Hospital accreditation

– what's in it for the patients?

PhD Thesis

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Acknowledgements

The idea for this Ph.D. emerged during my employment at IKAS and by nature spoke in favour of accreditation effectiveness - well knowing that the evidence for its effectiveness was limited. With this thesis, I achieved my goals of getting in-depth research skills and contributing with new knowledge to the field of accreditation.

This work was made possible by the co-financed support from IKAS, Center for Quality, and Department of Clinical Epidemiology, for which I am at most appreciative.

To my supervisors, I would like to express my sincerest appreciation. To my main supervisor, Søren Paaske Johnsen, I am utterly grateful for your trust in me and having faith in my project from the very beginning. I am deeply appreciative of your commitment, our inspiring discussions, your priceless feedback, and for sharing your extensive knowledge of clinical epidemiology with me over the years. Erik Hollnagel, thank you for our fruitful discussions, your invaluable feedback, and consistently bringing new perspectives to my work.

I warmly thank Arne Poulstrup for believing in my project and inviting me to the Center for Quality, an inspirational and welcoming working environment. I have immensely enjoyed working with my colleagues at the Center; thank you for giving me insight into matters not formerly known to me and for having fun with me throughout this process. My appreciation also goes to the Department for Clinical Epidemiology for providing a unique and stimulating working environment, enabling me to broaden my horizon and acquire new skills throughout the years.

A special thank you goes to Helen Crips for being an inspiring and talented mentor during my employment at IKAS and for welcoming me at The Health Foundation, London – this visit extended my understanding of quality in Healthcare. To Jeffrey Braithwaite, for your kind interest in my work and for showing me that one does not have to be dull to become an acclaimed and respected researcher.

Since the start I have met some wonderful people along the way. A very special thanks goes to Pia Kjær Kristensen, Søren Bie Bogh, Caroline Raben og Betina Thude Ravnsborg for helping me with everything and anything, and for the numerous of serious and not so serious office-discussions - your presence has made the proces so much more fun.

Finally, my most sincere gratitude goes to my husband Thomas and children Jeppe, Signe, and Asger for your never failing support and encouragement at all times.

Anne Mette Falstie-Jensen, 2016

Thesis papers

Paper I

Falstie-Jensen AM, Bogh SB, Hollnagel E, and Johnsen SP. Compliance with accreditation and recommended hospital care: a Danish nationwide population-based study.
Submitted

Paper II

Falstie-Jensen AM, Larsson H, Hollnagel E, Nørgaard M, Svendsen ML, and Johnsen SP. Compliance with hospital accreditation and patient mortality: a Danish nationwide population-based study.
Int J Qual Health Care. 2015 June;27:165-74.

Paper III

Falstie-Jensen AM, Larsson H, Hollnagel E, Nørgaard M, and Johnsen SP. Is compliance with hospital accreditation associated with length of stay and acute readmission? A Danish nationwide population-based study
Int J Qual Health Care. 2015 Dec; 27:450-7

List of abbreviations

AR: Acute readmission

CARF: Commission on Accreditation of Rehabilitation Facilities

CI: Confidence intervals

COPD: Chronic obstructive pulmonary disease

DDKM: The Danish Healthcare Quality Programme (in Danish: Den Danske Kvalitetsmodel)

DNPR: The Danish National Patient Registry

HQS: Health Quality Service

HR: Hazard ratio

IKAS: The Institute for Quality and Accreditation in Health Care

ISQua: The International Society of Quality in Healthcare

JACIE: The Joint Accreditation Committee for International Society for Cellular Therapy (ISCT) & European Society for Blood and Marrow Transplantation (EBMT)

JCAHO: Joint Commission Accreditation of Healthcare Organisations

JCI: The Joint Commission International

LOS: Length of stay

OR: Odds ratio

PDSA: Plan-Do-Study-Act circle

CONTENT

1.0 INTRODUCTION

The quality of healthcare is constantly under debate. Cases of inadequately delivered care and lack of resources are reported daily in the news media while stories about satisfactory experiences and excellence are sparse. This imbalance creates an image of a healthcare system that is incapable of meeting its main objective of providing high-quality care to patients. But what is high-quality care, and how can it be measured and documented? Taking into account that modern healthcare is provided by a highly complex system, the answers to these questions are obviously not simple.

Many strategies have been introduced to improve quality of care, along with the continuous introduction of new medical and technological developments. A popular strategy among healthcare leaders and politicians is standardisation in the form of standards, guidelines, and pathway packages. This strategy is often applied by introducing an accreditation programme designed to improve patient outcomes and organisational performance and to help the entire organisation to focus on safety and quality. Accreditation programmes are not a new phenomenon. The first programme was established in 1917 to improve the quality of medical education. The surprising and distressing result from the first perfomed survey clearly demonstrated a need for such programme (1). Since then, accreditation programmes have evolved and embraced new ways of evaluating the quality of healthcare.

During the last two decades, the use of healthcare accreditation has increased to more than 70 countries (2). Some countries have developed their own programmes while others have adapted international programmes, and the approach to implementation has varied between voluntary and compulsory. Despite a long history and widespread use, evidence for the effectiveness of accreditation, in particular in relation to improved patient care, remains sparse (3-8).

Using a quantitative approach and based on clinical epidemiological methods, this thesis aims to identify links between a hospital's ability to meet accreditation standards and the quality of the care by focusing on the association between compliance with an accreditation programme and clinical and organisational quality; reflected by recommended hospital care, 30-day mortality, length of stay (LOS), and acute readmission (AR).

2.0 BACKGROUND

This section will give a short introduction to the Danish healthcare system and national quality-improvement initiatives in Denmark prior to the national accreditation programme. Subsequently, accreditation is defined along with an introduction to the national accreditation programme. Finally, a literature review is provided focusing on the effectiveness of accreditation with regard to patient-related outcomes.

2.1 The Danish Healthcare System

Denmark has a comprehensive public healthcare system that covers the entire population of 5.7 million and is based on the principle of equal access to the healthcare system's services for all citizens because of tax funding (9). The Danish healthcare system is organised into primary and secondary sectors. The primary sector handles general health problems and is usually the first point of contact if general medical treatment is required. The secondary sector relates to hospitalisation for patients who require more specialised medical treatment with the public hospitals treating the vast majority of hospitalised patients including all emergencies. Denmark are organised in five regions that are accountable for secondary healthcare. The five regions are further divided into 98 Danish municipalities responsible for primary healthcare except the general practitioners and practicing specialist. A central feature in the organisation is the decentralised responsibility in which regions have the power to organise their services according to regional wishes and possibilities. However, collaboration and negotiation exist among state (e.g., Ministry of Health and The National Board of Health), regions, and municipalities to accommodate the increased focus on controlling healthcare costs (10).

2.2 Quality-improvement initiatives in Denmark prior to accreditation

Inspired by the World Health Organization's five principles for quality, the first Danish national strategy for quality improvement was launched in 1993 as a result of enhanced attention to improving quality in the healthcare system (11). The strategy outlined quality as a tool for self-monitoring with a special focus on the improvement perspective driven by "the good apple" approach, which focused on successes and learning from each other (12). Correspondingly, attention was also directed towards establishing clinical registries as tools for monitoring professional quality due to unexplained variations in clinical practice combined with knowledge that available evidence was not translated to clinical practice. Initiatives like "The good medical department" and "The National Indicator Project" used standards, systematic monitoring of performance measures, and auditing as methods to improve quality for selected groups of patients (13-15). At the state level, clinical guidelines were also developed for selected conditions to increase quality and decrease unwarranted variation. Concurrently with these initiatives, five hospitals in Copenhagen implemented the accreditation programme by The Joint Commission International (JCI) and were accredited in 1999, and a year later, "The Health Quality Services" (HQS; current The CHKS Healthcare Accreditation & Quality Unit)

accredited hospitals, municipalities, and general practitioners in the County of Southern Jutland (16,17).

Over the years, the focus on patients' rights increased, as was emphasised by the introduction in 2000 of a national, mandatory reporting system for adverse events and a national questionnaire survey on inpatient experiences (18). In this time period, the predominant perspective on quality in healthcare was Safety I, characterised by "when things go wrong" (19). To achieve an appropriate level of quality of care, malfunctions or failures of specific components had to be identified using methods like root cause analysis and subsequently eliminated. By the year 2000, the national approach to quality had shifted to a more regulatory perspective with quality-improvement efforts becoming a "must do" task (12). The quality assurance activities had produced an additional challenge regarding how to ensure that the medical staff adapted knowledge and requirements into their everyday practice; consequently, the need for a quality management system was apparent (20).

In 2001, the idea of a national quality programme consisting of standards and external evaluation was confirmed, and the decision was made to develop a national, Danish accreditation programme (21-23). Before this step could become a reality, however, further details about the framework and scope for the programme had to be decided. In 2005, the Danish Institute for Quality and Accreditation in Healthcare (IKAS (in Danish: Institut for Kvalitet og Akkreditering i Sundhedsvæsenet)) was founded with the aim of developing and managing a national accreditation programme, The Danish Healthcare Quality Programme (DDKM (in Danish: Den Danske Kvalitetsmodel)) (24-26). In the initial phase of developing the DDKM, the process was supported by an international accreditation body, HQS. As a core principle, all versions of the DDKM were to be accredited by The International Society of Quality in Healthcare (ISQua) (27).

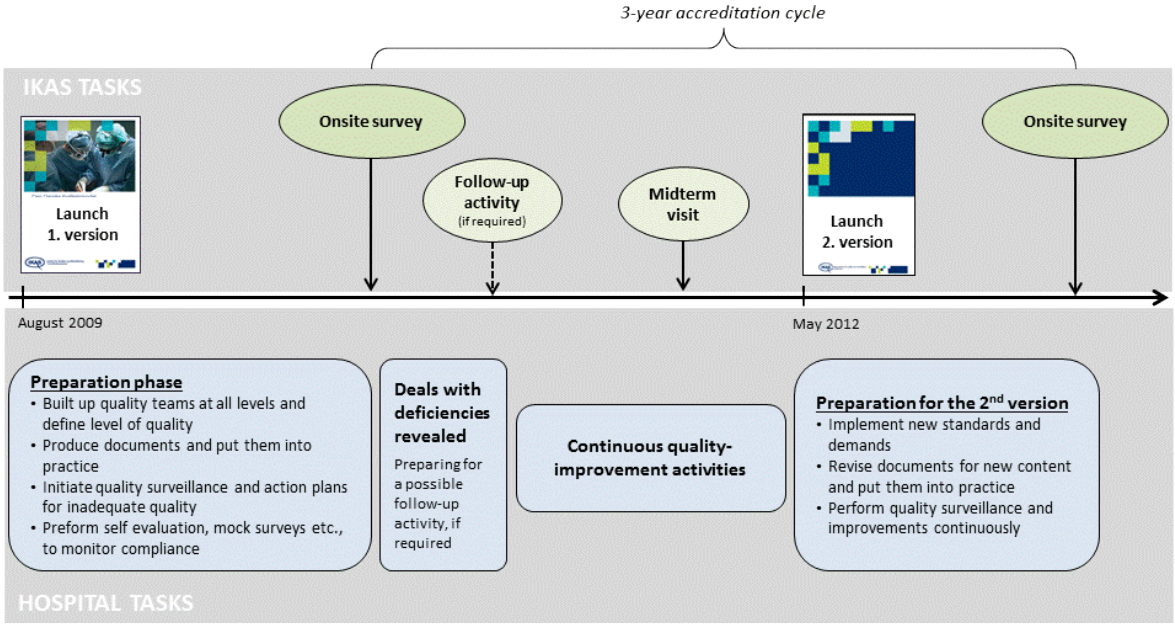
2.3 What is accreditation?

Accreditation is defined as an external review process with the aim of assessing how well an organisation performs relative to established standards (28). The standards outline good quality and help the organisations to identify what they do well and where they could do better and to initiate improvements where inadequate quality is identified. The organisations have to establish a continuous quality-improvement process to assess quality and to ensure improvements.

The external review is performed by a team comprising peer reviewers (also known as surveyors) and involves for most programmes a site visit, called the onsite survey. The surveyors' main task is to evaluate to what extent the organisation meets the standards. The evaluation is documented in a report used by the accreditation bodies to evaluate the results of the survey based on the determined level of compliance with the programme. Normally, the report identifies strengths and areas for improvement and is used by the organisations to create and implement action plans, continuing the cycle of ongoing quality improvement. The external review process is an ongoing one, with surveys usually repeated every 3 to 4 years, including a midterm visit to maintain momentum. Figure 1

illustrates the overall components that have to be performed by the accreditation bodies and by the hospital going through accreditation, according to the DDKM.

Figure 1. The general components in an accreditation cycle as given in the DDKM



2.4 The Danish Healthcare Quality Programme

2.4.1 The objectives

The DDKM should provide accreditation standards for good quality within the following objectives:

- To improve the quality of patient pathways
- To improve the development of the clinical, organisational, and patient-perceived quality
- To make the quality in the healthcare system visible
- To prevent errors that cause death and reduce quality of life

A policy note laid out the overall content of the DDKM, emphasising a special focus on patient safety and that ongoing quality initiatives were to be incorporated (25). Over the years, the intention for the DDKM was for it to become a complete, integrated, and joint system for the improvement and assessment of quality of strategically important services and activities in the entire Danish healthcare system. This goal should be achieved by introducing a programme that fosters learning and quality improvement within the participating organisations through ongoing assessments. This approach was supported by the principle that the DDKM must stimulate learning rather than exercise control. Another central aspect was the assurance that the organisations had room for local interpretation (method of freedom); thus, the standards were not linked to specific methods.

2.4.2 Participation in the DDKM

Although the DDKM was intended to incorporate the entire healthcare system, only hospitals were enrolled at the start by compulsory participation. This enrolment included both public and private hospitals. Tailored programmes for the other services, e.g., pharmacies, general practitioners, and practicing specialists, were developed later by IKAS after finalisation (please see www.ikas.dk for more details) (29,30). Costs were covered by tax funds for the public services whereas private healthcare providers' covered expenses directly related to their accreditation.

2.4.3 Establishing the first version of the DDKM for hospitals

An important focus in the establishment of the DDKM was collaboration with healthcare professionals to ensure ownership. Within the framework of IKAS, 37 groups were set up to develop the first version of the DDKM for the hospitals. Group members were recommended by the regions and appointed by IKAS to ensure professional competence and representation from all regions. All groups comprised a chairman, ordinary members, and a secretariat from IKAS. Each group was given a theme chosen by the founders and was to develop standards and measurable elements by applying the RUMBA principle (Realistic, Understandable, Measurable, Beneficial, and Achievable). The health professionals were responsible for the professional content within the standards and obligated to combine and use already existing data collected in the Danish healthcare system, where relevant. After the groups had completed their work, IKAS undertook a further revision to ensure that the programme met the requirements from ISQua and that the method of freedom was upheld. After two comprehensive hearings and a subsequent pilot test at seven public hospitals, the first version of the DDKM was launched in August 2009 (please go to www.ikas.dk for further description).

2.4.4 Challenges in introducing the DDKM

Although accreditation had become a widely used strategy, concerns regarding the demonstrable benefits, requirements and cost continued to surface with the introduction of the DDKM in Danish healthcare (21). Although the cost of the DDKM was covered by the funders, including a subsidy to the hospitals to cover implementation costs, this amount was not considered sufficient to reimburse for the human resources needed for putting this comprehensive programme into practice (31). Furthermore the ISQua standards encompassed requirements that was covered by other authoritative in Denmark (like fire inspections) thus some degree of duplication was roled out with the programme. Another challenge was the shift from a bottom-up to a top-down quality initiative by the compulsory introduction of accreditation, which was not a popular decision among all healthcare professionals. Despite the involvement of healthcare professionals in the development of DDKM, physicians in particular had doubts about whether accreditation as a method could improve patient-related outcomes; thus, resources were perhaps more effectively spent on medical equipment and staff (21).

2.5 Difficulties in studying accreditation

Although the effectiveness of accreditation has been of interest to many, it has turned out to be difficult to study. This difficulty can be attributed to its complicated and context-sensitive nature (32). The possibility of using an experimental design is often impractical because both voluntary and compulsory accreditation, in general, are introduced without an exact start date or a detailed implementation plan. In addition, because the time frame from launch of standards to onsite survey is often narrow, time is limited for designing methodologically high-quality studies and collecting solid baseline information. To provide scientific evidence using other approaches, researchers face some difficulties because accreditation programmes seldom fully articulate a programme theory (model of change) and often leave room for local interpretation while also including numerous activities that target multiple levels within the hospital going through accreditation (33,34). Thus, various implementation strategies are used in the effort to achieve accreditation because what works in one hospital may not work in another, and what some departments think is appropriate may be considered useless by others (35). Activities undertaken by the hospitals and departments to implement accreditation standards are very rarely systematically and prospectively described, with the consequence that researchers have only limited data to further explore the underlying mechanisms that supposedly are to produce improvement in the delivered care.

Despite these difficulties, there is a need for evaluating accreditation as a tool for improving healthcare. Several methods for evaluating accreditation have been proposed, exemplified by the ACCREDIT protocol describing 12 studies with different scopes as one way of overcoming the complicated and context-sensitive nature of accreditation (6,33,34,36,37). Use of quantitative and qualitative research methods, alone and in combination, has been suggested to achieve an in-depth understanding of the potential implications of introducing a quality-improvement framework as a way to improve the delivered hospital care.

In Denmark, the possibility of examining the effect of accreditation in a randomised controlled trial was hampered by the decision to roll out a compulsory introduction of the DDKM to all public hospitals at the same time. During the introduction of the DDKM, there was no systematic or consistent qualitative or quantitative information gathered e.g. on the method used for implementation or self evaluations. Hence, the possibility of identifying effective methods for implementing accreditation was hampered by the limited, sporadic data available and risk of recall bias by retrospective collection of such information. However, Denmark has a long-standing tradition of collecting patient data prospectively at a national level, providing detailed and updated information about the entire Danish population. Thus, the effectiveness of the compulsory accreditation on patient-related outcomes could be investigated from a clinical epidemiological perspective by comparing differences in accreditation accomplished by all the public hospitals participating in the DDKM with the prospectively captured outcomes in the national registries.

2.6 Literature review

The literature search focused on identifying publications regarding the association between accreditation and patient-related outcomes including recommended hospital care, 30-day mortality, LOS, and AR. The next paragraphs will outline the search strategy and the identified studies according to each of the four outcomes. An overall summary including an overview of the studies' limitations is given at the end.

2.6.1 Search strategy

The database PubMed was searched for published English or Scandinavian language literature up to and including December 2015 and with abstracts included. The literature search was initially built by Medical Subject Heading [MESH] to narrow down the extensive literature on accreditation beyond the scope of this thesis; however, this approach was not successful. Consequently, all search strategies were applied with "NOT "education"" to exclude literature on educational accreditation, and specific terms were added as a way of detecting specific publications on accreditation programme effectiveness on patient-related outcomes. Terms were "compliance with hospital accreditation [all fields]", "accredited [all fields]", "non-accredited [all fields]", "unaccredited [all fields]", "accreditation [Title]", "accreditation status [all fields]", and "accreditation decision [all fields]". These terms were used in combination with one of the four outcomes of interest, respectively: recommended hospital care ("Quality indicators, Health Care", "Process assessment (Health Care)"), "Mortality", "Length of stay", and "Patient readmission".

To handle the risk of missing relevant references, an intensive search was conducted by checking the references lists in the included studies and reviews on accreditation. Furthermore, textbooks on quality improvement were included in the search for relevant publications.

2.6.2 Compliance with a hospital accreditation programme

The literature on compliance with a hospital accreditation programme was scarce, as only four studies were identified (38-41). A short description of the identified publications is presented in Table 1.

The three oldest studies investigated hospitals accredited by the Joint Commission Accreditation of Healthcare Organisations (JCAHO) in the late 1990s and included mortality as an outcome, along with recommended hospital care in the study by Chen et al and LOS in the study by Griffith et al. The largest study by Chen et al included 3,179 surveyed US hospitals, and the distribution of hospitals in the four awarded levels of compliance was 13%, 2%, 84%, and 1%, respectively, starting with the finest award first (38). Clustering of hospitals within one category was likewise present in the study by Griffith et al (39). Thus level of JCAHO accreditation to distinguishing individual performance among accredited hospitals were of limited use. However, Chen et al did report a higher mortality risk for partially and not accredited hospitals compared with fully accredited hospitals. The third study by Joshi overcame this challenge by combining levels of accreditation into a dichotomous category of "high or low", and this author found that high accreditation was associated with favourable mortality rates (40). Both Joshi and Griffith et al subsequently used JCAHO accreditation scores to reflect compliance with the programme and found an indication of a mild correlation between high accreditation score and lower mortality rates (39,40). Although all studies aimed to account for patient case mix among hospitals, this inclusion was done at the hospital level assuming homogeneity among hospitals and not directly addressing any actual difference among patients.

In addition, Griffith et al also investigated the relation between JCAHO accreditation score and LOS but found no correlation between the score and adjusted LOS (39).

In 2013, a Lebanese study was published examining the role of compliance with accreditation by four categories awarded to hospitals contracted with the Ministry of Health (41). The study assessed the association with 30-day readmission to the same or any hospital for medically admitted patients, although readmissions due to cancers and psychiatric disorders were excluded. An increase in readmission with increasing accreditation category was reported; in other words, the best accreditation category had the highest rate of readmission for both readmission to the same and any hospital. The study adjusted for case mix by calculating a case mix index, but again adjustment was carried out according to hospital factors. Although the study also reported an increased risk of readmission by hospital size and ownership, the interrelationship with accreditation categories was not further explored.

In summary, the literature on compliance with accreditation is scant.

Table 1. Identified literature on compliance with accreditation and patient-related outcomes

STUDY I: COMPLIANCE WITH ACCREDITATION AND PATIENT-RELATED OUTCOMES				
Author, year	**Design, period, data source, analysis**	**Population, size, setting**	**Exposure and definition of outcome**	**Main results and limitations**
Ammar W, (41) 2013	▪ Historical follow-up study ▪ June 2011 to May 2012 ▪ The ministry hospitalisation database ▪ Accreditation categories: A (highest) to D (lowest) at hospital level	▪ Patients with medical admissions ▪ 217,550 cases at 122 hospitals contracted with the Ministry of Health (96.4%) ▪ Lebanon	▪ Accreditation in Lebanon ▪ Age and gender standardised 30-day readmission by two measures; readmissions to the same or any hospital	▪ The proportion of 30-day readmissions to the same and any hospitals increased with increased accreditation category (highest category having the highest rate) (same hospital: D: 0.7%, C: 1.5%, B: 2.3%, A: 2.7%; any hospital: D: 1.3%, C: 2.0%, B: 2.5%, A: 4.0%) ▪ No information on categories A to D, no measures of association or 95% confidence interval (CI) provided, exclusion of hospitals with less than 100 admissions, no adjustment for the other known hospital characteristics, readmissions for cancer and psychiatric disorders excluded
Chen J et al, (38) 2003	▪ Historical follow-up study ▪ Jan 1994 to Feb 1996 ▪ Cooperative Cardiovascular Project, Medicare Enrolment Database ▪ Level of accreditation at patient level	▪ Medicare patients with clinical confirmed first-time acute myocardial infarction ▪ 134,579 patients at 4,221 hospitals ▪ USA – 50 states and the District of Columbia	▪ JCAHO accreditation ▪ 5 clinical performance measures for AMI ▪ Risk standardised 30-day mortality rates (using a disease-specific prediction model for elderly patients)	▪ Limited usefulness in distinguishing individual performance among accredited hospitals by level of accreditation due to large variation in performance measures within levels ▪ Higher mortality rates for lower level of compliance with accreditation (highest level of accreditation reference; accredited HR 1.15, p=0.01; accredited with recommendation HR 1.06, p<0.01) ▪ Limited to patients over age 65 years, case mix adjustments performed at hospital level for each JCAHO group, assuming homogeneity, no 95% CI on the estimates
Joshi MS, (40) 2003	▪ Cross-sectional study ▪ May 1996 to April 1997 ▪ Data from CaduCIS Net (CareScience Philadelphia) ▪ Accreditation decision: High vs low at hospital level	▪ Medicare patients ▪ 957 hospitals (number of patients not stated) ▪ USA, general acute care non-federally owned hospital	▪ JCAHO accreditation ▪ Mortality by favourable or unfavourable mortality deviation (timeframe not stated)	▪ Accreditation decision was associated with favourable mortality deviation, in favour of high accredited hospitals (OR 1.381, p=0.093) ▪ No information on accreditation programme, the descriptive table includes 54 hospitals later excluded, thus analysis perform on 903 hospitals, only inpatient mortality included, no 95% CI on the estimates
Griffith JR et al, (39) 2002	▪ Historical follow-up study ▪ 1996 to 1998 ▪ Solucient data set and Joint Commission data ▪ Decision of accreditation status + overall evaluation score (OES) at hospital level	▪ Population not stated ▪ 742 hospitals ▪ USA	▪ JCAHO accreditation ▪ Mortality index: (number of actual deaths/number of expected deaths) ▪ Adjusted LOS defined as mean days of stay adjusted for case mix, severity, and market	▪ Decision for accreditation was not applicable because a vast majority of hospitals were awarded "accreditation with recommendation for improvements" ▪ Mortality was decreasing with higher OES (R=-0.085, p=0.021) ▪ No association between adjusted LOS and OES (R=-0.005, p=0.902) ▪ Only 25% of JCAHO-accredited hospitals had publicly available data; some JCAHO accredited hospitals scores were suppressed. No exact numbers presented

2.6.3 Accreditation and recommended hospital care

The association between accreditation and recommended hospital care was examined in all of the identified studies by comparing accredited with non-accredited hospitals (38,42-46). The identified publications are listed by publication year and first author in Table 2. All studies examined accreditation according to one programme and were conducted in the US setting, except a Danish study, which included accreditation according to two international programmes. All studies used 4 to 21 process performance measures to assess recommended hospital care for patients with selected medical conditions.

Chen et al reported for all five performance measures that patients with clinically confirmed acute myocardial infarction were less likely to receive the recommended measures at non-accredited hospitals when compared with patients at accredited hospitals. Other studies have reported positive findings in favour of accreditation only for some of the included measures (4 out of 16 and 2 out of 6) (42,44). Lutfiyaa et al also found that accredited hospitals were more likely than non-accredited hospitals to be in the better half of hospitals in delivering all recommended measures to patients. This finding corresponds to the results of two other studies stating that accredited hospitals are more likely to have high performance (45,46). Schmaltz et al also showed that accredited US hospitals had larger improvements than non-accredited hospitals in the quality of the delivered care over a 4-year period. Unlike Schmaltz, the Danish historical follow-up study showed larger improvement at non-accredited compared with accredited hospitals when looking at a patient's probability of receiving an individual recommended process of care (43). However, a patient's probability of receiving all recommended processes did not differ between accredited and non-accredited hospitals for the four medical conditions included in the study. In general, the studies did not adjust for differences in patient characteristics due to the exclusion of patients contraindicated from receiving a specific process of care. However, adjustment for hospital characteristics was included only in two of five studies that revealed differences between accredited and non-accredited hospitals characteristics (42,46). The inconsistency between the reported associations may arise from differences in the included performance measures, among medical conditions, and among cut-of-values for defining high-performing hospitals.

Table 2. Identified literature on accreditation and recommended hospital care

STUDY I: ACCREDITATION AND RECOMMENDED HOSPITAL CARE				
Author, year	**Design, period, data source, analysis**	**Population, size, setting**	**Exposure and definition of outcome**	**Main results and limitations**
Bogh SB et al, (43) 2015	▪ Historical follow-up study ▪ 2004 to 2008 ▪ National clinical quality registries ▪ Accredited versus non-accredited at patient level	▪ Patients with stroke, heart failure, and bleeding and perforated ulcers ▪ 27,274 patients at 33 hospitals ▪ Denmark	▪ Accreditation by Joint Commission International and Health Quality Service ▪ 21 processes of care: - stroke=7 - heart failure=6 - bleeding ulcer=4 - perforated ulcer=4	▪ Opportunity-based score: higher improvements at non-accredited hospitals (absolute difference: 3.8 (95% CI: 0.8–8.3) (accredited 9.9, 95% CI: 5.4–14.4; non-accr: 13.7, 95% CI: 10.6–16.8)) ▪ All-or-none composite score: no difference between accredited and non-accredited hospitals (absolute difference: 3.2 (95% CI: -3.6–9.9) (accredited 6.3, 95% CI: -0.6–13.2; non-accr: 9.4, 95% CI: 5.0–13.9)) ▪ No difference was found at disease level for both measures ▪ Combined information on two different accreditation programmes
Merkow RP et al, (45) 2014	▪ Historical follow-up study ▪ 2012 ▪ Hospital Compare database ▪ Accredited versus non-accredited at hospital level	▪ Patients with cancer ▪ 3,563 centres (number of patients not stated) ▪ USA	▪ National Cancer Institute (NCI) and Commission on Cancer ▪ Four "surgical care improvement projects" measures	▪ No difference between NCI centres compared to non-accredited or accredited centres ▪ Accredited centres were less likely to have poor performance compared with non-accredited for 3 of the 4 measures ▪ No information on the accreditation programmes, no description of the content of the four measures, measures of hospital characteristic were from 2010
Schmaltz SP et al, (46) 2011	▪ Historical follow-up study ▪ 2004 and 2008 ▪ CMS Hospital Compare database and The Joint Commission ORYX database ▪ Accredited versus never-accredited at hospital level	▪ Patients with myocardial infarction, heart failure, and pneumonia ▪ 3,891 hospitals (number of patients not stated) ▪ USA	▪ JCAHO accreditation ▪ 16 processes of care: - myocardial infarction=7 - heart failure=4 - pneumonia=5	▪ Overall composite score: accredited hospitals had larger improvements (absolute difference: 4.2 (95% CI: 3.2–5.1) (accredited 16.1 versus never-accredited 12.0)) ▪ At disease level, the accredited hospitals improved more for all three diseases ▪ Accredited hospitals were more likely to have high performance (>90%) for the overall and the three diseases separately (overall: adjusted OR 2.32, 95% CI: 1.76–3.06 (accr. 83.8% versus never-accr. 69.0%)) ▪ No information on the accreditation programme; the 19% excluded hospitals were more likely small, rural non-accredited hospitals; baseline characteristics included hospitals that later were excluded from the analyses as they were only accredited in part of the study period

Chandra A et al, (42) 2009	▪ Historical follow-up study ▪ 2005 ▪ CRUSADE database ▪ Accredited versus non-accredited at patient level	▪ Patients with non-ST segment elevation myocardial infarction and acute coronary syndrome ▪ 33,238 patients at 344 centres ▪ USA	▪ Society of Chest Pain Centres ▪ Six acute care process measures	▪ Patients at accredited hospitals were more likely to receive two of the six measures (acute aspirin: adjusted OR 1.73, 95% CI: 1.06–2.83; acute beta-blocker: adjusted OR 1.68, 95% CI: 1.04–2.70) ▪ No difference was found for the four remaining measures ▪ Limited information on accreditation programme, excluded 174 patients who died within 24 hours
Lutfiyya MN et al, (44) 2009	▪ Cross-sectional study ▪ March 2006 ▪ CMS Hospital Compare database ▪ and The Joint Commission ORYX database ▪ Accredited versus non-accredited at patient level	▪ Patients with AMI, heart failure, pneumonia, and surgical infection prevention ▪ 218,290 patients at 730 critical access hospitals ▪ USA (45 states)	▪ JCAHO accreditation ▪ 16 quality process measures - AMI/heart attack=4 - heart failure=4 - pneumonia=6 - surgical infection prevention=2	▪ Four process measures were in favour of accreditation (one AMI, two heart failure, one pneumonia) ▪ No difference in 12 measures (three AMI, two heart failure, five pneumonia, and all surgical infection) ▪ For 6 of the measures, accredited hospitals were more likely to place in the top half placement (one AMI, three heart failure, two pneumonia) ▪ Accredited hospitals were more likely to score in top than bottom half than non-accredited for a composite quality score (unadjusted OR 1.39 (95% CI: 1.09–1.76)) ▪ Limited information on accreditation programme, 44% excluded hospitals, voluntary reporting
Chen J et al, (38) 2003	▪ Historical follow-up study ▪ Jan 1994 to Feb 1996 ▪ Cooperative Cardiovascular Project, Medicare Enrolment Database ▪ Accredited versus non-accredited	▪ Medicare patients with clinically confirmed AMI ▪ 134,579 patients at 4,221 hospitals ▪ USA – 50 states and the District of Columbia	▪ JCAHO accreditation ▪ 5 clinical performance measures for AMI	▪ Patients at non-accredited hospitals were less likely to receive the five measures than patients at accredited hospitals ▪ Limited to patients over age 65 years, case mix adjustments performed at hospital level for each JCAHO group assuming homogeneity, no 95% CI on the estimates.

