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REVIEW

Quality indicators for hip fracture care, a systematic review

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Abstract

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. 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 Appraisal of Indicators through Research and Evaluation (AIRE) instrument. For structure and process indicators, the construct validity was assessed. 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. Seven indicators correlated with an outcome measure. A set of nine quality indicators was extracted from the literature, audits, and guidelines. 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.

Keywords Audit · Benchmark · Hip fracture · 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 elderly [1–4]. To optimize care for elderly HF patients, several guidelines for care and management have been developed worldwide [5–8].

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 categories of QIs are distinguished: structure, process, and outcome indicators [11]. Structure indicators describe what is needed within a hospital or health care system to provide good care and reflect the setting of the provided care [12]. Process indicators provide information about appropriateness of the delivered care and can be measured on patient level [10]. Process indicators are often based on guidelines. QI categorized as an outcome 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 valid [9]. To meet these criteria, a high-quality QI should undergo a well-described methodological development process [15].

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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-Analysis (PRISMA) statement [16]. 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 1–4. 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 (S.V.) 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 (S.V. and D.V.) 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 member (M.W.) was consulted. The full text of articles found to be relevant on the basis of title and abstract was read by the reviewers 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 outcomes 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 [11] was used to categorize the QIs as structure, process, or outcome indicator.

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 described [17]. If the articles did not provide the information needed for the application of the AIRE instrument, the construct validity of the QIs was assessed as the correlation of the structure and process QIs with one or more outcome measures [18]. Worthy of note is that the outcome measures that were used to judge the predictive value of the indicator are different from outcomes categorized as an outcome QI.

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 1210 hits (Fig. 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.

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

Websites of ongoing hip fracture audits

Nine national HF audits were identified: the National Hip Fracture Database (United Kingdom minus Scotland), Scottish Hip Fracture Audit (Scotland), Australian and New Zealand Hip Fracture Registry (Australia/New Zealand), Danish Multidisciplinary Hip Fracture Registry (Denmark), Rikshöft (Sweden), the Dutch Hip Fracture Audit (The Netherlands), Irish Hip Fracture Audit (Ireland), Kaiser Permanente National Implant Registries (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 e-mail. No QIs were described in the Norwegian Hip Fracture Register [46, 47].

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 Orthopedic 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

