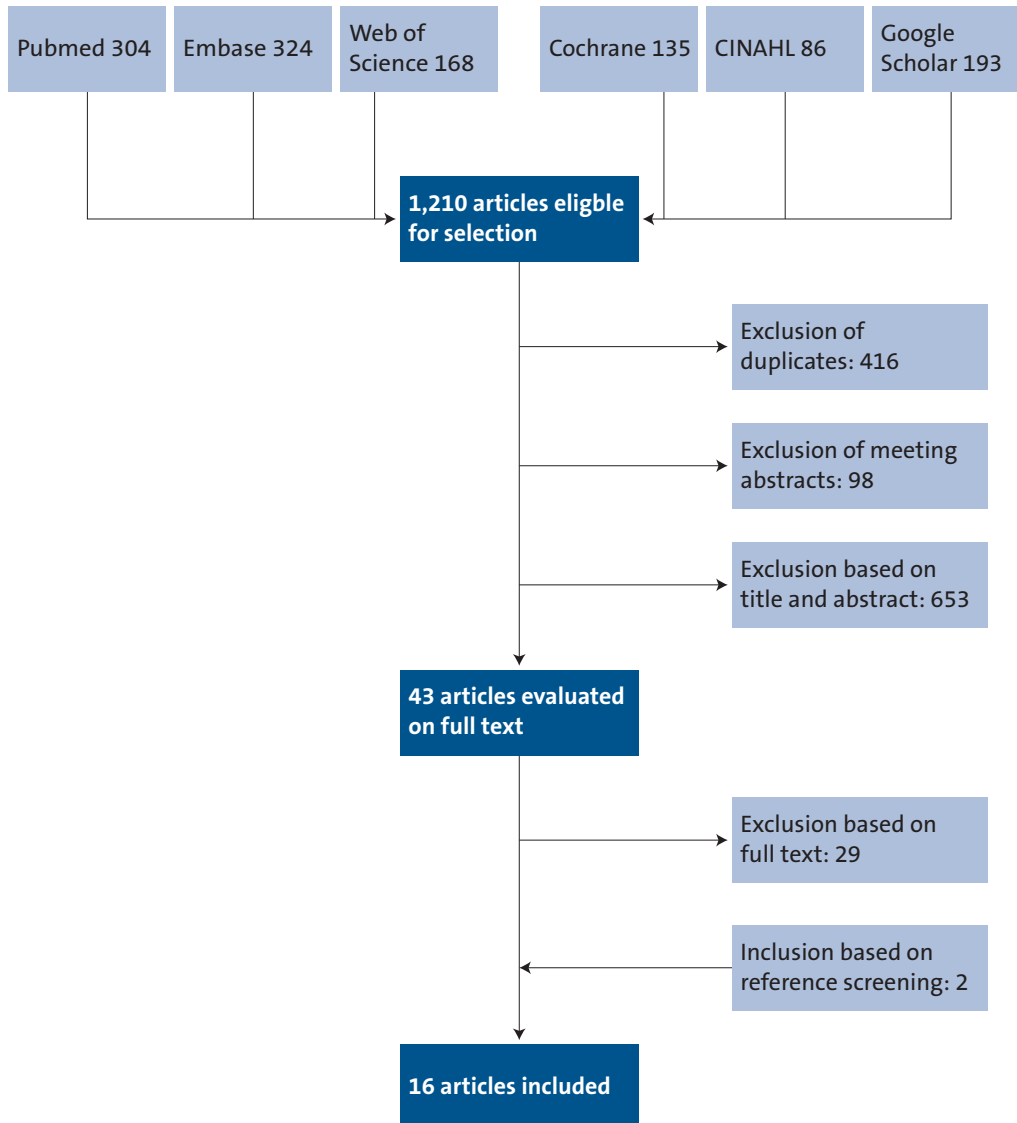
The set of QIs to be selected should be based on qualitative measures, preferably using the AIRE instrument or, if this was not possible, on the basis of their construct validity. Since not enough qualitative information was available, it was decided to use a quantitative measure for the QI selection. This selection criterion was that the QIs were described in at least two articles and were used in at least two audits or guidelines.

Results

Study selection

The literature search resulted in 1,210 hits (Figure 1). After removal of duplicates and meeting abstracts, 696 articles were available for assessment. Based on title and abstract, a total of 653 articles were excluded. After full-text screening of the remaining 43 articles, a further 29 articles were excluded. Two articles were included based on screening of the reference lists.

Figure 1. Flowchart of study selection



The 16 selected studies included 15 cohort studies (3 prospective and 12 retrospective) and 1 systematic review (Table 1a). The cohort studies covered a total of 593,584 HF patients, and the study of Neuburger represented almost 80% of these patients.

Table 1a. Quality indicators for in-hospital hip fracture care, reported in studies

| Study, year of publication | Country | Study period | n | Study design | Quality indicators |
|--|---------------------|--------------|--------|--------------|--|
| Beringer et al. ¹⁹ 2006 | Northern Ireland | 1999-2001 | 2,834 | Pro | 1. Discharge home within 56 days 2. 30-day mortality |
| Khan et al. ²⁰ 2014 | England | 2008-2011 | 516 | Retro | 1. Time to surgery < 36 hours 2. Admitted under joined geriatric / orthopaedic care 3. Using an agreed multidisciplinary protocol 4. Assessed by a geriatrician < 72 hours 5. Postoperative multi-professional rehabilitation team 6. Fracture prevention assessments (falls / bone health) |
| Kristensen et al. ²¹ 2016 | Denmark | 2010-2013 | 25,354 | Retro | 1. Daily systematic pain assessment 2. Mobilized within 24 hrs postoperatively 3. Mobility assessment before admission 4. Mobility assessment at discharge 5. Post-discharge rehabilitation program 6. Future fall prevention 7. Anti-osteoporotic medication |
| Lizaur-Utrilla et al. ²² 2016 | Spain | 2012-2014 | 628 | Pro | 1. Surgery within 2 days of admission |
| Majumdar et al. ²³ 2006 | Canada | 1994-2000 | 3,981 | Retro | 1. Surgery within 24 hours |
| Merle et al. ²⁴ 2009 | France | 2003-2004 | 857 | Retro | 1. Time to surgery 2. Height and weight mentioned in orthopaedic chart 3. Albuminaemia mentioned in orthopaedic chart 4. Nutritional supplement ordered during stay in orthopaedic ward 5. Pressure sore occurrence 6. Time between discharge and completion of orthopaedic hospitalization record 7. Time between admission and request for transfer to rehabilitation facility 8. Delay between surgery and first getting up 9. Percentage of in-hospital days with intervention of a physiotherapist 10. Time between surgery and completion of surgery record |