Table 3. Identified literature on accreditation and mortality

STUDY II: ACCREDITATION AND MORTALITY				
Author, year	**Design, period, data source, analysis**	**Population, size, setting**	**Exposure and definition of outcome**	**Main results and limitations**
Telem DA et al, (47) 2015	▪ Historical follow-up study ▪ 2004 to 2010 ▪ Statewide Planning and Research Cooperative System ▪ 1) Accredited versus never-accredited, 2) accredited versus non-accredited, 3) pre- and post-accreditation	▪ Patients undergoing bariatric surgery ▪ 47,342 patients ▪ US (New York)	▪ Metabolic and Bariatric Surgery Accreditation and Quality Improvement Programme ▪ Mortality calculated from surgery to day of death divided into short (<30) and long term (>30)	▪ Increase in 30-day mortality for never- and non-accredited hospitals (never 0.16% vs accr. 0.06%, p=0.009; non-accr 0.1% vs accr. 0.05%, p=0.049) ▪ No difference in long-term mortality with a mean follow-up of 5.4 years (never/accr.: adjusted HR 1.2, 95% CI: 0.96–1.5; non/accr: adjusted HR 0.89, 95% CI: 0.72–1.06) ▪ No difference in 30-day or long-term mortality for pre- and post-accreditation (0.8% vs 0.5%, p=0.19; adjusted HR 0.93, 95% CI: 0.76–1.13) ▪ No information on the accreditation programme. Accreditation was based on two programmes; patients admitted before the hospital was officially accredited were included in the non-accredited group.
Gratwohl A et al, (48) 2014	▪ Historical follow-up study ▪ Jan 1993 to Dec 2006 ▪ European Group for Blood and Marrow Transplantation database ▪ Accredited versus non-accredited	▪ Patients with HSCT ▪ 107,904 patients at 585 centres ▪ Europe	▪ JACIE ▪ Overall survival and non-relapse mortality	▪ Improvements in overall mortality rate was in favour of accredited centres (5.3% pr. year at accredited vs 3.5% pr. year at non-accredited) ▪ Difference in speed of improvements was in favour of accreditation by an overall survival of HR 0.83 (95% CI: 0.71–0.97). ▪ Limited information on accreditation programme, no absolute number provided
Morton JM et al, (49) 2014	▪ Historical follow-up study ▪ 2010 ▪ Nationwide Inpatient Sample data ▪ Accredited versus non-accredited at patient level	▪ Patients >18 years undergoing bariatric surgery ▪ 72,615 patients at 145 hospitals ▪ USA	▪ Metabolic and Bariatric Surgery Accreditation and Quality Improvement Programme ▪ Mortality not defined	▪ Higher mortality for non-accredited hospitals (0.13% vs 0.07%; p=0.019) ▪ OR for in-hospital mortality: 2.26 (95% CI: 1.24–4.10) for non-accredited compared with accredited hospitals ▪ No information on the accreditation programme, exclusion of 90 hospitals due to no name in the NIS, outcome not defined in the method section, no absolute numbers stated, 95% CI not provided for counts
Kwon S et al, (50) 2013	▪ Historical follow-up study ▪ Jan 2003 to Sept 2009 ▪ MarketScan Commercial Claims and Encounter Database ▪ Difference in difference approach between pre- and post-introduction of a National Coverage Decision (NCD) including accreditation at patient level	▪ Patients undergoing bariatric surgery and commercially insured ▪ 30,755 patients (number of centres not stated) ▪ USA	▪ American College of Surgeons and American Society for Metabolic and Bariatric Surgery ▪ Inpatient mortality	▪ Reduction in mortality rate from pre- to post NCD in accredited hospitals (0.3% to 0.1%, p=0.01) ▪ No difference in non-accredited hospitals (0.2% to 0.2%, p=0.6) ▪ After adjusting, there was a 0.4% decrease in inpatient mortality rate at accredited hospitals due to introduction of NCD ▪ No information on the accreditation programmes, no hospital

				characteristics presented, 2/3 of the source population excluded due to missing hospital ID number, small values for inpatient mortality (39 vs 28), only in-hospital mortality included
Nguyen NT et al, (51) 2012	▪ Historical follow-up study ▪ Oct 2007 to Dec 2009 ▪ University Health System Consortium database ▪ Accredited versus non-accredited at patient level	▪ Patients undergoing bariatric surgery ▪ 35,284 patents at 214 centres ▪ USA centres affiliated with the UCH	▪ American College of Surgeons ▪ In-hospital mortality defined as death before being discharged	▪ Non-accredited centres associated with a 3.5-fold increase in observed in-hospital mortality risk compared with accredited centres (95% CI: 1.5–8.0) ▪ No information on the accreditation programme, patients undergoing emergent surgery excluded, short time frame for outcome (in-hospitals) in the light of short mean LOS ~2.5 day, not able to adjust for covariates at patient level
Gratwohl A et al, (52) 2011	▪ Historical follow-up study ▪ Jan 1999 to Jan 2007 ▪ European Group for Blood and Marrow Transplantation database ▪ Phase of the accreditation process at patient level	▪ Patients with hematopoietic stem-cell transplantation (HSCT) ▪ 107,904 (number of institutions not specified) ▪ Europe	▪ JACIE ▪ Overall survival, relapse incidence, non-relapse mortality, relapse-free survival - Time frame not specified	▪ Overall survival significantly better for accredited centres than baseline (HR 0.87, 95% CI: 0.79–0.97) ▪ No difference in non-relapse mortality found between accredited and baseline (allogeneic HSCT patients: HR 0.89, 95% CI: 0.77–1.02). Autologous HSCT patients: HR 0.85, 95% CI: 0.57–1.26 ▪ Relapse-free survival was higher for accredited compared with baseline (allogeneic HSCT patients: HR 0.85, 95% CI: 0.75–0.95. Autologous HSCT patients: HR 0.83, 95% CI: 0.74–0.93 ▪ Limited information on accreditation programme, data from centres not seeking accreditation included in the baseline data, numbers of deaths not stated
Chandra A et al, (42) 2009	▪ Historical follow-up study ▪ 2005 ▪ CRUSADE database ▪ Accredited versus non-accredited at patient level	▪ Patients with non-ST segment elevation myocardial infarction and acute coronary syndrome ▪ 33,238 patients at 344 centres ▪ USA	▪ Society of Chest Pain Centres ▪ In-hospital mortality defined as death from any cause during hospitalisation	▪ No difference in mortality observed (adjusted OR 1.07, 95% CI: 0.80–1.42) (3.5% at non-accredited vs 3.4% at accredited) ▪ Limited information on accreditation programme, patients who died within 24 hours were excluded (n=174)
Chen J et al, (38) 2003	▪ Historical follow-up study ▪ Jan 1994 to Feb 1996 ▪ Cooperative Cardiovascular Project, Medicare Enrolment Database ▪ Accredited versus non-accredited	▪ Medicare patients with clinically confirmed AMI ▪ 134,579 patients at 4,221 hospitals ▪ USA – 50 states and the District of Columbia	▪ JCAHO accreditation ▪ 30-day mortality	▪ Non-accredited hospitals had higher 30-day mortality rates than accredited hospital:; HR 1.15; p<0.001 (mean observed risk-standardised 30-day mortality: 18.4% at accredited vs 20.4% at non-accredited) ▪ Limited to patients over age 65 years, case mix adjustments performed at hospital level for each JCAHO group assuming homogeneity, no 95% CI on the estimates.

2.6.4 Accreditation and mortality

The majority of identified publications on mortality were carried out by comparing accredited with non-accredited hospitals (38,42,47-49,51) or by investigating the improvements before and after the introduction of accreditation (47,50,52). Table 3 lists the identified publications by publication year and first author. The studies showed variable results, including results in favour of accreditation (38,48-52), no differences (42), or inconsistency within the study results (47).

To determine the effectiveness of accreditation on mortality, different measures have been used including in-hospital mortality, mortality index or ratio, and 30-day mortality. A broader perspective has recently been introduced by Gratwohl et al by using overall survival for up to 3 years for patients having haematopoietic stem cell transplantation (48,52). The later studies showed an increased survival for European patients at JACIE-accredited centres. In contrast, a recently published study found no difference in long-term mortality for patients undergoing bariatric surgery when comparing accredited and non-accredited hospitals in the state of New York (47). The three other studies performed on patients undergoing bariatric surgery included a large number of hospitals across the US and, thus, focused on in-hospital mortality (49-51). These studies all reported findings in favour of accreditation.

Differences in patient- and hospital-related characteristics between the accredited and non-accredited hospitals were handled in different ways in the identified studies. Some studies applied different models for standardised mortality (38,51) or in the more recent studies by adjusting for patient-related factors (between 4 and 18 factors) (47-49). Hospitals or non-clinical factors were included in some studies by stratification (48,52) or included as adjustments or within clustering in the analyses performed (38,42,49). Most studies did adjust for patient characteristics, but only half accounted for potential differences in hospital characteristics, all conducted within the last 5 years. The studies mainly included selected medical conditions in a specialised setting, but some also excluded a large number of hospitals from the analyses because of, for example, no hospital identification number or low enrolment of patients (39,40,42,49,50).

Based on the identified literature, no conclusion could be drawn. The studies comparing accredited with non-accredited hospitals give some indications of a trend towards accreditation being associated with lower mortality. However, the comparability among studies was limited because of considerable variation in study characteristics, use of accreditation programme, and definition of mortality.

2.6.5 Accreditation and length of stay

The literature search revealed only four studies examining the association between accreditation and LOS (49,51,53,54). Corresponding with the other outcomes, the association has predominantly been investigated by comparing accredited with non-accredited hospitals in the US setting, including patients with selected medical conditions (49,51,53). All studies used a different definition of LOS calculated in minutes or days. The studies are listed by publication year and first author in Table 4.

LOS was favoured by accreditation in two of the three studies (49,51) and by the introduction of accreditation in one (54), although the differences revealed in general were modest. In contrast, Kurichi et al reported a longer LOS for patients with major lower extremity amputation at accredited than non-accredited rehabilitation facilities (CARF-accredited). However, this accreditation programme required that specialised services were available for a comprehensive treatment, which may explain the revealed difference. In general, the studies did not provide 95% confidence intervals (CI) for the reported LOS or measure of association (49,51,53).

In summary, the literature search revealed a very limited number of studies investigating the relationship between accreditation and LOS.

2.6.6 Accreditation and readmission

The literature search revealed only two published studies on the association of accreditation and readmission, listed in Table 5, both with readmission as a secondary outcome (Kwon, Nguyen). The two studies were conducted on US patients undergoing bariatric surgery at centres non-accredited or accredited by the same programme but with different measures of readmission used: 30-day and 90-day, respectively (50,51). The largest historical follow-up study by Nguyen et al reported no difference in 30-day readmission from discharge to the index hospital for any reason between accreditation statuses (51). Comparing differences between pre- and post-accreditation, Kwon et al found that both accredited and non-accredited hospitals achieved a reduction in readmissions within 90 days from the performed procedure and reported no difference in accreditation status (50). None of the studies adjusted for differences between patient characteristics at accredited and non-accredited centres.

So far, hardly any attention has been paid to the role of accreditation in ARs.

Table 4. Identified literature on accreditation and length of stay

STUDY III: ACCREDITATION AND LENGTH OF STAY				
Author, year	**Design, period, data source, analysis**	**Population, size, setting**	**Exposure and definition of outcome**	**Main results and limitations**
Kurichi JE et al, (53) 2013	▪ Historical follow-up study ▪ Oct 2002 to Sep 2003 ▪ Nine Veteran Health Administrative databases ▪ Accredited versus non-accredited at patient level	▪ Patients with a new major lower extremity hip-to-ankle amputation ▪ 1536 patients at 100 centres ▪ USA	▪ Commission on Accreditation of Rehabilitation Facilities (CARF) ▪ LOS defined as time from admission to discharge	▪ Longer mean LOS for patients at accredited centres compared to non-accredited (36.0 days vs. 25.7 days) ▪ No information of the accreditation programme, exclusion of patients with no rehabilitation discharge date, time scale for LOS not stated, 95% CI not provided, no association measure calculated
Morton JM et al, (49) 2014	▪ Historical follow-up study ▪ 2010 ▪ Nationwide Inpatient Sample data ▪ Accredited versus non-accredited at patient level	▪ Patient >18 years undergoing bariatric surgery ▪ 72,615 patients at 145 hospitals ▪ USA	▪ Metabolic and Bariatric Surgery Accreditation and Quality Improvement Programme ▪ LOS not defined	▪ Higher mean LOS for non-accredited hospitals (2.20 vs 1.99 p<0.0001) ▪ No information of the accreditation programme, exclusion of 90 hospitals due to no name in the NIS, outcome not defined in the methods section, no absolute numbers stated, 95% CI not provided for counts
Nguyen NT et al, (51) 2012	▪ Historical follow-up study ▪ Oct 2007 to Dec 2009 ▪ University Health System Consortium database ▪ Accredited versus non-accredited at hospital level	▪ Patients undergoing bariatric surgery ▪ 35,284 patents at 214 centres ▪ USA centre affiliated with the UCH	▪ American College of Surgeons ▪ LOS: Time from surgery to discharge	▪ Mean LOS: 2.4 days at accredited and 2.7 days at non-accredited centres ▪ Mean difference in LOS was significantly longer at non-accredited centres with a mean difference of 0.3 days (95% CI: 0.16–0.44) ▪ No information of the accreditation programme, patients undergoing emergent surgery excluded, time scale for LOS not defined
Frasco PE et al, (54) 2005	▪ Cross-sectional study ▪ 2000 and 2002 ▪ Record review ▪ Before/after implementation at hospital level	▪ Patients having general anaesthesia and admitted at post-anaesthesia care unit ▪ 1,082 patients at one centre ▪ USA (Scottsdale, AZ)	▪ Joint Commission's Pain Initiative ▪ LOS was recorded from time of admission to the time when discharge criteria were met	▪ Mean overall LOS: 105.6 min (SD 52.6) in 2000 and 97.9 min (SD 47.1) in 2002 ▪ Overall mean LOS decreased by <10% (p<0.01) ▪ Limited information of the accreditation programme, no information on numbers of admissions in 2000 or 2002, assessing discharge criteria

2.6.7 Summary and limitations of the identified literature

Taking into account the considerable global use of accreditation, the number of identified studies was remarkably low. In addition, the number of studies investigating the association with patient-related outcomes was surprisingly low. Altogether, the reported studies reached discrepant results, and it was therefore not possible to draw a conclusion or to point to an strong direction of association.

The inconsistency in the reported associations may be based on several factors. Because all identified studies used an observational design, one cannot rule out that bias and/or confounding may have influenced the results because of a lack of randomisation. Many of the studies had limited available patient data to adjust for potential confounding factors, which may have contributed to the inconsistent findings. But the differences between analyses performed at the patient and hospital levels also must be taken into consideration when summing up the results. The comparison of accredited with non-accredited hospitals, used by the majority of identified studies, is likely to have introduced selection problems in the results. Hospitals seeking accreditation may be at a more advanced stage of quality improvement than those not going for accreditation, both arising from the voluntary nature of accreditation. Another difference is demonstrated in the descriptive tables of hospital characteristics according to accreditation status, where the accredited hospitals more often were larger, high-volume, university-affiliated, and urban (38,42,45,46,48,51). Despite these differences, only a limited number of studies performed additional analyses or adjusted for differences between hospitals to address this concern.

Surprisingly, hardly any information was provided by the authors on the content of accreditation programmes under investigation. It therefore remains unclear in what way the framework of accreditation could be attributed to improvements in the delivered care, e.g., lower mortality or receiving the recommended hospital care.

Overall, the literature review revealed continued uncertainty about the effectiveness of accreditation for patient-related outcomes, including the value of compliance with accreditation to distinguish the hospital's ability to improve patient-related outcome. Yet, the scepticism evoked among, e.g., healthcare providers when introducing the DDKM as a method to improve hospital care has not been accommodated. Hence, there is a need for well-designed studies taking into consideration some of the weaknesses of those previously conducted by addressing issues of selection bias, insufficient confounder control, and possible interactions with hospital characteristics.

Table 5. Identified literature on accreditation and readmission

STUDY III: ACCREDITATION AND READMISSION				
Author, year	**Design, period, data source, analysis**	**Population, size, setting**	**Exposure and definition of outcome**	**Main results and limitations**
Kwon S et al, (50) 2013	▪ Historical follow-up study ▪ Jan 2003 to Sep 2009 ▪ MarketScan Commercial Claims and Encounter Database ▪ Difference in approach between pre- and post-introduction of a NCD, including accreditation at patient level	▪ Patients undergoing bariatric surgery and commercially insured ▪ 30,755 patients (number of centres not stated) ▪ USA	▪ American College of Surgeons and American Society for Metabolic and Bariatric Surgery ▪ Readmission to a hospital within 90 days of the procedure	▪ Reduction in 90-day readmission from pre- to post-NCD in accredited hospital (10.8% to 8.8%, p<0.05) and in non-accredited hospitals (11.6% to 9.5%, p<0001) ▪ Introduction of NCD had no effect on 90-day readmission after adjusting (-0.2%) ▪ No information on the accreditation programmes, no hospital characteristics presented, 2/3 of the source population excluded due to missing hospital ID number, unclear whether readmission at any hospital was included
Nguyen NT et al, (51) 2012	▪ Historical follow-up study ▪ Oct 2007 to Dec 2009 ▪ University Health System Consortium database ▪ Accredited versus non-accredited at patient level	▪ Patients undergoing bariatric surgery ▪ 335,284 patients at 214 centres ▪ USA; centre affiliated with the UCH	▪ American College of Surgeons ▪ Readmission to the index hospital for any reason within 30 days of discharge	▪ 30-day readmission: 2.0% at accredited and 2.5% at non-accredited centres ▪ No significant difference in readmission was observed (Relative risk 1.22, 95% CI: 0.98–1.51) ▪ No information on the accreditation programme, patients undergoing emergent surgery excluded, only readmission to the index hospitals included

3.0 AIMS AND HYPOTHESIS

The findings from the literature review identified a need for studying the effectiveness of compliance with accreditation on patient-related outcomes. Using the Danish setting with all public hospitals being accredited by the first version of the DDKM, four patient-related outcomes were examined with aims and hypotheses as follows.

3.1 Recommended hospital care (Study I)

The aim was to examine the association between compliance with a national accreditation programme and recommended hospital care at Danish public hospitals. The hypothesis was that patients at a hospital fully compliant with the accreditation programme were more likely to receive the recommended care according to clinical guidelines than patients at hospitals partially compliant with accreditation.

3.2 30-day mortality (Study II)

The aim was to examine the association between compliance with a national accreditation programme and 30-day mortality after admittance at Danish public hospitals. The hypothesis was that patients admitted at a hospital fully compliant with the accreditation programme had a lower risk of dying within 30 days after admission than patients admitted at hospitals partially compliant with accreditation.

3.3 Length of stay (Study III)

The aim was to examine the association between compliance with a national accreditation programme and LOS at Danish public hospitals. The hypothesis was that patients admitted at a hospital fully compliant with the accreditation programme were more likely to be discharged before patients admitted at hospitals partially compliant with accreditation.

3.4 Acute readmission (Study III)

The aim was to examine the association between compliance with a national accreditation programme and AR after discharge from Danish public hospitals. The hypothesis was that patients admitted at a hospital fully compliant with the accreditation programme had a lower risk of being readmitted within 30 days after discharge than patients admitted at hospitals partially compliant with accreditation.

4.0 METHODS

The three studies are based on information from publicly available registries that included the entire Danish population.

4.1 Data sources

Data used was prospectively recorded in national population-based registries (55,56). All public registries can be unambiguously linked at the individual level due to a unique 10-digit civil registration number assigned to all residents since 1968 (57).

4.1.1 Data on accreditation (All studies)

Data from the accreditation of all public hospitals are publicly available at IKAS' accreditation website and the official portal of the public Danish Healthcare Services (www.ikas.dk or www.sundhed.dk). The information is available for the surveyed hospitals, separately, in a survey report containing information on I) the first day of the onsite survey; II) awarded level of accreditation; III) justification of level of accreditation and potential follow-up activity by the Accreditation Award Committee; and IV) fulfilment of measurable elements and standards including reasoning for measurable elements and standards not met. Each survey report was downloaded and edited for consistent coding, necessary for generating one usable research file due to data being entered routinely and not for research purposes. Data from accreditation was linked with the medical registries by the hospitals' unique classification numbers that also were present in the report.

4.1.2 The Classification of Danish hospitals and departments (All studies)

The Danish hospitals and departments are classified in a hierarchical structure. Each hospital is assigned a unique 4-digit number, each department a 6-digit number, and units a 7-digit number, the first four numbers of which are equal to the hospital's number (58). The classification was used to identify the provider of care for the included treatment in study I and admissions in studies II and III.

4.1.3 The National Clinical Quality Registries (Study I)

Data for study I were obtained from six national, clinical disease-specific registries covering acute stroke, chronic obstructive pulmonary disease (COPD), diabetes, heart failure, hip fracture, and ulcers, including both bleeding and perforated ulcers. These registries were established from 2003 and forward with the aim to document, monitor, and improve quality of care at a national and local level through auditing (13,59). Participation is compulsory for all hospitals according to Danish law. With a set of clinical performance measures reflecting recommendations in national clinical guidelines, delivered hospital care is monitored for each condition. Performance measures were identified for each condition by multidisciplinary expert groups based on scientific evidence and feasibility of data collection (60). The registries are responsible for data analysis, evaluation, and interpretation, regular

feedback to the providers, conducting national audits, and public disclosure of results annually (www.sundhed.dk). The providers are accountable for using the feedback to improve the delivered care. Information is collected prospectively as part of the daily clinical work by the staff caring for the patients. The staff reports for the individual patient whether or not specific processes of care are delivered in accordance with predefined, exhaustive criteria established by the expert group. In all registries, though, patients can be classified as not eligible for the individual performance measures e.g., due to contraindications. Consequently, the number of eligible patients varies among the performance measures. Quality and completeness of the registered information are checked regularly through audits and comparison with other data sources (e.g., The DNRP). The completeness of the registration of patients and variables registration is consequently in general high (i.e., over 90%) (61-63).

4.1.4 The Civil Registration System (Studies II and III)

The Civil Registration System was started in 1968 and is updated daily. The Civil Registration System assigns the civil registration number to the residents at birth or immigration and contains information on vital status including date on birth, death, emigration or immigration, and place of residence in Denmark.

4.1.5 The Danish National Patient Registry (Studies II and III)

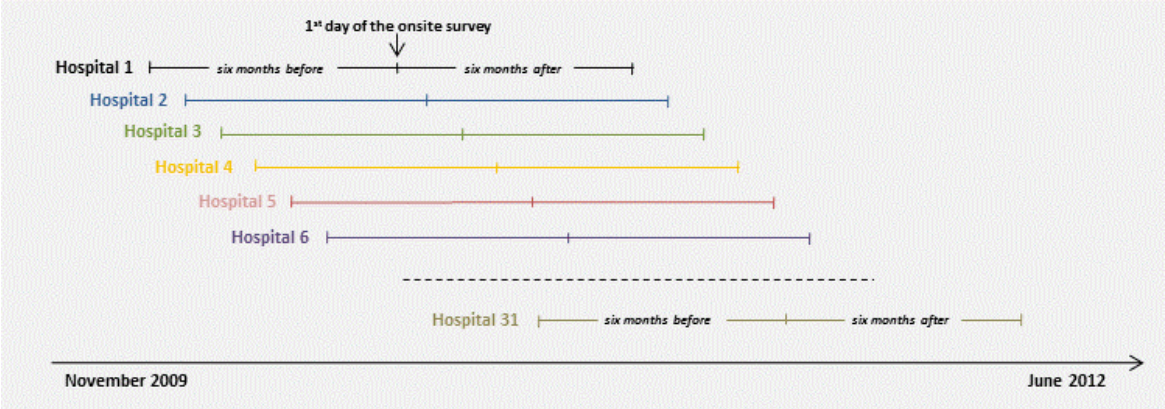
Since 1977, all somatic hospitalisations have been recorded in The Danish National Patient Registry (DNPR), and from 1995 psychiatric admission, outpatients, and emergency room contacts also have been recorded (64,65). Reporting to the DNPR is mandatory and consists of two types of data: administrative data (e.g., time and dates) and clinical data (e.g., diagnoses and procedures). For each hospitalisation, one primary diagnosis is coded at the time of discharge as the latest according to the 10th edition of the International Classification of Diseases since 1994 and before that the 8th edition (21). The primary diagnosis is to reflect the main reason for hospitalisation.

4.2 Study design

All three studies were designed as nationwide, population-based, follow-up studies covering the period from November 15, 2009, to December 13, 2012.

The 3-year inclusion time was based on a 1-year inclusion period from all hospitals calculated from ±6 months from the first day of their onsite survey as illustrated in Figure 2. This period was considered appropriate because the hospitals introduced accreditation at different rates, mainly according to the time of the survey. Approximately 6 months before the survey, an enhanced effort was undertaken to put guiding documents into practice and to monitor the quality surveillance (steps 2 and 3). After the survey, additional work to become fully compliant with the standards was carried out and ended most likely after 6 months.

Figure 2. Illustration of the difference in time between inclusion periods for the included hospitals



4.3 Study population

Study I included patients with acute stroke, COPD, diabetes, heart failure, hip fracture, and ulcers, including bleeding and perforated, registered in the national clinical quality registries for these six conditions.

Studies II and III included patients with 1 of 80 primary diagnoses accounting for 80% of all deaths within 30 days after admission according; please see paper II for a list of the 80 included diagnoses. This restriction was undertaken to reduce heterogeneity among patients hospitalised at the different included hospitals.

4.4 Compliance with accreditation

The first version of the DDKM was founded on the basic model for systematic quality development and launched in August 2009 (24). The first public hospital was accredited by the DDKM in May 2010. In the DDKM, accreditation was based on an onsite survey every 3 years and a midterm visit halfway to the next onsite survey to ensure continuous efforts for quality improvement related to the DDKM; please see Figure 1. This section outlines the basic principle for accreditation according to the DDKM, including the content of the programme and how compliance was assessed.

4.4.1 Content of the first version of the DDKM

The first version of the DDKM consisted of 104 accreditation standards grouped into 37 themes organised into three categories: organisational, general patient pathway, and disease-specific activities. The content of the DDKM is listed in Table 6. Each of the 104 standards was specified in detail with two or more measurable elements (e.g., an indicator or a criterion). The measurable element outlined the requirement of the standard text or aim and enumerated what the hospitals should meet to satisfy the standard in full. Hence, the wording provided support to the hospitals in clarifying the standard requirement for preparing for the survey.

Table 6. Content of the first version of the DDKM for hospitals (24)

Category	Theme	Standard
Organisational	Management	Business mission Management principles Planning and operations Financial management Data safety and confidentiality The institution's buildings, supplies, and other facilities
	Quality and risk management	Quality policy Quality organisation Documentation and monitoring of quality and patient safety Quality improvement Use of clinical guidelines Risk management Patient identification Reporting and follow-up of adverse events Care of patients, relatives, and staff after an adverse event Patient complaints and patient insurance matters
	Documentation and data management	Document management Patient health record Consistency and recognisability Allergy and intolerance
	Employment, work planning, and competence development	Employment of staff Employment of senior hospital physicians Introduction of new staff Work planning Training and competence development
	Hygiene	Hygiene policy Hygiene organisation Documentation and monitoring of nosocomial infections Procedures and work routines in the re-use of medical equipment, textiles, and materials Hand hygiene
	Preparedness and supplies	Emergency plan The institution's critical, patient-related technical supplies
	Equipment and technology	Acquisition and implementation of devices for clinical use Handling of equipment for clinical use Maintenance, repair, and phasing-out of equipment for clinical use
General patient pathway	Patient involvement	Informed consent to treatment The patient's involvement in decisions concerning treatment Involvement of relatives in treatment of patients Religious and cultural support for patients
	Religious and cultural support for patients	Important talks with the patient Written information during the course of treatment
	Coordination and continuity	Integrated care pathway Health professional contact person Responsibility for the pathway of patients with a chronic disease
	Referral	Referrals
	Triage	Triage of acute patients to correct unit Patient appointments for examination and treatment
	Admission	Emergency admissions Admission of elective referred patients
	Assessment and planning	Treatment plan in somatic care Treatment plan in psychiatry Detention and use of other coercion in psychiatry Assessment of suicide risk Pain assessment and treatment
	Diagnosis	Planning of clinical investigations Requisition of and sampling for diagnostic analyses Laboratory services Imaging services Procedures performed outside the diagnostic unit Timely reaction to test results
	Medication	Prescription of medicine Dispensing of medicines Administration of medicines

		Medicine reconciliation Storage of medicines Medicines for emergency situations
	Observation	Observation of and follow-up on critical observation results Sedation of patient in connection with invasive procedures without the involvement of anaesthesia staff
	Invasive treatment	Assessment prior to invasive treatment under anaesthesia Patient's stay in the recovery room Prevention of surgical confusions Counting and check of material used in connection with surgical and other invasive procedures
	Intensive care	Access to services in the intensive care unit Treatment in the intensive care unit
	Resuscitation	Treatment of cardiac arrest
	Nutrition	Nutritional screening Nutritional plan and follow-up
	Rehabilitation	Rehabilitation
	Prevention and health promotion	Policies for prevention and health promotion Identification of health-related risk Intervention towards patients with a health risk Training of patients with a chronic disease
	Transfer	Agreements on collaboration with the primary sector Information to general practitioner on discharge of patient Information to municipality on the discharge of a patient from the institution Information on the transfer between units and institutions
	Patient transport	Patient transport with healthcare professional escort
	At the end of life	Palliative care of the incurably ill patient and care for the patient's relatives Care of the deceased patient
Disease specific	Stroke	Stroke
	Breast cancer	Breast cancer
	Diabetes	Diabetes
	Pregnancy, delivery, and childbirth	Pregnancy Delivery Childbirth
	Cardiac insufficiency	Cardiac insufficiency
	Femoral fractures	Femoral fractures
	COPD	Chronic obstructive pulmonary disease
	Lung cancer	Lung cancer
	Gastric ulcer	Acute bleeding gastric ulcer Perforation of gastric ulcer
	Schizophrenia	Adults with schizophrenia Children and adolescents with schizophrenia

To emphasize the focus on continuous quality improvement, the four steps of the Plan-Do-Study-Act circle (PDSA) were incorporated into a generic template used for developing standards. Table 7 outlines an example of a standard "Observation of and follow-up on critical observation results" to illustrate the content and use of the generic template in a general patient pathway standard. The first step included the existince of guiding documents describing how the quality in the given standard is met (Plan). Subsequently, the hospitals had to ensure that the guiding documents were implemented and used by relevant staff (Do). The third step required that the hospitals surveyed the quality of the structures and processes delivered (Study), and based on the results, the hospital management had to document actions for improvement where their quality was inadequate (Act). Although no fully articulated programme theory was provided, the underlying theory was that the patients were more likely to receive optimal care if all four steps were accomplished. Thus, it would lead to improved patient-related outcome, when the staff worked in accordance with guiding documents reflecting clinical evidence-based guidelines (or best practice) AND when the specific elements in the standards were monitored and improved to ensure that the purpose was endorsed AND by ensuring that systems for, e.g., quality and risk management were in place.

As noted, the DDKM was to integrate ongoing projects into the programme; hence, the national clinical quality registries were incorporated into the disease-specific standards. Here, the hospitals were obligated to report data to the registries and document action plans for improvement where the established threshold was not met. Thus, the actual performance on the measures in the clinical registries did not factor into the decision on compliance with the standard or the accreditation decision.

Table 7. Example of the generic template used in all accreditation standards and the content of a general patient pathway standard in the first version of the DDKM (24)

Heading	Description
Title of standard	**Observation** **2.10.1 Observation of and follow-up on critical observation results (1/2)**
Standard	Patients are observed to identify any deterioration in their condition as early as possible.
Purpose of standard	To ensure: ▪ identification of patients whose condition deteriorates ▪ prompt intervention to prevent development of serious complications
Target group (responsible)	Managers and staff observing and treating patients
Application area	All units involved in the treatment of patients
Compliance with standard	Indicators assessing the compliance of the standard are listed in the steps below
Step 1: **Guiding documents**	**Indicator 1** There are guidelines for observation and follow-up of observation results. As a minimum, the guidelines describe the following: ▪ Who is responsible for surveillance/monitoring ▪ Parameters to be observed and documented ▪ Definitions of critical deterioration in a patient's condition ▪ Who is paged to ensure prompt and competent assessment of the patient in the event of critical deterioration, e.g., mobile emergency team or outreach psychosis team *Guidance* Observation may be included in the unit's/institution's specific guidelines prepared for frequent patient groups.
Step 2: **Implementation and use of guiding documents**	**Indicator 2** Managers and staff are familiar with and use the guidelines.
Step 3: **Quality surveillance**	**Indicator 3** Reports on adverse events resulting from late recognition of critical deterioration of a patient's condition are assessed at least once a year; cf., Quality and risk management, standard 1.2.8.
Step 4: **Quality improvement**	**Indicator 4** Based on the quality surveillance, the management prioritises specific action to take on quality improvements; cf., Quality and risk management, standard 1.2.4.
References	1. Lovbekendtgørelse nr. 95 af 7. februar 2008, kap. 61. Bekendtgørelse af sundhedsloven med eventuelle senere ændringer 2. Bekendtgørelse nr. 451 af 21. maj 2007 om rapportering af utilsigtede hændelser i sygehusvæsenet 3. Vejledning nr. 30 af 21. maj 2007 om rapportering af utilsigtede hændelser i sygehusvæsenet 4. Dansk Patient-Sikkerheds-Database (DPSD). www.dpsd.dk

4.4.2 Compliance with the first version of the DDKM

Compliance with the DDKM was evaluated at an onsite survey announced approximately 6 months beforehand. The survey was performed by an independent survey team including a lead surveyor with the main task of assessing the findings related to the programme and summarising them in an overall assessment at the hospital level (66). The surveyors were healthcare professionals recruited and trained by IKAS to handle this task. Based on a detailed survey plan, the surveyors assessed compliance by: 1) interviewing primarily staff and patients, in addition to others; 2) observing procedures; 3) reviewing guidelines and other documents; and 4) conducting tracers. The two first mentioned methods were the most commonly used in relation to the first version of the DDKM. For further information on the training of surveyors and an example of a survey plan, please see Appendix.