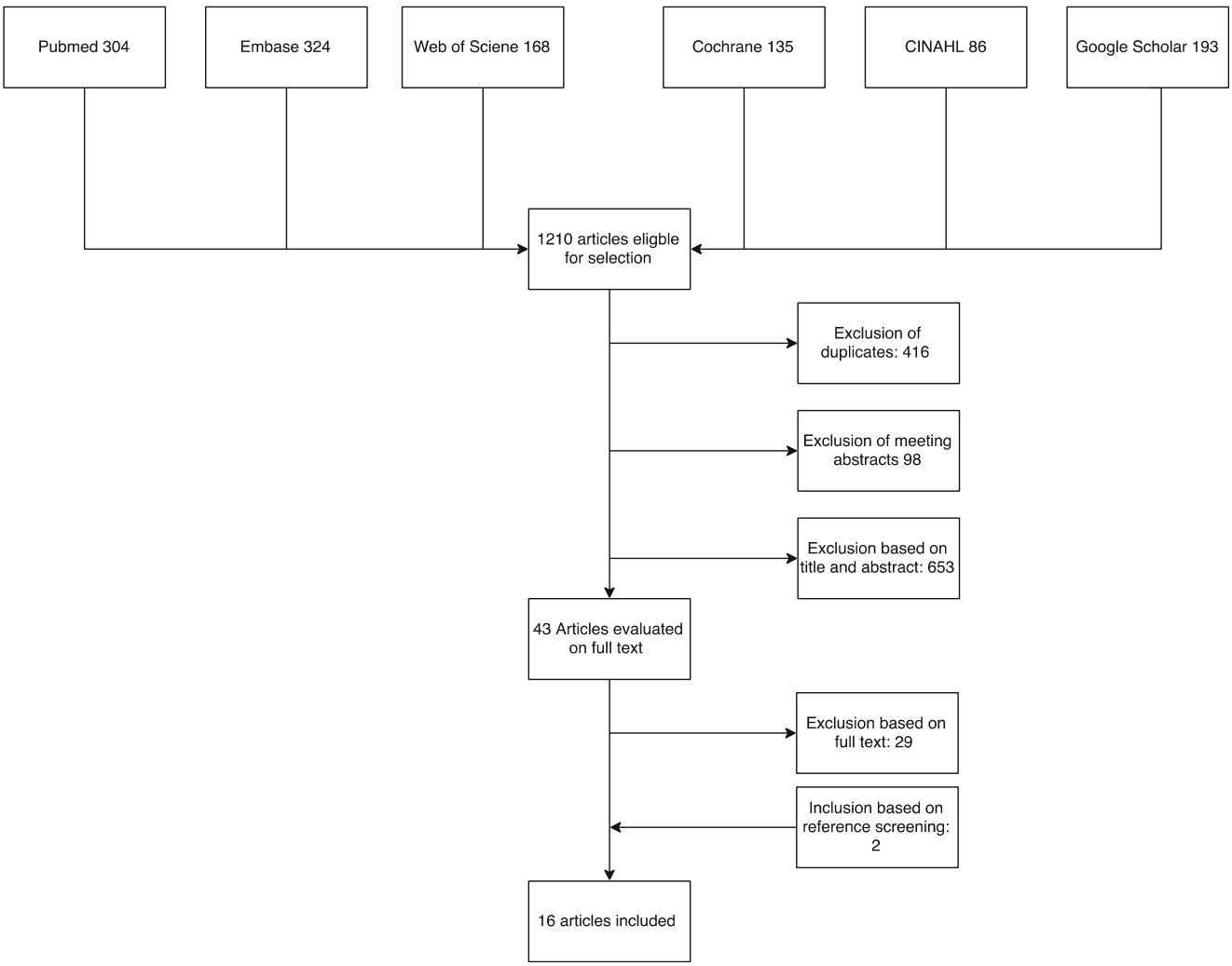

Fig. 1 Flowchart of study selection

Table 1 Overview of quality indicators for in-hospital hip fracture care, reported in studies, audits, or guidelines

Source (see reference list)	Author/audit/ guideline name, publication year/start of audit	Country	Study period/year of audit year or guideline	Number of patients in study or audit	Study design or audit/guideline	Quality indicators (process, structure, outcome)
[19]	Beringer et al., 2006	Northern Ireland	1999–2001	2834	Prospective cohort study	1. Discharge home within 56 days 2. 30-day mortality
[20]	Khan et al., 2014	England	2008–2011	516	Retrospective cohort study	1. Time to surgery < 36 h 2. Admitted under joined geriatric/orthopedic care 3. Using an agreed multidisciplinary protocol 4. Assessed by a geriatrician < 72 h 5. Postoperative multi-professional rehabilitation team 6. Fracture prevention assessments (falls/bone health)
[21]	Kristensen et al., 2016	Denmark	2010–2013	25,354	Retrospective cohort study	1. Daily systematic pain assessment 2. Mobilized within 24 h postoperatively 3. Mobility assessment before admission 4. Mobility assessment at discharge 5. Post-discharge rehabilitation pro-gram 6. Future fall prevention 7. Anti-osteoporotic medication
[22]	Lizaur-Utrilla et al., 2016	Spain	2012–2014	628	Prospective cohort study	1. Surgery within 2 days admission
[23]	Majumdar et al., 2006	Canada	1994–2000	3981	Retrospective cohort study	1. Surgery within 24 h
[24]	Merle et al., 2009	France	2003–2004	857	Retrospective cohort study	1. Time to surgery 2. Height and weight mentioned in orthopedic chart 3. Albuminemia mentioned in orthopedic chart 4. Nutritional supplement ordered during stay in orthopedic ward 5. Pressure sore occurrence 6. Time between discharge and completion of orthopedic 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 11. Patient satisfaction with information about hospital care 12. Patients 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