| Study, year of publication | Country | Study period | n | Study design | Quality indicators |
|---|----------|--------------------|---------|--------------|---|
| Merle et al. ²⁴ 2009 (cont'd) | France | 2003-2004 | 857 | Retro | 11. Patient satisfaction with information about hospital care 12. Patient satisfaction with pain management 13. Time between discharge from rehabilitation ward and completion of rehabilitation hospitalization record 14. Osteoporosis assessment and/or treatment 15. Prevention of falls initiated |
| Neuburger et al. ²⁵ 2015 | England | 2003-2011 | 471,590 | Retro | 1. Prompt admission to orthopaedic care 2. Surgery within 48 hours 3. Prevention of pressure ulcers 4. Access to acute orthogeriatric care 5. Assessment for bone protection therapy 6. Falls assessment |
| Currie et al. ²⁶ 2005 | Scotland | 1998-2003 | 30,000 | Retro | 1. No delay in transfer from Accident and Emergency Department 2. Surgery performed within 24 hours of admission 3. Preoperative care and rehabilitation provided by a multidisciplinary team 4. Standardized data collected for all patients |
| Ferguson et al. ²⁷ 2016 | Scotland | 2003-2008 and 2013 | 31,400 | Retro | 1. Discharge from Accident and Emergency Department within 2 hours of waiting time 2. Surgery within 48 hours of admission 3. Length of hospital stay 4. Discharge destination 5. 30-day mortality rate 6. 120-day mortality rate |
| Freeman et al. ²⁸ 2002 | England | 1992 and 1997 | 1,478 | Retro | 1. Surgery within 48 hours of admission 2. Use of prophylactic anticoagulation 3. Mobilization within 48 hours of surgery 4. Use of prophylactic antibiotics 5. Seen by a geriatrician 6. Standard risk assessment for pressure sores on admission to orthopaedic ward 7. Little or no hip pain at 3 months 8. Return to pre-fracture activities of daily living at 3 months 9. Return to pre-fracture level of accommodation at 3 months |

| Study, year of publication | Country | Study period | n | Study design | Quality indicators |
|---|---------------|-----------------------------------|--------|--------------|--|
| Freeman et al. ²⁸ 2002 (cont'd) | England | 1992 and 1997 | 1,478 | Retro | 10. Mortality within 3 months 11. Pneumonia within 3 months 12. Pulmonary embolism within 3 months 13. Myocardial infarction within 3 months 14. Wound and hip joint infection within 3 months 15. Pressure sore grade II or worse within 3 months |
| Holly et al. ²⁹ 2014 | United States | - | - | SR | 1. Assessment for delirium risk factors using a valid and reliable tool 2. The environment is assessed daily for preventive strategies to maintain sensory orientation 3. Receive essential nursing care 4. Appropriate clinical criteria applied to confirm diagnosis of delirium 5. Non-pharmacologic interventions employed before pharmacologic interventions in patients with a diagnosis of delirium |
| Khan et al. ³⁰ 2013 | England | 2010-2011 versus 2011- 2012 | 873 | Retro | 1. Time to surgery < 36 hours 2. Admitted under joined geriatric / orthopaedic care 3. Using an agreed multidisciplinary protocol 4. Assessed by a geriatrician < 72 hours 5. Postoperative multi-professional rehabilitation team 6. Fracture prevention assessments (falls / bone health) |
| Patel et al. ³¹ 2013 | England | 2009-2010 | 372 | Retro | 1. Time to surgery < 36 hours 2. Admitted under joined geriatric / orthopaedic care 3. Using an agreed multidisciplinary protocol 4. Assessed by a geriatrician < 72 hours 5. Postoperative multi-professional rehabilitation team 6. Fracture prevention assessments (falls / bone health) |
| Sund et al. ³² 2005 | Finland | 1998-2001 | 16,881 | Retro | 1. Time to surgery within 48 hours, from arrival to start of surgery |
| Nielsen et al. ³³ 2009 | Denmark | 2005-2006 | 6,266 | Retro | 1. Early assessment of nutritional risk 2. Systematic pain assessment during mobilization 3. Assessment of Activities of Daily Living (ADL) before fracture 4. Assessment of Activities of Daily Living (ADL) before discharge 5. Treatment to prevent future osteoporotic fractures |

| Study, year of publication | Country | Study period | n | Study design | Quality indicators |
|----------------------------------|---------------|--------------|-----|--------------|---|
| Siu et al. ³⁴ 2006 | United States | 1997-1998 | 554 | Pro | <ol style="list-style-type: none"> 1. Time from admission to surgery 2. Abnormal clinical findings before surgery (laboratory tests) 3. Start of anticoagulation to prevent thromboembolism 4. Anticoagulation regimen 5. Use of prophylactic antibiotics 6. Removal of urinary catheter postoperatively 7. Mobilization to a chair in first 3 postoperative days 8. Mobilization beyond chair in first 3 postoperative days 9. Physical therapy in first 3 postoperative days 10. Days of moderate or severe pain over first 5 hospital days 11. Number of days of severe pain with no or only slight relief 12. Avoidance of restraints 13. Stability at discharge (unresolved active clinical issues) |

Pro Prospective cohort study

Retro Retrospective cohort study

SR Systematic review

Websites of ongoing hip fracture audits

Nine national HF audits were identified: the National Hip Fracture Database (United Kingdom minus Scotland), the Scottish Hip Fracture Audit (Scotland), the Australian and New Zealand Hip Fracture Registry (Australia/New-Zealand), the Danish Multidisciplinary Hip Fracture Registry (Denmark), Rikshöft (Sweden), the Dutch Hip Fracture Audit (The Netherlands), the Irish Hip Fracture Database (Ireland), the Kaiser Permanente Hip Fracture Registry (United States) and the Norwegian Hip Fracture Register (Norway). On the websites of the first seven audits, QIs were described. The QIs used in the United States were obtained by email. No QIs were described in the Norwegian Hip Fracture Register^{46,47}.

Table 1b. Quality indicators for in-hospital hip fracture care, reported in audits

| Name, initial year | Country | Year of report | n | Quality indicators |
|---|----------------------|----------------|--------|--|
| National Hip Fracture Database ³⁵ 2007 | UK minus Scotland | 2016 | 64,864 | <ol style="list-style-type: none"> 1. Surgery on the day of, or the day after, admission 2. Pain assessment upon presentation at hospital 3. Administration of nerve blocks if no preoperative pain control 4. Offer a choice of spinal or general anaesthesia 5. Intraoperative nerve blocks for all patients undergoing surgery 6. Hip fracture surgery scheduled on a planned trauma list 7. Consultants or senior staff supervise trainee of the anaesthesia, surgical and theater teams 8. Arthroplasty in a displaced intracapsular fracture 9. Total hip replacement in defined conditions[#] 10. Cemented implants with arthroplasty 11. Extramedullary implants in AO classification types A1 and A2 12. IM nail in case of a subtrochanteric fracture 13. Physiotherapy assessment and mobilization on the day after surgery 14. Hip Fracture Program (HFP) during admission[^] 15. If a hip fracture complicates or precipitates a terminal illness, consider surgery as part of a palliative care approach 16. Early supported discharge as part of the HFP[^] 17. Intermediate care in certain conditions[§] 18. Patients admitted from care or nursing homes should not be excluded from community or hospital rehabilitation programs 19. Patients offered verbal and printed information about treatment and care 20. All inpatients and outpatients at their first clinic appointment screened for malnutrition 21. Minimize risk of delirium by actively looking for cognitive impairment and reassessing patients to identify a delirium 22. Multidisciplinary assessment of future risk and individualized intervention to prevent falls 23. Strength and balance training 24. Bisphosphonates in postmenopausal women with osteoporosis |
| Scottish Hip Fracture Audit ³⁶ 1993-2008, restarted 2016 | Scotland | 2016 | 1,041 | <ol style="list-style-type: none"> 1. Transfer from emergency department to orthopaedic ward within four hours 2. The 'Big Six' interventions / treatments applied before leaving the Emergency Department[†] |