A set of generic guidelines outlined the principles for rating measurable elements and standards (24). A 3-point scale was used for rating measurable elements, in which "met" meant that all requirements were met, "partially met" meant that most requirements were met or that activities were initiated to reach fulfilment, and "not met" indicated that no requirement was met and that no action was undertaken to reach fulfilment. The level of compliance with the standard depended on the rating of the measurable elements and on any shortcomings that were significant for the achievement of the standards' purpose and contents. A standard was "met" if i) all measurable elements were met; ii) there were shortages in the compliance, but the shortages were relatively less significant for the hospital's ability to comply with the overall purpose of the standard; or iii) there were shortages in the compliance, but specific action had been taken which according to the surveyors' assessment would result in "met" without further assessment. It was, however, emphasized that the survey team's independent assessment depended on the context of the survey.

During the survey, the survey team submitted its findings to a web-based system that generated a report after the survey was completed. The report was forwarded to the surveyed hospital with the opportunity to correct errors and raise objections. This phase was managed by IKAS, but changes and corrections were exclusively decided on by the lead surveyor. The survey report and additional files were presented to the Accreditation Awards Committee, which is an independent authority separated from IKAS to ensure a fair and equal assessment of the surveyed organisations. Based on all written material, the Committee awarded a level of accreditation corresponding to one of three categories: "accredited", "accredited with comments", or "conditionally accredited", as a way of categorising the hospitals' ability to implement the programme in depth (first proceeding). Hospitals were awarded "accredited" when demonstrating the ability to ensure quality in the areas covered by DDKM; i.e., if the standards were substantially met and any deficiencies in compliance (based on an overall assessment) were considered less significant corresponding to none, few, or minor comments or recommendations for follow-up (66). "Accredited with comments" was awarded when all standards were not met and there were comments of a certain nature and/or importance, but corrections were

expected to be achieved within a reasonable time. "Conditionally accredited" was awarded when a hospital was considered unable to comply with the standards within a reasonable timeframe and special actions had to be taken. The two first levels of accreditation were to be considered to indicate "accredited" but with different degrees for further improvement. Hospitals "accredited with comments" were offered the possibility to improve their compliance with the deficient measurable elements through a follow-up activity determined by the Accreditation Award Committee. If deficiencies were mainly related to staff's not using the guiding documents (Do-part), the hospitals were offered a return visit by a reduced survey team, whereas deficiencies mainly related to the other three steps resulted in the hospital's forwarding additional documents to IKAS. After the follow-up activity was completed, the Accreditation Awards Committee allocated the hospital a final level of accreditation, whereby the hospital was informed and the definitive report was published (final proceeding).

4.4.3 Standards with impact on the outcomes

Not all 104 standards were expected to have a direct impact on the chosen patient-related outcomes in this thesis (i.a because of DDKM's multi-dimensional objectives). Prior to the study execution, an expert group of nine persons with extensive knowledge of the DDKM and/or the Danish healthcare system were appointed to identify such standards. Using a self-designed web-based questionnaire, each expert selected the standards considered to have an impact on the outcome and afterwards prioritised these by importance. In this way, the 25 highest prioritised standards were identified. Standards included for further analyses were selected among those selected by at least three experts and with which at least three hospitals were not fully compliant. The expert panel identified between three to five standards for further analysis, listed by outcome in Table 8.

Table 8. A priori selected standards by the expert panel for the four outcomes

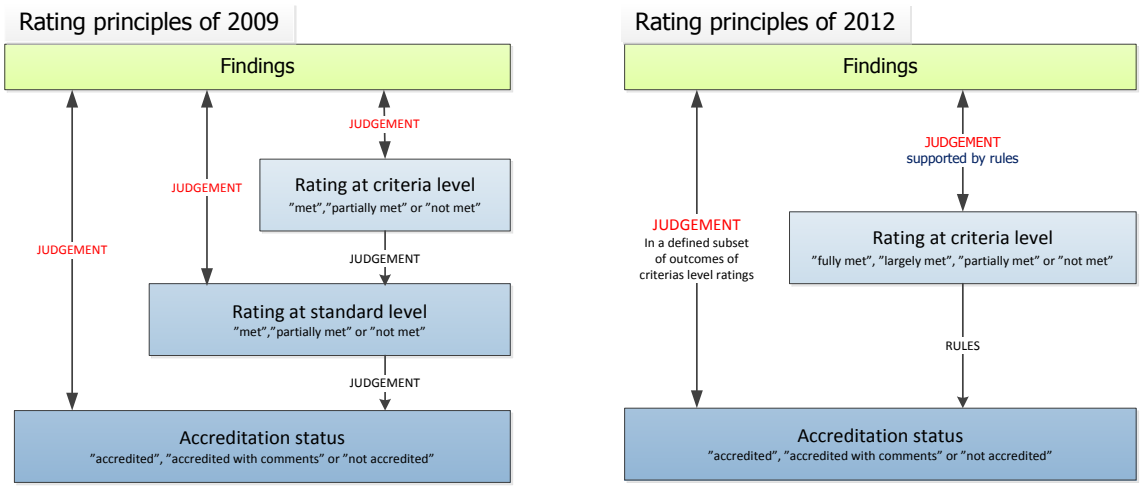
Outcome	Selected standards
Recommended hospital care	Risk management[1] Document management[1] Patient health record[1] Training and competence development[1] Observation of and follow-up on critical observation results[2]
30-day mortality	Risk management[1] Timely reaction to test results[2] Observation of and follow-up on critical observation results[2] Treatment of cardiac arrest[2]
Length of stay	Documentation and monitoring of nosocomial infections[1] Pain assessment and treatment[2] Timely reaction to test results[2] Observation of and follow-up on critical observation results[2]
Acute readmission	Pain assessment and treatment[2] Timely reaction to test results[2] Medicine reconciliation[2]

[1] Organisational standard
[2] General patient pathway standard

4.4.4 Alternative definition of compliance with accreditation

Despite several efforts undertaken by IKAS to ensure consistent assessments of compliance with accreditation, this risk of misclassification cannot be ruled out, in particular because the surveyors, IKAS, and the Accreditation Award Committee by definition were inexperienced given that this was the first cycle of accreditation ever performed according to the DDKM. This potential became evident when counting the numbers of fulfilled measurable elements and standards for all included hospitals, which highlighted a great variance in the fulfilled numbers among partially accredited hospitals. In addition, it showed that some hospitals that were designated as fully accredited especially had more measurable elements that were partially met than some hospitals designated as partially accredited (fully: up to 20 vs partially: down to 7). The latter scenario was mainly caused by the rating principles of 2009 being generic guidelines that did not include transparent rules for allocating level of accreditation. To overcome this issue, new rating principles were developed for the second cycle of accreditation, as illustrated in Figure 3 (67).

Figure 3. Decision path for assessing compliance with the standards according to the rating principles of 2009 and 2012, respectively (67)



A substudy was undertaken to reassess all partially and not met measurable elements for the public hospitals to account for a potentially inaccurate allocation of accreditation level. The reassessment was performed by three specialists using a pre-specified protocol outlining the rule for reassessment, with any differences to be solved by consensus. A total of 707 measurable elements were reassessed. All three specialists agreed in 72% of the reassessments, and in 1% of the reassessments, total disagreement was present. After a consensus meeting, all changes were documented in a file, and a level of accreditation was allocated the hospitals hereby referred to as in "compliance with the rating principles of 2012".

4.5 Outcome

4.5.1 Recommended hospital care (Study I)

Recommended hospital care was defined as a patient's probability of receiving the recommended care according to national clinical recommendations. It was measured by the process performance measures available in six national clinical quality registries included in the disease-specific standards in the DDKM and valid throughout the study inclusion period. A total of 48 process performance measures were included, and the content of and time frame for each measure are listed by medical condition in Table 9.

4.5.2 30-day mortality (Study II)

30-day mortality was defined as all deaths within 30 days after admission, included whether a patient died in the hospital or after leaving and irrespective of cause of death. Information on mortality was obtained from The Danish Civil Registration System (57).

4.5.3 Length of stay (Study III)

LOS was calculated from the date of the patient's admission in the study period (index date) to date of discharge. In case of transfer to another hospital, the admissions were linked together, and all days spent in hospitals were included in the LOS. Information on LOS was obtained from The DNPR (64).

4.5.4 Acute readmission (Study III)

AR defined as all-cause AR at any hospital within 30 days from the discharge date. Readmissions due to elective procedures performed were not included as an AR. Information on AR was obtained from The DNPR (64).

4.6 Covariate

Prior to conducting the study, a number of patient- and hospital-related factors with known or potential impact on the association under examination were identified and included in the analyses.

4.6.1 Hospital-related factors (All studies)

A history of previous accreditation was identified because some Danish hospitals had been accredited before by either JCI or HQS. Another known factor for improving delivered care is university affiliation (68,69). In the 2-year period during which the onsite surveys were conducted, continuous efforts were made by the hospitals to reduce mortality, LOS, and AR, respectively, and there was therefore a risk that the outcomes could be influenced by a calendar time effect. We thus included the hospital factor "time to survey" and categorised it into two equal time periods (before/after July, 2011).

Table 9. Content of and time frame for the 48 included process performance measures in the six national clinical quality registries

Condition	Process performance measure	Description	Time frame
Acute stroke	Admission after symptom onset (3 h)	Admission after symptom onset	3 hours after symptom onset
	Admission after symptom onset (4.5 h)	Admission after symptom onset	4.5 hours after symptom onset
	Admission to a stroke unit	A unit that exclusively or primarily is dedicated to patients with stroke and that is characterised by having multidisciplinary teams, a staff with a specific interest in stroke, involvement of relatives, and continuous education of the staff	Second day of hospitalisation
	Antiplatelet therapy initiated	Initiation of treatment with antiplatelet therapy	Second day of hospitalisation
	Oral anticoagulant therapy	Initiation of treatment with oral anticoagulant therapy	14th day of hospitalisation
	Examination with CT/MR scan	Examination with CT/MR scan	First day of hospitalisation
	Assessment by a physiotherapist	Formal bedside assessment of the patient's need for rehabilitation	Second day of hospitalisation
	Assessment by an occupational therapist	Formal bedside assessment of the patient's need for rehabilitation	Second day of hospitalisation
	Assessment of nutritional risk	Assessment following the recommendations of the European Society of Parenteral and Enteral Nutrition	Second day of hospitalisation
	Angiography of carotid arteries	Examination with ultrasound/CT-/MR-angiography of carotid arteries	Fourth day of hospitalisation
Chronic obstructive pulmonary disease	Lung function	Measured and recorded "forced expiratory volume1" in % of expected	During the last year
	Lung function including WLHLS	Measured and recorded "forced expiratory volume1" in % of expected including WLHLS	During the last year
	State of nutrition	Calculated and recorded body mass index	During the last year
	Respiratory distress	Measured and recorded respiratory distress with the use of the Medical Research Council's scale	
	Smoking status	Recorded smoking status	During the last year
	Smoking cessation	Recommended smoking cessation	
Diabetes	Measured HbA1c	Measure HbA1c level	During the last year
	Medication (antidiabetic)	Treatment with antidiabetic medication	At time of registration
	Blood pressure	Measure blood pressure	During the last year
	Medication (type 1)	Treatment with antihypertensive medication	At time of registration
	Medication (type 2)	Treatment with antihypertensive medication	At time of registration
	Medication (cholesterol)	Measure lipid level including low-density lipoprotein cholesterol	During the last 2 years
	Medication (dyslipidaemia)	Medical treatment of dyslipidaemia	At time of registration
	Examination of renal function	Examination of albuminuria level	During the last 2 years
	Medication (renal dysfunction)	Treatment with angiotensin-converting enzyme inhibitor/angiotensin II antagonist-receptor antagonist	At time of registration
	Eye examination (2 y)	Formal examination for complications including ophthalmoscopy performed by an ophthalmologist or fundus picture rated by ophthalmologist/specialist nurse	During the last 2 years
	Eye examination (4 y)		During the last 4 years
	Foot examination	Formal examination for complications including inspection of skin lesions and wounds, palpation of pulse, systematic examination of sensibility/vibration sensitivity	During the last 2 years
Heart failure	Echocardiography	Examination with echocardiography	During hospitalisation

	NYHA classification	Formal assessment following the New York Heart Association classification	At discharge or first outpatient visit
	Medication (ACE/ATII inhibitor)	Initiation of treatment with angiotensin-converting enzyme inhibitor/angiotensin II antagonist-receptor antagonist	During hospitalisation
	Medication (beta-blocker)	Initiation of treatment with beta-blockers	During hospitalisation
	Medication (aldosterone)	Initiation of treatment with aldosterone therapy	During hospitalisation
	Physical training	Referred to individual physical training	During hospitalisation
	Patient education	Formal start of a structured patient education (inclusive nutrition, physical training, understanding medical treatment, risk factors, and symptoms of the disease)	12 weeks after hospitalisation or first outpatient visit
Hip fracture	Systematic pain assessment	Daily systematic pain assessment in rest and during mobilisation using a validated scale	During hospitalisation
	Early mobilisation	Assisting the patient from bed rest to walking or rest in a chair	First day of hospitalisation
	Basic mobility assessment	Basic mobility assessment using a validated scale	During hospitalisation
	Post-discharge rehabilitation programme	A description of the patient's rehabilitation needs including assessment of activities of daily living before the fracture and before discharge	During hospitalisation
	Medication (anti-osteoporotic)	Initiation of treatment with anti-osteoporotic medication	During hospitalisation
	Prevention of future fall accidents	Initiation of treatment to prevent future fall accidents	During hospitalisation
Perforated and bleeding ulcer	Preoperative delay	Delay from hospital admission to surgery (out-of-hospital perforation) or from decision to operate to surgery (in-hospital perforation)	≤6 hours
	Prophylactic antibiotic therapy	Routine prophylactic antibiotics discontinued	Third day after surgery
	Systematic monitoring of body weight	Daily weight measurement (3 times daily)	Third day after surgery
	Postoperative monitoring	Measurement and registration of vital signs (blood pressure, heart rate, temperature, pulse oximetry, level of consciousness) twice daily	Third day after surgery
	Treatment/therapeutic endoscopic	Achievement of primary haemostasis	During hospitalisation
	Endoscopic treatment of rebleeding	Achievement of endoscopic haemostasis	During hospitalisation
	Surgical treatment	Surgical treatment of primary-/rebleeding ulcus	During hospitalisation or planned after discharge

4.6.2 Patient-related factors (Studies II and III)

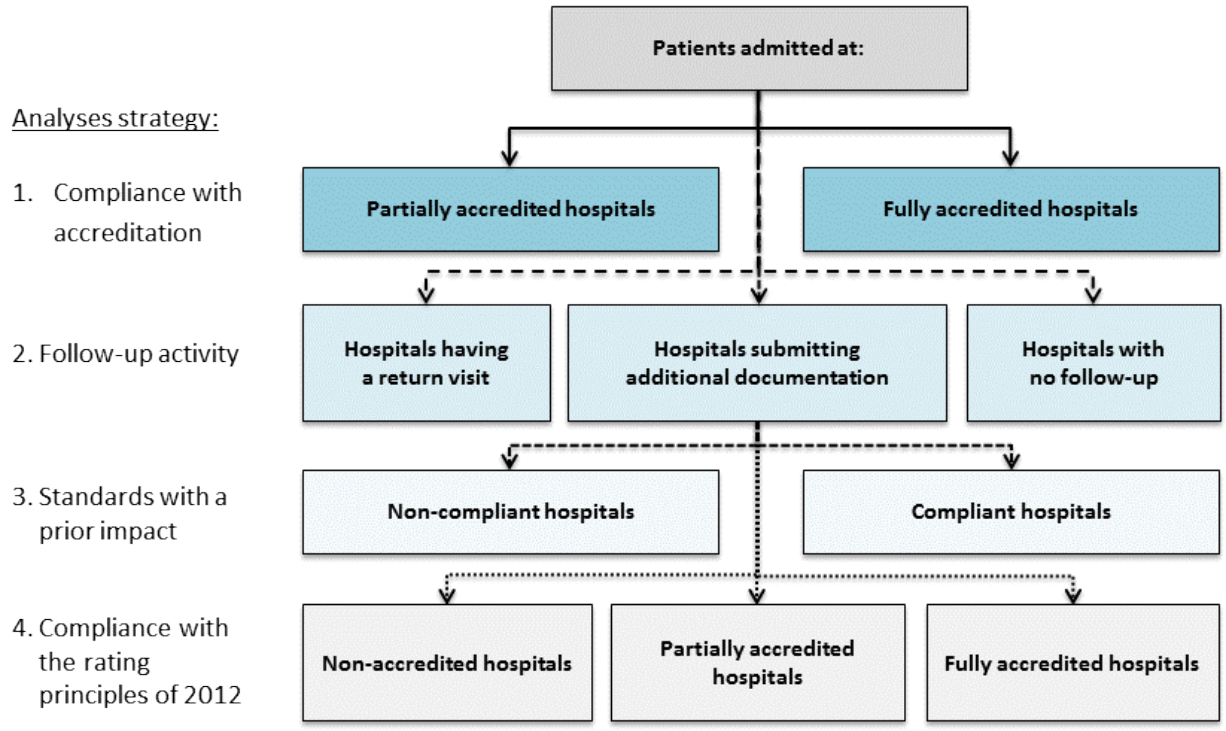
The patient-related factors identified included gender, age, primary diagnoses, type of admission, marital status, and comorbidity. All information was collected through the DNRP, except marital status, which was obtained from the Danish Civil Registration System. All factors were included as a categorical variable. For type of admission and marital status, the categories were defined by the registry (type of admission: acute/elective; marital status: unmarried/married/divorced/widowed), whereas age were converted into four categories (<50 years; ≥50 to 64; ≥65 to 80; ≥80 years). Primary diagnosis was categorised into 11 categories for underlying diseases corresponding to the chapters in the International Classification of Diseases, 10th revision (please see baseline tables in papers II and III) (21). The Charlson comorbidity index was used to assess the severity of comorbidity (70). All diagnoses registered in DNPR on admission (since 1977) or outpatient contacts (since 1995) prior to the time of inclusion in this study were included in the calculations of a comorbidity score. The coding of the 19 Charlson conditions in the DNPR have previously been shown to be consistently high (71). The index assigns between one and six points to a range of diseases, depending on their relation to mortality. If the patient's primary diagnosis was one of the index's 19 diseases, this diagnosis was excluded in the calculation of that patient's comorbidity score. On the basis of this method, a comorbidity score was computed for each patient, and three categories were defined: "No comorbidity"; "Low" if the patient had one or two comorbidities; and "High" if the patient had three or more comorbidities.

4.7 Data analyses

4.7.1 Analysis strategy (All studies)

In all studies, the same analysis strategy was used as illustrated in Figure 4. In the primary analysis, outcomes was compared by compliance with accreditation defined by the first proceeding because this was considered to reflect the hospital's genuine ability to incorporate quality improvement within their organisations. Hospitals awarded "accredited" are hereby referred to as "fully accredited hospitals", and hospitals awarded "accredited with comments" are designated as "partially accredited hospitals" (no hospitals were conditionally accredited). Second, outcomes were compared by compliance according to follow-up activity determined by the Accreditation Award Committee: "having a return visit", "submitting additionally documentation", or "no follow-up". Tertiary analyses were performed according to compliance with the *a priori* selected standards, first combined and then separately. For each outcome, hospitals that were compliant with all *a priori* selected standards were designated "compliant" hospitals and hospitals that were partially or not compliant with one or more standards "non-compliant". To account for the possible misclassification of level of accreditation, sensitivity analyses were carried out by comparing patients admitted to the hospitals according to their compliance with the rating principles of 2012 by fully, partially, or non-accredited hospitals.

Figure 4. Illustration of the applied analysis strategy for all studies



To secure independence among the observations, only the patients' first admission/hospital contact during the study period were included in the studies. Descriptive data for patient and hospital characteristics are presented as counts and percentages according to compliance with accreditation. All statistical tests incorporated a two-sided significance level of 0.05 and were performed using STATA, version 12 (StataCorp., 2011, College Station, TX: StataCorp LP).

4.7.2 Analyses on recommended hospital care

Recommended hospital care was evaluated in two ways by examing i) if a recommended process of care was provided a patient, referred to here as the individual measure; and ii) all relevant recommended processes of care were provided in the entire patient pathway, reflected by an composite all-or-none score referred to as 'all-or-none'. Following the described analysis strategy, the two measures was analysised across conditions and subsequently for each medical condition separately (for the latter, the data are not shown for *a priori* selected standards). Odds ratios (ORs) with 95% CI values were computed using logistic regression including adjustment for medical conditions, because only patients relevant to receiving a process performance measure were included in the study.

Stratified analyses were conducted according to previous accredited and university affiliation to account for possible differences in hospital characteristics.

Finally, a multilevel regression analyse was performed taking into account the hierarchical structure of data. The results are, though, not presented in the thesis because they to a large extent were similar with the results of the primary analysis (please see paper III's supplementary for results of the multilevel model).

4.7.3 Analyses on 30-day mortality

Patients were followed from the date of admission until 30 days after admission or date of death, whichever occurred first. The 30-day mortality is presented as a percentage with 95% CI. Multivariable logistic regression was used to compute OR and 95% CI, controlling for the patient covariates of gender, age, primary diagnoses, type of admission, marital status, and comorbidity by adding them as categorical variables in the logistic regression equation.

Stratified analyses were conducted according to previous accredited status, university affiliation, and time of onsite survey to investigate the influence of a possible variation in hospital characteristics on the results.

Additional analysis for a subgroup of patients

For two of the selected standards, 'Observation of and follow-up on critical observations results'' and 'Treatment of cardiac arrest', a subgroup of patients were identified for whom the standards were presumed to be of particular importance. Patients with an acute critical condition were selected for analysis of 'Observation of and follow-up on critical observation results', corresponding to 15 out of the 80 diagnoses, and for 'Treatment of cardiac arrest', the included patients had 1 of 10 cardiovascular diseases; please see paper II for a description of the included diagnoses. The analyses were performed according to compliance with the standard; patients admitted to hospitals compliant with the standard versus patients admitted to hospitals non-compliant with the standard.

4.7.4 Analyses on length of stay

In the analyses of LOS, the date of admission was the entry date, and follow-up ended at the date of discharge or death, whichever came first. Patients admitted and discharged the same day were included in the analyses with a LOS of half a day (0.5). LOS was presented as both median days including 5^{th}–95^{th} percentiles and mean days with 95% CI.

The association between compliance with accreditation and LOS was estimated as a hazard ratio (HR) including 95% CI using Cox proportional hazard regression (72). The proportional hazards assumption was checked visually for LOS by comparing the plots between patients admitted at fully and partially accredited hospitals and by using the Schoenfeld test and were not found invalid. All analyses were controlled for the six patient factors, and stratified analyses were conducted to examine the role of the three hospital factors.

Additional analysis for the subgroup of patients was designed for LOS using patients with a LOS between the 5th and 95th percentiles. This restriction was applied to explore whether the result was influenced by potential outliers.

4.7.5 Analyses on acute readmission

For AR, the date of discharge was the entry date, and follow-up ended 30 days after discharge, date of AR, or death, whichever came first. AR is presented as a percentage with 95% CI.

The association between compliance with accreditation and AR was estimated as HR, including 95% CI, using Cox proportional hazard regression (72). The proportional hazards assumption was checked visually for AR by comparing the plots between patients admitted at fully and partially accredited hospitals and by using the Schoenfeld test and were not found invalid. The six patient factors were included in all analyses, and stratified analyses were conducted to examine the role of the three hospital factors.

For an additional analysis for the subgroup of patients, all patients with a short LOS defined as shorter or equal to 2 days were identified in order to investigate any change in the likelihood of AR when discharge took place relatively fast after admission.

4.7.6 Within-hospital clustering

To account for the hierarchical nature of data in which patients at one hospital are more likely treated similarly relative to patients at another hospital, robust standard error estimation was included in all analyses. By adding hospitals as a cluster variable, unmeasured hospital characteristics potentially associated with the outcome were taken into account, minimising the risk of type-1 error.

5.0 RESULTS

5.1 Compliance with accreditation

The first of 34 public non-psychiatric hospitals were accredited by the first version of the DDKM in May 2010 and the last in June 2012. Three hospitals were excluded from the studies, however, because they treated only patients with specified diagnoses (obstetric patients, elective orthopaedic patients, and patients undergoing intensive care or anaesthesia, respectively). Of the 31 included hospitals, 11 hospitals were fully accredited, and 20 were partially accredited in the first proceeding, thus no hospital was conditionally accredited. Fully accredited hospitals had at most one standard partially or not met and a maximum of 20 measurable elements partially or not met. For partially accredited hospitals the number of standards partially or not met varied from 2 to 22, with up to 81 partially or not met measurable elements. To improve compliance through the follow-up activity, eleven hospitals were requested to have a return visit by a reduced survey team, and nine hospitals were requested to submit additional documentation. All hospitals completed the offered follow-up activity and were accredited in the final proceeding.

The reassessment of compliance according to the rating principles of 2012 led to a downgrading of five hospitals. Three fully accredited hospitals, in the first proceding, were lowered to partially accredited and two partially accredited hospitals to 'conditionally accredited', referred to here as "non-accredited hospitals". Thus, 8 hospitals were fully accredited, 21 were partially accredited, and 2 were non-accredited according to the rating principles of 2012.

5.2 Recommended hospital care (Study I)

A total of 68,780 patient pathways were included in the analyses of recommended hospital care corresponding to 449,248 processes of care in the six clinical registries. The inclusion of the patient pathway is illustrated in Figure 5, including numbers of pathway per medical condition. The processes of care were distributed with 31.6% being delivered at fully accredited hospitals and 68.4% at partially accredited hospitals.

5.2.1 Results across medical conditions

The patients' probability of receiving the individual measures according to clinical guideline recommendations were 89.5% (95% CI: 89.4–89.7) at fully accredited hospitals and 88.1% (95% CI: 88.0–88.2) at partially accredited hospitals, respectively, across medical conditions. Hence, patients at fully accredited hospitals were more likely to receive the recommended hospital care compared with patients at partially accredited hospitals, which reached statistical significance (individual measure: adjusted OR: 1.20, 95% CI: 1.01–1.43). The patients' provided all recommended measures by the all-or-none score was also in favour of fully accredited hospitals, corresponding to an adjusted OR of 1.27 (95% CI: 1.02–1.58). Both results supported our study hypotheses. All results are shown in Table 10.

Figure 5. Flow chart of patient pathways included for study I for the six medical conditions combined and separately

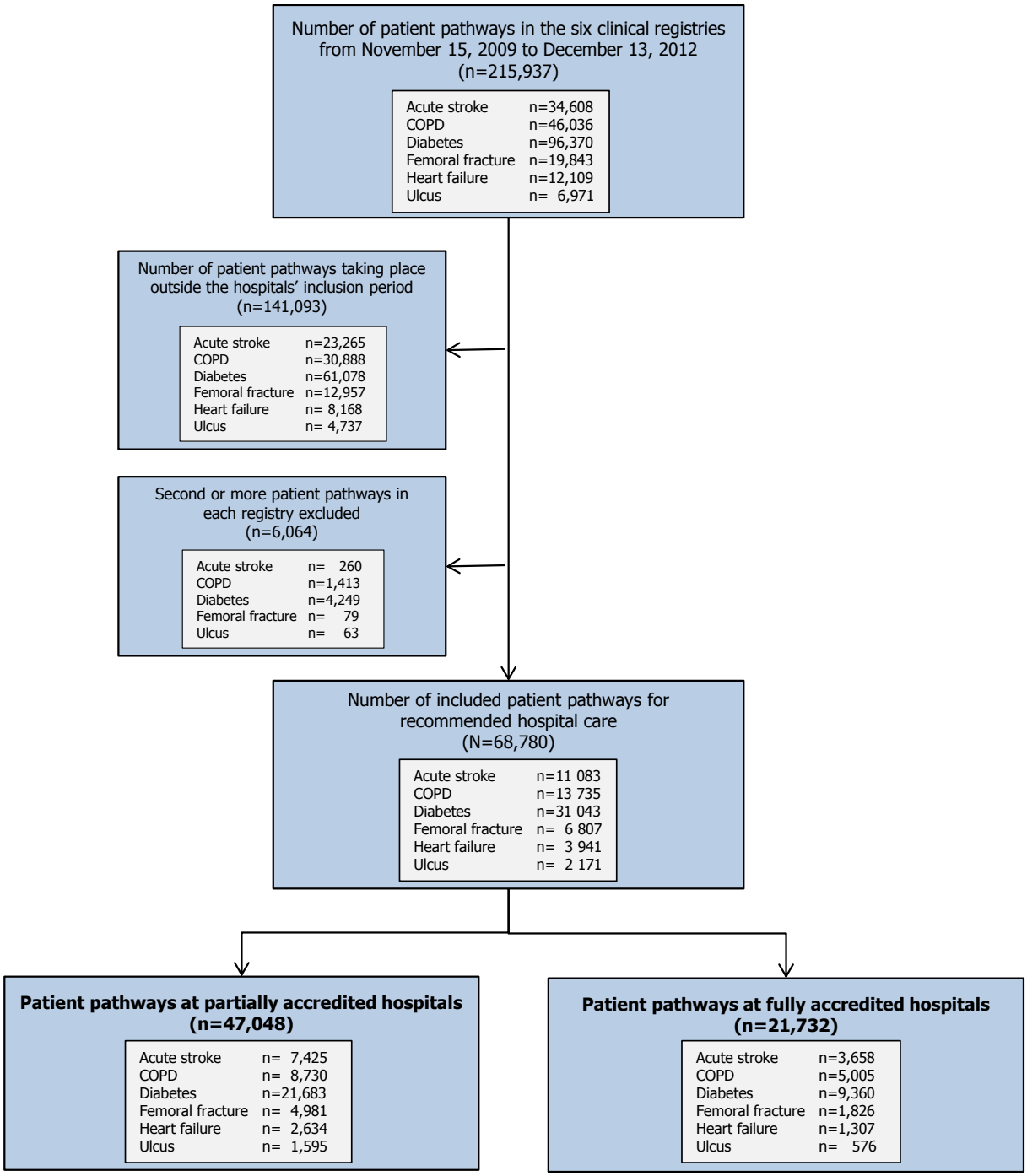


Table 10. The association among different measures of compliance with accreditation and recommended hospital care across six medical conditions treated at accredited, Danish hospitals according to the first version of the DDKM for hospitals

	Individual measure			All-or-none score		
	Fulfilled	OR (95% CI)		Fulfilled	OR (95% CI)	
	% (95% CI)	Crude	Adjusted[1]	% (95% CI)	Crude	Adjusted[1]
COMPLIANCE WITH ACCREDITATION						
Patients at partially accredited hospitals[2]	88.1 (88.0–88.2)	1.00	1.00	62.6 (62.2–63.1)	1.00	1.00
Patients at fully accredited hospitals	89.5 (89.4–89.7)	1.16 (0.92–1.46)	1.20 (1.01–1.43)	67.2 (66.6–67.8)	1.22 (0.94–1.60)	1.27 (1.02–1.58)
COMPLIANCE ACCORDING TO FOLLOW-UP ACTIVITY						
Patients at hospitals having a return visit[2]	88.0 (87.8–88.1)	1.00	1.00	62.8 (62.2–63.3)	1.00	1.00
Patients at hospitals submitting documentation	88.2 (88.0–88.4)	1.02 (0.74–1.40)	1.11 (0.84–1.46)	62.5 (61.8–63.1)	0.99 (0.69–1.44)	1.10 (0.79–1.54)
Patients at hospitals with no follow-up	89.5 (89.4–89.7)	1.17 (0.86–1.59)	1.26 (0.97–1.62)	67.2 (66.6–67.8)	1.22 (0.90–1.64)	1.33 (1.00–1.76)
COMPLIANCE WITH THE FIVE SELECTED STANDARDS						
Patients at non-compliant hospitals[2]	88.0 (87.9–88.1)	1.00	1.00	62.3 (61.8–62.8)	1.00	1.00
Patients at compliant hospitals	89.1 (89.0–89.2)	1.11 (0.87–1.42)	1.16 (0.95–1.41)	66.1 (65.6–66.6)	1.18 (0.90–1.55)	1.24 (0.98–1.57)
COMPLIANCE WITH THE SELECTED STANDARDS INDIVIDUALLY						
Risk management						
Patients at non-compliant hospitals[2]	76.8 (76.2–77.4)	1.00	1.00	44.9 (43.2–46.6)	1.00	1.00
Patients at compliant hospitals	89.1 (89.0–89.2)	2.46 (1.88–3.23)	2.31 (1.58–3.37)	65.0 (64.7–65.4)	2.28 (1.73–3.02)	2.36 (1.43–3.90)
Document management						
Patients at non-compliant hospitals[2]	88.0 (87.9–88.2)	1.00	1.00	62.9 (62.4–63.5)	1.00	1.00
Patients at compliant hospitals	88.9 (88.8–89.0)	1.09 (0.82–1.45)	1.16 (0.90–1.49)	64.9 (64.4–65.3)	1.09 (0.80–1.47)	1.20 (0.90–1.59)
Patient health record						
Patients at non-compliant hospitals[2]	88.9 (88.7–89.1)	1.00	1.00	63.6 (62.8–64.4)	1.00	1.00
Patients at compliant hospitals	88.5 (88.3–88.6)	0.96 (0.71–1.29)	0.97 (0.75–1.25)	64.2 (63.8–64.6)	1.03 (0.67–1.56)	1.07 (0.75–1.51)
Training and competence development						
Patients at non-compliant hospitals[2]	88.9 (88.7–89.2)	1.00	1.00	62.1 (61.1–63.2)	1.00	1.00
Patients at compliant hospitals	88.5 (88.4–88.6)	0.96 (0.62–1.47)	0.95 (0.68–1.33)	64.4 (64.0–64.7)	1.10 (0.77–1.58)	1.01 (0.69–1.49)
Observation and follow-up on critical observation results						
Patients at non-compliant hospitals[2]	89.5 (89.3–89.8)	1.00	1.00	65.9 (64.7–67.0)	1.00	1.00
Patients at compliant hospitals	88.4 (88.3–88.5)	0.89 (0.77–1.03)	0.97 (0.82–1.14)	63.9 (63.5–64.3)	0.92 (0.67–1.22)	1.02 (0.79–1.33)
COMPLIANCE WITH THE RATING PRINCIPLES OF 2012						
Patients at fully accredited hospitals	89.12 (88.9–89.3)	1.00 (0.80–1.25)	1.02 (0.89–1.17)	65.8 (65.1–66.5)	1.03 (0.77–1.37)	1.07 (0.86–1.33)
Patients at partially accredited hospitals[2]	89.13 (89.0–89.2)	1.00	1.00	65.2 (64.7–65.6)	1.00	1.00
Patients at non-accredited hospitals	80.86 (80.4–81.3)	0.52 (0.31–0.86)	0.52 (0.31–0.89)	48.9 (47.6–50.3)	0.51 (0.34–0.77)	0.47 (0.29–0.77)

[1]Adjusted for medical condition

[2]Reference group

The findings according to follow-up activity showed that patients at hospitals submitting additional documentation and with no follow-up to a higher extent received the recommended care compared to patients at hospitals having a return visit, although it was only significant for all-or-none at hospitals with no-follow-up. The findings did not differ significantly when stratifying hospitals according to previous accreditation or university affiliation (data not shown).