Table 1 (continued)

Source (see reference list)	Author/audit/ guideline name, publication year/start of audit	Country	Study period/year of audit year or guideline	Number of patients in study or audit	Study design or audit/guideline	Quality indicators (process, structure, outcome)
[25]	Neuburger et al., 2015	England	2003–2011	471,590	Retrospective cohort study	1. Prompt admission to orthopedic care 2. Surgery within 48 h 3. Prevention of pressure ulcers 4. Access to acute orthogeriatric care 5. Assessment for bone protection therapy 6. Falls assessment
[26]	Currie et al., 2005	Scotland	1998–2003	30,000	Retrospective cohort study	1. No delay in transfer from Accident and Emergency department 2. Surgery performed within 24 h of admission 3. Preoperative care and rehabilitation provided by a multidisciplinary team 4. Standardized data collected for all patients
[27]	Ferguson et al., 2016	Scotland	2003–2008 and 2013	31,400	Retrospective cohort study	1. Discharge from Accident and Emergency department within 2 h waiting times 2. Surgery within 48 h of admission 3. Length of hospital stay 4. Discharge destination 5. 30-day mortality rate 6. 120-day mortality rate
[28]	Freeman et al., 2002	England	1992 and 1997	1478	Retrospective cohort study	1. Operation within 48 h of admission 2. Use of prophylactic anticoagulation 3. Mobilization within 48 h of surgery 4. Use of prophylactic antibiotics 5. Seen by a geriatrician 6. Standard risk assessment for pressure sores on admission to orthopedic ward 7. 3 months' little or no hip pain 8. 3 months' return to pre-fracture activities of daily living 9. 3 months' return to pre-fracture level of accommodation 10. 3 months' mortality rate 11. 3 months pneumonia rate 12. 3 months' pulmonary embolism rate 13. 3 months' myocardial infarction rate 14. 3 months' wound and hip joint infection rate 15. 3 months' pressure sore grade II or worse
[29]	Holly et al., 2014	United States	–	–	Systematic review	1. Assessment for delirium risk factors using a valid and reliable tool 2. The environment is assessed daily for preventive strategies to maintaining 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
[30]	Khan et al., 2013	England	2010–2011 versus 2011–2012	873	Retrospective cohort study	1. Time to surgery <36 h 2. Admitted under joined geriatric/orthopedic care 3. Using an agreed multidisciplinary protocol 4. Assessed by a geriatrician <72 h

Table 1 (continued)

Source (see reference list)	Author/audit/ guideline name, publication year/start of audit	Country	Study period/year of audit year or guideline	Number of patients in study or audit	Study design or audit/guideline	Quality indicators (process, structure, outcome)
						5. Post-operative multi-professional rehabilitation team 6. Fracture prevention assessments (falls/bone health)
[31]	Patel et al., 2013	England	2009–2010	372	Retrospective cohort study	1. Time to surgery < 36 h 2. Admitted under joined geriatric/orthopedic care 3. Using an agreed multidisciplinary protocol 4. Assessed by a geriatrician < 72 h 5. Postoperative multi-professional rehabilitation team 6. Fracture prevention assessments (falls/bone health)
[32]	Sund et al., 2005	Finland	1998–2001	16,881	Retrospective cohort study	1. Time to surgery within 48 h from arrival upon start of operation
[33]	Nielsen et al., 2009	Denmark	2005–2006	6266	Retrospective cohort study	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
[34]	Siu et al., 2006	United States	1997–1998	554	Prospective cohort study	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)
[35]	National Hip Fracture Database, 2007	England	2016	64,864	Audit	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 anesthesia 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 anesthesia, surgical, and theater teams