| Name, initial year | Country | Year of report | n | Quality indicators |
|--|---------------------------|----------------|-------|--|
| Scottish Hip Fracture Audit ³⁶ (cont'd) | Scotland | 2016 | 1,041 | 3. 'Inpatient Bundle of Care' within 24 hours of admission [§] 4. Surgical repair within 36 hours of admission 5. No repeated fasting in preparation for surgery 6. Preoperative catheterization only for medical reasons 7. Cemented hemi-arthroplasty implants 8. Frail patients have a geriatric assessment within three days of admission 9. Mobilization on the first day after surgery and physiotherapy assessment by end of day two 10. Occupational therapy assessment by the end of day three postoperatively 11. Assessment of bone health prior to leaving the acute orthopaedic ward 12. Discharge back to original place of residence within 30 days from date of admission |
| Australian and New Zealand Hip Fracture Registry ³⁷ 2016 | Australia and New Zealand | 2016 | 3,519 | 1a. Local arrangements for the management of hip fracture patients in the emergency department 1b. Preoperative cognitive status assessment 2a. Local arrangements for pain management 2b. Assessment of pain within 30 minutes of arrival 3. Orthogeriatric management during admission 4. Surgery within 48 hours of presentation 5a. Mobilized on day one post hip fracture surgery 5b. Unrestricted weight-bearing status immediately after hip fracture surgery 5c. Stage II or higher pressure ulcer during hospital stay 5d. Return to pre-fracture mobility 6a. Bone protection medicine before discharge 6b. Readmission with another femoral fracture within 12 months of admission from initial hip fracture 7a. Local arrangements for development of individualized care plan 7b. Proportion returning to private residence within 120 days after discharge from hospital 8a. Reoperation of hip fracture patients within 30 days 8b. Survival at 30 days post admission |

| Name, initial year | Country | Year of report | n | Quality indicators |
|--|---------------|----------------|------------------|---|
| Rikshöft ³⁸ 1988* | Sweden | 2016 | 15,062 | <ol style="list-style-type: none"> 1. Operation within 24 hours 2. Dislocated fractures operated with arthroplasty 3. Pain measurement 4. Pressure ulcer measurement 5. Patients going directly home and patients back home after 4 months |
| Dutch Hip Fracture Audit ³⁹ 2016 | Netherlands | 2016 | 19,000 avg/yr | <ol style="list-style-type: none"> 1. Participation in the DHFA 2. Functional outcome scores registered at admission and 3 months after admission |
| Irish Hip Fracture Database ⁴⁰ 2012 | Ireland | 2016 | 3,159 | <ol style="list-style-type: none"> 1. Prompt admission to orthopaedic care 2. Surgery within 48 hours 3. Prevention of pressure ulcers 4. Access to acute orthogeriatric care 5. Assessment for bone protection therapy 6. Falls assessment |
| Kaiser Permanente Hip Fracture Registry ⁴¹ 2009** | United States | 2015 | 29,414 | <ol style="list-style-type: none"> 1. Time to surgery 2. Time to surgery > 48 hours 3. Length of inpatient stay 4. 30-day emergency visit 5. 30-day inpatient readmission 6. 90-day revision 7. 90-day mortality |
| Danish Multidisciplinary Hip Fracture Registry ⁴² 2003 | Denmark | 2016 | 6,789 | <ol style="list-style-type: none"> 1. Assessment within 4 hours by a specialist 2a. Operated within 24 hours 2b. Operated within 36 hours 3. Mobilized within 24 hours after surgery 4a. Functional assessment before fracture 4b. Functional assessment at discharge 5. Dietary advice 6. Bone health assessment 7. Start of anticoagulation to prevent thromboembolism 8. 30-day mortality rate 9. Rehabilitation plan before discharge 10. Readmission within 30 days 11a. Reoperation rate within 2 years of collum fractures operated with osteosynthesis 11b. Reoperation rate within 2 years of non-dislocated collum fractures operated with osteosynthesis |

| Name, initial year | Country | Year of report | n | Quality indicators |
|---|---------|----------------|-------|---|
| Danish Multidisciplinary Hip Fracture Registry ⁴² (cont'd) | Denmark | 2016 | 6,789 | 11c. Reoperation rate within 2 years of dislocated collum fractures operated with osteosynthesis 12. Reoperation rate within 2 years of trochanteric fractures operated with osteosynthesis 13. Reoperation rate within 2 years after total or hemi-arthroplasty 14. Reoperation rate within 2 years due to deep wound infection |

* Report in Swedish, indicators received by e-mail reaction from A. Hommel (coordinator Rikshöft).

** Indicators received by e-mail reaction from B.H. Fasig (project manager Kaiser Permanente).

Able to walk independently out of doors with no more than the use of a stick; not cognitively impaired; and medically fit for anaesthesia and the procedure.

^ Hip Fracture Program (HFP) includes the following: orthogeriatric assessment; rapid optimization of fitness for surgery; early identification of individual goals for multidisciplinary rehabilitation to recover mobility and independence, and to facilitate return to pre-fracture residence and long-term well-being; continued, coordinated orthogeriatric and multidisciplinary review; liaison or integration with related services, particularly mental health, fall prevention, bone health, primary care and social services; and clinical and service governance responsibility for all stages of the pathway of care and rehabilitation, including those delivered in the community.

§ Conditions for intermediate care: a) intermediate care is included in the HFP and the HFP team retains the clinical lead, including patient selection; b) agreement of length of stay and ongoing objectives for intermediate care; c) the HFP team retains the managerial lead, ensuring that intermediate care is not resourced as a substitute for an effective acute hospital program.

† The 'Big Six': Provision of Pain Relief, Delirium Screening, Early Warning Score, Blood Investigations, Fluid Therapy and Pressure Area Inspection.

§ The 'Inpatient Bundle of Care': Cognitive, Nutritional, Pressure Area and Falls Assessments.

Hip fracture guidelines

Five hip fracture guidelines were probed for quality indicators. Two guidelines did not report on QIs: Management of hip fractures in the elderly by The American Academy of Orthopaedic Surgeons (AAOS) and Management of hip fracture in older people by the Scottish Intercollegiate Guidelines Network (SIGN)^{6,7}. The National Institute for Health and Care Excellence (NICE) wrote The management of hip fracture in adults (CG 124). This guideline was the basis of two different standards with QIs: the Hip fracture in Adults: Quality Standard 16, and the British Orthopaedic Association Standards for Trauma^{5,43,44}. The Australian & New Zealand Hip Fracture Registry has published an overall Hip Fracture Care Clinical Care Standard, which contains both the audit's and the guidelines' QIs^{8,37,48}. In Canada, the national QIs were described in the National Hip Fracture Toolkit⁴⁵.

Table 1c. Quality indicators for in-hospital hip fracture care, reported in guidelines

| Name | Country | Year | Quality indicators |
|--|----------------|--------------------|---|
| The management of hip fracture in adults (CG 124) ^{43,44} Distracted from the guideline: • Hip fracture in Adults: Quality standard 16 (1-6) • British Orthopaedic Association Standards for Trauma (5-17) | United Kingdom | 2011, updated 2017 | <ol style="list-style-type: none"> 1. Total hip replacement in defined conditions[#] 2. Extramedullary implants in AO classification types A1 and A2 3. IM nail in case of a subtrochanteric fracture 4. Rehabilitation once a day, started no later than the day after surgery 5. Hip Fracture Program during admission[^] 6. Surgery on the day of, or day after, admission 7. Anti-osteoporosis therapy and fall assessment 8. Orthogeriatric management 9. Patients unable to bear weight with negative X-rays should be offered MRI 10. Immediate analgesia on presentation and in case of pain 11. Treat correctable comorbidities immediately 12. Direct weight-bearing mobilization with physiotherapist postoperatively 13. Assess risk of delirium and dementia 14. Consider surgery as palliative treatment 15. Assessment and treatment of thrombo-embolism and pressure sore 16. Printed and verbal information on treatment and rehabilitation 17. Data submission to the NHFD |
| National Hip Fracture Toolkit ⁴⁵ | Canada | 2011 | <ol style="list-style-type: none"> 1. Surgery within 24 hours 2. Surgery within 48 hours 3. Total surgery time 4. Intraoperative adverse events 5. Length of stay 6. Discharge destination 7. In-hospital mortality 8. Mortality at 1 year 9. Not discharged to pre-fracture living conditions 10. Admission to long-term care in 6 months 11. Refracture 1 year post surgery |

Able to walk independently out of doors with no more than the use of a stick; not cognitively impaired; and medically fit for anaesthesia and the procedure.