When combining the five *a priori* selected standards, patients at compliant hospitals were more likely to receive the recommended hospital care than patients at non-compliant hospitals (individual measures: adjusted OR 1.16, 95% CI: 0.95–1.41; all-or none score: adjusted OR 1.24, 95% CI: 0.98–1.57). Analysing the standards individually, the strongest association was found for the standard "risk management" with a significantly better delivered care in favour of patients at compliant hospitals in both analyses (individual measure: adjusted OR 2.31, 95% CI: 1.58–3.37; all-or-none score: OR 2.36, 95% CI: 1.43–3.90).

In grouping hospitals according to compliance with the rating principles of 2012, no differences were seen between fully and partially accredited hospitals for both measures. However, for patients at non-accredited hospitals, the odds for receiving the recommended care were reduced by half compared with partially accredited hospitals (individual measures: adjusted OR 0.52, 95% CI: 0.31–0.89; all-or-none score: adjusted OR 0.47, 95% CI: 0.29–0.77).

5.2.2 Results for medical conditions, separately

The results for the individual medical conditions are shown in Table 11. For five of the conditions, the probability receiving the recommended care were in favour of patients at fully accredited hospitals. The association reached statistical significance for patients with acute stroke and hip fracture.

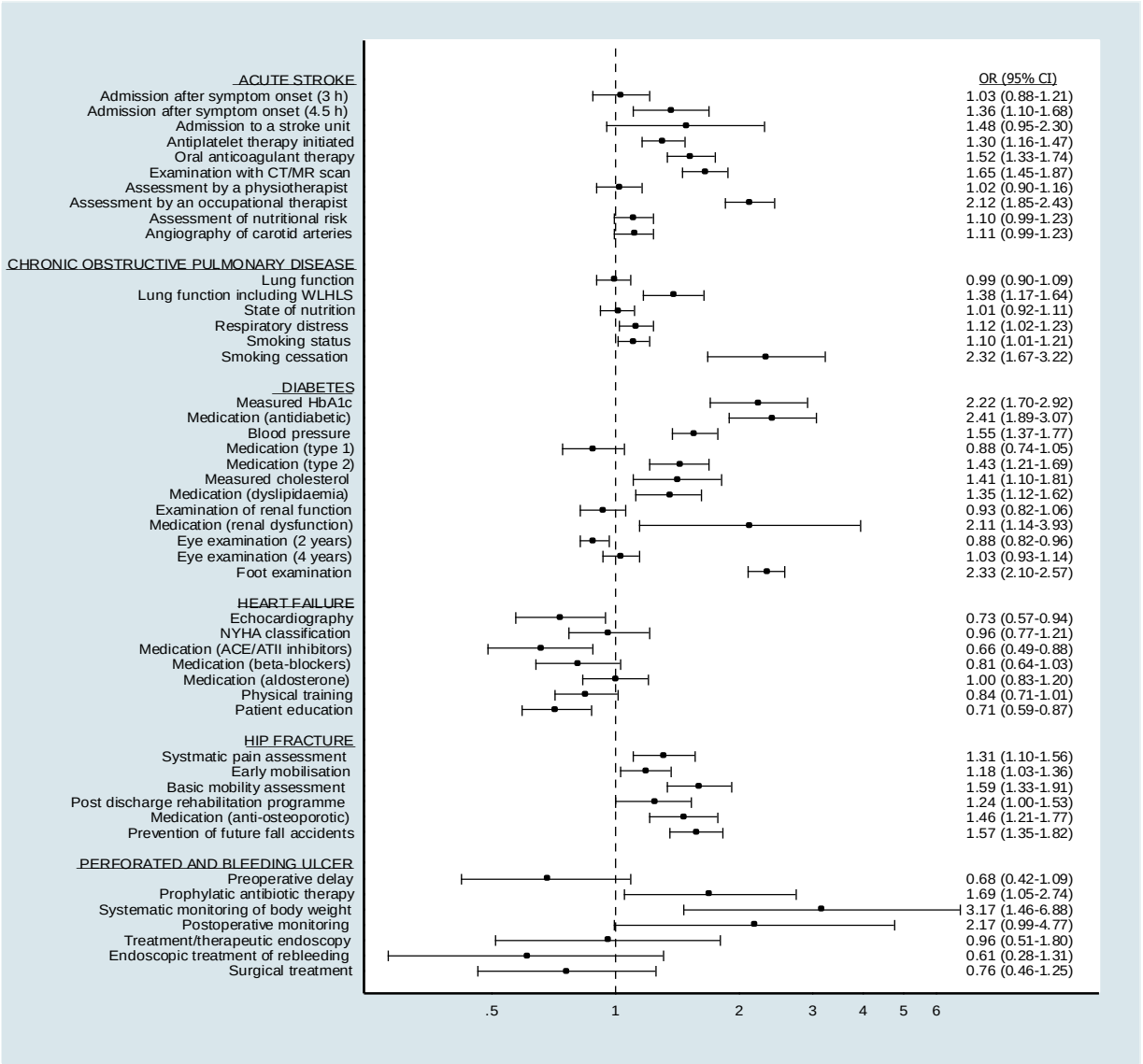
Table 11. The association among different measures of compliance with accreditation and recommended hospital care for the six medical conditions treated at accredited, Danish hospitals according to the first version of the DDKM for hospitals

COMPLIANCE WITH ACCREDITATION BY MEDICAL CONDITION	Individual measures		All-or-none score	
	Fulfilled % (95% CI)	OR (95% CI)	Fulfilled % (95% CI)	OR (95% CI)
ACUTE STROKE				
Patients at partially accredited hospitals[2]	79.14 (78.79–79.49)	1.00	36.04 (34.95–37.13)	1.00
Patients at fully accredited hospitals	82.98 (82.52–83.45)	1.29 (1.03–1.61)	43.93 (42.32–45.54)	1.39 (1.05–1.83)
CHRONIC OBSTRUCTIVE PULMONARY DISEASE				
Patients at partially accredited hospitals[2]	84.53 (84.20–84.87)	1.00	75.04 (74.13–75.95)	1.00
Patients at fully accredited hospitals	85.65 (84.20–84.87)	1.09 (0.68–1.74)	79.36 (78.24–80.48)	1.28 (0.78–2.09)
DIABETES				
Patients at partially accredited hospitals[2]	93.65 (93.53–93.77)	1.00	72.17 (71.58–72.77)	1.00
Patients at fully accredited hospitals	94.91 (94.75–95.07)	1.26 (0.80–1.99)	75.54 (74.67–76.42)	1.19 (0.79–1.79)
HEART FAILURE				
Patients at partially accredited hospitals[2]	75.77 (75.08–76.45)	1.00	23.08 (21.47–24.69)	1.00
Patients at fully accredited hospitals	73.98 (72.96–74.99)	0.91 (0.76–1.08)	22.65 (20.38–24.92)	0.98 (0.71–1.34)
HIP FRACTURE				
Patients at partially accredited hospitals[2]	84.50 (84.08–84.92)	1.00	53.60 (52.21–54.99)	1.00
Patients at fully accredited hospitals	88.33 (87.70–88.95)	1.39 (0.97–1.98)	64.51 (62.32–66.71)	1.57 (1.00–2.49)
PERFORATED AND BLEEDING ULCER				
Patients at partially accredited hospitals[2]	84.57 (83.31–85.82)	1.00	82.13 (81.02–87.03)	1.00
Patients at fully accredited hospitals	86.47 (84.44–88.49)	1.17 (0.81–1.69)	84.03 (80.25–84.01)	1.14 (0.83–1.58)

[1]Reference group

Variation was seen between fully and partially accredited hospitals in the odds of receiving an individual process performance measure when exploring the medical conditions separately, as illustrated in Figure 6. The figure shows that the vast majority of the measures for acute stroke, COPD, diabetes, and hip fracture were in favour of fully accredited hospitals, whereas the finding for heart failure was the opposite, favouring partially accredited hospitals. The result for ulcer was, however, inconclusive.

Figure 6. The odds ratio of receiving an individual process performance measure according to compliance with accreditation for the 48 included process performance measures



5.3 30-day mortality (Study II)

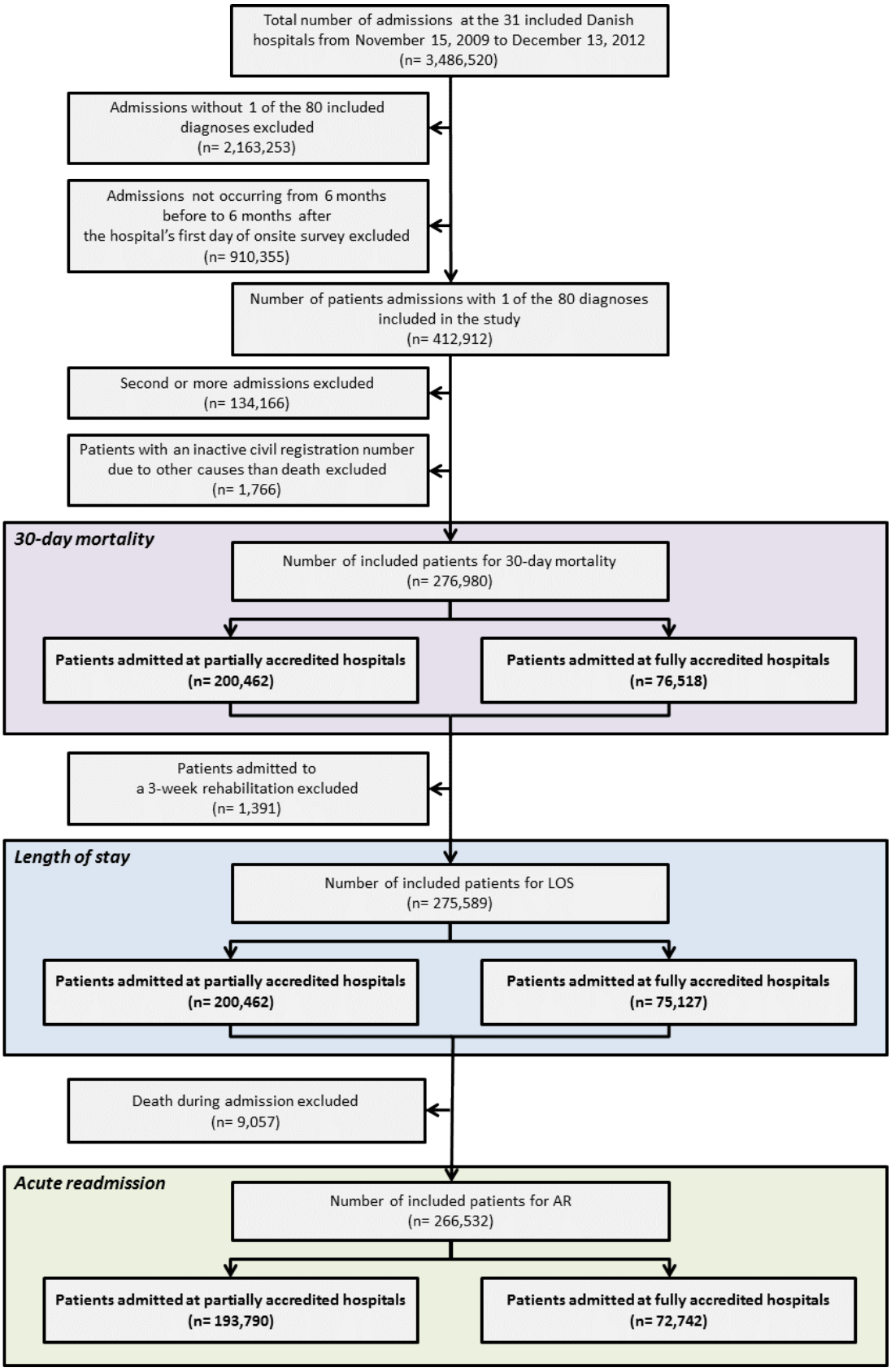
The study cohort for the 30-day mortality analyses consisted of 276,980 patients, of whom 76,518 were admitted at fully accredited hospitals (27.6%) and 200,462 at partially accredited hospitals (72.4%). A flow chart of included patients is shown in Figure 7. All patient data were complete, except marital status, with three observations registered as unknown; for baseline patient and hospital characteristics, please see paper II.

Of the included 276,980 patients, a total of 11,755 died within 30 days of admission. The 30-day mortality risk for patients at fully accredited hospitals was 4.14% (95% CI: 4.00–4.28) and 4.28% (95% CI: 4.20–4.37) for patients at partially accredited hospitals. Mortality risk including crude and adjusted ORs for all analyses are presented in Table 12.

The analyses revealed that patients at fully accredited hospitals had a lower risk of dying within 30 days of admission compared with patients at partially accredited hospitals (adjusted OR 0.83, 95% CI: 0.72–0.96). Grouping partially accredited hospitals according to follow-up activity showed that patients at hospitals submitting additional documentation were less likely to die within 30 days of admission compared with patients at hospitals having a return visit (adjusted OR 0.83, 95% CI: 0.67–1.02). When stratifying for the hospital characteristics of previous accreditation, university affiliation, and time of onsite survey, the results did not substantially change (data not shown).

For the four standards with *a priori* expected impact on 30-day mortality risk, a similar pattern was found, as patients admitted at compliant hospitals had a lower risk of dying within 30 days of admission than patients at non-compliant hospitals (adjusted OR 0.82, 95% CI: 0.70–0.97). Analysing the standards individually revealed a particularly strong association for the standards "risk management" and "observation of and follow-up on critical observation results" (risk management: adjusted OR 0.69, 95% CI: 0.52–0.91; critical observation results: adjusted OR 0.67, 95% CI: 0.54–0.82).

Figure 7. Flow chart of patients included in studies II and III



When hospitals were classified according to the rating principles of 2012, the findings from the primary analyses were corroborated. Using patients at partially accredited hospitals as reference, patients at fully accredited hospitals were non-significantly less likely to die within 30 days of admission (adjusted OR 0.87, 95% CI: 0.74–1.02), whereas the risk of dying within 30 days for patients at non-accredited hospitals was significantly increased (adjusted OR 1.18, 95% CI: 1.05–1.34).

For the subanalysis of the association between compliance with the standard "Observation of and follow-up on critical observation results" and 30-day mortality, a total of 37,464 patients were admitted with 1 of the 15 identified acute critical diagnoses. Using as a reference the patients admitted to hospitals that were non-compliant to the standard, a substantially lower 30-day mortality risk was shown for patients admitted with acute critical conditions at hospitals compliant with the standard (adjusted OR 0.49, 95% CI: 0.37–0.65). A similar finding was revealed for the 25,798 patients admitted with 1 of the 10 cardiovascular diagnoses. Again, a lower risk of dying within 30 days of admission was found for cardiovascular patients admitted at hospitals compliant with the standard "Treatment of cardiac arrest" compared to hospitals that were non-compliant (adjusted OR 0.61, 95% CI: 0.38–0.99).

Table 12. Results of the association among different measures of compliance with accreditation and 30-day mortality for patients admitted at accredited, Danish hospitals according to the first version of the DDKM for hospitals

	Hospitals Counts (N=31)	Patients Counts (N=276,980)	30-day mortality risk % (95% CI)	30-day mortality OR (95% CI)	
				Crude	Adjusted[1]
COMPLIANCE WITH ACCREDITATION					
Patients at partially accredited hospitals[2]	20	200,462	4.28 (4.19–4.37)	1.00	1.00
Patients at fully accredited hospitals	11	76,518	4.14 (4.00–4.28)	0.97 (0.93–1.01)	0.83 (0.72–0.96)
COMPLIANCE ACCORDING TO FOLLOW-UP ACTIVITY					
Patients at hospitals having a return visit	11	103,677	4.62 (4.45–4.75)	1.00	1.00
Patients at hospitals submitting additional documentation[2]	9	96,785	3.92 (3.80–4.05)	0.84 (0.81–0.88)	0.83 (0.68–1.02)
Patients at hospitals with no follow-up (fully accredited)	11	76,518	4.14 (4.00–4.28)	0.89 (0.85–0.93)	0.76 (0.65–0.89)
COMPLIANCE WITH FOUR SELECTED STANDARDS COMBINED					
Patients at non-compliant hospitals[2]	9	74,626,	4.48 (4.33–4.63)	1.00	1.00
Patients at compliant hospitals	22	202,354	4.16 (4.07–4.25)	0.93 (0.89–0.96)	0.82 (0.70–0.97)
COMPLIANCE WITH THE SELECTED STANDARDS INDIVIDUALLY					
Risk management					
Patients at non-compliant hospitals[2]	3	25,643	4.18 (3.94–4.43)	1.00	1.00
Patients at compliant hospitals	28	251,337	4.25 (4.17–4.33)	1.02 (0.95–1.08)	0.69 (0.52–0.91)
Timely reaction to test results					
Patients at non-compliant hospitals[2]	3	36,489	4.34 (4.13–4.56)	1.00	1.00
Patients at compliant hospitals	28	240,491	4.23 (4.15–4.31)	0.97 (0.92–1.03)	0.95 (0.83–1.09)
Observation and follow-up on critical observation results					
Patients at non-compliant hospitals[2]	3	33,366	4.82 (4.59–5.05)	1.00	1.00
Patients at compliant hospitals	28	243,614	4.16 (4.08–4.24)	0.86 (0.81–0.91)	0.67 (0.54–0.82)
Treatment of cardiac arrest					
Patients at non-compliant hospitals[2]	4	13,937	5.49 (5.11–5.87)	1.00	1.00
Patients at compliant hospitals	27	263,043	4.18 (4.10–4.25)	0.75 (0.70–0.81)	0.89 (0.78–1.01)
COMPLIANCE WITH THE RATING PRINCIPLES OF 2012					
Patients at fully accredited hospitals	8	64,563	4.06 (3.91–4.21)	0.96 (0.92–1.00)	0.87 (0.74–1.02)
Patients at partially accredited hospitals[2]	21	188,585	4.23 (4.14–4.32)	1.00	1.00
Patients at non-accredited hospitals	2	23,832	4.85 (4.57–5.12)	1.15 (1.08–1.23)	1.18 (1.05–1.34)

[1]Adjusted for age, gender, comorbidity, primary diagnosis, type of admission, and marital status, including robust standard error at hospital level based on data from 276,977 patients

[2]Reference group

5.4 Length of stay (Study III)

Of the 276,980 patients identified for the analysis of 30-day mortality, we excluded 1,391 because they were admitted for a fixed 3-week rehabilitation programme, as illustrated in Figure 7. Thus, the final study cohort consisted of 275,589 patients of whom 75,127 (27.3%) were admitted at fully accredited hospitals and 200,462 (72.7%) at partially accredited hospitals; please see paper III for baseline patient and hospital characteristics. For patients at fully accredited hospitals, the mean LOS was 4.51 days (95% CI: 4.46–4.57); it was 4.54 days (95% CI: 4.50–4.57) for patients at partially accredited hospitals. Results for the analyses on LOS are presented in Table 13, including mean and median LOS.

The results revealed that patients admitted at fully accredited hospitals were likely to be discharged before patients at partially accredited hospitals after controlling for potential confounding factors (adjusted HR 1.07, 95% CI: 1.01–1.14). Using follow-up activity to classify admissions, patients admitted at hospitals submitting additional documentation were more likely to be discharged before patients at hospitals having a return visit (submitting documentation: adjusted HR 1.12, 95% CI: 1.01–1.24). The result did not change substantially when stratifying hospitals according to previous accreditation, university affiliation, and time of onsite survey (data not shown). Restricting the analysis to the subgroup of patients with LOS between 1 and 17 days (5^{th} to 95^{th} percentiles), the results were confirmed in favour of fully accredited hospitals (adjusted HR 1.07, 95% CI: 1.02–1.11).

All fully accredited and 10 partially accredited hospitals were compliant with all four standards identified *a priori* to be of particular relevance for LOS. Hence, the remaining 10 partially accredited hospitals were non-compliant. Corresponding to the main findings, patients admitted at compliant hospitals were discharged before patients at non-compliant hospitals (adjusted HR 1.10, 95% CI: 1.02–1.19). The association for the standards "Documentation and monitoring of nosocomial infections" and "observation of and follow-up on critical observation results" revealed a relatively shorter LOS than all four standards combined (documentation: adjusted HR 1.19, 95% CI: 1.07–1.32; critical observation results: adjusted HR 1.23, 95% CI: 1.07–1.41).

The result of compliance with the rating principles of 2012 revealed a finding similar to that for the primary analyses, with patients admitted at fully accredited hospitals being discharged before patients at partially accredited hospitals (adjusted HR 1.07, 95% CI: 1.00–1.14). No difference was found between admissions at partially versus non-accredited hospitals (adjusted HR 0.96, 95% CI: 0.84–1.11).

Table 13. Results of the association between different measures of compliance with accreditation and LOS for patients admitted at accredited, Danish hospitals according to the first version of the DDKM for hospitals

	Hospitals Counts (N=31)	Patients Counts (N=275,589)	Median length of stay Days (5–95 perc.)	Mean length of stay Days (95% CI)	Length of stay HR (95% CI)	
					Crude	Adjusted[1]
COMPLIANCE WITH ACCREDITATION PROGRAMME						
Patients at partially accredited hospitals[2]	20	200,462	2 (0.5–17)	4.54 (4.50–4.57)	1.00	1.00
Patients at fully accredited hospitals	11	75,127	2 (0.5–17)	4.51 (4.46–4.57)	1.00 (0.99–1.01)	1.07 (1.01–1.14)
COMPLIANCE ACCORDING TO FOLLOW-UP ACTIVITY						
Patients at hospitals having a return visit[2]	11	103,677	2 (0.5–18)	4.75 (4.70–4.80)	1.00	1.00
Patients at hospitals submitting additional documentation	9	96,785	1 (0.5–17)	4.31 (4.26–4.35)	1.09 (1.08–1.10)	1.12 (1.01–1.24)
Patients at hospitals with no follow-up (fully accredited)	11	75,127	2 (0.5–17)	4.51 (4.46–4.57)	1.04 (1.03–1.05)	1.13 (1.04–1.23)
COMPLIANCE WITH THE FOUR SELECTED STANDARDS COMBINED						
Patients at non-compliant hospitals[2]	10	119,570	2 (0.5–18)	4.68 (4.64–4.73)	1.00	1.00
Patients at compliant hospitals	21	156,019	2 (0.5–17)	4.42 (4.38–4.45)	1.05 (1.04–1.06)	1.12 (1.03–1.21)
COMPLIANCE WITH THE SELECTED STANDARD INDIVIDUALLY						
Documentation and monitoring of nosocomial infections						
Patients at non-compliant hospitals[2]	3	28,012	2 (0.5–19)	5.46 (5.35–5.57)	1.00	1.00
Patients at compliant hospitals	28	247,577	2 (0.5–17)	4.43 (4.40–4.46)	1.15 (1.14–1.17)	1.20 (1.07–1.34)
Pain assessment and treatment						
Patients at non-compliant hospitals[2]	6	79,145	1 (0.5–17)	4.37 (4.32–4.43)	1.00	1.00
Patients at compliant hospitals	25	196,444	2 (0.5–18)	4.59 (4.56–4.63)	0.98 (0.97–0.99)	1.00 (0.93–1.09)
Timely reaction to test results						
Patients at non-compliant hospitals[2]	3	36,489	1 (0.5–16)	4.13 (4.05–4.20)	1.00	1.00
Patients at compliant hospitals	28	239,100	2 (0.5–18)	4.59 (4.56–4.62)	0.94 (0.93–0.95)	0.94 (0.87–1.02)
Observation and follow-up on critical observation results						
Patients at non-compliant hospitals[2]	3	33,366	2 (0.5–19)	5.16 (5.06–5.25)	1.00	1.00
Patients at compliant hospitals	28	242,233	2 (0.5–17)	4.44 (4.41–4.48)	1.11 (1.10–1.12)	1.25 (1.09–1.44)
COMPLIANCE WITH THE RATING PRINCIPLES OF 2012						
Patients at fully accredited hospitals	8	63,172	2 (0.5–17)	4.46 (4.40–4.52)	1.01 (1.00–1.02)	1.07 (1.00–1.14)
Patients at partially accredited hospitals[2]	21	188,585	2 (0.5–17)	4.54 (4.51–4.58)	1.00	1.00
Patients at non-accredited hospitals	2	23,832	2 (0.5–17)	4.65 (4.55–4.74)	0.96 (0.95–0.98)	0.96 (0.84–1.11)

[1]Adjusted for age, gender, comorbidity, primary diagnosis, type of admission, and marital status, including robust standard error at hospital level based on data from 275,586 patients

[2]Reference group

5.5 Acute readmission (Study III)

Of the 275,589 patients identified for the analysis of LOS, a total of 266,532 were discharged alive and included for AR (Figure 7). The AR for patients admitted at fully accredited hospitals was 13.70% (95% CI: 13.45–13.95), and AR was 12.72% (95% CI: 12.57–12.86) for patients at partially accredited hospitals; please see paper III for baseline patient and hospital characteristics. Results for AR are presented in Table 14, including distribution of patients by compliance with accreditation.

When comparing patients admitted at fully accredited hospitals with partially accredited hospitals, no differences were found in AR rate (adjusted HR 1.01, 95% CI: 0.92–1.10) or when grouping admissions according to the required follow-up activity (adjusted HR 1.07, 95% CI: 0.96–1.19). The result was not modified by previous accreditation, university affiliation, and time of onsite survey (data not shown). Restricting the analyses to patients with a short LOS revealed no difference in AR either (adjusted HR 1.02, 95% CI: 0.91–1.14).

All fully accredited and 11 partially accredited hospitals were compliant with all three standards identified as having an anticipated impact on AR. Hence, nine partially accredited hospitals were non-compliant. The primary findings were corroborated when grouping patients according to compliance with standards combined (adjusted HR 1.05, 95% CI: 0.97–1.14). Likewise, no differences in AR were shown for the standards individually.

The reclassification of hospitals according to the rating principles of 2012 revealed for patients at non-accredited hospitals an adjusted HR for time to discharge of 0.87 (95% CI: 0.81–0.93) compared with partially accredited hospitals. No difference was found between admission at fully versus partially accredited hospitals (adjusted HR 1.00, 95% CI: 0.91–1.10).

Table 14. Results of the association between different measures of compliance with accreditation and AR for patients admitted at accredited, Danish hospitals according to the first version of the DDKM for hospitals

	Hospitals Counts (N=31)	Patients Counts (N=266,532)	Acute readmission % (95% CI)	Acute readmission HR (95% CI)	
				Crude	Adjusted[1]
COMPLIANCE WITH ACCREDITATION					
Patients at partially accredited hospitals[2]	20	193,790	12.72 (12.57–12.86)	1.00	1.00
Patients at fully accredited hospitals	11	72,742	13.70 (13.45–13.95)	1.08 (1.06–1.11)	1.01 (0.92–1.10)
COMPLIANCE ACCORDING TO FOLLOW-UP ACTIVITY					
Patients at hospitals having a return visit[2]	11	99,861	12.21 (12.01–12.42)	1.00	1.00
Patients at hospitals submitting documentation	9	93,929	13.25 (13.03–13.46)	1.09 (1.06–1.12)	1.07 (0.96–1.19)
Patients at hospitals with no follow-up (fully accredited)	11	72,742	13.70 (13.45–13.95)	1.13 (1.10–1.16)	1.04 (0.92–1.17)
COMPLIANCE WITH THREE SELECTED STANDARDS COMBINED					
Patients at non-compliant hospitals[2]	9	98,635	12.21 (12.00–12.41)	1.00	1.00
Patients at compliant hospitals	22	167,897	13.44 (13.28–13.61)	1.11 (1.08–1.13)	1.05 (0.97–1.14)
COMPLIANCE WITH THE SELECTED STANDARDS INDIVIDUALLY					
Pain assessment and treatment					
Patients at non-compliant hospitals[2]	6	76,408	12.34 (12.11–12.57)	1.00	1.00
Patients at compliant hospitals	25	190,124	13.24 (13.09–13.40)	1.08 (1.05–1.10)	1.05 (0.96–1.15)
Timely reaction to test results					
Patients at non-compliant hospitals[2]	3	35,239	12.59 (12.25–12.94)	1.00	1.00
Patients at compliant hospitals	28	231,293	13.04 (12.91–13.18)	1.04 (1.00–1.07)	1.04 (0.95–1.13)
Medicine reconciliation					
Patients at non-compliant hospitals[2]	5	32,004	12.45 (12.08–12.81)	1.00	1.00
Patients at compliant hospitals	26	234,528	13.06 (12.92–13.20)	1.05 (1.02–1.09)	0.93 (0.71–1.23)
COMPLIANCE WITH THE RATING PRINCIPLES OF 2012					
Patients at fully accredited hospitals	8	61,187	13.68 (13.41–13.96)	1.06 (1.03–1.08)	1.00 (0.91–1.10)
Patients at partially accredited hospitals[2]	21	182,421	12.99 (12.84–13.15)	1.00	1.00
Patients at non-accredited hospitals	2	22,924	11.05 (10.64–11.45)	0.84 (0.81–0.88)	0.87 (0.81–0.93)

[1]Adjusted for age, gender, comorbidity, primary diagnosis, type of admission, and marital status, including robust standard error at hospital level based on data from 266,529 patients

[2]Reference group

6.0 DISCUSSION

6.1 Summary of findings

These first nationwide population-based studies showed that the level of compliance with an accreditation programme was associated with patient-related outcome. The studies found that patients treated at hospitals fully accredited by the first version of the DDKM were more likely to receive the recommended hospital care, had a lower risk of dying within 30 days of admission, and had a shorter LOS compared with patients at partially accredited hospitals. The studies' hypotheses were consequently confirmed. No differences were found regarding acute readmission between patients admitted at fully and partially accredited hospitals.

6.2 Comparison with existing literature

6.2.1 Compliance with accreditation

The majority of hospitals included in the thesis clustered in the middle level of accreditation, which was similar to the four existing studies studying compliance with accreditation (38-41). In the DDKM, the lowest level of accreditation was not used, probably because the DDKM set out minimum standards for quality, and all public hospitals thus were expected to achieve them. The two studies by Chen et al and Griffith et al were not able to use compliance to convey meaningful information because the analyses were performed at the hospital level (38,39). In this thesis, this issue was managed by performing all analyses at the patient level including clusteranalyses at hospital level combined with a population-based design. None of the four studies performed any subanalyses according to the additional action hospitals were requested to complete to improve compliance if the survey had revealed considerable deficiencies (in this thesis, referred to as follow-up activity). This inclusion may have been useful to distinguish differences between large numbers of hospitals clustering in the middle level of accreditation; thus, the values for additional action for improvements remain to be further unexplored.

6.2.2 Accreditation and recommended hospital care (Study I)

Study I seems to be the first to report on the association between compliance with accreditation and recommended hospital care, with patients at fully accredited hospitals having a higher probability of being provided with the recommended hospital care than patients at partially accredited hospitals. Overall, the findings support the relationship between accreditation and the increased likelihood of receiving the recommended care, confirming previous studies investigating accredited and non-accredited hospitals (38,42,44-46). Compared to the previous studies, study I is also, by far, the largest study performed by including 48 process performance measures for six medical conditions.

6.2.3 Accreditation and mortality (Study II)

The association found in this study between a lower risk of dying within 30 days of admission and high compliance with accreditation is in line with the finding from Chen et al and the two studies reporting a correlation between lower mortality and higher accreditation score (38-40). The three studies' main limitation was the use of standardised mortality assuming a homogeneous patient population among hospitals, which was accommodated in Study II by adjusting for six potential confounders at the patient level, including both demographic and clinical factors.

Within the last decade, the identified studies have examined accreditation and mortality according to accreditation programmes targeting specific centres within the hospitals treating patients undergoing bariatric surgery and hematopoietic stem-cell transplantation (47-52). Although most of the findings from these studies were in favour of accreditation, a direct comparison is difficult to undertake. This difficulty arises in part because the programmes most likely are targeted to address specific concerns related to the included conditions, whereas the DDKM was developed to improve the entire hospital performance, and recommendations for specific conditions thus were not outlined.