Table 1 (continued)

Source (see reference list)	Author/audit/ guideline name, publication year/start of audit	Country	Study period/year of audit year or guideline	Number of patients in study or audit	Study design or audit/guideline	Quality indicators (process, structure, outcome)
						8. Arthroplasty in a displaced intracapsular fracture 9. Total hip replacement in defined conditions[1] 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 during admission[2] 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[2] 17. Intermediate care in certain conditions[3] 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
[36]	Scottish Hip Fracture Audit, 1993–2008, restart 2015	Scotland	2016	1041	Audit	1. Transfer from the Emergency Department to the Orthopedic ward within 4 h 2. The "Big Six" interventions/treatments applied before leaving the Emergency Department[4] 3. "Inpatient Bundle of Care" within 24 h of admission[5] 4. Surgical repair within 36 h 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 3 days of admission 9. Mobilization on the first day after surgery and physiotherapy assessment by end of day 2

Table 1 (continued)

Source (see reference list)	Author/audit/ guideline name, publication year/start of audit	Country	Study period/year of audit year or guideline	Number of patients in study or audit	Study design or audit/guideline	Quality indicators (process, structure, outcome)
						10. Occupational therapy assessment by the end of day 3 postoperatively 11. Assessment of bone health prior to leaving the acute orthopedic ward 12. Discharge back to original place of residence within 30 days from the date of admission
[37]	Australian and New Zealand Hip Fracture Registry (ANZHFR), 2013	Australia and New Zealand	2016	3519	Audit/guideline	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 min of arrival 3: Orthogeriatric management during admission 4: Surgery within 48 h 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 their hospital stay. 5d: Returning to pre-fracture mobility 6a: Bone protection medicine before discharge 6b: Readmissions with another femoral fracture within 12 months of admission from initial hip fracture 7a: Local arrangements for the development of an individualized care plan 7b: Proportion returning to private residence within 120 days after discharge from hospital 8a: Re-operation of hip fracture patients within 30-days 8b: Survival at 30 days post-admission
[38]	Rikshöft, 1988*	Sweden	2016	15,062	Audit	1. Operation within 24 h 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
[39]	Dutch Hip Fracture Audit (DHFA), 2016	The Netherlands	2016	19,000 avg/year	Audit	1. Participation in the DHFA 2. Functional outcomes scores registered at admission and 3 months after admission
[40]	Irish Hip Fracture Database (IHFD)	Ireland	2016	3159	Audit	1. Prompt admission to orthopedic care 2. Surgery within 48 h 3. Prevention of pressure ulcers 4. Access to acute orthogeriatric care 5. Assessment for bone protection therapy 6. Falls assessment
[41]	Kaiser Permanente National Implant Registries, 2009**	United States	2015	29,414	Audit	1. Time to surgery 2. Time to surgery > 48 h 3. Length of in-patient stay 4. 30-day emergency visit

Table 1 (continued)

Source (see reference list)	Author/audit/ guideline name, publication year/start of audit	Country	Study period/year of audit year or guideline	Number of patients in study or audit	Study design or audit/guideline	Quality indicators (process, structure, outcome)
						5. 30-day inpatient readmission 6. 90-day revision 7. 90-day mortality
[42]	Danish Multidisciplinary Hip Fracture Registry (DMHFR), 2013	Denmark	2016	6789	Audit	1. Assessment within 4 h by a specialist 2a. Operated within 24 h 2b. Operated within 36 h 3. Mobilized within 24 h after operation 4a. Functional assessment before fracture 4b. Functional assessment with 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 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
[43, 44]	National Institute for Health and Care Excellence. The management of hip fracture in adults (CG124). Distracted from the guideline: – Hip fracture in Adults: Quality standard 16 (1–6) – British Orthopaedic Association Standards for Trauma (5–17)	UK	2011, updated 2017	–	Guideline	1. Total hip replacement in defined conditions [1] 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[2] 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 a MRI 10. Immediate analgesia on presentation and in case of pain. 11. Treat correctable comorbidities immediately 12. Direct weight-bearing mobilization with physiotherapist postoperative 13. Assess risk of delirium and dementia 14. Consider surgery as palliative treatment 15. Assessment and treatment of thromboembolism and pressure sore