^ For full description, please refer to the corresponding note underneath Table 1b.

Identified quality indicators

In the included articles, audits and guidelines 217 QIs were described. Some of the reported QIs were similar, leaving 97 unique QIs: 9 structure indicators (Table 2), 63 process indicators (Table 3) and 25 outcome indicators (Table 4). Sixty-five QIs were described in one article or audit only. The process indicator ‘time to surgery within a specific time frame’ was described most frequently: in 12 of 16 articles and in all audits and guidelines.

Table 2. Structure indicators for hip fracture care

| Structure quality indicator | Source [#] | Outcome measure used to correlate to indicator ^{&} | Correlation (P = present, NP = not present, NTI = not tested individually) and source ^{#, &} |
|---|---------------------------------------|---|---|
| 1. Orthogeriatric management during admission | ^{20, 25, 30, 31, 37, 40, 44} | 2, 3, 4, 5, 12, 13, 15 | NTI: all outcome measures ^{20, 25, 30, 31} |
| 2. Using an agreed multidisciplinary protocol | ^{20, 26, 30, 31, 37} | 3, 4, 5, 12, 13, 15 | NTI: all outcome measures ^{20, 30, 31} |
| 3. Hip fracture surgery planned on a trauma list | ³⁵ | 1, 3, 5, 6, 7, 8, 9, 11, 13, 14 | NTI: all outcome measures ³⁵ |
| 4. Postoperative multi-professional rehabilitation team | ^{20, 30, 31} | 3, 4, 5, 12, 13, 15 | NTI: all outcome measures ^{20, 30, 31} |
| 5. Post-discharge rehabilitation program | ^{21, 37, 42} | 5, 10, 13 | P: 13 ²¹ NP: 5, 10 ²¹ |
| 6. Appropriate clinical criteria are applied to confirm a diagnosis of delirium | ²⁹ | - | - |
| 7. Consultants or senior staff supervise trainee of the anaesthesia, surgical and theater teams | ³⁵ | 1, 3, 5, 6, 7, 8, 9, 11, 13, 14 | NTI: all outcome measures ³⁵ |
| 8. Patients are offered verbal and printed information about treatment and care | ^{35, 44} | 1, 3, 5, 6, 7, 8, 9, 11, 13, 14 | NTI: all outcome measures ³⁵ |
| 9. Participation in nationwide hip fracture audit | ^{26, 39, 44} | - | - |

Superscript numbers refer to reference list.

& Non-superscript numbers refer to the following outcome measures:

- | | |
|---|--|
| 1. Case ascertainment | 9. Return to original residence within 30 days |
| 2. Surgery on day of or after admission | 10. 30-day readmission |
| 3. Postoperative length of trauma ward stay | 11. 30-day reoperation rate |
| 4. Postoperative length of hospital stay | 12. In-hospital mortality |
| 5. Overall length of hospital stay | 13. 30-day mortality |
| 6. Final discharge destination | 14. Adjusted 30-day mortality rate (gender, age, ASA completed, ASA grade, walking ability, fracture type) |
| 7. No development of a pressure ulcer | 15. 1-year mortality |
| 8. Hip fractures sustained as inpatient | |

Table 3. Process indicators for hip fracture care

| Process quality indicator | Source [#] | Outcome measure used to correlate to indicator ^{&} | Correlation (P = present, NP = not present, NTI = not tested individually) and source ^{#, &} |
|--|--------------------------------|--|--|
| 1. Patients unable to bear weight with negative X-rays should be offered MRI | 44 | - | - |
| 2. Prompt admission to orthopaedic care | 25, 40 | 2, 26 | NTI: all outcome measures ²⁵ |
| 3. The 'Big Six' interventions / treatments must be done before leaving the Emergency Department | 36 | - | - |
| 4. Transfer from the Accident and Emergency Department within specific time frame | 26, 27, 36 | - | - |
| 5. Treat correctable comorbidities immediately | 44 | - | - |
| 6. Assessed by a geriatrician within specific time frame | 20, 28, 30, 31, 36 | 3, 4, 5, 25, 26, 30 | NTI: all outcome measures ^{20, 30, 31} |
| 7. Assessment by a specialist within 4 hours | 42 | - | - |
| 8. The 'Inpatient Bundle of Care' must be provided within 24 hours of admission | 36 | - | - |
| 9. Preoperative cognitive status assessment | 37, 44 | - | - |
| 10. Preoperative catheterization only for medical reasons | 36 | - | - |
| 11. Abnormal clinical findings before surgery | 34 | 12, 21, 22, 29 | P: - NP: 12, 21, 22, 29 ³⁴ |
| 12. Immediate analgesia on presentation and in case of pain | 44 | - | - |
| 13. Add nerve blocks if no preoperative pain control | 35 | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 14. Offer a choice of spinal or general anaesthesia | 35 | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 15. Use of prophylactic antibiotics | 28, 34 | 12, 21, 22, 29 | P: - NP: 12, 21, 22, 29 ³⁴ |
| 16. No patients should be repeatedly fasted in preparation for surgery | 36 | - | - |
| 17. Time to surgery within specific time frame | 20, 22-28, 30-32, 34-38, 40-45 | 1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 13, 15, 16, 17, 19, 20, 21, 22, 25, 26, 27, 28, 29, 30 | P: 19, 30 ^{32, 43} NP: 7, 12, 21, 22, 25, 28, 29, 30 ^{22, 23, 34} NTI: 1, 2, 3, 4, 5, 6, 8, 11, 13, 15, 16, 17, 20, 25, 26, 27, 28, 30 ^{20, 24, 25, 30, 31, 35} |
| 18. Total surgery time | 45 | - | - |

| Process quality indicator | Source [#] | Outcome measure used to correlate to indicator ^{&} | Correlation (P = present, NP = not present, NTI = not tested individually) and source ^{#, &} |
|--|---|---|--|
| 19. Consider intraoperative nerve blocks for all patients undergoing surgery | 35 | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 20. Mobilized within specific time after surgery | 21, 24, 28, 35-37, 42, 43 | 1, 3, 5, 6, 7, 8, 10, 11, 13, 15, 16, 17, 19, 20, 26, 27, 28 | P: 5, 7, 10, 17, 19, 26 ^{21, 43} NP: - NTI: 1, 3, 5, 6, 8, 11, 13, 15, 16, 17, 20, 26, 27, 28 ^{24, 35} |
| 21. Postoperative physical therapy | 24, 34 | 5, 11, 12, 16, 20, 21, 22, 28, 29 | P: - NP: 12, 21, 22, 29 ³⁴ NTI: 5, 11, 16, 20, 28 ²⁴ |
| 22. Unrestricted weight-bearing status immediately postoperatively | 37, 44 | - | - |
| 23. Percentage of days with intervention of physiotherapist | 24 | 5, 11, 16, 20, 28 | NTI: all outcome measures ²⁴ |
| 24. Mobilization to a chair in first 3 postoperative days | 34 | 12, 21, 22, 29 | P: - NP: 12, 21, 22, 29 ³⁴ |
| 25. Mobilization beyond chair in first 3 postoperative days | 34 | 12, 21, 22, 29 | P: - NP: 12, 21, 22, 29 ³⁴ |
| 26. Strength and balance training | 35 | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 27. Mobility assessment before admission | 21 | 5, 10, 26 | P: - NP: 5, 10, 26 ²¹ |
| 28. Mobility assessment at discharge | 21 | 5, 10, 26 | P: - NP: 5, 10, 26 ²¹ |
| 29. Fracture prevention assessment (fall / bone health) | 20, 21, 24, 25, 30, 31, 33, 35-37, 40, 42, 44 | 1, 2, 3, 4, 5, 6, 8, 10, 11, 13, 15, 16, 17, 20, 25, 26, 27, 28, 30 | P: 10, 26 ^{21, 33} NP: 5, 26 ²¹ NTI: 1, 2, 3, 4, 5, 6, 8, 11, 13, 15, 16, 17, 20, 25, 26, 27, 28, 30 ^{20, 24, 25, 30, 31, 35} |
| 30. Bisphosphonates in postmenopausal women who have osteoporosis | 35 | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 31. Systematic pain assessment | 21, 33, 35, 37, 38 | 1, 3, 5, 6, 8, 10, 13, 15, 17, 26, 27 | P: 10, 26 ^{21, 33} NP: 5, 26 ²¹ NTI: 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 ³⁵ |