6.2.4 Accreditation and length of stay (Study III)

Study III is the first to examine the association between compliance with accreditation and LOS and report a reduced LOS for patients admitted at fully accredited hospitals. However, the finding was in accordance with those of the identified studies comparing accredited with non-accredited hospitals, with the exception of Kurichi et al (49,51,54). However, the average admission of one month reported in this study differs remarkably from the others, including study III; thus, the studies' patient populations are not comparable. Similar to study III were the moderate differences in mean reported LOS (49,51,54). Most of the studies included LOS as a secondary outcome, and only Nguyen presented a measure of association estimated to quantify the difference (49,51,53).

6.2.5 Accreditation and acute readmission (Study III)

In contrast to the study by Ammar et al, there was no association between compliance with accreditation according to the first version of the DDKM and AR (41). Like Ammar et al, the number of ARs was higher for fully accredited hospitals but did not reach statistical significance when taking into consideration five important patient characteristics other than case mix. Study III's result incorporates all ARs including cancers, which furthermore may explain the discrepancy between the studies.

The study by Nguyen reported a lower number of ARs to accredited versus non-accredited hospitals but included only readmission to the index hospital; however, the difference was not statistically significant either (51). Kwon et al reported on differences between pre- and post-accreditation in 90-day readmissions after the procedure, and comparison to their findings thus is not meaningful (50).

6.3 Methodological considerations

All of the studies in this thesis used an observational design to reflect the association between compliance with accreditation and patient-related outcomes. However, the use of an observational design requires thorough methodological considerations of potential systematic or random errors that may affect the results before an overall conclusion can be drawn. Hence, the studies' internal validity will be discussed in the following paragraphs.

6.3.1 Selection problems

All 34 public hospitals included in the thesis initially were accredited by the DDKM. However, three hospitals varied from the common perception of being "a hospital" due to the nature of the patients treated (elective orthopaedic patients, obstetric patients, and patients undergoing intensive care or anaesthesia, respectively). Because none of the hospitals contributed with data in the included medical registries, the exclusion did not affect the presented results.

The risk of selection was furthermore addressed in all studies by including all relevant patients in the entire Danish population. The unfettered access to healthcare including hospitalisation due to tax funding and the systematic registration of all admissions to receive compensation (complete follow-up) are both factors that reduce the probability of a systematic exclusion of patients. As a result of the unique personal identifier, the number of patients with missing data was very low. In study I, completeness in the clinical registries was in general high by including more than 90% compared with local hospital discharge registries (63,73). Any lack of data in the thesis studies was considered to be missing completely at random because of the systematic and prospective reporting of data upon admission.

Consequently, selection problems are considered to be insignificant in the conducted studies and thus not affecting the present results.

6.3.2 Information problems - compliance with accreditation

The accuracy of compliance with the accreditation standards by nature depended on consistency in the assessment within and between survey teams because they comprised persons with different professional skills and personal qualities from survey to survey. So far, only one study has published data on the intra- or inter-reliability of the assessments made by surveyors (4,74,75). The study by Greenfield et al intended to assess reliability by comparing two survey teams evaluating the same hospital but failed because the experiment caused considerable debate among surveyors about the principles of standards and ratings and unexpected events (75). Because the reliability of surveys is essential for the credibility of accreditation but has been difficult to evaluate by an experimental design, Greenfield et al used a qualitative design to identify topics of importance for survey reliability (76,77). Six factors were identified, and the factors of accreditation program, governance and

philosophy, and accrediting agency management of the accreditation process were accommodated in the Danish setting because only one accreditation body was responsible for the entire programme, ensuring a similar approach in all surveys conducted within a relatively short period of time. However, no information was available about the other three identified factors of survey team dynamics, individual surveyors, and the hospitals' approach toward accreditation; thus, their implications for the conducted survey are unknown.

To address the concern of variation among the assessments made by different survey teams, IKAS endorsed several efforts to minimise this. Before the onsite survey, the surveyors completed a training course including exercises on standard interpretation and rating principles, and a structured survey plan was put in place (please see Appendix for further details). The plan specified specific topics for a number of activities to ensure that these were evaluated at every survey, and it also included scheduled team and consensus meetings to ensure agreement between surveyors' decisions during the onsite survey. After the survey, every report was checked for consistency with the rating principles applied before being forwarded to the Accreditation Award Committee. The Committee awarded the level of compliance based on *all* eligible standards, and the first 10 reports were presented to the Committee at the same time, allowing them to calibrate their decisions.

The overlap in numbers of deficient measurable elements between fully and partially accredited hospitals may indicate a potential misclassification of compliance with the accreditation. However, the survey reports according to the first version of the DDKM were not useful for clarifycation because specific details about departments visited or the nature of the deficiencies were not systematically noted. Yet, any potential misclassification of compliance included in this thesis was most likely non-differential (e.g., independent of the four outcomes of interest) because of the prospective registration of the outcome data (recommended hospital care, LOS, readmission and death), which was done independently of the result of the onsite survey. Thus, if misclassification occurred, it would most likely bias the results towards the null. To further address the risk of information problems in the thesis, hospitals were compared by follow-up activity and the rating principles of 2012, which generally confirmed the primary results.

In conclusion, the main potential source of information bias lies in problems arising from misclassification of compliance with accreditation and in the complexity in interpreting this variable. Based on the abovementioned efforts, however, any potential misclassification was considered most likely to be of non-differential nature and bias the presented results toward the null.

6.3.3 Information problems - clinical outcomes

All outcome data were collected systematically and prospectively from national medical registries. The extraction of 1-year data from each hospital entailed that the majority of the registered outcome data were reported before the level of accreditation was awarded. The result of the accreditation process

was consequently not known among the staff in most of the study period, and any misclassification of the outcomes would therefore also be non-differential.

Process performance measures were registered in the routine clinical setting by healthcare professionals caring for the patients. To ensure consistency in the data collection, each measure was defined in detail, including exhaustive criteria to determine when it was contraindicated to provide a patient with a specific measure. However, variation in the reported data will by nature be a concern because different staff from different departments carried out the registration. Another source of concern is the possibility of incorrect registration resulting from gaming. This scenario could arise because the registries are used quarterly and annually to outline the units' ability to provide the recommended hospital care, including public disclosure of annual reports. Still, there is no financial incentive for reporting superior measures, so gaming was unlikely to have affected the results. Finally, missing values in the registries are considered to be missing completely at random by data collected prospectively.

Data on death was extracted from the Civil Registration System, which updates information daily and keeps track of all Danish citizens, and recoded with negligible error (57). The number of patients with no data on mortality (lost to follow-up) was minimal, and misclassification of mortality was highly unlikely.

All information on LOS and AR was gathered from the DNPR. The validity and completeness of data from the DNPR has in general been shown to be high (65). However, the data will inevitably suffer from some misclassification caused by an inherent variation in registration practices among the numerous different departments and healthcare professionals reporting the data to the DNPR. Any misclassification, however, was expected to be independent of exposure and thus non-differential (equally distributed among patients admitted at fully and partially accredited hospitals). Our data on LOS did not include the specific hour of admission and discharge, which could have provided more accurate information on LOS. Although real-time data will provide more precise estimates of the potential difference, the implication in the clinical setting must be investigated by other designs.

In summary, the influence of information bias according to outcome data is, in general, considered to be low.

6.3.4 Confounding

Because of the observational design with the exposure not being randomly assigned, confounding is inevitably an issue that should be considered in the studies included in the thesis. To accommodate this concern, a thorough consideration of possible confounders was undertaken to identify factors that subsequently could be addressed in the studies' design by restriction or in the statistical analysis by adjustments and stratification.

In study I, the study population was restricted to include patients with eligible measures as a way to increase homogeneity among the patients included at fully and partially accredited hospitals. However, it might be a concern that the responsibilities for determining each individual patient's eligibility for a specific process of care were placed on the staff caring for the patients. Confounding according to dissimilarities in judgement performed by different staff might have occurred, but because of the exhaustive defined criteria for assessing "not relevant", discrepancies were less likely to occur. Consequently, a patient was to be provided with a recommended process of care, irrespective of age or other characteristics, and no adjustments according to patient characteristics thus were included.

In studies II and II, restriction to the 80 primary diagnoses was applied to ensure some homogeneity across the hospitals in the patient populations that were compared. The available information on a wide range of important patient characteristics (age, gender, comorbidity, primary diagnoses, marital status, and type of admission) in the registries made it possible to adjust for factors known to be associated with the studied outcomes, which reduced the risk that the presented findings could be explained by confounding. However, information on disease severity, which is a strong prognostic factor in risk of death, LOS, and readmission, is not encompassed by the registries. Adjustment was therefore not feasible; thus, unaccounted confounding according to this factor cannot be excluded. The influence of residual confounding due to the use of categorical variables for, e.g., age and comorbidity, or unaccounted confounding due to unknown patient characteristics cannot be ruled out either, the latter because of the non-randomised design. However, it seems unlikely that unmeasured patient characteristics would change the overall result because the adjustment for the six important characteristics, in general, strengthened the presented associations.

In all three studies, the use of robust standard error estimation was applied to account for clustering of patients within hospitals to include unmeasured hospital characteristics that may be associated with outcome. Additional precautions were undertaken to address concerns related to differences in hospital characteristics by stratifying for previous accreditation, university affiliation, and time of survey, which did not substantially change the estimates presented. It cannot be precluded, though, that other unknown hospital characteristics like hospital size, or leadership may have influenced on the presented association. But also factors related to the surroundings could affected the finding like capacity of outpatient health services for discharged patients and geographical variation in re-admission patterns according to traditions. However, it seems unlikely that these surrounding factors should be connected to compliance with accreditation.

Throughout the last decade, Danish hospitals have invested substantial resources in implementing quality-improvement programmes in the effort to deliver high-quality patient care. Concurrently with accreditation, a number of other nationwide quality-improvement initiatives were carried out. Initiatives aimed at reducing mortality included a Danish version of the Institute of Healthcare Improvement's 100,000 Lives Campaign (active from 2007 to 2009) and continuous performance measures for monitoring and auditing through the national clinical quality registries for numerous

diseases besides the six included in study I (78). In addition to reducing mortality, the clinical quality registries also focused on reducing LOS and AR together with the compulsory healthcare agreements introduced in 2009. The agreements among regions (hospital owners) and the surrounding municipalities (primary care owners) was initiated to ensure efficient transfers by addressing access and capacity of outpatient health services for discharged patients. It is possible that all of these activities may have had a direct effect on the outcome under investigation. But because all hospitals, regardless of compliance with accreditation, were encompassed by these initiatives, any inherent variation was unlikely to explain the differences found. On the other hand, it seems more likely that the hospitals' ability to implement such programmes successfully may have affected their ability to improve patient-related outcomes. The ability to shape and train hospital staff according to accreditation may be valuable for ensuring an effective implementation of other quality-improvement initiatives.

In summary, all presented studies included substantial efforts to account for possible confounding by restricting the study population, adjusting for important patient-related characteristics, and stratifying for hospital-related characteristics. Because of the use of a non-randomised design and the role of especially unknown hospital characteristics, the risk of residual or unmeasured confounding cannot be ruled out.

6.3.5 Precision

All four studies in the thesis were based on large sample sizes and complete cohorts extracted from high-quality national population-based registries, which greatly reduced the risk of random error. All presented results in the thesis were reported with 95% CI values with the purpose of evaluating the strength and precision of the estimates, not to provide a surrogate significance test based on the inclusion of the "null value" in the interval.

The results of all main and most subgroup analyses yielded convincingly precise estimates, as reflected by the quite narrow 95% CIs in most analyses. However, some of the analyses of recommended hospital care for specific medical conditions did yield relatively broad CIs, and these results should consequently be interpreted with caution (illustrated in Figure 6).

7.0 CONCLUSION

In conclusion, the studies included in this thesis showed that a high level of compliance with the first version of the DDKM was associated with improved patient-related outcomes according to a higher probability of receiving the recommended hospital care, a reduced 30-day mortality, and a reduced LOS. No difference was found for AR. However, before generalising the findings to other accreditation programmes and settings, differences must be evaluated to identify how potential dissimilarities could modify the presented results.

The presented results do not provide unambiguous answers to whether high compliance with accreditation per se contributes to the improved outcomes. High compliance with the accreditation standards could merely be a marker of high-performing hospitals, which are characterised by delivering a high quality of care that ensures good patient-related outcomes. More insights into the effectiveness of accreditation are needed, preferably by using mixed-method designs.

8.0 PERSPECTIVES

Enhancing outcomes for patients is an ongoing task for healthcare providers, and numerous strategies have been introduced in the effort to achieve this goal. Identifying the potential association between compliance with hospital accreditation and the hospitals care provided is an important step on the pathway to understand potential implications for patients treated at hospitals undergoing accreditation. Based on the four patient-related outcomes, the findings in this thesis support the hypothesis that there are benefits at the patient level if the patient is treated at a hospital demonstrated to have high compliance with the accreditation standards. However, the thesis does not provide unambiguous answers but contributes to unfolding an aspect of accreditation not previously established.

Nonetheless, several questions remain to be further explored. *What are the underlying mechanisms that cause improvements in patient-related outcome?* Because accreditation consists of interventions at many levels, further research could focus on identifying potential reasons, insights that could be used in the effort to streamline accreditation programmes. *Are the findings from the next cycle of accreditation consistent with the presented findings from the first cycle?* In the second version of the DDKM, the number of standards was reduced and the focus shifted from "putting a system in place" to quality improvement being an integrated part of everyday practice. The version emphasised the importance of staff working as agreed and that improvements were started immediately after inadequate quality was identified. Thus, it could be interesting to replicate the studies because potential agreement in a subsequent accreditation cycle would further strengthen the argument for the use of compliance with accreditation as a marker for high-performing hospitals. *Is accreditation cost-effective?* Because resources in healthcare are limited, they must be used effectively. Hence, it is highly relevant to investigate whether the investment in accreditation is justified by improved patient-related outcomes or whether introducing the DDKM is just another cost-increasing exercise. Studies investigating the cost-effectiveness of accreditation have been scarce due to the lack of research identifying costs and benefits for patients (4,79,80). Identifying the cost of introducing the DDKM is, though, complicated because the participating hospitals did not prospectively record the amount of ressources spent on the accreditation process; thus, this kind of investigation must be retrospective. On the other hand, this thesis contributes an important building block to the cost-effectiveness analysis by quantifying potential benefits for treated patients, so it is feasible although complicated to estimate some aspects of the cost-effectiveness of the DDKM.

Future studies based on data gathered from national clinical registries are, however, at risk of being restricted by new legislation and concerns among politicians and the public about access to healthcare data for research purposes. Based on data permission, Danish researchers can get access to register-based data without informed patient consent, which has yielded a large amount of valuable knowledge about the causes of unwarranted variations in healthcare. If this access is constrained, it could jeopardise healthcare research including that undertaken in this thesis as these prospectively

collected data is inestimable to evaluate programmes intended to improve health care. Thus researchers must constantly advocate, both national and internationally, for sustaining this option.

Despite the initial involvement of healthcare professional in establishing the first version the DDKM faced continuously and considerably resistance from frontline staff throughout the years. The DDKM became synonymous with redundant registration. This may be caused by its contribution to ensure that the content of the healthcare law was implemented and systematically monitored and by the fixed decision of all versions had to achieve ISQua accreditation. The intention of providing a tool for empowering all levels of the hospitals to focus and improve quality of care primarily succeeded at management level and for the quality improvement teams and to a lesser extent for the frontline staff, if at all. Like risk management systems in other industries, it seem like the good intentions behind the DDKM were lost during implementation with the consequence that many staff members considered it rigid and contra productive (81,82). But perhaps also by assuming that what works in one industry with slight moderations will work in another; underestimating differences in complexity between industries (83).

The Ministry of Health and the Danish regions decided to phase out the DDKM in favour of a new quality-improvement programme by the end of 2015 (84). A part of the new programme is to re-engage frontline staff, in particular physicians, in the quality improvement work by ensuring fewer and more meaningful registrations and feedback from real-life data to assess the recommended care delivered. The new programme outlined that the potential for further quality improvement through accreditation were no longer considered to be present, thus an innovative way of running the healthcare was needed; "From bureaucracy process requirements to focus on specific goals and outcomes that is meaningful for patients and staff" (84). However this argument is not substantiated with references or by presented healthcare data. The new programme includes a three-part stated objective i) improved health status of the population; ii) high patient-perceived and -experienced quality; and iii) low cost per treated citizen; all objectives one only can agree on. There are similarities between the objectives of this new programme and the DDKM but also in some of the main criticisms targeting the introduction of accreditation because the evidence for its effectiveness is unclear and its costs uncertain, and there is no clear statement of the programme theory and no evaluation plan included. One hopes that the lessons learned from introducing accreditation will be used prospectively in defining and maintaining the new programme, including engaging all stakeholders to work in unity for the programme and to ensure that criticisms and new ideas are continuously addressed.

9.0 SUMMARY

Accreditation provides a framework for continuous quality improvement and is a widely used strategy for improving the quality of hospital care. Accreditation is defined as an external review process to assess how well a hospital performs relative to established standards. Despite the use of accreditation for decades, concerns regarding the costs, requirements, and demonstrable benefits for patient-related outcomes continue to surface. In 2009, the DDKM was launched as a mandatory accreditation programme for all public hospitals. Furthermore, Denmark has a large number of national registries covering the entire population, including medical registries containing prospectively collected detailed information on all hospitalisations. Thus, the Danish setting provides a unique opportunity to examine the relationship between accreditation and patient-related outcomes using register data.

To advance knowledge about accreditation, the studies included in this thesis aimed to examine the association between compliance with hospital accreditation and recommended hospital care (study I), all-cause 30-day mortality (study II), LOS (study III), and AR (study III). All studies were designed as follow-up studies using data on the 31 public hospitals' compliance with the first version of the DDKM for hospitals. Compliance was assessed by a team of surveyors conducting an onsite survey and who awarded the hospital as a whole; 11 were fully and 20 partially accredited. Data were obtained from November 15, 2009, to December 13, 2012, corresponding to a one-year inclusion period for each hospital (±6 months for the onsite survey). In the first study, outcome data were gathered from national clinical quality registries and in the second and third studies from the DNPR combined with The Civil Registration System.

In the study on recommended hospital care, a total of 449,248 process performance measures were included, corresponding to 68,870 patient pathways. Patients at fully accredited hospitals were more likely to receive the recommended hospital care according to clinical guideline recommendations than patients at partially accredited hospitals across conditions (individual measure: adjusted OR 1.20, 95% CI: 1.01–1.43; all-or-none: adjusted OR 1.27, 95% CI: 1.02–1.58). The association between compliance with the accreditation standards and a higher probability of receiving the recommended hospital care was found for five of the six included conditions. The pattern appeared particularly strong among patients with acute stroke and hip fracture (all-or-none; acute stroke: adjusted OR 1.39, 95% CI: 1.05–1.83; hip fracture: adjusted OR 1.57, 95% CI: 1.00–2.49).

In the study on 30-day mortality, a total of 276,980 patients were included, and the 30-day all-cause mortality risks for patients at fully (n=76,518) and partially accredited hospitals (n=200,462) were 4.14% (95% CI: 4.00–4.28) and 4.28% (95% CI: 4.20–4.37), respectively. Patients at fully accredited hospitals had a lower risk of dying within 30 days after admission than patients at partially accredited hospitals (adjusted OR 0.83, 95% CI: 0.72–0.96). A lower risk of 30-day mortality was observed among patients at partially accredited hospitals required to submit additional documentation

compared with patients at partially accredited hospitals having a return visit (adjusted OR 0.83, 95% CI: 0.67–1.02).

In the study on LOS, a total of 275,589 patients were identified with mean LOS values of 4.51 days (95% CI: 4.46–4.57) at fully and 4.54 days (95% CI: 4.50–4.57) at partially accredited hospitals. After adjusting for confounding factors, the adjusted HR for time to discharge was 1.07 in favour of patients at fully accredited hospitals (95% CI: 1.01–1.14). When comparing to patients at hospitals having a return visit, patients at hospitals submitting additional documentation and with no follow-up were more likely to be discharged earlier (documentation: adjusted HR 1.12, 95% CI: 1.01–1.24; no follow-up: adjusted HR 1.13, 95% CI: 1.04–1.23).

In the study on AR, a total of 266,532 patients were included with an AR of 13.70% within 30 days after discharge (95% CI: 13.45–13.95) at fully and 12.72% (95% CI: 12.57–12.86) at partially accredited hospitals. No difference was found according to compliance with accreditation (adjusted HR 1.01, 95% CI: 0.92–1.10) or when categorising according to follow-up activity (documentation: adjusted HR 1.07, 95% CI: 0.96–1.19; no follow-up: adjusted HR 1.04, 95% CI: 0.92–1.17).

In conclusion, compliance with hospital accreditation was associated with recommended hospital care, 30-day mortality, and LOS. No difference was observed for AR.

10.0 DANSK RESUME

Akkreditering danner rammen for kontinuert kvalitetsforbedringsarbejde og er en bredt anvendt strategi til at forbedre hospitalernes behandlingskvalitet. Akkreditering defineres som en ekstern evalueringsproces, hvis formål er at vurdere, hvor godt et hospital præsterer i forhold til fastlagte standarder. Til trods for at akkreditering har været anvendt i årtier, hersker der stadigvæk usikkerhed om akkrediteringens omkostninger, krav og dokumenterede fordele for patienter. I 2009 blev Den Danske Kvalitetsmodel (DDKM) indført som et obligatorisk akkrediteringsprogram for alle offentlige hospitaler. Danmark har tillige et stort antal nationale tilgængelige registre over hele befolkningen inklusiv medicinske registre, der indeholder detaljerede og opdaterede information om alle hospitalsindlæggelser. Dette giver en unik mulighed for at undersøge sammenhængen mellem akkreditering og patient relaterede outcomes i den danske kontekst.

For at tilvejebringe ny viden om akkreditering havde tesens studier til formål at undersøge associationen mellem opfyldelsesgraden af akkreditering og anbefalet klinisk proceskvalitet (studie I), 30-dages dødelighed (studie II), indlæggelseslængde (studie III) og akut genindlæggelse (studie III). Alle tesens studier var designet som followup studier baseret på 31 hospitalers opfyldelsesgrad af akkreditering målt ved den 1. version af DDKM. Opfyldelsesgraden blev vurderet af et surveyteam ved et på forhånd annonceret hospitalsbesøg kaldet eksternt survey og tildelt hospitalet som en helhed: 11 hospitaler blev fuldt akkrediteret og 20 blev delvist akkrediteret. Data blev indsamlet i perioden fra 15. november 2009 til og med 13. december 2012 svarende til et års inklusionsperiode for hvert hospital (± 6 måneder fra eksternt survey). I det første studie blev informationer om anbefalet hospitalsbehandling indhentet via de nationale kliniske kvalitetsdatabaser, og for de resterende studier fra henholdsvis Landspatientregisteret koblet med Det Centrale Personregister.

I studiet om anbefalet klinisk proceskvalitet blev i alt 449,248 procesindikatorer inkluderet svarende til 68,870 patientforløb. Patienter behandlet på fuldt akkrediterede hospitaler havde en signifikant højere sandsynlighed for at modtage den anbefalede hospitalsbehandling ifølge kliniske retningslinjer end patienter behandlet på delvist akkrediterede hospitaler på tværs af sygdomsområder (individuel procesindikator: justeret odds ratio (OR) 1.20, 95 % konfidensinterval (CI): 1.01-1.43, all-or-none: justeret OR 1.27, 95 % CI: 1.02-1.58). Der blev ligeledes fundet en sammenhæng mellem opfyldelsesgraden af akkrediteringen og en højere sandsynlighed for at modtage den anbefalede proceskvalitet for fem af de seks inkluderede sygdomsområder. Den fundne sammenhæng var særligt stærk for patienter med apopleksi og hoftenære lårbensbrud (all-or none; apopleksi: justeret OR 1.39, 95 % CI: 1.05-1.83, hoftenære lårbensbrud: justeret OR 1.57, 95 % CI: 1.00-2.49).

I studiet om 30-dags dødelighed blev 276,980 patienter inkluderet og risikoen for at dø indenfor 30 dage efter indlæggelsen for patienter indlagt på fuldt akkrediterede (n=76,518) og delvist akkrediterede hospitaler (n=200,462) var henholdsvis 4,14 % (95 % CI: 4,00-4,28) and 4,28 % (95 % CI: 4,20-4,37). Patienter på fuldt akkrediterede hospitaler have en lavere risiko for at dø indenfor

30 dage efter indlæggelsen end patienter indlagt på delvist akkrediterede hospitaler (justeret OR of 0,83; 95 % CI: 0,72-0,96). En lavere risiko for at dø indenfor 30 dage blev også fundet for patienter indlagt på hospitaler opfordret til at indsende supplerende dokumentation sammenlignet med patienter på hospitaler, der fik fokuseret genbesøg (justeret OR 0,83; 95 % CI: 0,67-1,02).

I studiet om indlæggelseslængde blev 275,589 patienter identificeret med en gennemsnitlig indlæggelseslængde på henholdsvis 4,51 dage (95 % CI: 4,46-4,57) på fuldt akkrediterede og 4,54 dage (95 % CI: 4,50-4,57) på delvis akkrediterede hospitaler. Efter justering for seks mulige konfounder var den justerede Hasard ratio (HR) 1,07 til fordel for patienter indlagt på fuldt akkrediterede hospitaler (95 % CI: 1,01-1,14). Patienter indlagt på hospitaler opfordret til at indsende supplerende dokumentation eller uden opfølgning blev udskrevet tidligere sammenlignet med patienter indlagt på hospitaler, der fik fokuseret genbesøg (dokumentation: justeret HR 1,12, 95 % CI: 1,01-1,24; igen opfølgning: justeret HR 1,13, 95 % CI: 1,04-1,23).

I studiet om akut genindlæggelse blev 266,532 patienter inkluderet, hvor 13,70 % (95 % CI: 13,45-13,95) af patienterne på fuldt akkrediterede hospitaler blev akut genindlagt, mens det var 12,72 % (95 % CI: 12,57-12,86) patienterne på delvis akkrediterede hospitaler. Der var ingen sammenhæng til opfyldelsesgraden af akkrediteringen (justeret HR: 1,01 (95 % CI: 0,92-1,10)) eller i forhold til opfølgningsaktiviteten (dokumentation: justeret HR 1,07, 95 % CI: 0,96-1,19; ingen opfølgning: justeret HR 1,04, 95 % CI: 0,92-1,17).

Det konkluderes, at opfyldelsesgraden af akkrediteringen var associeret med den anbefalede klinisk proceskvalitet, 30 dages dødelighed og indlæggelseslængde. For akut genindlæggelse blev der ikke fundet nogen forskel.

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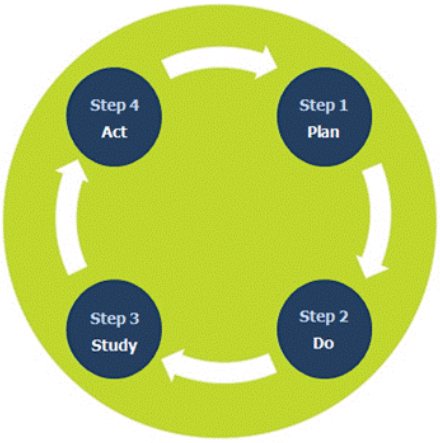
12. APPENDIX WITH DETAILS ON SURVEYOR TRAINING AND THE SURVEY PLAN

The main objectives of the surveyor training were to enable the surveyors to use the learned principles and to communicate the goals of the DDKM during the onsite survey (notat om surveyorkursus, Januar 2009).

The training of the potential surveyors was based on two theoretical modules followed by an observational survey. The training was completed by two residential courses within the framework of IKAS assisted by the international consultant, Health Quality Services. The course met the standards from ISQua.

The first module introduced the surveyors to the objectives with the DDKM, its principles, and values, including the focus on assisting learning and quality improvement within the surveyed organisation, as illustrated in Figure 1. The surveyors were provided insights to be able to understand and use the purpose and content of all standards to apply a valid judgement later on. The modules enabled the surveyors to understand data on quality by introducing them to different definitions of quality, the basic model for improvement, and how the results can be measured and monitored. This module also briefly touched on ethical and legal aspects, including health legislation referred to in the standards and the duty of confidentiality.

Figure 1. The basic model for improvement incorporated into the four steps of the DDKM (www.ikas.dk)



The second module introduced the surveyors to the onsite survey by providing knowledge about all phases in accreditation including the planning of the survey, using the rating principles and documenting findings in the survey report. By the end of the module, the surveyors should demonstrate the ability to collect evidence from documents, interviews, and observations and subsequently use this information to make a valid judgement. The module also focused on communication skills that enabled the surveyors to facilitate a good and constructive dialog with the surveyed organisation.

The first observational surveys were conducted abroad in relation to surveys performed by the Health Quality Services. Later observational surveys were done in Denmark, when surveys according to the DDKM began. During the observational surveys, the surveyors were only to observe and ask questions in relation to the surveyor task – not to factor their opinion into the survey undertaken.

Based on their performance in the modules and observational surveys, surveyors were appointed by IKAS. The surveyors were then contracted with IKAS and obligated to perform a number of surveys and to take part in an annual training day.

Before an onsite survey was undertaken, a consultant from IKAS put a structured survey plan in place together with the hospital's accreditation coordinator and the lead surveyor. The hospitals were categorised according to size and hospital sites to estimate the number of surveyors needed for each survey. The hospitals were informed about the members of the survey team and had the opportunity to raise objections in relation to incapacity. An example of a survey plan for a hospital, categorised as medium, is outlined in Table X.

Table 1. Example of a survey plan for a Danish hospital categorised as a medium hospital corresponding to five surveyors for 5 days

Day 1	Lead surveyor	Surveyor 2	Surveyor 3	Surveyor 4	Surveyor 5
08.00–08.30	Met with the accreditation coordinator including assignment of office, PC, inter- and possible intranet connection				
08.45–10.00	Management's presentation of the company and management, including quality plan (short presentations from leading surveyor)				
10.00–12.00	Reviewing the overall guiding documents				
12.00–13.00	Lunch and team meeting				
13.00–14.00	Reviewing the overall guiding documents				
14.00–16.00	Cross-disciplinary interview Overall use of data for the development of quality and patient safety	Patient tracer	Patient tracer	Cross-disciplinary interview Buildings, supplies, and other facilities, including local observation and interview	
16.00–16.30	Entry of data in the survey report				
16.30–17.30	Team meeting and selection of patient tracer to the next day				
Day 2	**Lead surveyor**	**Surveyor 2**	**Surveyor 3**	**Surveyor 4**	**Surveyor 5**
08.00–08.30	Feedback to the hospital (participants from the day before)				
08.45–10.00	Interview of surveillance of patient safety, including complaints	Patient tracer	Patient tracer	Cross-disciplinary interview Hygiene and infection control, including local observation and interview	Patient tracer
10.00–12.00	Management of the survey team	Follow-up and entry of data	Follow-up and entry of data		Follow-up and entry of data
12.00–13.00	Lunch and team meeting				
13.00–15.00	Patient tracer	Cross-disciplinary interview Monitoring of medication, including local observation and interview	Patient tracer	Patient tracer	Patient tracer
15.00–15.30	Team meeting and coffee				
15.30–16.30	Entry of data into the survey report				
Evening visit 18.00–20.00	Visit selected units				

Day 3	Lead surveyor	Surveyor 2	Surveyor 3	Surveyor 4	Surveyor 5
08.00–08.30	Feedback to the hospital (participants from the day before)				
08.45–10.45	Cross-disciplinary interview *Employment policy, work planning, and competence development*	Patient tracer	Patient tracer	Patient tracer	Patient tracer
11.00–12.00	Entry of data into the survey report				
12.00–13.00	Lunch and team meeting				
13.00–15.00	Management of the survey team	Cross-disciplinary interview Emergency and critical supplies, including local observation and interview	Cross-disciplinary interview Laboratory services, including local observation and interview	Patient tracer	Cross-disciplinary interview Medical technology and IT, including local observation and interview
15.00–15.30	Team meeting and coffee				
15.30–16.30	Entry of data into the survey report				
Day 4	**Lead surveyor**	**Surveyor 2**	**Surveyor 3**	**Surveyor 4**	**Surveyor 5**
08.00–08.30	Feedback to the hospital (participants from the day before)				
08.45–10.30	Management of the survey team	Patient tracer	Cross-disciplinary interview Imaging services, including local observation and interview	Patient tracer	Cross-disciplinary interview Coordination and continuity and cooperation with the primary sector
11.00–12.00	Entry of data in the survey report				
12.00–13.30	Lunch and team meeting				
13.30–16.00	Consensus meeting				
16.00–16.30	Entry of data into the survey report				
Day 5	**Lead surveyor**	**Surveyor 2**	**Surveyor 3**	**Surveyor 4**	**Surveyor 5**
08.00–08.30	Feedback to the hospital (participants from the day before)				
08.30–10.00	Management interview		Follow-up and entry of data		
10.00–11.00	Consensus meeting				
11.00–12.00	Entry of data into the survey report				
12.00–13.00	Lunch and team meeting				
13.00–14.00	Feedback to the hospital (can be given in two presentations according to management wishes)				
14.00–15.00	Survey team debriefing				

PAPERS

Compliance with accreditation and recommended hospital care

– A Danish nationwide population-based study

Paper I

Compliance with hospital accreditation and patient mortality

– A Danish nationwide population-based study

Paper II

Is compliance with hospital accreditation associated with length of stay

and acute readmission – A Danish nationwide population-based study

Paper III

PAPERS

Paper I

Compliance with accreditation and recommended hospital care

– A Danish nationwide population-based study

Compliance with accreditation and recommended hospital care – A Danish nationwide population-based study

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Word count for the abstract: 268
Word count for the text of the manuscript: 3310
Keywords: Accreditation, Healthcare quality improvement, processes of care, performance measures

ABSTRACT

Objective: To examine the association between compliance with accreditation and recommended hospital care

Design: A Danish nationwide population-based follow-up study based on data from six national, clinical quality registries between November, 2009 and December, 2012.