Table 1 (continued)

Source (see reference list)	Author/audit/ guideline name, publication year/start of audit	Country	Study period/year of audit year or guideline	Number of patients in study or audit	Study design or audit/guideline	Quality indicators (process, structure, outcome)
[45]	National Hip Fracture Toolkit	Canada	2011	–	Guideline	16. Printed and verbal information on treatment and rehabilitation 17. Data submission to the NHFD 1. Surgery within 24 h 2. Surgery within 48 h 3. Total operation time 4. Intra-operative 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. Admissions to long-term care in 6 months 11. Refracture 1 year post-surgery

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

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

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

2: 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

3: 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

4: The "Big Six": Provision of Pain Relief, Delirium Screening, Early Warning Score, Bloods Investigations, Fluid Therapy, and Pressure Area Inspection

5: The "Inpatient Bundle of Care": Cognitive, Nutritional, Pressure Area and Falls Assessments

Standard 16 and the British Orthopaedic Association Standards for Trauma [5, 43, 44]. The Australian and New Zealand Hip Fracture Registry has published an overall Hip Fracture Care Clinical Care Standard, which contains both the audits' and the guidelines' QIs [8, 37, 48]. In Canada, the national QIs were described in the National Hip Fracture Toolkit [45].

Identified quality indicators

In the included articles, audits, and guidelines 217 QIs were described (Table 1). Some of the reported QIs were similar, leaving 97 unique QIs. The unique QIs included 9 structure indicators (Table 2), 63 process indicators (Table 3), and 25 outcome indicators (Table 4). Sixty-five QIs were only described in one article or audit. The process indicator "time to surgery within a specific time frame" was described most frequent in 12 of 16 articles and in all audits and guidelines.

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 16 articles, one audit and one guideline QIs were correlated with an outcome measure. In total, 30 different outcome measures to judge the predictive value of the indicators 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 hospital length of stay),

Table 2 Structure indicators for hip fracture care

Structure quality indicator*	Source (see reference list)	Outcome measure used to correlate to indicator**	Correlation with outcome present (P), not present (NP), not tested individually (NTI), and source (see reference list)
1. Orthogeriatric management during admission	[20, 25, 30, 31, 37, 40, 44]	2, 3, 4, 5, 12, 13, 15	NTI for 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 for 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 for all outcome measures [35]
4. Postoperative multi-professional rehabilitation team	[20, 30, 31]	3, 4, 5, 12, 13, 15	NTI for 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 anesthesia, surgical, and theater teams	[35]	1, 3, 5, 6, 7, 8, 9, 11, 13, 14	NTI for 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 for all outcome measures [35]
9. Participation in nationwide Hip Fracture Audit	[26, 39, 44]	–	–

* Quality indicators as described in included studies

** Outcome measure used to judge the predictive value of the indicator

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

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, HFs sustained as an 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 nine structure indicators (presence of a 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 a specified time, total hip replacement in defined conditions, extramedullary implants in AO classification types A1 and A2, IM nail with a subtrochanteric fracture, fracture prevention assessment, being mobilized within a 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