| Process quality indicator | Source [#] | Outcome measure used to correlate to indicator ^{&} | Correlation (P = present, NP = not present, NTI = not tested individually) and source ^{#, &} |
|--|---------------------|---|---|
| 32. Assessment of malnutrition | 24, 33, 35, 42 | 1, 3, 5, 6, 8, 11, 13, 15, 16, 17, 20, 26, 27, 28 | P: - NP: 26 ³³ NTI: 1, 3, 5, 6, 8, 11, 13, 15, 16, 17, 20, 26, 27, 28 ^{24, 35} |
| 33. Prevention / assessment of pressure ulcer | 25, 28, 38, 40 | 2, 26 | NTI: all outcome measures ²⁵ |
| 34. Occupational Therapy (OT) assessment by the end of day three postoperatively | 36 | - | - |
| 35. Assessment and treatment of thrombo-embolism and pressure sore | 44 | - | - |
| 36. All elderly are assessed daily for delirium risk factors using a valid and reliable tool | 29, 35 | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 37. Assessment of Activities of Daily Living (ADL) before fracture | 33, 42 | 26 | P: 26 ³³ NP: - |
| 38. Assessment of Activities of Daily Living (ADL) before discharge | 33 | 26 | P: 26 ³³ NP: - |
| 39. Use of anticoagulation to prevent thrombo-embolism | 28, 34, 42 | 12, 21, 22, 29 | P: - NP: 12, 21, 22, 29 ³⁴ |
| 40. Type of anticoagulation regimen | 34 | 12, 21, 22, 29 | P: - NP: 12, 21, 22, 29 ³⁴ |
| 41. The environment of hip fracture patients is assessed daily for preventive strategies to maintain sensory orientation | 29 | - | - |
| 42. Non-pharmacologic interventions are employed before pharmacologic interventions in patients with a delirium | 29 | - | - |
| 43. Removal of urinary catheter postoperatively | 34 | 12, 21, 22, 29 | P: - NP: 12, 21, 22, 29 ³⁴ |
| 44. Avoidance of restraints | 34 | 12, 21, 22, 29 | P: - NP: 12, 21, 22, 29 ³⁴ |
| 45. Time between discharge and completion of orthopaedic hospitalization record | 24 | 5, 11, 16, 20, 28 | NTI: all outcome measures ²⁴ |
| 46. Time between surgery and completion of surgery record | 24 | 5, 11, 16, 20, 28 | NTI: all outcome measures ²⁴ |
| 47. Time between discharge from rehabilitation ward and completion of rehabilitation hospitalization record | 24 | 5, 11, 16, 20, 28 | NTI: all outcome measures ²⁴ |

| Process quality indicator | Source [#] | Outcome measure used to correlate to indicator ^{&} | Correlation (P = present, NP = not present, NTI = not tested individually) and source ^{#, &} |
|--|-----------------------|---|---|
| 48. Height and weight mentioned in orthopaedic chart | ²⁴ | 5, 11, 16, 20, 28 | NTI: all outcome measures ²⁴ |
| 49. Albuminemia mentioned in orthopaedic chart | ²⁴ | 5, 11, 16, 20, 28 | NTI: all outcome measures ²⁴ |
| 50. Time between admission and request of place in rehabilitation facility | ²⁴ | 5, 11, 16, 20, 28 | NTI: all outcome measures ²⁴ |
| 51. Stability at discharge (unresolved active clinical issues) | ³⁴ | 12, 21, 22, 29 | P: - NP: 12, 21, 22, 29 ³⁴ |
| 52. Cemented implants with arthroplasty | ^{35, 36} | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 53. Arthroplasty in a displaced intracapsular fracture | ^{35, 38} | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 54. Total hip replacement in defined conditions | ^{35, 43} | 1, 3, 5, 6, 8, 13, 15, 17, 23, 24, 26, 27 | P: 23, 24 ⁴³ NP: - NTI: 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 ³⁵ |
| 55. Extramedullary implants in AO classification types A1 and A2 | ^{35, 43} | 1, 3, 5, 6, 8, 13, 14, 15, 17, 26, 27 | P: 14 ⁴³ NP: - NTI: 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 ³⁵ |
| 56. IM nail with a subtrochanteric fracture | ^{35, 43} | 1, 3, 5, 6, 8, 9, 13, 15, 17, 26, 27 | P: 9 ⁴³ NP: - NTI: 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 ³⁵ |
| 57. Hip Fracture Program during admission | ^{35, 43, 44} | 1, 3, 5, 6, 8, 13, 15, 17, 23, 25, 26, 27 | P: 23, 25 ⁴³ NP: - NTI: 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 ³⁵ |
| 58. If a hip fracture complicates or precipitates a terminal illness, consider surgery as part of a palliative care approach | ^{35, 44} | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 59. Consider early supported discharge as part of the HFP | ³⁵ | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 60. Only consider intermediate care in certain conditions | ³⁵ | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |

| Process quality indicator | Source [#] | Outcome measure used to correlate to indicator ^{&} | Correlation (P = present, NP = not present, NTI = not tested individually) and source ^{#, &} |
|--|---------------------|---|---|
| 61. Patients admitted from care or nursing homes should not be excluded from community or hospital rehabilitation programs | ³⁵ | 1, 3, 5, 6, 8, 13, 15, 17, 26, 27 | NTI: all outcome measures ³⁵ |
| 62. Rehabilitation plan before discharge | ⁴² | - | - |
| 63. Functional outcome scores registered at admission and 3 months after admission | ³⁹ | - | - |

Superscript numbers refer to reference list.