Participants and setting: All patients treated at one of the 31 public, non-psychiatric hospitals were identified with their first record in the registries covering acute stroke, chronic obstructive pulmonary disease, diabetes, heart failure, hip fracture, and bleeding/perforated ulcers.

Intervention: All hospitals were accredited by the 1st version of mandatory Danish Healthcare Quality Programme. Compliance with accreditation was defined by level of accreditation awarded the hospital after an announced onsite survey; hence hospitals were either fully (n=11) or partially accredited (n=20).

Main outcome measures: Recommended hospital care included 48 process performance measures reflecting recommendations from clinical guidelines. We assessed recommended hospital care as fulfilment of the process performance measures individually and as an all-or-none composite score.

Results: A total of 449,248 processes of care were included corresponding to 68,780 patient pathways. Patients at fully accredited hospitals had a significantly higher probability of receiving care according to clinical guideline recommendations than patients at partially accredited hospitals across conditions (individual measure: adjusted OR 1.20, 95%CI: 1.01-1.43, all-or-none: adjusted OR 1.27, 95%CI: 1.02-1.58). An association was found for five of the six included conditions; the pattern appeared particular strong among patients with acute stroke and hip fracture (all-or none; acute stroke: adjusted OR 1.39, 95%CI: 1.05-1.83, Hip fracture: adjusted OR 1.57, 95%CI: 1.00-2.49).

Conclusion: Patients admitted at fully accredited hospitals were more likely to receive care according to clinical guidelines recommendations than patients at partially accredited hospitals.

INTRODUCTION

Receiving treatment according to clinical recommendations when hospitalised is an ongoing challenge worldwide. To overcome this many efforts have been introduced with one being accreditation. Accreditation provides a framework for quality improvements which guide the hospitals to reflect on recommended care and to initiate improvements when necessary (1). The hospitals are required to work with a set of standards covering different areas such as diagnoses, treatment, and risk management (2). Although the use of accreditation has increased tremendously in the last two decades, there is limited evidence for its effectiveness on the care provided by the hospitals (3-7).

The use of recommended hospital care is in Denmark continuously monitored through process performance measures reflecting recommendations from national clinical guidelines (8). Only one study have to our knowledge investigated the relationship to compliance with accreditation, however it was inconclusive due to clustering of hospitals within one accreditation category combined with too much variation in the recommended care provided (9). Other studies have investigated accreditation and recommended hospital care by comparing accredited with non-accredited hospitals with some (9-12) but not all being in favour of accreditation (13-15). Most of the studies have been limited by restriction to specific diagnostic groups (e.g., patients with stroke, heart failure, or cancer) and therefore only include a small number of performance measures. Furthermore, a comparison between accredited and non-accredited hospitals may introduce a substantial risk of selection bias reflected in these studies by accredited hospitals more often being larger, having teaching status, and being located in cities, perhaps as result of accreditation being voluntary (10,11,13).

Denmark is a unique setting to examine the association between compliance with accreditation and recommended hospital care since both accreditation and continuously monitoring of process performance measures have been mandatory for all Danish hospitals for years. Two previous Danish studies have revealed an improved patient outcome in term of lower 30-day mortality and shorter length of stay for patients treated at hospitals fully compliant with the national accreditation programme (16,17). Thus we hypothesised that patients treated at hospitals fully compliant with accreditation standards were more likely to receive the recommended process performance measures according to clinical guidelines than patients treated at hospitals partially compliant with accreditation standards.

METHODS

A nationwide population-based follow-up study was performed by linking data from the national accreditation programme with data on recommended hospital care from six national clinical quality databases. The registries encompass all potential patients with these conditions, as all Danish citizens have free access to healthcare because of tax-funding (18).

Accreditation in Denmark

All Danish, public hospitals were accredited from 2010 to 2012 according to the 1st version of the Danish Healthcare Quality Programme (DDKM; in Danish: Den Danske Kvalitetsmodel) (19). This mandatory programme comprised of 104 standards addressing a range of objectives within the overall aims to ensure continuous quality improvement in the hospitals and to foster coherent patient pathways (an English version is available at http://www.ikas.dk/ddkm/ddkm-in-english/). All standards used a generic template incorporating the Plan-Do-Study-Act cycle (PDSA) to facilitate improvement. The 1st version of the DDKM incorporated specific standards for ten diseases to ensure the patients received diagnostic work up, care and rehabilitation in accordance with national clinical guidelines. The standards described the need for clinical guidelines (plan), the awareness and use of guidelines by the staff (do), reporting to national clinical quality registers as documented by the existence of the annual reports from the national registries (study) and improvement initiatives made in case inadequate recommended care was identified (act). Thus, the actual performance on the measures in the clinical registries did not factor into the decision on compliance with the standard or accreditation decision. All standards used measurable elements to guide the hospitals in their implementation of the programme. Yet, the measurable elements were also used in the evaluation of a hospital's compliance with the standard.

Compliance with the DDKM was assessed by a survey team during an announced, on-site survey. The surveyors used several methods to evaluate compliance including interviewing staff and patients primarily, reviewing guidelines, and to a lesser extent observing procedures. The surveyors used the measurable elements to assess compliance by grading them on a three-point scale containing fully, partially or not met. The grading was, subsequently, used to rank the standards. All findings were documented in a survey report forwarded to the Accreditation Award Committee whom awarded the level of accreditation to the hospital as a whole. Hospitals were accredited when they had demonstrated the ability to ensure quality in the areas covered by DDKM. Accreditation with comments was awarded when not all standards were met and there were failures of a significant nature and/or importance, but were full compliance was expected to be achieved within a reasonable time. If a hospital was accredited with comments (first proceeding), it was offered a follow-up activity by either having a return visit by a reduced survey team or to submit additional documentation. After completing this activity the Accreditation Award Committee awarded a final level of accreditation (final proceeding). All survey reports are fully accessible at public website including information on the first and final proceeding (www.sundhed.dk). We defined hospitals compliance with accreditation in accordance to the first proceeding, as this was considered to reflect the hospital's genuine ability to incorporate quality improvement within their organisations. Accredited hospitals are in the following referred to as fully accredited hospitals and hospitals accredited with comments referred to as partially accredited.

Not all 104 standards were expected to have a direct impact on the provided care. Before study start we therefore used an expert group with extensive knowledge of the DDKM and/or the Danish healthcare system to identify standards with an expected possible direct impact on recommended care. Each expert selected the standards considered to have an impact on recommended hospital care and afterwards ranked these according to importance. We hereby identified the 25 highest prioritised standards and included for further analysis those whom were selected by at least three experts and where at least three hospitals did not met the standard. Hospitals compliant to all selected standards were referred to as compliant hospitals and hospitals partially or not compliant to one or more standards as non-compliant.

Recommended hospital care

Recommended hospital care reflected the hospitals ability to provide a patient with clinical, evidence-based care. Recommended hospital care was assessed using process performance measures in six national clinical quality registries reflecting recommendations with national clinical guidelines. The registries cover six major or severe medical conditions; acute stroke, chronic obstructive pulmonary disease (COPD), diabetes (including outpatient contacts), heart failure, hip fracture, and perforated and bleeding ulcers.

The registries were established through a national initiative from 2000 and onwards with the aim to monitor and improve recommended hospital care for specific conditions (20). The registries all focus on process performance measure monitoring combined with systematic auditing. For each registry, an expert group involving multidisciplinary professions identified and defined a number of process performance measures on the basis of scientific evidence and feasibility of data collection. Reporting to the registries is mandatory according to Danish law. The staff responsible for treating the individual patient reported whether the process performance measures were fulfilled in accordance with predefined, exhaustive criteria established by the expert group. Data was collected prospectively upon admission/outpatient contact. The registries check completeness and quality of data provided through audits and comparisons with administrative registries on a continuously basis (21,22).

A total of 48 process performance measures were included (content of and timeframe for each measure are listed by medical condition in supplementary 1). All registries accommodate the possibility to classify a patient as "not relevant" for some processes performance measures due to e.g. contraindications or if a patient is dying. Consequently, the numbers of patient pathways varied for the included process performance measures in each condition.

Study population

We identified all patients assessed to receive one or more eligible recommended processes of care in the included registries. The patients were included if the recommended hospital care were to be provided in the period from +/- six month from the hospitals first day of on-site survey. This period

was considered appropriate as an enhanced effort to get the staff to work in accordance with requirements of the accreditation programmes were started approximately six months before the on-site survey, and additional work to become fully compliant most likely ended within six months after the on-site survey. Thus, data were gathered from November 15, 2009 to December 13, 2012. For each medical condition we included a patient's first clinical pathway. Consequently, a patient could be included with two or more medical conditions as we considered fulfilment of process performance measures according to one condition to be independent of fulfilment in another condition.

STATISTICAL ANALYSIS

Recommended hospital care was evaluated by examining a patient's probability of receiving i) the individual recommended process of care hereby referred to as individual measure and ii) all recommended processes of care in his/hers clinical pathway reflected by an composite all-or-none score referred to as all-or-none. Across conditions we analysed the two measures by comparing the delivered care by compliance with accreditation, follow-up activity, and according to hospitals compliant or non-compliant with the *a priori* selected standards combined and separately. Odds ratios with 95% CI were computed using logistic regression including adjustment for medical conditions. Robust standard error estimation was likewise included in the model with hospitals as cluster variable to ensure that within-hospital grouping was taken into account. We did not adjust for other patient related covariates as only patients relevant to receive the individual processes of care were included in the study. Missing data was excluded from our analyses; the proportion in the registries was low (<10%) and expected to be missing completely at random. All analyses were repeated for each medical condition separately (data not shown for *a priori* selected standards). Stratified analyses were conducted according to previous accreditation (yes/no), and university affiliation (yes/no).

A sensitivity analysis was performed to account for any possible misclassification due to by nature inexperience owing to this was the first cycle of DDKM accreditation. Compliance with accreditation was reassessed using the rating principles of 2012 developed to ensure a transparent allocation of level of accreditation. Three specialists performed the reassessment using of pre-specified protocol and any differences were solved by consensus. Hospitals were hereafter re-categorised as fully, partially or non-accredited.

Additionally, a multilevel regression analyse was performed taking into account the hierarchical structure of data. But because the results did not substantially change the estimates, we only presents the results of the logistic regression in this paper (please see the supplementary for results of the multilevel model).

A 2-sided significance level of 0.05 was used in the statistical tests performed using STATA, version 12 (StataCorp. 2011. College Station, TX: StataCorp LP).

RESULTS

We included 68,780 patient pathways covering 449,248 process performance measures. The inclusion of the patient pathway is illustrated in Figure 1, including numbers of pathway per medical condition. The patients were treated at 31 public, non-psychiatric hospitals of which 11 were fully and 20 partially accredited equivalent to 31.6% of the recommended hospital care were to be delivered by fully accredited and 68.4% by partially accredited hospitals.

Compliance with accreditation across conditions

Across medical conditions, patients at fully accredited hospitals were significantly more likely to receive care according to clinical guideline recommendations compared with patients at partially accredited hospitals in agreement with our hypotheses (individual measure: adjusted OR: 1.20, 95%CI: 1.01-1.43, and all-or-none: adjusted OR: 1.27, 95%CI: 1.02-1.58). Results for the individual measures and all-or-none are presented in Table 1 and 2, respectively. The results remained virtually unchanged when stratifying hospitals according to previous accreditation or university affiliation (data not shown).

The findings according to follow-up activity indicated that patients at hospitals submitting additional documentation and with no follow-up to a higher extent received the recommended hospital care compared with patients at hospitals having a return-visit, although it was only statistical significant for all-or-none at hospitals with no-follow-up (individual measure: documentation: adjusted OR: 1.11, 95%CI: 0.84-1.46; no follow-up adjusted OR: 1.26, 95%CI: 0.97-1.62 and all-or none: documentation: adjusted OR: 1.10, 95%CI: 0.79-1.54; no follow-up adjusted OR: 1.33, 95%CI: 1.00-1.76).

Hospitals classified as non-accredited according to the rating principles of 2012 were significantly inferior compared to partially accredited hospitals in delivering the recommended hospital care to the patients corresponding to an adjusted OR for the individual measures of 0.52 (95%CI: 0.31-0.89) and 0.47 for the all-or-none score (95%CI: 0.29-0.77).

A priori selected standards with potential direct impact on recommended hospital care

Five standards were identified *a priori* to have a potential impact on recommended hospital care of which four dealt with organisational aspects and one with clinical aspects (please see Table 1 for further details). Using patients at non-compliant hospitals as the reference group, patients at compliant hospitals were more likely to receive the recommended hospital care (individual measure: OR: 1.16, 95%CI: 0.95-1.41 and all-or none: OR 1.24, 95%CI: 0.98-1.57). The main driver of this finding was attributed to the standard "risk management" (individual measure: OR: 2.31, 95%CI: 1.58-3.37 and all-or none: OR: 2.36, 95%CI: 1.43-3.90).

Individual medical conditions

Restricting the analysis to individual medical conditions yielded a variation between conditions in the ability to provide a patient with the recommended care as shown in Table 3. The largest difference in the performance between fully and partially accredited hospitals was found among patients admitted with acute stroke and hip fractures (all-or none; acute stroke: OR: 1.39, 95%CI: 1.05-1.83 and hip fracture: OR: 1.57, 95%CI: 1.00-2.49).

Analysing the individual process performance measures demonstrated that patients at fully accredited hospitals were more likely to receive the recommended hospital care than patients at partially accredited hospitals for the four conditions: acute stroke, COPD, diabetes, and hip fracture for almost all measures, as illustrated in Figure 2. In contrast, the probability of receiving the recommended hospital care for patients with heart failure was highest for patients admitted at partially accredited hospitals, whereas no difference was found for patients with ulcer.

DISCUSSION

Our study based on data from almost 450,000 processes of care revealed a higher probability of receiving the recommended hospital care according to clinical guidelines recommendations for patients treated at fully accredited hospital compared with partially accredited hospitals.

The study's strength is that the presented association is unlikely to be influenced by selection bias, because all possible patient data were included for all public, non-psychiatric hospitals and missing values in the clinical registries are considered to be missing completely at random owing to data is collected prospectively. The assessment of patients considered non-eligible for the individual measure was likewise based on exhaustive criteria defined by disease specific expert groups which minimise the risk of differences in registration practice at fully and partially accredited hospitals. Furthermore was level of accreditation award approximately three month after the onsite survey, thus, for almost the entire inclusion period information on exposure was unknown to the staff reporting data.

As staffs were obligated to provide the patient with a recommended process of care, irrespectively of patient's age or other characteristics, we did not adjust for patient characteristics. The restriction to include patient with eligible measures was undertaken to address concerns of confounding because of the non-randomised design applied. Previous accreditation and university affiliation did not influence the results presented, however we cannot rule out other hospital characteristics influencing the association.

Incorrect registration of the process performance data due to gaming is, however, at least in theory, a possibility as results from the registries are used quarterly, and annually to bench mark the units. However, there is no financial incentive for reporting correct measures and as data was reported irrespectively of compliance with accreditation, any misclassification is considered to be of non-differential nature and bias the result towards the null.

The unknown validity of the assessment of compliance with accreditation is a limitation to this study. Until now, there are to our knowledge no published studies confirming the reliability of and between survey team judgements (7,23-25). A recent publication have identified six issues of importance to survey reliability and thereby essential for the credibility of accreditation (25). In the Danish setting the first three factors; accreditation program, governance and philosophy, and accrediting agency management of the accreditation process were accommodated as only one accreditation body was responsible for the entire programme ensuring a similar approach in all surveys conducted. Three procedures were likewise put into practise in the effort to minimise potential variation; i) structured survey plans including interviews addressing specific standards were used in all survey, ii) survey teams meet several times daily to discuss and obtain consensus on any potential findings and iii) survey reports were checked for consistency with the rating principles. This was done in order to reduce intra-surveyor and inter-survey team variation. However we have no information on the last three factors; survey team dynamics, individual surveyors, or the hospitals approach to survey which are emphasised as important for the surveys reliability by Greenfield et al (25).

It should be noted that hospitals in general provided a high percentage of the recommended care to patients (individual measure: fully accredited 89.53% vs partially accredited 88.06%). However, still approximately 1/3 of the patients did not receive the full bundle of recommended care (all-or-none: fully accredited 67.22% vs partially hospitals 62.63%). This highlights the need of an ongoing focus on delivering adequate care. The absolute difference in recommended care between fully and partially accredited hospitals was relatively moderate, however it should be taken into account that studies using data from the registries, have demonstrated an improved patient outcomes, including survival, for patients provided with all of the recommended care (all-or-none) and even small differences may therefore have important clinical implications (26-28).

An essential part of the clinical registries was to ensure the clinicians and managers a continuously feedback of results monthly and annually. Results are provided at national, regional, and local level including structured clinical audits with the aim to explain the results and provide professional interpretations to use for improvements. The audits have throughout the years increased the probability for receiving the recommended care (29,30). However this does not explain the differences between fully and partially accredited hospital ability to provide the recommended care, as all hospitals were included in the auditing, irrespectively, of the compliance with the accreditation programme.

Our study hypothesis was supported by our finding. Thus, this study is the first to provide useful information on compliance with accreditation to distinguish in the recommended hospital care provided. The introduction of a framework for continuous quality improvement at the hospitals may help us to understand the mechanisms behind this association. By utilising the PDSA in the standards, the DDKM encouraged the hospitals to incorporate the framework as a part of their quality improvement process. This was based on the theory that the patients' were more likely to be provided with the recommended care if the staff worked in according with guiding documents

reflecting clinical evidence-based guidelines (or best practice). During the implementation of the 1st version of the DDKM, the hospitals were recommended to perform a number of mock surveys in order to facilitate the use of clinical guidelines and improve reporting to the clinical registries. Combined with the requirement to implement initiatives to improve identified inadequate quality, the cycle was completed. However, this study does not give us the answer to whether fully accredited hospitals to higher extent used the framework to initiate quality improvements within their organisation. Or if compliance with accreditation could be a marker for high-performing hospitals characterised by the ability to achieve high compliance with accreditation standards simultaneously with delivering high recommended hospital care. Hence, the nature of the revealed association remains to be further investigated in order to understand the contributing reasons.

CONCLUSION

This nationwide population-based study showed that patients with six major medical condition treated at fully accredited hospitals were more likely to receive recommended hospital care according to national clinical guidelines than patients at hospitals partially accredited by the 1st version of the Danish Healthcare Quality Programme.

COMPETING INTERESTS

All authors have completed the ICMJE uniform disclosure form at and declare: no disclosure for the submitted work; First author was former employed by the Institute of Quality and Accreditation in Healthcare (IKAS). No other relationships or activities that could appear to have influenced the submitted work.

FUNDING

The Ph.D.-project was funded by Centre for Quality in the Region of Southern Denmark, Department of Clinical Epidemiology, Aarhus University Hospital, and the Institute of Quality and Accreditation in Healthcare (IKAS). IKAS had no role whatsoever regarding study design, data collection, analysis, decision to publish or preparation of the manuscript. All authors are independent researchers without any financial interest in the results presented.

ETICHS APPROVAL

The study was approved by the Danish Data Protection Agency. According to Danish law, ethical approval and informed content are not needed for registry-based studies.

CONTRIBUTORS

The first and last authors designed and conducted the study; collected, managed, analysed, and interpreted the data; manuscript drafting and revision; following The STROBE guideline. All other authors were responsible for study design, interpretation of data, and critical manuscript revision and approval. The first and last authors had full access to all data and take responsibility for the integrity of the data and the accuracy of the data analysis.

DATA SHARING

Codebook and statistical code (all in Danish) are available from the corresponding author.

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TABLES

Table 1 | Recommended hospital care evaluated by individual measure and odds ratio (OR) for patients treated at accredited, Danish hospitals according to their compliance with the 1st version of DDKM

	Patient processes Counts (%) (N=449 249)	Hospitals Counts (%) (N=31)	Fulfilment of individual measure % (95% CI)	Individual measure OR (95% CI)	
				Crude	Adjusted[1]
COMLIANCE WITH ACCREDITATION PROGRAMME					
Patients at partially accredited hospitals[2]	307 387 (68.4)	20 (64.5)	88.06 (87.95-88.18)	1.00	1.00
Patients at fully accredited hospitals	141 862 (31.6)	11 (35.5)	89.53 (89.37-89.68)	1.16 (0.92-1.46)	1.20 (1.01-1.43)
COMPLIANCE ACCORDING TO FOLLOW-UP ACTIVITY					
Patients at hospitals having a return visit[2]	169 295 (37.7)	11 (35.5)	87.97 (87.81-88.12)	1.00	1.00
Patients at hospitals submitting documentation	138 092 (30.7)	9 (29.0)	88.18 (88.01-88.35)	1.02 (0.74-1.40)	1.11 (0.84-1.46)
Patients at hospitals with no follow-up	141 862 (31.6)	11 (35.5)	89.53 (89.37-89.68)	1.17 (0.86-1.59)	1.26 (0.97-1.62)
COMPLIANCE WITH THE FIVE SELECTED STANDARDS					
Patients at non-compliant hospitals[2]	238 251 (53.0)	16 (51.6)	88.01 (87.88-88.14)	1.00	1.00
Patients at compliant hospitals	210 998 (47.0)	15 (48.4)	89.11 (88.97-89.24)	1.11 (0.87-1.42)	1.16 (0.95-1.41)
COMPLIANCE WITH SELECTED STANDARDS INDIVIDUALLY					
Risk management					
Patients at non-compliant hospitals[2]	19 310 (4.3)	3 (9.7)	76.77 (76.18-77.37)	1.00	1.00
Patients at compliant hospitals	429 939 (95.7)	28 (90.3)	89.05 (88.96-89.15)	2.46 (1.88-3.23)	2.31 (1.58-3.37)
Document management					
Patients at non-compliant hospitals[2]	184 556 (41.1)	13 (41.9)	88.01 (87.86-88.16)	1.00	1.00
Patients at compliant hospitals	264 693 (58.9)	18 (58.1)	88.89 (88.77-89.01)	1.09 (0.82-1.45)	1.16 (0.90-1.49)
Patient health record					
Patients at non-compliant hospitals[2]	82 976 (18.5)	4 (12.9)	88.87 (88.66-89.09)	1.00	1.00
Patients at compliant hospitals	366 273 (81.5)	27 (87.1)	88.45 (88.34-88.56)	0.96 (0.71-1.29)	0.97 (0.75-1.25)
Training and competence development					
Patients at non-compliant hospitals[2]	55 155 (12.3)	4 (12.9)	88.93 (88.67-89.19)	1.00	1.00
Patients at compliant hospitals	394 094 (87.7)	27 (87.1)	88.47 (88.37-88.57)	0.96 (0.62-1.47)	0.95 (0.68-1.33)
Observation and follow-up on critical observation results					
Patients at non-compliant hospitals[2]	43 154 (9.6)	3 (9.7)	89.54 (89.25-89.83)	1.00	1.00
Patients at compliant hospitals	406 095 (90.4)	28 (90.3)	88.42 (88.32-88.52)	0.89 (0.77-1.03)	0.97 (0.82-1.14)
COMLIANCE ACCORDING TO THE RATING PRINCIPLES OF 2012					
Patients at fully accredited hospitals	115 087 (25.6)	8 (25.8)	89.12 (88.94-89.30)	1.00 (0.80-1.25)	1.02 (0.89-1.17)
Patients at partially accredited hospitals[2]	301 494 (67.1)	21 (67.7)	89.13 (89.02-89.24)	1.00	1.00
Patients at non-accredited hospitals	32 668 (7.3)	2 (6.5)	80.86 (80.44-81.29)	0.52 (0.31-0.86)	0.52 (0.31-0.89)

[1] Adjusted for medical condition

[2] Reference group

Table 2:

Table 2| Recommended hospital care evaluated by all-or-none score and odds ratio (OR) for patients treated at accredited, Danish hospitals according to their compliance with the 1st version of DDKM

	Patient pathways Counts (%) (N=68 780)	**Hospitals Counts** (%) (N=31)	**Fulfilment of all-or-none** % (95% CI)	**All-or-none OR (95% CI)**	
				Crude	Adjusted[1]
COMLIANCE WITH ACCREDITATION PROGRAMME					
Patients at partially accredited hospitals[2]	47 048 (68.4)	20 (64.5)	62.63 (62.19-63.06)	1.00	1.00
Patients at fully accredited hospitals	21 732 (31.6)	11 (35.5)	67.22 (66.59-67.84)	1.22 (0.94-1.60)	1.27 (1.02-1.58)
COMPLIANCE ACCORDING TO FOLLOW-UP ACTIVITY					
Patients at hospitals having a return visit[2]	25 834 (37.6)	11 (35.5)	62.75 (62.16-63.33)	1.00	1.00
Patients at hospitals submitting documentation	21 214 (30.8)	9 (29.0)	62.48 (61.83-63.13)	0.99 (0.69-1.44)	1.10 (0.79-1.54)
Patients at hospitals with no follow-up	21 732 (31.6)	11 (35.5)	67.22 (66.59-67.84)	1.22 (0.90-1.64)	1.33 (1.00-1.76)
COMPLIANCE WITH FIVE STANDARDS					
Patients at non-compliant hospitals[2]	36 494 (53.1)	16 (51.6)	62.27 (61.77-62.77)	1.00	1.00
Patients at compliant hospitals	32 286 (46.9)	15 (48.4)	66.12 (65.60-66.63)	1.18 (0.90-1.55)	1.24 (0.98-1.57)
COMPLIANCE WITH STANDARD INDIVIDUALLY					
Risk management					
Patients at non-compliant hospitals[2]	3 276 (4.8)	3 (9.7)	44.90 (43.20-46.61)	1.00	1.00
Patients at compliant hospitals	65 504 (95.2)	28 (90.3)	65.04 (64.67-65.40)	2.28 (1.73-3.02)	2.36 (1.43-3.90)
Document management					
Patients at non-compliant hospitals[2]	28 305 (41.2)	13 (41.9)	62.93 (62.37-63.49)	1.00	1.00
Patients at compliant hospitals	40 475 (58.2)	18 (58.1)	64.88 (64.41-65.34)	1.09 (0.80-1.47)	1.20 (0.90-1.59)
Patient health record					
Patients at non-compliant hospitals[2]	12 605 (18.3)	4 (12.9)	63.61 (62.77-64.44)	1.00	1.00
Patients at compliant hospitals	56 175 (81.7)	27 (87.1)	64.18 (63.79-64.58)	1.03 (0.67-1.56)	1.07 (0.75-1.51)
Training and competence development					
Patients at non-compliant hospitals[2]	8 382 (12.2)	4 (12.9)	62.11 (61.07-63.15)	1.00	1.00
Patients at compliant hospitals	60 398 (87.8)	27 (87.1)	64.35 (63.97-64.73)	1.10 (0.77-1.58)	1.01 (0.69-1.49)
Observation and follow-up on critical observation results					
Patients at non-compliant hospitals[2]	6 389 (9.3)	3 (9.7)	65.88 (64.72-67.04)	1.00	1.00
Patients at compliant hospitals	62 391 (90.7)	28 (90.3)	63.89 (63.52-64.27)	0.92 (0.67-1.22)	1.02 (0.79-1.33)
COMLIANCE ACCORDING TO THE RATING PRINCIPLES OF 2012					
Patients at fully accredited hospitals	17 581 (25.5)	8 (25.8)	65.82 (65.12-66.52)	1.03 (0.77-1.37)	1.07 (0.86-1.33)
Patients at partially accredited hospitals[2]	45 937 (66.8)	21 (67.7)	65.15 (64.71-65.58)	1.00	1.00
Patients at non-accredited hospitals	5 262 (7.7)	2 (6.5)	48.90 (47.55-50.25)	0.51 (0.34-0.77)	0.47 (0.29-0.77)

[1] Adjusted for medical condition

[2] Reference group

Table 3:

Table 3| Recommended hospital care and Odds ratio (OR) according to medical condition for patients treated at accredited, Danish hospitals according their compliance with the 1st version of DDKM

	Individual measure		All-or-none	
	Fulfilment % (95% CI)	OR (95% CI)	**Fulfilment** % (95% CI)	OR (95% CI)
ACUTE STROKE				
Patients at partially accredited hospitals[1]	79.14 (78.79-79.49)	1.00	36.04 (34.95-37.13)	1.00
Patients at fully accredited hospitals	82.98 (82.52-83.45)	1.29 (1.03-1.61)	43.93 (42.32-45.54)	1.39 (1.05-1.83)
CHRONIC OBSTRUCTIVE LUNG DISEASE				
Patients at partially accredited hospitals[1]	84.53 (84.20-84.87)	1.00	75.04 (74.13-75.95)	1.00
Patients at fully accredited hospitals	85.65 (84.20-84.87)	1.09 (0.68-1.74)	79.36 (78.24-80.48)	1.28 (0.78-2.09)
DIABETES				
Patients at partially accredited hospitals[1]	93.65 (93.53-93.77)	1.00	72.17 (71.58-72.77)	1.00
Patients at fully accredited hospitals	94.91 (94.75-95.07)	1.26 (0.80-1.99)	75.54 (74.67-76.42)	1.19 (0.79-1.79)
HEART FAILURE				
Patients at partially accredited hospitals[1]	75.77 (75.08-76.45)	1.00	23.08 (21.47-24.69)	1.00
Patients at fully accredited hospitals	73.98 (72.96-74.99)	0.91 (0.76-1.08)	22.65 (20.38-24.92)	0.98 (0.71-1.34)
HIP FRACTURE				
Patients at partially accredited hospitals[1]	84.50 (84.08-84.92)	1.00	53.60 (52.21-54.99)	1.00
Patients at fully accredited hospitals	88.33 (87.70-88.95)	1.39 (0.97-1.98)	64.51 (62.32-66.71)	1.57 (1.00-2.49)
PERFORATED AND BLEDING ULCER				
Patients at partially accredited hospitals[1]	84.57 (83.31-85.82)	1.00	82.13 (81.02-87.03)	1.00
Patients at fully accredited hospitals	86.47 (84.44-88.49)	1.17 (0.81-1.69)	84.03 (80.25-84.01)	1.14 (0.83-1.58)

[1] Reference group

Figure 1:

Figure 1. Flow chart of patient pathways included for the six medical conditions combined and separately