Table 3 Process indicators for hip fracture care

Process quality indicator*	Source (see reference list)	Outcome measure used to correlate to indicator**	Correlation with outcome present (P), not present (NP), not tested individually (NTI), and source (see reference list)
1. Patients unable to bear weight with negative X-rays should be offered a MRI	[44]	–	–
2. Prompt admission to orthopedic care	[25, 40]	2, 26	NTI for all outcome measures [25]
3. The "Big Six†" interventions/t reatments must be done before leaving the emergency department	[36]	–	–
4. Transfer from the accident and emergency department within a 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 for all outcome measures [20, 30, 31]
7. Assessment by a specialist within 4 h	[42]	–	–
8. The "Inpatient Bundle of Care§" must be provided within 24 h 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 for all outcome measures [35]
14. Offer a choice of spinal or general anesthesia	[35]	1, 3, 5, 6, 8, 13, 15, 17, 26, 27	NTI for 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 a 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 operation time	[45]	–	–
19. Consider intraoperative nerve blocks for all patients undergoing surgery	[35]	1, 3, 5, 6, 8, 13, 15, 17, 26, 27	NTI for 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 postoperative	[37, 44]	–	–

Table 3 (continued)

Process quality indicator*	Source (see reference list)	Outcome measure used to correlate to indicator**	Correlation with outcome present (P), not present (NP), not tested individually (NTI), and source (see reference list)
23. Percentage of days with intervention of a physiotherapist	[24]	5, 11, 16, 20, 28	NTI for 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] NTI: –
26. Strength and balance training	[35]	1, 3, 5, 6, 8, 13, 15, 17, 26, 27	NTI for 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 for 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]
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 for all outcome measures [25]
34. Occupational therapy (OT) assessment by the end of day 3 postoperatively	[36]	–	–
35. Assessment and treatment of thromboembolism 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 for 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 thromboembolism	[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]	–	–

Table 3 (continued)

Process quality indicator*	Source (see reference list)	Outcome measure used to correlate to indicator**	Correlation with outcome present (P), not present (NP), not tested individually (NTI), and source (see reference list)
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 restrains	[34]	12, 21, 22, 29	P: – NP: 12, 21, 22, 29 [34]
45. Time between discharge and complementation of orthopedic hospitalization record	[24]	5, 11, 16, 20, 28	NTI for all outcome measures [24]
46. Time between surgery and completion of surgery record	[24]	5, 11, 16, 20, 28	NTI for all outcome measures [24]
47. Time between discharge from rehabilitation ward and completion of rehabilitation hospitalization record	[24]	5, 11, 16, 20, 28	NTI for all outcome measures [24]
48. Height and weight mentioned in orthopedic chart	[24]	5, 11, 16, 20, 28	NTI for all outcome measures [24]
49. Albuminemia mentioned in orthopedic chart	[24]	5, 11, 16, 20, 28	NTI for all outcome measures [24]
50.Time between admission and request of place in rehabilitation facility	[24]	5, 11, 16, 20, 28	NTI for 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 for all outcome measures [35]
53. Arthroplasty in a displaced intracapsular fracture	[35, 38]	1, 3, 5, 6, 8, 13, 15, 17, 26, 27	NTI for 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 for 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 for all outcome measures [35]
60. Only consider intermediate care in certain conditions	[35]	1, 3, 5, 6, 8, 13, 15, 17, 26, 27	NTI for all outcome measures [35]
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 for all outcome measures [35]

Table 3 (continued)

Process quality indicator*	Source (see reference list)	Outcome measure used to correlate to indicator**	Correlation with outcome present (P), not present (NP), not tested individually (NTI), and source (see reference list)
62. Rehabilitation plan before discharge	[42]	–	–
63. Functional outcomes scores registered at admission and 3 months after admission	[39]	–	–

¶ 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, falls 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

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

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

* Quality indicators as described in included studies

** Outcome measure used to judge the predictive value of the indicator

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

Table 4 Outcomes categorized as quality indicators for hip fracture care

Outcome quality indicator*	Source (see reference list)
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 readmissions rate*	[41, 42]
11. Readmissions with another femoral fracture within 12 months of admission from initial hip fracture	[37, 45]
12. Admissions 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. Returning 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 infections rate after 3 months	[28]
25. All patients with a hip fracture receive essential nursing care	[29]