& Non-superscript numbers refer to the following outcome measures:

- | | |
|---|--|
| 1. Case ascertainment | 17. Return to original residence within 30 days |
| 2. Surgery on day of or after admission | 18. 3-month place of residence |
| 3. Postoperative length of trauma ward stay | 19. Return to pre-hip fracture level of mobility |
| 4. Postoperative length of hospital stay | 20. Functional outcome (Parker score and KATZ-ADL) |
| 5. Overall length of hospital stay | 21. 2-month functional status (FIM-score) |
| 6. Hip fractures sustained as inpatient | 22. 6-month functional status (FIM-score) |
| 7. Complication rate | 23. 1-year functional outcome |
| 8. No development of a pressure ulcer | 24. 5-year functional outcome |
| 9. Non-union of fracture | 25. In-hospital mortality |
| 10. 30-day readmission | 26. 30-day mortality |
| 11. 3-month readmission | 27. Adjusted 30-day mortality rate (gender, age, ASA completed, ASA grade, walking ability, fracture type) |
| 12. 6-month readmission | 28. 3-month mortality |
| 13. 30-day reoperation rate | 29. 6-month mortality |
| 14. Reoperation rate | 30. 1-year mortality |
| 15. Documented final discharge destination | |
| 16. Living at home after fracture | |

Table 4. Outcome indicators for hip fracture care

| Outcome quality indicator | Source [#] |
|--|---------------------|
| 1. Short-term mortality rate* | 19, 27, 37, 42, 45 |
| 2. Long-term mortality rate* | 27, 28, 41, 45 |
| 3. Short-term reoperation rate* | 37 |
| 4. Long-term reoperation rate* | 41, 42 |
| 5. Intraoperative adverse events | 45 |
| 6. Pressure sore occurrence | 24, 28, 37 |
| 7. Discharge destination | 27, 45 |
| 8. Back to original place of residence within specific time frame | 19, 28, 36-38, 45 |
| 9. Short-term emergency visit* | 41 |
| 10. Short-term readmission rate* | 41, 42 |
| 11. Readmission with another femoral fracture within 12 months of admission for initial hip fracture | 37, 45 |
| 12. Admission to long-term care in 6 months | 45 |
| 13. Days of moderate or severe pain over first 5 hospital days | 34 |
| 14. Number of days of severe pain with no or only slight relief | 34 |
| 15. Little or no hip pain 3 months after surgery | 28 |
| 16. Patient satisfaction with pain management | 24 |
| 17. Patient satisfaction with information about hospital care | 24 |
| 18. Return to pre-fracture mobility | 37 |
| 19. Return to pre-fracture activities of daily living after 3 months | 28 |
| 20. Length of hospital stay | 27, 41, 45 |
| 21. Pneumonia rate after 3 months | 28 |
| 22. Pulmonary embolism rate after 3 months | 28 |
| 23. Myocardial infarction rate after 3 months | 28 |
| 24. Wound and hip joint infection rate after 3 months | 28 |
| 25. All patients with a hip fracture receive essential nursing care | 29 |

Superscript numbers refer to reference list.

* Short-term: < 30 days, long-term: ≥ 30 days

Quality of the QIs

Limited information was found in the articles, on the audit websites, and in the guidelines that could be used to assess the quality of the identified QIs regarding clinical relevancy, scientific acceptability, feasibility and usability. In addition, the articles, audits and guidelines used different definitions for the same QI. The AIRE instrument could therefore not be applied.

Information on the construct validity was obtained for the structure and process QIs. In 11 of the 16 articles, one audit and one guideline QIs were correlated with an outcome measure. In total, 30 different outcome measures were used: mortality rate (in-hospital, within 1 month (crude and adjusted), and after 3, 6 and 12 months), readmission (after 1, 3 and 6 months), length of stay (postoperative length of stay on trauma ward, postoperative length of hospital stay and overall length of hospital stay), reoperation rate, 30-day reoperation rate, functional outcome (FIM score after 2 and 6 months, Parker/KATZ-ADL score after 3 months, functional outcome after 1 and 5 years), discharge back home, place of residence (after discharge, after 30 days and after 3 months), return to pre-hip fracture level of mobility, complication rate, pressure ulcer occurrence, non-union of fracture, hip fractures sustained as inpatient, case ascertainment and surgery on day of admission. In six articles QIs were correlated to one or more outcome measures. In five articles only a set of QIs was correlated to outcome measures and in five articles no correlation was assessed.

One of the nine structure indicators (post-discharge rehabilitation program) was reported to have a positive correlation with an outcome measure (30-day mortality, Table 2). Ten of the 63 process indicators were correlated with various outcome measures (Table 3): Hip Fracture Program during admission, time to surgery within specific time frame, total hip replacement in defined conditions, extramedullary implants in AO classification types A1 and A2, IM nail with a subtrochanteric fracture, fracture prevention assessment, mobilized within specific time after surgery, systematic pain assessment, assessment of activities of daily living before fracture and assessment of activities of daily living before discharge.

Selected set of quality indicators for a hip fracture audit

Information about the methodological quality of the HF QIs was lacking. Furthermore, the construct validity of the QIs was assessed for just 24 of the 72 structure and process QIs and for only 11 QIs a correlation with a limited number of outcome measures was found. It was therefore impossible to select a set of QIs based on qualitative criteria.

As an alternative, we applied quantitative criteria and selected QIs that were described in at least two articles and were used in at least two existing audits/guidelines. This produced the following set of nine QIs consisting of one structure indicator, six process indicators and two outcome indicators:

- Orthogeriatric management during admission (structure indicator, correlation with outcome not tested)
- Time to surgery (process indicator, correlated with 1-year mortality)
- Time to mobilization after surgery (process indicator, correlated with length of stay, 30-day readmission and 30-day mortality)

- Fracture prevention assessment (process indicator, correlated with 30-day readmission and 30-day mortality)
- Systematic pain assessment (process indicator, correlated with 30-day readmission and 30-day mortality)
- Assessment of malnutrition (process indicator, no correlation with outcome found)
- Prevention / assessment of pressure ulcer (process indicator, no correlation with outcome found)
- Mortality rate (outcome indicator)
- Return to the place of residence within a specific time frame (outcome indicator).

Discussion

This study is the first systematic review of the available literature, existing audits and guidelines that summarizes existing QIs for HF care. A wide variety of QIs was found, covering different aspects and outcomes of HF care. No information on the clinical relevancy, scientific acceptability, feasibility and usability of the QIs was found to assess the methodological quality.

Development of methodologically sound quality indicators

QIs differ from recommendations made in guidelines, as QIs must indicate the quality of delivered care¹⁵. Methodologically sound QIs should be developed in a systematic manner^{49,50}. For instance, Martin-Khan et al. used a three-step development process to define a set of QIs for measuring the quality of care provided to elderly in the Emergency Department⁵¹. Ideally, the QIs for HF care should have been developed in a similar manner, but this has not been described in the literature. It seems that the QIs described and used in the included articles and audits are obtained from guideline recommendations and applied without being systematically evaluated first. This might explain the wide variety of QIs that were found and the fact that 59 of the 97 QIs were described / used in only one article, audit, or guideline.

The clinimetric properties of the identified quality indicators

If QIs are properly developed and described, the clinical relevancy, validity, reliability, feasibility and usability can be assessed⁴⁹. Thus, the methodological quality of QIs for several clinical conditions has been reviewed using the AIRE instrument⁵²⁻⁵⁶. For the identified QIs for HF care in our review, however, information about these parameters was missing and the AIRE instrument could not be applied.

Only information on the construct validity of some of the QIs could be found in the literature. A correlation with one or more outcome measures was studied for 24 of the 72 structure and process QIs, and reported present for 11 of these QIs. Future research should focus on

the assessment of relevancy, reliability, feasibility and usability of the existing QIs through interviews, surveys, audits or focus groups⁵⁰. Assessing a set of QIs rather than individual QIs could be considered, as in three of the included articles a set of QIs was associated with an improvement in outcome measures whereas individual QIs were not^{21,33,34}.

Evaluation of the proposed quality indicator set

Since the methodological quality of the identified QIs could not be assessed, the proposed set of nine QIs was based on quantitative instead of qualitative criteria. The following discussion of each proposed QI is based on the available evidence.