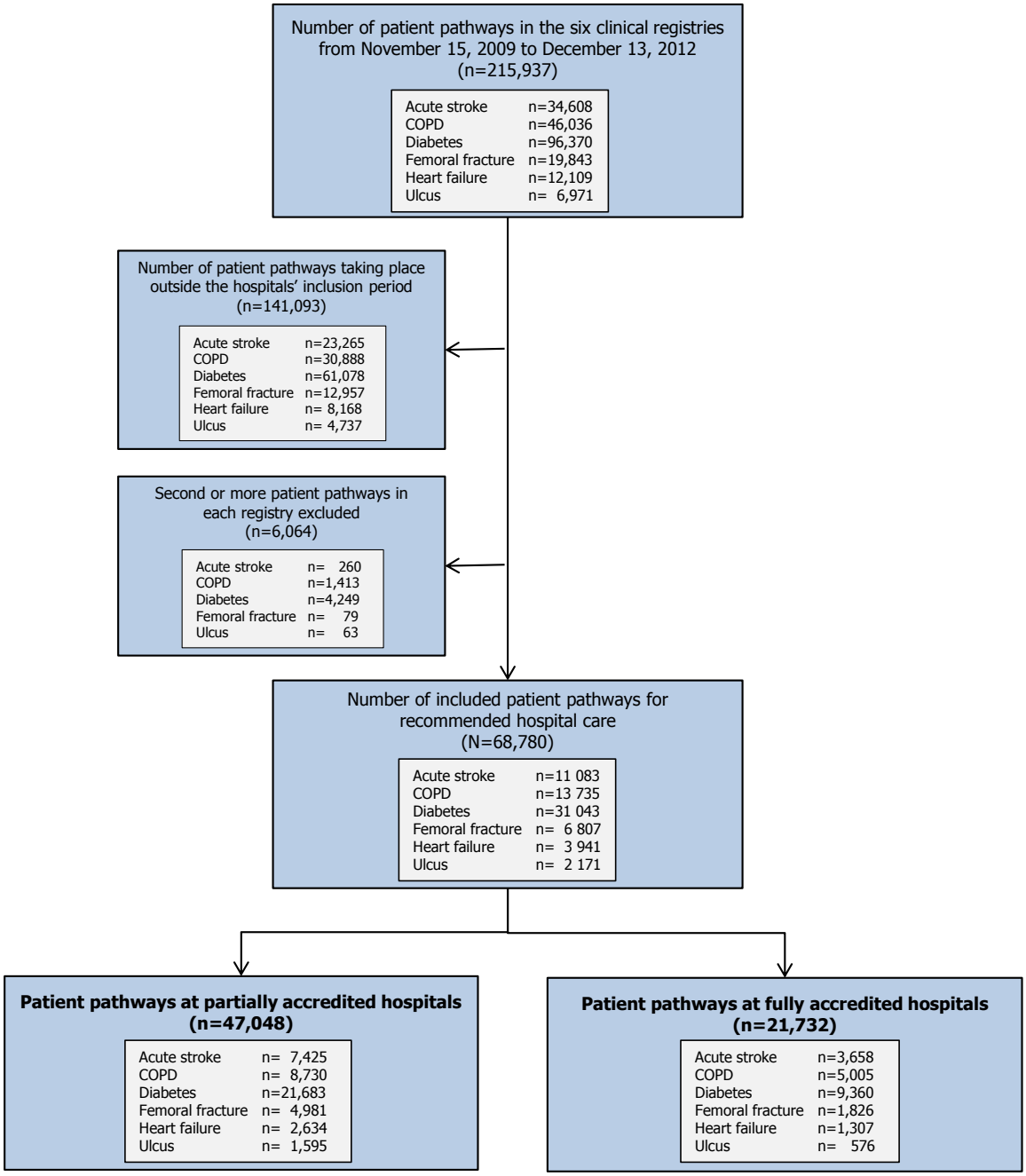
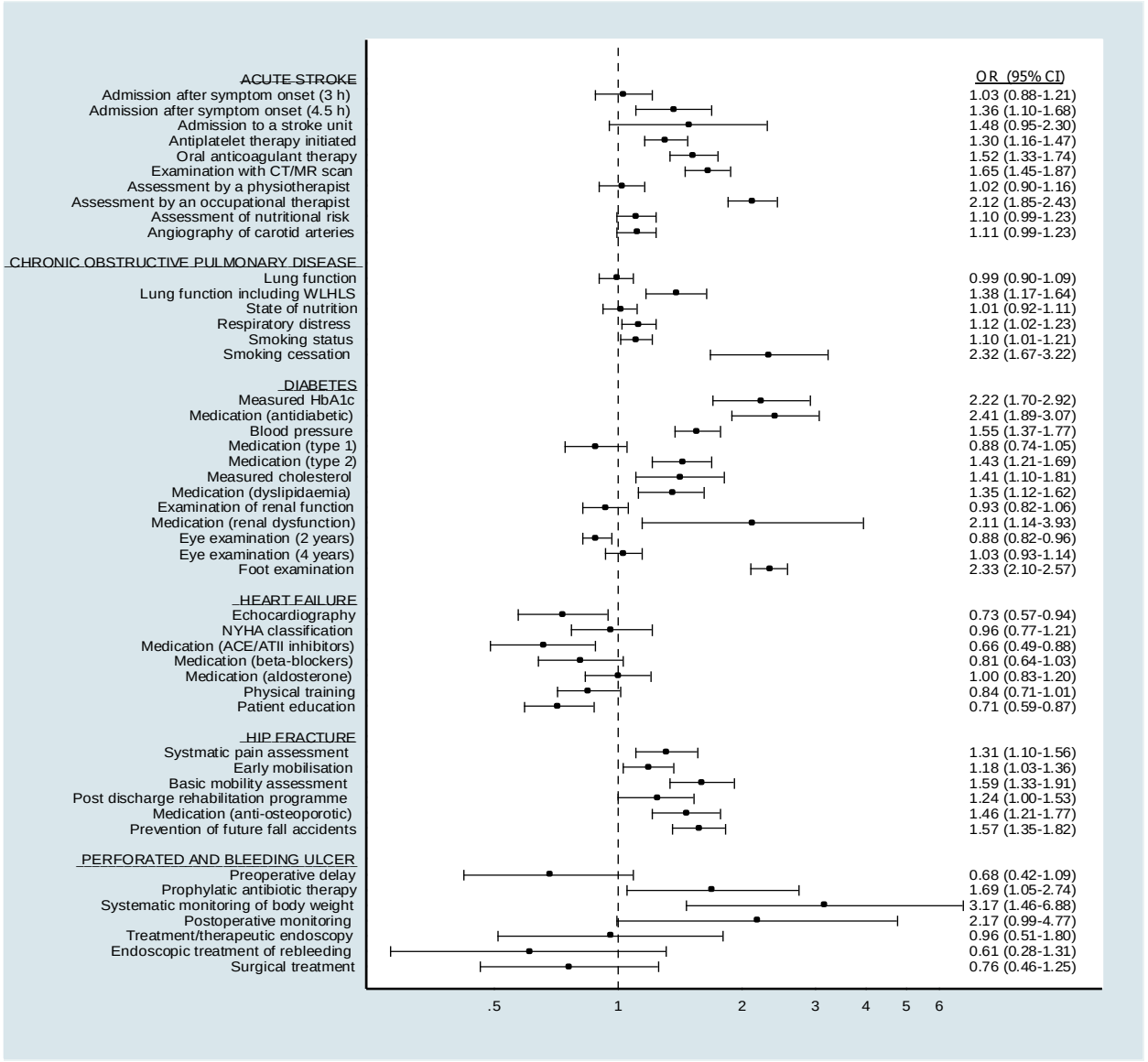


Figure 2:

Figure 2: The odds ratio of receiving a process of care according to medical condition and compliance with the 1st version of DDKM for the 48 included processes performance measures



Paper II

Compliance with hospital accreditation and patient mortality

– A Danish nationwide population-based study

ISQua®

International Journal for Quality in Health Care, 2015, 27(3), 165–174
doi: 10.1093/intqhc/mzv023
Advance Access Publication Date: 28 April 2015
Article

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Compliance with hospital accreditation and patient mortality: a Danish nationwide population-based study

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Accepted 17 March 2015

Abstract

Objective: To examine the association between compliance with hospital accreditation and 30-day mortality.
Design: A nationwide population-based, follow-up study with data from national, public registries.
Setting: Public, non-psychiatric Danish hospitals.
Participants: In-patients diagnosed with one of the 80 primary diagnoses.
Intervention: Accreditation by the first version of The Danish Healthcare Quality Programme for hospitals from 2010 to 2012. Compliance were assessed by surveyors on an on-site survey and awarded the hospital as a whole; fully ($n = 11$) or partially accredited ($n = 20$). A follow-up activity was requested for partially accredited hospitals; submitting additional documentation ($n = 11$) or by having a return-visit ($n = 9$).
Main Outcome Measure(s): All-cause mortality within 30-days after admission. Multivariable logistic regression was used to compute odds ratios (ORs) for 30-day mortality adjusted for six confounding factors and for cluster effect at hospital level.
Results: A total of 276 980 in-patients were identified. Thirty-day mortality risk for in-patients at fully ($n = 76\,518$) and partially accredited hospitals ($n = 200\,462$) was 4.14% (95% confidence interval (CI):4.00–4.28) and 4.28% (95% CI: 4.20–4.37), respectively. In-patients at fully accredited hospitals had a lower risk of dying within 30-days after admission than in-patients at partially accredited hospitals (adjusted OR of 0.83; 95% CI: 0.72–0.96). A lower risk of 30-day mortality was observed among in-patients at partially accredited hospitals required to submit additional documentation compared with in-patients at partially accredited hospitals requiring a return-visit (adjusted OR 0.83; 95% CI: 0.67–1.02).
Conclusion: Admissions at fully accredited hospitals were associated with a lower 30-day mortality risk than admissions at partially accredited hospitals.

Key words: certification/accreditation of hospitals, external quality assessment, patient outcomes (health status, quality of life, mortality), measurement of quality

Introduction

Despite considerable use of accreditation to ensure quality in healthcare, studies on its effectiveness remain sparse [1–4]. Previous systematic reviews have reached diverging conclusions [1–3]. A positive association between accreditation and professional development, and some processes of care, has been demonstrated [3, 5]. However, little is known about the impact of accreditation on clinical outcomes and more insight is needed to justify the substantial effort dedicated to achieve compliance with accreditation programmes [4].

Few studies have examined the association between accreditation of healthcare organizations and patient mortality, mainly by studying differences between accredited and non-accredited hospitals or before and after accreditation was introduced [6–10]. Reduced in-hospital mortality was found in favour of accreditation in three studies [6, 8, 9], while two studies were unable to demonstrate such differences [7, 10]. The studies were limited by examining only the possible role of accreditation in relation to specific conditions (i.e. acute myocardial infarction or acute ischaemic stroke) and in counting in-hospital death, only. A US study analysed the association between the accredited hospitals' overall compliance with the accreditation programme and mortality for patients with acute myocardial infarction also and found a higher mortality risk for partially and not accredited hospitals compared with fully accredited hospitals [9]. However, the overall evidence-base understanding regarding the relation between accreditation and patient outcomes remain weak and in combination with the worldwide use of accreditation to evaluate healthcare organizations more insight is clearly warranted.

Therefore, we examined the association between compliance with national accreditation programme and 30-day mortality after admittance to Danish hospitals. The hypothesis was that the risk of dying within 30 days after admission was lower for in-patients admitted at hospitals fully compliant with the accreditation programme than for in-patients admitted at hospitals partially compliant.

Methods

A nationwide population-based follow-up study was performed covering in-patients admitted to public, non-psychiatric hospitals in Denmark during 15 November 2009 to 10 December 2012. Denmark's 5.6 million inhabitants have unfettered access to hospitals because of publicly funding through taxes. All inhabitants are assigned a unique central personal registry number at birth or at immigration enabling accurate and unambiguous individual-level record linkage across all public registries [11].

Accreditation of the Danish healthcare system

The first version of Danish Healthcare Quality Programme (DDKM) for hospitals was launched in 2009 and met the requirements of ISQua's international principles for developing healthcare standards [12]. The vision of DDKM is multi-dimensional, ranging from highlighting the quality of health care to preventing errors that cause death and lower quality of life [13].

Accreditation by the DDKM is mandatory for all public Danish hospitals, thus all hospitals were accredited between 2010 and 2012 [14]. The DDKM comprised of 104 standards divided into 453 measurable elements (e.g. an indicator or a criterion). The standards incorporated the Plan-Do-Check-Act circle and were grouped into organizational, general patient pathway and disease-specific standards (an English version is available at http://www.ikas.dk/IKAS/English.aspx).

A team of surveyors judged hospital's compliance to the DDKM during an on-site survey. Hospital performance was assessed on a three-dimensional scale by means of interviewing staff, reviewing guidelines and, to a lesser extent, observing procedures and conducting tracers. Based on these findings, the hospital as a whole was awarded a level of accreditation; 'Accredited', 'Accredited with comments' or 'Conditionally accredited' (first proceeding). Hospitals awarded 'accredited with comments' or 'conditionally accredited' were offered a follow-up activity in order to support improvements. If the majority of the deficiencies were related to the 'Do'-part of the quality circle, a return-visit by a reduced survey team would take place, whereas hospitals with deficiencies mainly related to the 'Plan, Study or Act'-parts were given the opportunity to submit additional documentation. Based on completion of the follow-up activity, a final level of accreditation was awarded (final proceeding). All survey reports are fully accessible at a public website, including information on the level of accreditation, and compliance with standards and measurable elements [15].

A total of 34 public, non-psychiatric hospitals were accredited by the DDKM between 2010 and 2012. Three hospitals were excluded from this study due to the nature of patient population treated (hospitals treating only: obstetric and pregnant patients, elective patients, and in-patients undergoing intensive care or anaesthesia). Compliance with accreditation was defined in accordance with the first proceeding, where 11 hospitals were accredited and 20 were accredited with comments, in this paper referred to as fully accredited and partially accredited hospitals (no hospitals were conditionally accredited). Fully accredited hospitals had at most one standard partially or not met, while partially accredited hospitals had between 2 and 22 standards partially or not met. Follow-up activity in the form of a return-visit took place at 10 of the partially accredited hospitals whereas the remaining 11 hospitals submitted additional documentation. Hospitals characteristics including previous accreditation (yes/no), university affiliation (yes/no) and time of survey (before/after July 2011) are presented in Table 2. As these characteristics may be linked with mortality, their roles as possible confounding factors/effect modifiers of the association between compliance with hospital accreditation and mortality were examined in stratified analyses [16, 17].

Owing to the DDKM's multi-dimensional vision, some standards were intended to have a greater impact on mortality than others. An expert panel with profound knowledge of the DDKM and/or the Danish healthcare system was appointed to identify standards with a priori expected impact on 30-day mortality. Independently, the experts picked the standards considered to have impact on 30-day mortality and subsequently prioritized these in terms of importance. A standard was selected for further analysis if all three criteria were fulfilled; (i) at least three experts had selected the standard as important, (ii) the standard was ranked among the 25 most important, and (iii) at least three hospitals were partially or non-compliant. Four standards fulfilled the inclusion criteria. We defined hospitals compliant with all four standards as compliant hospitals ($n = 22$; corresponding to 11 fully and 11 partially accredited hospitals in the first proceeding) and hospitals partially or not compliant with one or more of the standards as non-compliant ($n = 9$; all partially accredited hospitals in the first proceeding).

As a supplementary analysis, we reassessed the original level of accreditation by applying the updated rating principles of 2012 to account for any possible misclassification of the accreditation level [15]. The new rating principles were developed to ensure a transparent allocation to the accreditation level. Three specialists reassessed all partially and non-compliant standards using a pre-specified protocol

Table 1 Description of the 80 included diagnoses accounting for 80% of all death within 30 days after admissions in Denmark in 2008

ICD-10 code	Description	Diagnoses included for supplementary analysis according to the standards:	
		"Observation and follow-up on critical observation results"	"Treatment of cardiac arrest"
J18	Pneumonia, organism unspecified		
Z03	Medical observation and evaluation for suspected diseases and conditions		
A41	Other sepsis	X	
J96	Respiratory failure, not elsewhere classified		
C34	Benign neoplasm of thyroid gland		
S72	Fracture of femur	X	
E86	Volume depletion		
J44	Other chronic obstructive pulmonary disease		
I21	Acute myocardial infarct	X	
I50	Heart failure		X
I61	Intracerebral haemorrhage	X	
I46	Cardiac arrest	X	X
J15	Bacterial pneumonia, not elsewhere classified		
I64	stroke, not specified as haemorrhage or infarction	X	
I63	Cerebral infarction	X	
C18	Malignant neoplasm of colon		
C78	Secondary malignant neoplasm of respiratory and digestive organs		
K92	Other diseases of digestive system		
K56	Paralytic ileus and intestinal obstruction without hernia	X	
R10	Abdominal and pelvic pain		
I71	Aortic aneurysm and dissection	X	
C25	Malignant neoplasm of pancreas		
D64	Other anaemias		
N30	Cystitis		
I48	Atrial fibrillation and flutter		X
K70	Alcoholic liver disease		
C79	Secondary malignant neoplasm of other and unspecified sites		
S06	Intracranial injury	X	
N39	Other disorders of urinary system		
C61	Malignant neoplasm of prostate		
N18	Chronic kidney disease		
R09	Other symptoms and signs involving the circulatory and respiratory systems		X
C50	Malignant neoplasm of breast		
R52	Pain, not elsewhere classified		
R06	Abnormalities of breathing		
D63	Anaemia in chronic diseases classified elsewhere		
I26	Pulmonary embolism	X	X
I70	Atherosclerosis		X
J81	Pulmonary oedema		X
C20	Malignant neoplasm of rectum		
J22	Unspecified acute lower respiratory infection		
Z50	Care involving use of rehabilitation procedures		
I60	Subarachnoid haemorrhage		
C67	Malignant neoplasm of bladder		
K72	Hepatic failure, not elsewhere classified	X	
R57	Shock, not elsewhere classified	X	X
R18	Ascites		
K59	Other functional intestinal disorders		
K25	Gastric ulcer		
K26	Duodenal ulcer		
C16	Malignant neoplasm of stomach		
Z51	Other medical care		
E87	Other disorders of fluid, electrolyte and acid-base balance		
R50	Fever of other and unknown origin		
I25	Chronic ischaemic heart disease		X
N19	Unspecified kidney failure		
C15	Malignant neoplasm of oesophagus		
I35	Nonrheumatic aortic valve disorders		X

Table continued

Table 1 Continued

ICD-10 code	Description	Diagnoses included for supplementary analysis according to the standards:	
		"Observation and follow-up on critical observation results"	"Treatment of cardiac arrest"
I69	Sequelae of cerebrovascular disease		
E11	Non-insulin-dependent diabetes mellitus		
N17	Acute renal failure		
A49	Bacterial infection of unspecified site		
K62	Other diseases of anus and rectum		
F10	Mental and behavioural disorders due to use of alcohol		
K55	Vascular disorders of intestine	X	
J69	Pneumonitis due to solids and liquids		
C56	Malignant neoplasm of ovary		
K65	Peritonitis	X	
C71	Malignant neoplasm of brain		
C92	Myeloid leukaemia		
R17	Unspecified jaundice		
C22	Malignant neoplasm of liver and intrahepatic bile ducts		
C90	Multiple myeloma and malignant plasma cell neoplasms		
J90	Pleural effusion, not elsewhere classified		
A09	Other gastroenteritis and colitis of infectious and unspec origin		
R31	Unspecified haematuria		
K57	Diverticular disease of intestine		
S32	Fracture of lumbar spine and pelvis		
C64	Malignant neoplasm of kidney, except renal pelvis		
G12	Spinal muscular atrophy and related syndromes		

and any differences were resolved after discussion and consensus. The reassessment resulted in a lower level of accreditation for five hospitals of which two hospitals were lowered to 'conditionally accredited' defined as 'non-accredited hospitals'. For the selection of standards with a priori expected impact on 30-day mortality, the reassessment resulted in 12 standards fulfilled the inclusion criterion listed in the paragraph above. The numbers of standards increased, as a higher proportion of hospitals was classified partially compliant due to tougher requirements for fulfilling an indicator. Again, hospitals were defined as compliant if all 12 standards were fulfilled ($n = 7$; five fully and two partially accredited hospitals) and hospitals as non-compliant if one or more standards were partially fulfilled ($n = 24$; 6 fully and 18 partially accredited hospitals).

Study population

The Danish National Registry of Patients (DNRP) was used to identify all in-patients admitted from 15 November 2009 to 10 December 2012 [18]. The registry encompasses information on all admissions and discharges from all Danish non-psychiatric hospitals. Based on all admissions in 2008 we identified the primary diagnoses, listed in Table 1, ($n = 80$) which accounted for 80% of all deaths occurring within 30 days after admission at Danish hospitals. These diagnoses have been used since 2008 to compute hospital-standardized mortality ratio [19]. To reduce the heterogeneity of the included patients, the present study was restricted to in-patients with one of these 80 diagnoses. In-patients were included if admission took place in a 12-month inclusion period for each hospital; computed from ±6 month from the hospitals first day of on-site survey. We considered this period appropriate as an enhanced effort to meet the accreditation requirements started ~6 months before the on-site survey and additional work to become fully compliant to the DDKM ended within 6 months after the on-site survey. If the in-patients had more than one admission in the hospitals inclusion period, we included only the first admission. In-patients with an invalid civil registration number, e.g. foreign nationals treated in Danish hospitals, were excluded. A flowchart of the identification of the study population is presented in Fig. 1.

Mortality

The outcome was death from any cause within 30 days after admission. Information on all-cause mortality was obtained from The Danish Civil Registration System, regardless of whether the patient was admitted or discharged at the time of death [11]. Since 1968, this registry has recorded all changes in vital status and migration for the entire Danish population on a daily basis and is regarded as highly accurate.

Covariates

As potential confounding factors, information was obtained from DNRP on age (<50 years, 50–64, 65–80 and >80 years), gender, primary diagnosis (in 11 categories corresponding to ICD-10s chapters), type of admission (acute and elective), marital status (married, unmarried, divorced, and widow (obtained and defined by the Danish Civil Registration System)) and comorbidity. The Charlson comorbidity index was used to assess comorbidity [20]. The index assigns between one and six points to a range of diseases, depending on their relation to mortality in the subsequent year during the era when the index was developed. The predictive value of the diagnoses included in the Charlson index has previously been shown to be high in DNRP [21]. All diagnoses registered in DNRP on admission (since 1977) or outpatient contact (since 1995), prior to the time of inclusion in this study, were included in the calculations of a comorbidity score. If the patient's primary diagnosis was one of the 19 conditions

Table 2 Patients characteristic for in-patients admitted at accredited, Danish hospitals according to the first version of DDKM for hospitals ($N = 276\,980$) and hospitals characteristic ($N = 31$) Counts (%)

In-patients characteristics	Admissions at partially accredited hospital ($n = 200\,462$)	Admissions at fully accredited hospital ($n = 76\,518$)
Age (years)		
<50	64 743 (32)	22 486 (29)
50–64	41 772 (21)	15 371 (20)
65–80	57 605 (29)	22 656 (30)
>80	36 342 (18)	16 005 (21)
Gender		
Women	102 804 (51)	40 395 (53)
Men	97 658 (49)	36 123 (47)
Marital status		
Unmarried	55 254 (28)	19 124 (25)
Married	85 335 (43)	31 802 (42)
Divorced	24 916 (12)	10 998 (14)
Widow	34 955 (17)	14 593 (19)
Unknown	2 (0)	1 (0)
Comorbidity status[a]		
No comorbidity	108 563 (54)	40 038 (52)
Low	60 942 (30)	23 946 (31)
High	30 957 (15)	12 534 (16)
Type of admission		
Acute	163 413 (82)	67 881 (89)
Elective	36 870 (18)	8640 (11)
Primary diagnosis[b]		
Certain infectious and parasitic diseases	7491 (4)	2774 (3)
Neoplasms	17 157 (9)	2787 (3)
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	2743 (1)	1104 (1)
Endocrine, nutritional and metabolic diseases	6653 (3)	2934 (4)
Diseases of the circulatory system	28 799 (14)	12 882 (17)
Diseases of the respiratory system	20 945 (10)	9830 (13)
Diseases of the digestive system	12 784 (6)	4690 (6)
Diseases of the genitourinary system	8 650 (4)	3251 (4)
Factors influencing health status	52 051 (26)	21 093 (28)
Injury, poisoning etc.	11 169 (6)	3868 (5)
Others	32 020 (16)	11 305 (15)
Hospitals characteristics	**Partially accredited ($n = 20$)**	**Fully accredited ($n = 11$)**
University affiliation		
Yes	8 (40)	4 (36)
No	12 (60)	7 (64)
Previous accreditation		
Yes	5 (25)	8 (73)
No	15 (75)	3 (27)
Time of on-site survey		
June 2010 to June 2011	13 (65)	2 (18)
July 2011 to June 2012	7 (35)	9 (82)

[a]Categories of comorbidity were based on Charlson comorbidity index scores (no comorbidity = 0, low = 1 and 2, and high = ≥3).
[b]Categories of underlying diseases were based on chapters of the WHO's International Classification of Diseases and Related Health Problem, 10. Revision.

originally included in the index, we modified the comorbidity score by not taking the condition into account when computing the score for the patient. On the basis of this method, a comorbidity score was computed for each patient and three categories were defined (no comorbidity, low, and high (≥3 comorbidities)).

Statistical analysis

In-patients were followed up from the date of admission until 30 days after admission or date of death, whichever occurred first. In the primary analysis, 30-day mortality of in-patients admitted at fully accredited hospitals were compared with 30-day mortality in-patients at partially accredited hospital. The analysis was repeated with partially accredited hospitals divided according to the type of follow-up activity. Secondary analyses examined the association between compliance to the four selected standards and 30-day mortality by comparing in-patients admitted at compliant with non-compliant hospitals. These analyses were done for both the entire study population and for subgroups of in-patients in which hospital compliance with two of the selected standards individually were presumed to be of particular importance, see Table 1 (i.e. compliance with 'Observation and follow-up on critical observations results' was based on in-patients

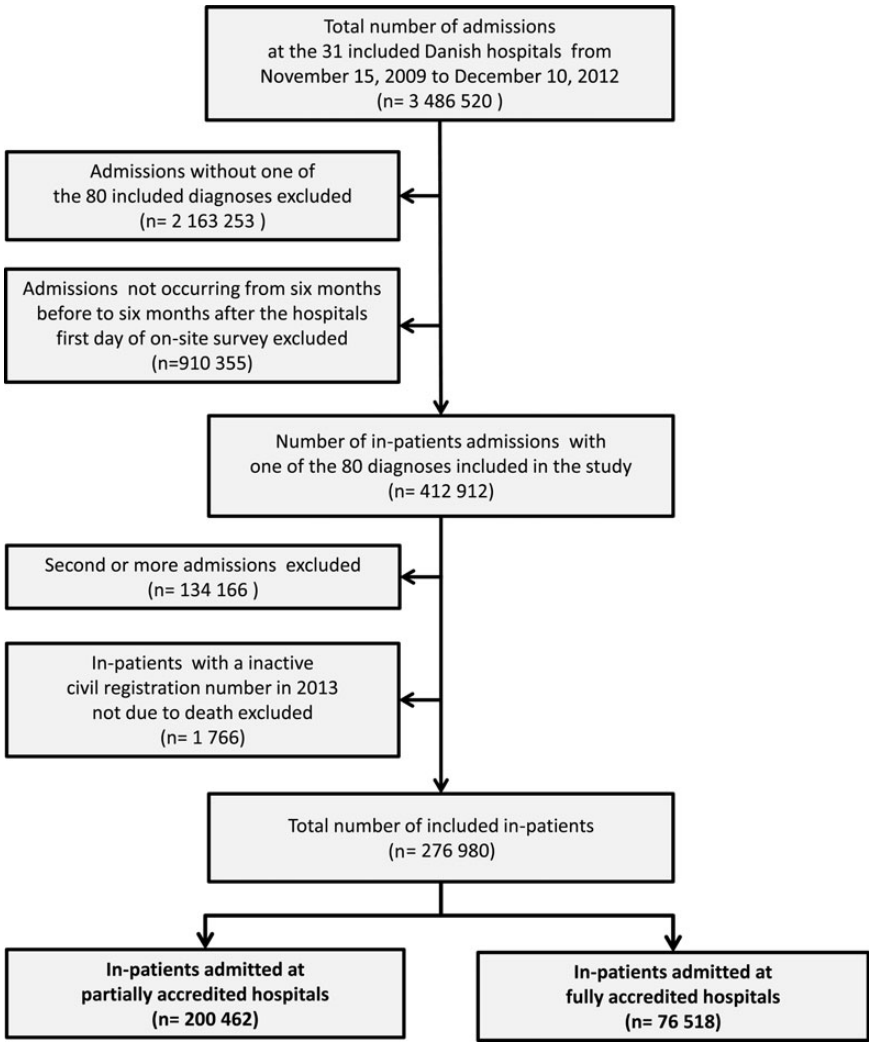

Figure 1 Flowchart of in-patients included in the study.

with acute critical conditions (15 diagnoses) and 'Treatment of cardiac arrest' on in-patients with cardiovascular diseases (10 diagnoses)). All analyses were also repeated in supplementary analysis using the updated rating principles from 2012.

Multivariable logistic regression was performed in all analyses to compute odds ratio (OR) and 95% confidence interval (95% CI). In all analyses we controlled for the covariates described above. Robust standard error adjustment was used to account for a possible within-hospital clustering because in-patient at the one hospital are more likely treated similarly relative to in-patients at another hospital (minimize the risk of type-1 error). Stratified analyses were conducted according to hospitals characteristics; previous accredited (yes/no), university affiliation (yes/no) and time of on-site survey (June 2010 to June 2011/July 2011 to June 2012) to examine the role of calendar time.

Differences <0.05 were considered statistical significant. All analyses were performed using STATA, version 12 (StataCorp. 2011. College Station, TX: StataCorp LP).

Results

The final study cohort consisted of 276 980 in-patients, of whom 76 518 were admitted at fully accredited hospitals (27.63%) and 200 462 at partially accredited hospitals (72.37%). Baseline patient characteristics are presented in Table 2.

Of the included 276 980 in-patients, 11 755 died within 30-days of admission. The 30-day mortality risk for in-patients at fully accredited hospitals was 4.14% (95% CI 4.00–4.28) and 4.28% (95% CI 4.20–4.37) for in-patients at partially accredited hospitals. Mortality risk including crude and adjusted ORs are presented in Table 3. A lower risk of dying within 30-days of admission was found for in-patients at fully accredited hospitals than for in-patients at partially accredited hospitals (adjusted OR 0.83; 95% CI 0.72–0.96). Dividing partially accredited hospitals according to the type of follow-up activity revealed that in-patients at hospitals requested to submit documentation were less likely to die within 30 days of admission compared with in-patients at hospitals having a return-visit (adjusted OR 0.83; 95%CI 0.67–1.02). Stratifying for previous accreditation, university affiliation and time of on-site survey did not substantially change the estimates (data not shown).

For the four standards with *a priori* expected impact on 30-day mortality risk, we found a similar pattern with in-patients admitted at compliant hospitals having a lower 30-day mortality risk than in-patient at non-compliant hospitals (adjusted OR 0.82; 95% CI 0.70–0.97); see Table 3. The association was particularly strong for

Table 3 Thirty-day mortality risk and OR for in-patients admitted at accredited, Danish hospitals according to the first version of DDKM for hospitals

	Hospitals counts ($N = 31$)	In-patients counts ($N = 276\,980$)	30-day mortality risk % (95% CI)	30-day mortality	
				OR (95% CI)	
				Crude	Adjusted[a]
Compliance with accreditation					
In-patients at partially accredited hospitals	20	200 462	4.28 (4.19–4.37)	1.00	1.00
In-patients at fully accredited hospitals	11	76 518	4.14 (4.00–4.28)	0.97 (0.93–1.01)	0.83 (0.72–0.96)
Compliance according to follow-up activity					
In-patients at hospitals having a return visit	11	103 677	4.62 (4.45–4.75)	1.00	1.00
In-patients at hospitals submitting documentation	9	96 785	3.92 (3.80–4.05)	**0.84** (0.81–0.88)	0.83 (0.68–1.02)
In-patients at hospitals with no follow-up (fully accredited)	11	76 518	4.14 (4.00–4.28)	**0.89** (0.85–0.93)	**0.76** (0.65–0.89)
Compliance with four standards combined					
In-patients at non-compliant hospitals	9	74 626	4.48 (4.33–4.63)	1.00	1.00
In-patients at fully compliant hospitals	22	202 354	4.16 (4.07–4.25)	**0.93** (0.89–0.96)	**0.82** (0.70–0.97)
Compliance with individual standards					
Organisational standard					
Risk management					
In-patients at non-compliant hospitals	3	25 643	4.18 (3.94–4.43)	1.00	1.00
In-patients at fully compliant hospitals	28	251 337	4.25 (4.17–4.33)	1.02 (0.95–1.08)	**0.69** (0.52–0.91)
General patient pathway standards					
Timely reaction to test results					
In-patients at non-compliant hospitals	3	36 489	4.34 (4.13–4.56)	1.00	1.00
In-patients at fully compliant hospitals	28	240 491	4.23 (4.15–4.31)	0.97 (0.92–1.03)	0.95 (0.83–1.09)
Observation and follow-up on critical observation results					
In-patients at non-compliant hospitals	3	33 366	4.82 (4.59–5.05)	1.00	1.00
In-patients at fully compliant hospitals	28	243 614	4.16 (4.08–4.24)	**0.86** (0.81–0.91)	**0.67** (0.54–0.82)
Treatment of cardiac arrest					
In-patients at non-compliant hospitals	4	13 937	5.49 (5.11–5.87)	1.00	1.00
In-patients at fully compliant hospitals	27	263 043	4.18 (4.10–4.25)	**0.75** (0.70–0.81)	0.89 (0.78–1.01)

[a]Adjusted for age, gender, comorbidity, primary diagnose, type of admission, and marital status, including robust standard error at hospital level based on data from 276 977 in-patients

the standards on risk management and observation and follow-up on critical observation results (risk management: adjusted OR 0.69; 95% CI 0.52–0.91; critical observation results: adjusted OR 0.67; 95% CI 0.54–0.82).

When examining the association between compliance with the individual standards and 30-day mortality risk in subgroups of the study population, we found that in-patients with acute critical conditions admitted at hospitals compliant with the standard 'Observation and follow-up on critical observation results' ($n = 10\,445$) had a substantially lower 30-day mortality risk than corresponding in-patients admitted to non-compliant hospitals ($n = 27\,019$) (adjusted OR 0.49; 95% CI 0.37–0.65). Likewise patients with cardiovascular disease admitted to hospitals compliant with the standard 'Treatment of cardiac arrest' ($n = 8\,169$) had a lower 30-day mortality risk than cardiovascular in-patients admitted to non-compliant hospitals ($n = 17\,629$) (adjusted OR 0.61; 95% CI 0.38–0.99).

The findings from the primary analyses were corroborated by the results of the supplementary analyses where hospitals were classified according to the rating principles of 2012. Here 64 563 in-patients were admitted at fully accredited hospitals (23.31%), 188 585 at partially accredited hospitals (68.09%) and 23 832 at non-accredited hospitals (8.60%). The proportion of in-patients dying within 30 days of admission was 4.06% (95% CI 3.91–4.21) at fully accredited hospitals, 4.23% (95% CI 4.14–4.32) at partially accredited hospitals and 4.85% (95% CI 4.57–5.12) for in-patients at not accredited hospitals. Mortality risk including crude and adjusted estimates are presented in Table 4. Using in-patients at partially accredited hospitals as reference group, the adjusted ORs for death within 30 days after admission were 0.87 (95% CI 0.74–1.02) for in-patients at fully accredited hospitals and 1.18 (95% CI 1.05–1.34) for in-patients at not-accredited hospitals, respectively.

Discussion

The present study is the first nationwide study to explore the association between compliance to accreditation standards and 30-day mortality. We found a lower 30-day mortality risk for in-patients with one of the 80 selected diagnoses admitted at fully accredited hospitals compared with in-patients at partially accredited hospitals. This finding was corroborated in all of the additionally analyses performed.