* Quality indicators as described in included studies

Short-term: < 30 days

Long-term: > 30 days

was assessed for just 24 of the 72 structure and process QIs. For only 11 QIs a correlation with a limited number of outcome measures used to judge the predictive value of the indicator 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)
- Future fracture prevention assessment (process indicator, correlated with 30-day readmission and 30-day mortality rate)
- Systematic pain assessment (process indicator, correlated with 30-day readmission and 30-day mortality rate)
- 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 care [15]. Methodologically sound QIs should be developed in a systematic manner [49, 50]. For instance, Martin-Khan et al. [51] used a three-step development process to define a set of QIs for measuring the quality of care provided to elderly in the emergency department. 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 relevance, validity, reliability, feasibility, and usability can be assessed [49]. Thus, the methodological quality of QIs for several clinical conditions has been reviewed using the AIRE instrument [52–56]. 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 relevance, reliability, feasibility, and usability of the existing QIs through interviews, surveys, audits, or focus groups [50]. 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 presented in this systematic review, supplemented with information found in other available literature on these individual QIs.

Orthogeriatric management during admission (structure indicator)

This QI is described in four articles and three 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. [59] that showed a significant decrease in the 1-year mortality rate from 35.1 to 23.2% after implementation of an integrated orthogeriatric treatment model. 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 16 included articles. Various time frames for surgical delay (varying from 24 to 48 h) are used in the definition of this QI. Sund et al. [32] 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, 34]. The Hip fracture in Adults: Quality Standard 16 stated that delays in surgery are negatively associated with mortality and return to prefracture mobility [43].

In the literature, a debate is ongoing whether a specific time frame should be used and, if so, what this time frame should be (ranging from 24 to 48 h). Three systematic reviews stated that the timing of surgery is complex and that confounding might be present in all included articles [60–62]. 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 operation.

As suggested by Panesar et al. [63], 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 I–II) and frail patients (ASA III–IV).

Time to mobilization after surgery (process indicator)

This QI was described in three articles and five audits/guidelines. For this QI, the time frame differed from 24 to 48 h 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 [21, 43], which renders this a promising QI. On the other hand, a review by Handoll et al. [64] concluded that there is insufficient evidence to substantiate the supposed effect of specific postoperative mobilization strategies.

Future fracture prevention assessment (process indicator)

In seven articles and in six audits/guidelines, future 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 [20, 30, 31, 44] and others as two separate QIs [21, 24, 25, 33, 35, 36, 42, 65].A correlation between anti-osteoporotic medication and 30-day readmission was found by Kristensen et al. [21]; bone health assessment and treatment was not correlated with 30-day mortality rate and length of hospital stay. 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. [33] found a correlation between the initiation of anti-osteoporotic medication and a lower 30-day mortality rate.

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 literature but is difficult to obtain with well-designed trials [66]. Recommendations in guidelines are therefore based on consensus rather than evidence [5].

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. [33] correlated this indicator with an outcome measure. 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. [67] showed that nutritional supplementation did not have an effect on the mortality of HF patients. 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 thromboembolism assessment/treatment in their QI [44]. 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 QIs [25].

As stated before, in the literature a longer waiting time to operation is associated with an increase in complications especially pressure ulcers [60–62]. 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 rate [70]. 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 casemix correction enables a fair comparison [71]. In the HF audit of England, Wales, and Northern Ireland, a casemix correction model has already been developed and is used in the evaluation of mortality [35]. This casemix 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 two articles and four 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 have also been described by Johansen et al. who recently published a HF audit overview [73].

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 policy-makers 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

In conclusion, many HF structure/process/outcome QIs are available and being used in audits worldwide, but there is little evidence for their methodological quality and usability. The focus of future research should therefore be on assessing the methodological aspects of the existing QIs. In particular, further study of the predictive validity of QIs on outcomes that are meaningful to patients and those running health care systems is needed. 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.

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Compliance with ethical standards

Conflicts of interest All authors have no commercial associations (e.g., consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article.

Abbreviations HF, hip fracture; QI, quality indicator

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 5 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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