- *Orthogeriatric management during admission (structure indicator)*. This QI is described in 4 articles and 3 audits / guidelines. In the included articles, audits and guidelines this indicator was not evaluated against outcome measures to assess the construct validity. However, in other literature evidence for this QI was found, as two reviews support the beneficial effects of orthogeriatric care models on mortality^{57,58}. This finding was confirmed in a recent prospective cohort study by Folbert et al. that showed a significant decrease in the 1-year mortality rate from 35.1% to 23.2% after implementation of an integrated orthogeriatric treatment model⁵⁹. The available evidence suggests that this might be a promising QI.
- *Time to surgery (process indicator)*. This QI is described in all the identified audits / guidelines and in 12 of the 16 included articles. Various time frames for surgical delay (varying from 24 to 48 hours) are used in the definition of this QI. Sund et al. found a correlation between operative delay and a higher mortality rate, the other included articles found no correlation with the complication rate, place of residence after 3 months, functional status after 2 and 6 months, in-hospital mortality, and mortality after 3, 6 and 12 months^{22,23,32,34}. The Hip fracture in Adults: Quality standard 16 stated that delays in surgery are negatively associated with mortality and return to pre-fracture mobility⁴³.

In the literature, a debate is ongoing whether a specific time frame should be used in the definition of this QI and, if so, what the time frame should be (ranging from 24 to 48 hours). Three systematic reviews stated that the timing of surgery is complex and that confounding might be present in all included articles⁶⁰⁻⁶². Patients with delayed surgery have more comorbidities, so it might be better to optimize them first. Based on evidence currently available, the time frame after which the risk of mortality increases is still unclear. The complication rate seems to increase with every delay in time to surgery.

As suggested by Panesar et al., the physical condition of weak patients should be optimized before surgery. In our opinion the ideal time frame in the definition of this QI should be specified differently for fit patients (ASA 1-2) and frail patients (ASA 3-4)⁶³.

- *Time to mobilization after surgery (process indicator)*. This QI was described in 3 articles and 5 audits / guidelines. For this QI the time frame differed from 24 to 48 hours after surgery. A correlation with better performance on six outcome measures (length of hospital stay, complication rate, return to pre-hip fracture level of mobility, 30-day readmission, return to original residence and 30-day mortality) was described, which renders this a promising QI^{21,43}. On the other hand, a review by Handoll et al. concluded that there is insufficient evidence to substantiate the supposed effect of specific postoperative mobilization strategies⁶⁴.
- *Fracture prevention assessment (process indicator)*. In 7 articles and in 6 audits / guidelines fracture prevention was described as a QI. Two types of fracture prevention were reported: 1. bone health assessment and treatment (if necessary), and 2. risk of falls assessment and future fall prevention. Some articles, audits and guidelines consider this as one QI and others as two separate QIs^{20,21,24,25,30,31,33,35,36,42,44,65}.

A correlation between anti-osteoporotic medication and 30-day readmission was found by Kristensen et al.; bone health assessment and treatment was not correlated with 30-day mortality rate and length of hospital stay²¹. For prevention of future fall incidents, they found no correlation with 30-day mortality rate, 30-day readmission rate and length of hospital stay. The study of Nielsen et al. found a correlation between the initiation of anti-osteoporotic medication and a lower 30-day mortality rate³³.

We believe that the two types of fracture prevention (assessment and treatment of bone quality and fall prevention) can be taken together as one single QI, as they both have the same aim. It is important that the composite QI is described clearly and that the numerator and denominator are well defined. With this composite QI, it may be more likely that changes in quality of care due to preventive measures can be identified.

- *Systematic pain assessment (process indicator)*. This indicator is described in two articles and three audits / guidelines. For this indicator, a correlation with lower 30-day readmission and 30-day mortality was described^{21,33}. The timing of pain assessment differed between the articles and audits / guidelines. Evidence for the timing and strategy of analgesia is also lacking in the literature but is difficult to obtain with well-designed trials⁶⁶. Recommendations in guidelines are therefore based on consensus rather than evidence⁵.
- *Assessment of malnutrition (process indicator)*. The assessment of the nutritional status is described as a QI in two articles and two audits / guidelines. Of the included articles and audits, only Nielsen et al. correlated this indicator with an outcome measure³³. They found no correlation with the 30-day mortality rate, while the correlation with other outcome measures was not tested for this QI individually.

The review by Avenell et al. showed that nutritional supplementation did not have an effect on the mortality of HF patients⁶⁷. There is low-quality evidence that oral nutritional supplementation started before or soon after surgery might prevent complications (pressure sore, infection, venous thrombosis, pulmonary embolism) and might shorten the length of hospital stay^{68,69}.

- *Prevention / assessment of pressure ulcer (process indicator)*. Two articles, two audits and one guideline used this QI. However, the guideline combined the pressure sore assessment / treatment with the trombo-embolism assessment / treatment in its QI⁴⁴. The correlation with the outcome measures 'time to surgery' and '30-day mortality' was not tested for the QI individually, but as part of a set including five other QIs²⁵.

As stated before, in the literature a longer time to surgery is associated with an increase in complications, especially pressure ulcers⁶⁰⁻⁶². In a prospective cohort study of 567 patients the influence of pressure ulcers on the 6-month mortality rate was studied. Magny et al. found that having a pressure ulcer was associated with an increased 6-month mortality rate⁷⁰. The occurrence of pressure ulcers was also used as outcome QI in two articles and one guideline^{24,28,37}.

- *Mortality rate (outcome indicator)*. This QI was used in three articles and four audits / guidelines. The time frame for mortality varied between 30-day, 90-day, 120-day and 1-year mortality. When comparing outcomes of care such as mortality between hospitals (benchmarking), differences in patient characteristics between the hospital populations should be accounted for in the analysis. This so-called case-mix correction enables a fair comparison⁷¹. In the HF audit of the United Kingdom minus Scotland a case-mix correction model has already been developed and is used in the evaluation of mortality³⁵. This case-mix correction model might also be suitable for other HF audits, but should be validated first in other settings.
- *Return to the place of residence within a specific time frame (outcome indicator)*. This QI was described in 2 articles and 4 audits / guidelines. Whether HF patients can return to their original place of residence does not only depend on the in-hospital care, but also on the quality of the rehabilitation program. This QI may therefore provide insight into the overall quality of HF care. To obtain this information may be a logistical challenge, as the final place of residence may not be known at discharge.

Strengths

The broad spectrum of the identified QIs is in line with a recent scoping literature review of (potential) QIs for HF care conducted by Pitzul et al.⁷². As opposed to their review in which they grouped the QIs in a limited number of constructs, we evaluated the QIs individually

and retrieved the available evidence for the methodological quality of the identified QIs. In addition, the search underlying the present review not only covered the available literature but also ongoing audits and HF guidelines. Our search for ongoing audits seems to be complete, as all the identified audits were also described by Johansen et al. who recently published a HF audit overview⁷³. In our review we also recommend a set of QIs for future clinical research, including the most frequently mentioned and used indicators.

Limitations

Many QIs were identified, but their methodological quality could not be determined. Also, a clear definition was lacking for most of the existing QIs, or the definition differed between articles, audits and guidelines. For this review, we therefore grouped the QIs that concern the same aspect of care. This makes it even more difficult to evaluate their methodological quality and to decide how these QIs can be defined best for the purpose of evaluating the quality of HF care. Due to these limitations, a set of QIs for use in clinical practice could not be selected on the basis of scientific evidence. As an alternative, we propose a set of nine QIs that are frequently described in the literature and are commonly used in clinical audits and guidelines. As this selection is based on quantitative criteria, we want to underline that the recommended set of quality indicators is only a suggestion. Their value as instruments for evaluating and improving HF care has yet to be ascertained. This set should therefore not be implemented as standard and should not prevent clinicians and policymakers from using other QIs. The ultimate goal should be to define a standard set of evidence-based QIs that can be used for (inter)national benchmarking and for improving HF care based on best practices worldwide.

Conclusion

Many HF structure / process / outcome QIs are available and being used in audits worldwide, but there is little evidence of their methodological quality and usability. The focus of future research should therefore be on assessing the methodological aspects of the existing QIs. As evidence-based QIs for HF care cannot be identified based on the available literature, we recommend to use the set of nine indicators described in this review as the basis for further clinical research. Should the development of additional or new QIs be required, this should be done through a systematic approach.

Acknowledgement

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Appendices

Appendix 1. Search terms PubMed

((“Hip Fractures”[majr] OR “hip fracture”[tiab] OR “hip fractures”[tiab] OR “fractured hip”[tiab] OR “fractured hips”[tiab] OR “trochanteric fracture”[tiab] OR “trochanteric fractures”[tiab] OR “intertrochanteric fracture”[tiab] OR “intertrochanteric fractures”[tiab] OR “subtrochanteric fracture”[tiab] OR “subtrochanteric fractures”[tiab] OR “Femoral Neck Fracture”[tiab] OR “Femoral Neck Fractures”[tiab] OR “fracture of the hip”[tiab]) AND (“Quality Indicators, Health Care”[majr] OR quality indicator*[ti] OR “quality indicator”[ti] OR “quality indicators”[ti] OR “Risk Adjustment”[ti] OR “Standard of Care”[ti] OR (qualit*[ti] AND indicator*[ti]) OR “Clinical Audit”[majr:noexp] OR “Medical Audit”[majr] OR “Management Audit”[majr] OR “Benchmarking”[majr] OR “benchmarking”[ti] OR benchmark*[ti] OR “audit”[ti] OR “audits”[ti] OR “auditing”[ti] OR “auditor”[ti] OR “auditors”[ti] OR “outcome assessment”[ti] OR “outcome assessments”[ti] OR “Outcome Assessment (Health Care)”[majr:noexp] OR “Process Assessment (Health Care)”[majr] OR “process assessment”[ti] OR “process assessments”[ti] OR “Quality Assurance, Health Care”[majr:NoExp] OR “quality assurance”[ti] OR “quality assurances”[ti] OR “performance measure”[ti] OR “performance measures”[ti])) AND (“1990/01/01”[PDAT] : “3000/12/31”[PDAT])

Appendix 2. Search terms Embase (OVID-version)

((exp *”Hip Fracture”/ OR “hip fracture”.ti,ab OR “hip fractures”.ti,ab OR “fractured hip”.ti,ab OR “fractured hips”.ti,ab OR “trochanteric fracture”.ti,ab OR “trochanteric fractures”.ti,ab OR “intertrochanteric fracture”.ti,ab OR “intertrochanteric fractures”.ti,ab OR “subtrochanteric fracture”.ti,ab OR “subtrochanteric fractures”.ti,ab OR “Femoral Neck Fracture”.ti,ab OR “Femoral Neck Fractures”.ti,ab OR “fracture of the hip”.ti,ab) AND (*”clinical indicator”/ OR quality indicator*.ti OR “quality indicator”.ti OR “quality indicators”.ti OR “Risk Adjustment”.ti OR “Standard of Care”.ti OR (qualit*.ti AND indicator*.ti) OR *”Medical Audit”/ OR *”quality control”/ OR “benchmarking”.ti OR benchmark*.ti OR “audit”.ti OR “audits”.ti OR “auditing”.ti OR “auditor”.ti OR “auditors”.ti OR “outcome assessment”.ti OR “outcome assessments”.ti OR *”Outcome Assessment”/ OR “process assessment”.ti OR “process assessments”.ti OR “quality assurance”.ti OR “quality assurances”.ti OR “performance measure”.ti OR “performance measures”.ti)) NOT conference review.pt

Appendix 3. Search terms Web of Science

TS=(“Hip Fracture” OR “hip fracture” OR “hip fractures” OR “fractured hip” OR “fractured hips” OR “trochanteric fracture” OR “trochanteric fractures” OR “intertrochanteric fracture” OR “intertrochanteric fractures” OR “subtrochanteric fracture” OR “subtrochanteric fractures” OR “Femoral Neck Fracture” OR “Femoral Neck Fractures” OR “fracture of the hip” OR (fractur* AND hip*)) AND TI=(“clinical indicator” OR quality indicator* OR

“quality indicator” OR “quality indicators” OR “Risk Adjustment” OR “Standard of Care” OR (qualit* AND indicator*) OR “Medical Audit” OR “quality control” OR “benchmarking” OR benchmark* OR “audit” OR “audits” OR “auditing” OR “auditor” OR “auditors” OR “outcome assessment” OR “outcome assessments” OR “Outcome Assessment” OR “process assessment” OR “process assessments” OR “quality assurance” OR “quality assurances” OR “performance measure” OR “performance measures”)

Appendix 4. Search terms COCHRANE Library

(“Hip Fracture” OR “hip fracture” OR “hip fractures” OR “fractured hip” OR “fractured hips” OR “trochanteric fracture” OR “trochanteric fractures” OR “intertrochanteric fracture” OR “intertrochanteric fractures” OR “subtrochanteric fracture” OR “subtrochanteric fractures” OR “Femoral Neck Fracture” OR “Femoral Neck Fractures” OR “fracture of the hip” OR (fractur* AND hip*)) AND (“clinical indicator” OR quality indicator* OR “quality indicator” OR “quality indicators” OR “Risk Adjustment” OR “Standard of Care” OR (qualit* AND indicator*) OR “Medical Audit” OR “quality control” OR “benchmarking” OR benchmark* OR “audit” OR “audits” OR “auditing” OR “auditor” OR “auditors” OR “outcome assessment” OR “outcome assessments” OR “Outcome Assessment” OR “process assessment” OR “process assessments” OR “quality assurance” OR “quality assurances” OR “performance measure” OR “performance measures”)

Appendix 5. Search terms Cinahl

(“Hip Fracture” OR “hip fracture” OR “hip fractures” OR “fractured hip” OR “fractured hips” OR “trochanteric fracture” OR “trochanteric fractures” OR “intertrochanteric fracture” OR “intertrochanteric fractures” OR “subtrochanteric fracture” OR “subtrochanteric fractures” OR “Femoral Neck Fracture” OR “Femoral Neck Fractures” OR “fracture of the hip” OR (fractur* AND hip*)) AND (“clinical indicator” OR quality indicator* OR “quality indicator” OR “quality indicators” OR “Risk Adjustment” OR “Standard of Care” OR (qualit* AND indicator*) OR “Medical Audit” OR “quality control” OR “benchmarking” OR benchmark* OR “audit” OR “audits” OR “auditing” OR “auditor” OR “auditors” OR “outcome assessment” OR “outcome assessments” OR “Outcome Assessment” OR “process assessment” OR “process assessments” OR “quality assurance” OR “quality assurances” OR “performance measure” OR “performance measures”)

Appendix 6. Search terms Google Scholar

allintitle: “Quality Indicator” hip
allintitle: “Quality Indicators” hip
allintitle: Quality Indicators hip
allintitle: “Risk Adjustment” hip
allintitle: “Standard of Care” hip
allintitle: “Medical Audit” hip

allintitle: "benchmarking" hip
allintitle: "clinical audit" hip
allintitle: "outcome assessment" hip
allintitle: "process assessment" hip
allintitle: "quality assurance" hip
allintitle: "performance measure" hip
allintitle: audit hip fracture

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