Strengths and weaknesses

The strengths of the study included the nationwide, population-based design, the availability of prospectively collected comprehensive patient data and the complete follow-up that limits the risk of selection and information bias. Furthermore, the control for important patient characteristics in the analyses such as gender, age and comorbidities

Table 4 Thirty-day mortality risk and OR for in-patients admitted at accredited, Danish hospitals according to the first version of DDKM for hospitals by the rating principles of 2012

	Hospitals counts ($N = 31$)	In-patients counts ($N = 276\,980$)	30-day mortality risk % (95% CI)	30-day mortality OR (95% CI)	
				Crude	Adjusted[a]
Compliance with accreditation according to the rating principles of 2012					
In-patients at fully accredited hospitals	8	64 563	4.06 (3.91–4.21)	0.96 (0.92–1.00)	0.87 (0.74–1.02)
In-patients at partially accredited hospitals	21	188 585	4.23 (4.14–4.32)	1.00	1.00
In-patients at non-accredited hospitals	2	23 832	4.85 (4.57–5.12)	**1.15** (1.08–1.23)	**1.18** (1.05–1.34)
Compliance with 12 standards combined					
In-patients at non-compliant hospitals	24	216 880	4.48 (4.39–4.57)	1.00	1.00
In-patients at fully compliant hospitals	7	60 100	3.40 (3.25–3.54)	**0.75** (0.71–0.79)	**0.77** (0.66–0.90)
Compliance with individual standards					
Organisational standards					
Quality improvement					
In-patients at non-compliant hospitals	6	81 166	4.86 (4.71–5.01)	1.00	1.00
In-patients at fully compliant hospitals	25	195 814	3.99 (3.90–4.07)	**0.81** (0.78–0.85)	**0.70** (0.62–0.79)
Risk management					
In-patients at non-compliant hospitals	3	25 643	4.18 (3.94–4.43)	1.00	1.00
In-patients at fully compliant hospitals	28	251 337	4.25 (4.17–4.33)	1.02 (0.95–1.08)	**0.69** (0.52–0.91)
Hand hygiene					
In-patients at non-compliant hospitals	6	63 779	4.28 (4.12–4.44)	1.00	1.00
In-patients at fully compliant hospitals	25	213 201	4.23 (4.15–4.32)	0.99 (0.95–1.03)	1.04 (0.90–1.20)
General patient pathway standards					
Integrated care pathway					
In-patients at non-compliant hospitals	3	30 563	4.30 (4.07–4.52)	1.00	1.00
In-patients at fully compliant hospitals	28	246 417	4.24 (4.16–4.32)	0.99 (0.93–1.05)	0.91 (0.74–1.12)
Treatment plan in somatic care					
In-patients at non-compliant hospitals	4	31 884	4.59 (4.36–4.82)	1.00	1.00
In-patients at fully compliant hospitals	27	245 096	4.20 (4.12–4.28)	**0.91** (0.86–0.96)	0.94 (0.78–1.33)
Assessment of suicide risk					
In-patients at non-compliant hospitals	3	40 375	4.50 (4.30–4.70)	1.00	1.00
In-patients at fully compliant hospitals	28	236 605	4.20 (4.12–4.28)	**0.93** (0.88–0.98)	0.97 (0.87–1.09)
Timely reaction to test results					
In-patients at non-compliant hospitals	7	79 278	4.16 (4.02–4.30)	1.00	1.00
In-patients at fully compliant hospitals	24	197 705	4.28 (4.19–4.37)	1.03 (0.99–1.07)	0.99 (0.87–1.13)
Prescription of medicine					
In-patients at non-compliant hospitals	4	33 823	4.90 (4.67–5.13)	1.00	1.00
In-patients at fully compliant hospitals	27	243 157	4.15 (4.07–4.23)	**0.84** (0.80–0.89)	**0.84** (0.75–0.94)
Observation and follow-up on critical observation results					
In-patients at non-compliant hospitals	4	43 835	4.97 (4.76–5.17)	1.00	1.00
In-patients at fully compliant hospitals	27	233 145	4.11 (4.03–4.19)	**0.82** (0.78–0.86)	**0.70** (0.58–0.83)
Treatment of cardiac arrest					
In-patients at non-compliant hospitals	7	37 839	4.76 (4.55–4.98)	1.00	1.00
In-patients at fully compliant hospitals	24	239 141	4.16 (4.08–4.24)	**0.87** (0.82–0.91)	0.94 (0.79–1.12)
Disease-specific standards					
Cardiac insufficiency[b]					
In-patients at non-compliant hospitals	4	37 877	4.47 (4.26–4.68)	1.00	1.00
In-patients at fully compliant hospitals	25	226 823	4.22 (4.14–4.31)	**0.94** (0.89–0.99)	0.91 (0.74–1.12)
Perforation of gastric ulcer[c]					
In-patients at non-compliant hospitals	3	34 593	4.99 (4.76–5.22)	1.00	1.00
In-patients at fully compliant hospitals	18	206 726	4.12 (4.03–4.20)	**0.82** (0.77–0.86)	**0.86** (0.76–0.97)

[a]Adjusted for age, gender, comorbidity, primary diagnose, type of admission, and marital status, including robust standard error at hospital level based on data from 276 977 in-patients.

[b]The standard was not relevant for two hospitals as no in-patients were treated with cardiac insufficient.

[c]The standard was not relevant for ten hospitals as no in-patients were treated with perforated gastric ulcer.

and the robustness of the findings across a range of subgroup and alternative analyses reduces the risk that the findings could be explained by confounding. The limitations included the accuracy of the DDKM accreditation data, including the unknown inter-reliability of assessments made by surveyors and survey teams [22, 23]. However, hospitals were accredited by the same accreditation programme within 2 years and any potential misclassification would most likely be of a non-differential nature and bias the results towards the null.

Information on disease severity was not available in the medical registries for which reason unaccounted confounding cannot be excluded. Furthermore, we cannot exclude the possibility that our results may be influenced by residual or unaccounted confounding due to the non-randomized design, although substantial efforts were made to account for possible confounding. Thus, before generalizing our findings to other accreditation programmes and settings differences must be evaluated to identify how potential differences could modify our results.

Comparison with other studies

Our study extends the findings from the study by Chen *et al.* based on 3179 surveyed US hospitals [6]. The study compared 30-day mortality risk after haematopoietic stem-cell transplantation according to four levels of compliance to accreditation standards provided by the Joint Commission. A higher mortality risk was found in partially and not accredited hospitals compared with fully accredited hospitals which agreed with our findings (crude hazard ratio; partially: 1.15 and not accredited: 1.06). Similarly to the DDKM accreditation, the vast majority of the hospitals were accredited with recommendation (2668 out of 3179 hospitals) but no attempts were made by Chen *et al.* in order to subcategorize these hospitals.

Despite years of using accreditation, only two randomized controlled trials were identified in a Cochrane review that examined the effect of accreditation [2]. In Denmark a political decision of a mandatory accreditation programme for public hospitals hampered the possibility to perform a randomized controlled trial. On the other hand, it may be questioned whether randomized control accreditation trials will be appropriate to reach firm conclusions since there are large methodological challenges in exploring complicated and context-sensitive methods like accreditation by an experimental design [24, 25]. Furthermore, accreditation is primarily introduced either by healthcare's authorities or as a financial incentive which will reduce the possibility to find eligible participants for such a design.

Perspectives

Our findings lend to support the hypothesis that compliance with accreditation standards is associated with improved clinical outcomes, including lower patient mortality. However, the nature of this association remains to be further clarified. Although better compliance with the accreditation standards was associated with lower mortality risk in our study, this does not necessarily reflect that the accreditations standards *per se* were responsible for the lower mortality. In addition to accreditation, a number of other nationwide quality improvement initiatives have been launched within the last decade in Denmark. This includes a Danish version of Institute of Healthcare Improvement's 100 000 Lives Campaign (active from 2007 to 2009) and continuous indicator monitoring and auditing through Clinical Quality Databases covering major disease areas including stroke, heart failure, diabetes and hip fracture. It is likely that these initiatives may have had a direct effect on patient mortality. However, the possibly impact of these initiatives does not preclude that compliance with hospital accreditation may play a role and perhaps even a causal one in relation to a reduced patient mortality. In fact, an ability to effectively implement other quality improvement initiatives could well be a direct consequence of shaping and training an organization according to the accreditation standards. Alternatively, high compliance with the accreditation standards could just be non-causal markers of high-performing hospitals, which are characterized by delivering high-quality care that ensure good clinical outcomes, including low mortality risks. More insights into the effect of accreditation on patient outcomes and processes of care, including the cost-effectiveness of this quality improvement strategy, are clearly needed.

Conclusion

The 30-day mortality risk was lower for in-patients admitted at hospitals fully accredited by the first version of the DDKM than for in-patients admitted to partially accredited hospitals. Further efforts are warranted in order to determine whether the association is causal.

Ethics approval

The study was approved by the Danish Data Protection Agency. According to Danish law, ethical approval is not needed for registry-based studies.

Authors' contributions

A.M.F.J. and S.P.J. designed and conceived the study; collected, managed, analysed and interpreted the data; manuscript drafting and revision; following The STROBE guideline. All other authors were responsible for study design, interpretation of data and critical manuscript revision and approval. A.M.F.J., S.P.J. and H.J.L. had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Data sharing

Codebook and statistical code (all in Danish) are available from the corresponding author at amfj@clin.au.dk.

Funding

The Ph.D.-project was funded by Centre for Quality in the Region of Southern Denmark, Department of Clinical Epidemiology, Aarhus University Hospital, and the Institute of Quality and Accreditation in Healthcare (IKAS). IKAS had no role whatsoever regarding the study design, data collection, analysis, decision to publish or preparation of the manuscript. All authors are independent researchers without any financial interest in the results presented.

Conflict of interest

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare no disclosure for the submitted work. A.M.F.J. was former employed by IKAS. No other relationships or activities that could appear to have influenced the submitted work.

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Paper III

Is compliance with hospital accreditation associated with length of stay and acute readmission? – A Danish nationwide population-based study

ISQua®

International Journal for Quality in Health Care, 2015, 1–8
doi: 10.1093/intqhc/mzv070
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Is compliance with hospital accreditation associated with length of stay and acute readmission? A Danish nationwide population-based study

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Accepted 2 September 2015

Abstract

Objective: To examine the association between compliance with hospital accreditation and length of stay (LOS) and acute readmission (AR).
Design: A nationwide population-based follow-up study from November 2009 to December 2012.
Setting: Public, non-psychiatric Danish hospitals.
Participants: In-patients admitted with one of 80 diagnoses.
Intervention: Accreditation by the first version of The Danish Healthcare Quality Programme. Using an on-site survey, surveyors assessed the level of compliance with the standards. The hospital was awarded either fully ($n = 11$) or partially accredited ($n = 20$).
Main Outcome Measures: LOS including transfers between hospitals and all-cause AR within 30 days after discharge. The Cox Proportional Hazard regression was used to compute hazard ratios (HRs) adjusted for potential confounding factors and cluster effect at hospital level.
Results: For analyses of LOS, 275 589 in-patients were included of whom 266 532 were discharged alive and included in the AR analyses. The mean LOS was 4.51 days (95% confidence interval (CI): 4.46–4.57) at fully and 4.54 days (95% CI: 4.50–4.57) at partially accredited hospitals, respectively. After adjusting for confounding factors, the adjusted HR for time to discharge was 1.07 (95% CI: 1.01–1.14). AR within 30 days after discharge was 13.70% (95% CI: 13.45–13.95) at fully and 12.72% (95% CI: 12.57–12.86) at partially accredited hospitals, respectively, corresponding to an adjusted HR of 1.01 (95% CI: 0.92–1.10).
Conclusion: Admissions at fully accredited hospitals were associated with a shorter LOS compared with admissions at partially accredited hospitals, although the difference was modest. No difference was observed in AR within 30 days after discharge.

Key words: certification/accreditation of hospitals, external quality assessment, readmissions, length of stay

Introduction

During the last decade, hospitals have focussed on reducing LOS as it may reduce the risk of iatrogenic harm (e.g. hospital-acquired infections), reduce costs and be in accordance with patient preferences. Consequently, a shorter LOS is considered to be an indicator for hospital efficiency [1]. To achieve this goal, proactive planning of the patients' clinical pathway as well as active discharge planning needs to be in place. On the other hand, a focus solely on reducing LOS could lead to an increased risk of acute readmission (AR) as patients might be discharged before they have reached medical stability. AR is therefore often used as an indicator for hospital quality [2].

One strategy, introduced to hospitals worldwide as a method of improving quality of care, is accreditation. Accreditation is based on an external review process in which trained surveyors evaluate the organization's compliance with pre-established standards by focussing on continuous improvements within the organization [3]. In general, accreditation programmes include standards aimed at supporting efficient treatment and coherent patient pathways in order to ensure that patients are admitted for the adequate amount of time and to avoid preventable readmissions. Although the intention behind accreditation is understandable and the method has been used for decades, data on the relation between accreditation and these patient-related outcomes are sparse [4–7]. Existing studies investigating the link between accreditation of healthcare organizations and LOS and AR have shown diverging results as some are in favour of accreditation [8–10] and others not [11, 12]. The studies have focussed on specific conditions (e.g. stroke and heart failure) and have either compared accredited with non-accredited hospitals or compared the periods before and after the introduction of accreditation. So far, however, no studies have examined the association between the level of compliance with accreditation standards and LOS or AR.

Recently, we reported a lower risk of dying within 30 days after admission for in-patients admitted to hospitals fully compliant with accreditation standards compared with in-patients at partially compliant hospitals in a Danish nationwide population-based study [13]. To extend these findings, we examined the association between hospitals compliance with accreditation and LOS, and AR in this cohort of in-patients. We hypothesized that patients admitted at fully compliant hospitals may experience shorter LOS and have less AR compared with patients admitted at partially compliant hospitals.

Methods

We conducted a nationwide population-based follow-up study among in-patients admitted to public, non-psychiatric hospitals in Denmark. All of Denmark's 5.6 million citizens have free access to all public, tax-financed hospitals. A unique central personal registry number is assigned to all citizens at birth or at immigration enabling accurate and unambiguous individual-level record linkage across all public registries [14].

Accreditation of the Danish healthcare system

In 2009, the first version of the Danish Healthcare Quality Programme (DDKM; in Danish *Den Danske Kvalitetsmodel*) was launched with the vision (among others) to ensure continuous improvement of quality, create better and more coherent patient care and prevent errors and adverse events that cause death, lower quality of life, and lead to unintended use of resources [15, 16]. DDKM met the requirements of the International Society of Quality in Health Care for developing healthcare standards [17].

Participation in DDKM was mandatory for all public Danish hospitals; thus, all hospitals were accredited by the first version between 2010 and 2012. The DDKM comprised of 104 standards, all addressing different scopes and incorporating the Plan-Do-Check-Act cycle. The standards were grouped into organizational, general patient pathway, or disease-specific standards (an English version is available at http://www.ikas.dk/IKAS/English/Accreditation-standards.aspx).

Compliance with the standards in the DDKM was measured by a team of surveyors during an on-site visit. The surveyors assessed compliance on a three-dimensional scale by means of interviewing staff, reviewing guidelines and, to a lesser extent, observing procedures and conducting tracers. Based on this on-site survey, the level of accreditation was awarded for the hospital as a whole by 'accredited', 'accredited with comments' or 'conditionally accredited' (first proceeding). A follow-up activity was offered to hospitals awarded 'accredited with comments' or 'conditionally accredited' in order to improve compliance. A return-visit by a reduced survey team would take place if a hospital's deficiencies predominantly related to the 'Do'-part of the Plan-Do-Check-Act cycle while hospitals with deficiencies mainly related to the 'Plan, Study or Act'-part were requested to submit additional documentation. A final level of accreditation was awarded based on the completion of the follow-up activity (final proceeding). In order to ensure public disclosure, survey reports were fully accessible including information on the level of accreditation and compliance with the standards (http://www.ikas.dk/Afgørelser/Sygehuse.aspx).

A total of 34 public, non-psychiatric hospitals were accredited by the first version of DDKM. Three hospitals were excluded from this study because they treated selected patient populations. Compliance with accreditation was defined in accordance with the first proceeding, where 11 of the 31 hospitals were 'accredited' and 20 were 'accredited with comments' hereby defined as fully accredited and partially accredited hospitals. Fully accredited hospitals had at most one standard that was partially or not met, whereas partially accredited hospitals had between 2 and 22 standards that were partially or not met. Of the 20 partially accredited hospitals, 11 hospitals had a return-visit while the remaining nine submitted additional documentation.

Since not all of the 104 standards were expected to have impact on LOS and AR, an expert panel with extensive knowledge on the DDKM and/or the Danish healthcare system was appointed to identify standards with *a priori* expected impact on LOS and AR. Each expert selected the standards he/she considered to have an impact on LOS and subsequently ranked them in accordance with importance. A standard was included for analysis in this study if (i) the standard was ranked as one of the 25 most important, (ii) at least 3 experts had selected the standard as important for LOS and (iii) at least 3 hospitals were partially or not compliant with the standard. We designated hospitals compliant to all selected standards as compliant and hospitals partially or not compliant to one or more standards as non-compliant. This method was repeated for AR.

Study population

We included in-patients admitted at one of the 31 included hospitals during a 12-month period calculated from first day of the on-site survey ± 6 months using the same inclusion criteria as in the previous study on 30-day mortality [13]. The inclusion period was considered appropriate as an enhanced effort to meet the accreditation requirements started approximately 6 months before the on-site survey and additional work to become fully compliant to the DDKM likely ended within 6 months after the on-site survey. Consequently, data

were collected between 15 November 2009 and 13 December 2012. The Danish National Registry of Patients (DNRP) was used to identify all in-patients admitted in the hospitals' inclusion period [18]. The registry encompassed information on the dates of admission and discharge from all non-psychiatric hospitals, and information was submitted daily by the healthcare providers. Based on all admissions in 2008, we identified the primary diagnoses ($n = 80$), which accounted for 80% of all deaths occurring within 30 days after admission (please see Ref. [13] for further description) [19]. Our study population was restricted to in-patients with one of these 80 diagnoses to reduce differences in the populations between hospitals included in order to facilitate comparison. Only in-patients with a valid civil registration number were included for further analyses.

Outcomes

Outcomes were LOS and AR within 30 days after discharge. LOS was calculated from the date of the in-patient's first admission in the study period (index date) to the date of discharge. In case of transferral to another hospital, the admissions were linked together and all days spent in hospitals were included in LOS. AR was defined as all-cause AR at any hospital within 30 days from the discharge date. Readmissions due to elective procedures performed were not included as an AR.

Covariates

Patient-related factors that may have a potential impact on LOS and AR were *a priori* selected as potential confounding factors [20]. These variables included age (<50, 50–64, 65–80 and >80 years), gender, primary diagnosis (in 11 categories for underlying diseases corresponding to ICD-10 chapters), type of admission (acute and elective), marital status (unmarried, married, divorced and widow; defined by the Danish Civil Registration System) and comorbidity (no, low and high). The Charlson comorbidity index was used to assess the severity of comorbidity [21]. All diagnoses, registered in DNRP on admission (since 1977) or outpatient contact (since 1995), prior to the time of inclusion in this study, were included in the calculations of a comorbidity score. The coding of the 19 Charlson conditions in the DNRP has previously been shown consistently high [22]. The index assigns between one and six points to a range of diseases, depending on their relation to mortality. If the patient's primary diagnosis was one of the index's 19 diseases, this diagnosis was excluded in the calculation of that patient's comorbidity score. On the basis of this method, a comorbidity score was computed for each patient and three categories were defined (no, low (1 or 2 comorbidities) and high (3 or more comorbidities)).

Of hospitals' characteristics, previous accreditation (yes/no), university affiliation (yes/no) and time of survey (before/after July 2011) were included as they potentially could act as confounding factors/effect modifiers of the association between compliance with accreditation and LOS, and AR.

Statistical analysis

Descriptive data for the in-patients' characteristics were presented as counts and percentage. In the analyses of LOS, the date of admission was the entry date and follow-up ended at the date of discharge or death, whichever came first. In-patients admitted and discharged the same day were included in the analyses with an LOS of half a day (0.5). LOS was presented as both median days including 5–95 percentiles and mean days with 95% confidence interval (CI). For AR, the date of discharge was the entry date and follow-up ended 30 days after discharge, date of AR or death, whichever came first. AR was presented as percentage with 95% CI.

In the primary analysis, LOS and AR were compared between in-patients admitted at fully accredited hospitals and partially accredited hospital. This analysis was repeated with partially accredited hospitals grouped according to the follow-up activity. In a set of supplementary analyses, in-patients were categorized according to the hospital's compliance with specific standards that had been identified *a priori* by an expert panel as likely to be of particular importance for LOS and AR, respectively. The analyses were performed both when including all of the identified standards combined and subsequently, with the standards included individually. All analyses were controlled for the six potential confounding factors. To account for the hierarchical nature of data in which in-patients at one hospital are more likely treated similar relative to in-patients at another hospital, we used robust standard error adjustment at hospital level (to minimize the risk of type-1 error). Sensitivity analysis was performed for LOS for in-patients with an LOS between 5 and 95 percentile and for AR for in-patients with a short LOS defined as shorter or equal to 2 days. In stratified analyses, we examined the role of the three hospitals' characteristics for both outcomes.

The association between compliance with accreditation and LOS, and AR was estimated as a hazard ratio (HR) including 95% confidence interval (95% CI) using Cox Proportional Hazard regression [23]. The proportional hazards assumption was checked visually for LOS and AR, by comparing the plots between in-patients admitted at fully and partially accredited hospitals, and by using the Schoenfeld-test and were not found invalid. All statistical tests used a two-sided significance level of 0.05 and were performed using STATA, version 12 (StataCorp., 2011. College Station, TX: StataCorp LP).

Results

Of the 276 980 in-patients identified, we excluded 1391 as they were admitted for a fixed 3 week's rehabilitation programme. Figure 1 illustrates the identification of the study population. All in-patient data were complete, except marital status with three observations registered as unknown.

The final study cohort for the analyses on LOS consisted of 275 589 in-patients of whom 75 127 (27.26%) were admitted at fully accredited hospitals and 200 462 (72.74%) at partially accredited hospitals. Baseline in-patient and hospital characteristics are presented in Table 1. The mean LOS was 4.51 days (95% CI: 4.46–4.57) for in-patients at fully accredited hospitals and 4.54 days (95% CI: 4.50–4.57) for in-patients at partially accredited hospitals. When comparing in-patients admitted to fully with partially accredited hospitals, the difference in LOS increased after controlling for potential confounding factors (adjusted HR 1.07; 95% CI: 1.01–1.14), shown in Table 2. When grouping admissions according to follow-up activity, in-patients admitted at hospitals requested to submit additional documentation were more likely to be discharged before in-patients at hospitals having a return-visit (submitting documentation: adjusted HR 1.12; 95% CI: 1.01–1.24). The estimates did not change substantially in the sensitivity analyses for in-patients with an LOS between 5 and 95 percentile (1–17 days) or when stratifying according to previous accreditation, university affiliation or time of on-site survey (data not shown). Four individual standards were identified by the expert panel as being of particular *a priori* relevance for LOS and included for analysis. Twenty-one hospitals were compliant to all four

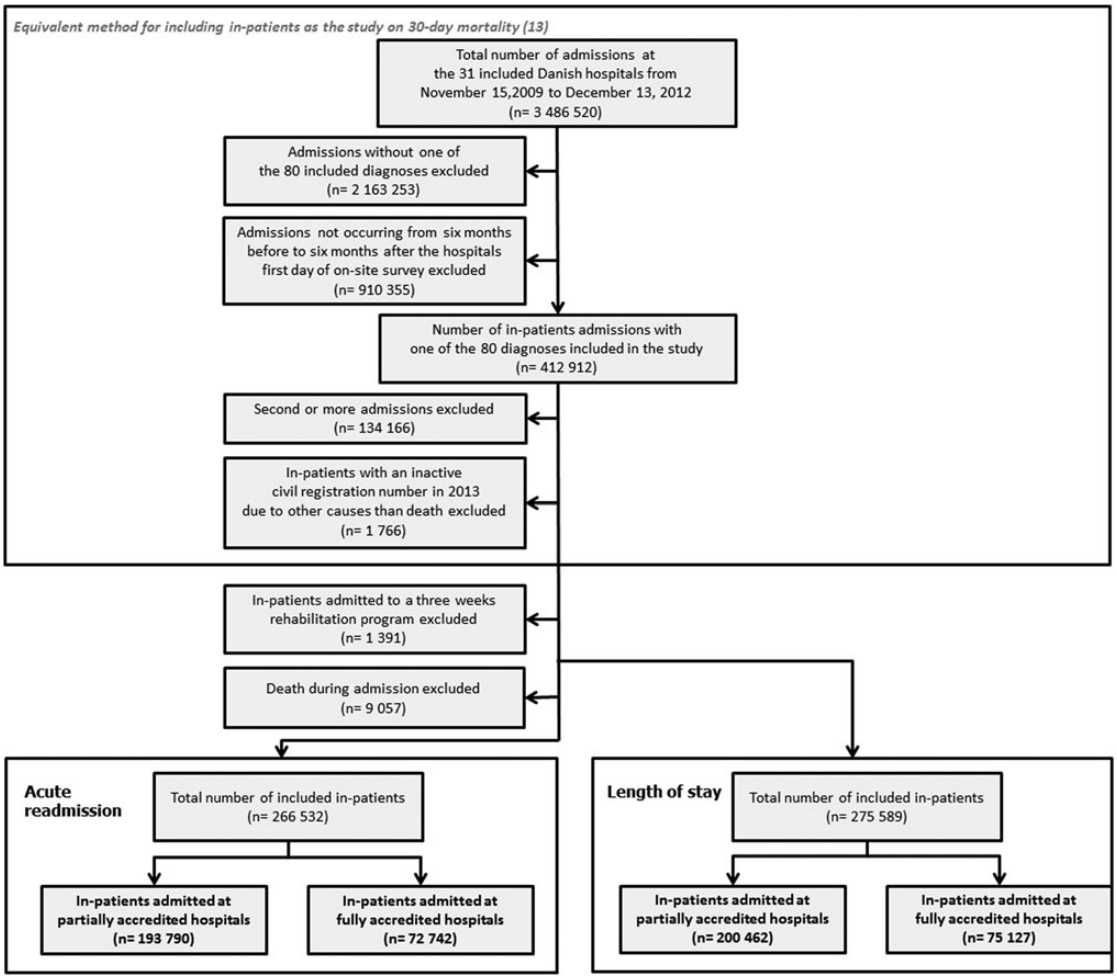

Figure 1 Flowchart of in-patients included in the study.

standards and designated as compliant (corresponding to all fully and 10 partially accredited hospitals in the first proceeding) and the remaining 10 as non-compliant (corresponding to 10 partially accredited hospitals). Similar pattern was observed for in-patients admitted to compliant hospitals compared with in-patients admitted to non-compliant hospitals (adjusted HR 1.10; 95% CI: 1.02–1.19). Compliance with the standards 'Documentation and monitoring of nosocomial infections' and 'observation and follow-up on critical observation results' was associated with a relatively shorter LOS than all four standards combined (Documentation and monitoring of nosocomial infections: adjusted HR 1.19; 95% CI: 1.07–1.32; critical observation results: adjusted HR 1.23; 95% CI: 1.07–1.41).

For the analyses of AR, the final study cohort consisted of 266 532 in-patients who were discharged alive (see Fig. 1) of whom 72 742 (27.29%) were admitted at fully accredited hospitals and 193 790 (72.71%) at partially accredited hospitals. Table 1 shows baseline characteristics. Of the 266 532 included in-patients, 34 610 (12.99%) were readmitted within 30 days after discharge. The AR rate for in-patients admitted at fully accredited hospitals was 13.70% (95% CI: 13.45–13.95) and for in-patients at partially accredited hospitals 12.72% (95% CI: 12.57–12.86). Table 3 presents all estimates for AR including crude and adjusted HR. No differences in AR rate were found comparing in-patients admitted to fully accredited hospitals with partially accredited hospitals (adjusted HR 1.01; 95% CI: 0.92–1.10) or when grouping admissions according to the required accreditation follow-up activity (adjusted HR 1.07; 95% CI: 0.96–1.19). The estimates did not change substantially when stratifying according to previous accreditation, university affiliation and time of on-site survey or when restricting to in-patients with a short LOS (data not shown). Three individual standards were included for analyses with the expected *a prior* anticipated high impact on AR. Here, 22 hospitals were compliant (corresponding to all fully and 11 partially accredited hospitals) and 9 non-compliant (corresponding to 9 partially accredited hospitals). When grouping in-patients according compliance to three standards, the primary findings were corroborated (adjusted HR 1.05; 95% CI: 0.97–1.14). Likewise, no differences were found looking at the standards individually.

Discussion

This is the first nationwide study to examine the association between compliance with accreditation and LOS, and AR. Our findings showed that in-patients admitted at fully accredited hospitals had shorter LOS and thus extend our previous finding that compliance with accreditation was associated with lower 30-day mortality. Notably, among the patients admitted at fully accredited hospitals, the shorter LOS was not followed by an increase in early ARs.

Table 1 Patients' characteristic for in-patients admitted at fully and partially accredited hospitals according to the first version of DDKM including hospitals' characteristic (counts (%))

In-patients characteristics	Length of stay ($N = 275\,589$)		Acute readmission ($N = 266\,532$)	
	Admissions at partially accredited hospital ($n = 200\,462$)	Admissions at fully accredited hospital ($n = 75\,127$)	Admissions at partially accredited hospital ($n = 193\,790$)	Admissions at fully accredited hospital ($n = 72\,742$)
Age				
<50 years	64 743 (32)	22 212 (30)	64 486 (33)	22 159 (30)
50–64 years	41 772 (21)	14 866 (20)	40 827 (21)	14 613 (20)
65–80 years	57 605 (29)	22 098 (29)	55 279 (29)	21 248 (29)
>80 years	36 342 (18)	15 951 (21)	33 198 (17)	14 722 (20)
Gender				
Women	102 804 (51)	39 467 (53)	99 637 (51)	38 247 (53)
Men	97 658 (49)	35 660 (47)	94 153 (49)	34 495 (47)
Marital status				
Unmarried	55 254 (28)	18 938 (25)	54 553 (28)	18 682 (26)
Married	85 335 (43)	31 158 (41)	82 698 (43)	30 326 (42)
Divorced	24 916 (12)	10 646 (14)	24 010 (12)	10 263 (14)
Widow	34 955 (17)	14 384 (19)	32 527 (17)	13 470 (19)
Unknown	2 (0)	1 (0)	2 (0)	1 (0)
Comorbidity status[a]				
No comorbidity	108 563 (54)	39 247 (52)	106 632 (55)	38 613 (53)
Low	60 942 (30)	23 479 (31)	58 315 (30)	22 538 (31)
High	30 957 (15)	12 401 (17)	28 843 (15)	11 591 (16)
Type of admission				
Acute	163 413 (82)	67 879 (90)	157 033 (81)	65 536 (90)
Elective	36 870 (18)	7248 (10)	36 757 (19)	7206 (10)
Primary diagnosis[b]				
Certain infectious and parasitic diseases	7491 (4)	2774 (4)	6948 (4)	2579 (4)
Neoplasms	17 157 (9)	2787 (4)	16 674 (9)	2647 (4)
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	2743 (1)	1104 (1)	2693 (1)	1087 (1)
Endocrine, nutritional and metabolic diseases	6653 (3)	2934 (4)	6419 (3)	2843 (4)
Diseases of the circulatory system	28 799 (14)	12 882 (17)	27 093 (14)	12 269 (17)
Diseases of the respiratory system	20 945 (10)	9830 (13)	19 492 (10)	9239 (13)
Diseases of the digestive system	12 784 (6)	4690 (6)	12 301 (6)	4515 (6)
Diseases of the genitourinary system	8650 (4)	3251 (4)	8496 (4)	3190 (4)
Factors influencing health status	52 051 (26)	19 702 (26)	51 371 (27)	19 488 (27)
Injury, poisoning, etc.	11 169 (6)	3868 (5)	10 792 (6)	3757 (5)
Others	32 020 (16)	11 305 (15)	31 511 (16)	11 128 (15)
Hospitals' characteristics	Partially accredited hospitals ($n = 20$)		Fully accredited hospitals ($n = 11$)	
University affiliation				
Yes	8 (40)		4 (36)	
No	12 (60)		7 (64)	
Previous accreditation				
Yes	5 (25)		8 (73)	
No	15 (75)		3 (27)	
Time of on-site survey				
From 2010 to June 2011	13 (65)		2 (18)	
From July 2011 to the end of 2012	7 (35)		9 (82)	

[a]Categories of comorbidity were based on Charlson comorbidity index scores (no comorbidity = 0, low = 1 and 2 and high = ≥3).
[b]Categories of underlying diseases were based on chapters of the WHO's International Classification of Diseases and Related Health Problem, 10. revision.

The strength of the study was the nationwide population-based design with the prospective collection of comprehensive patient data. This combined with the un-fettered access to healthcare for all Danish citizens, and complete follow-up in the medical registries limits the risk of both selection and information bias. The restriction to the 80 primary diagnoses was applied to minimize the risk of confounding. The information on important patient characteristics allowed us to adjust for a range of potentially confounders, which strengthens the presented results. Adding to that, the fact that all hospitals were accredited by the same programme in a relatively short period of time (3 years) enables us to compare the level of accreditation and reduce concerns of internal generalizability.

The limitations included the uncertain accuracy of the DDKM accreditation data (i.e. the unknown inter-reliability of assessments made by surveyors and survey teams) [24, 25]. To address this concern, efforts were made by the accreditation body to check the survey findings for consistency to the rating principles applied before forwarding the report to the Accreditation Award Committee. This

Table 2 Length of stay and HR for in-patients admitted at accredited Danish hospitals according to the first version of DDKM for hospitals

	No. of hospitals ($N = 31$)	No. of patients ($N = 275\,589$)	Length of stay; mean (days) (95% CI)	Length of stay; median (days) (5–95 percentiles)	Length of stay HR (95% CI)	
					Crude	Adjusted[a]
Compliance with accreditation programme						
In-patients at partially accredited hospitals[b]	20	200 462	4.54 (4.50–4.57)	2 (0.5–17)	1.00	1.00
In-patients at fully accredited hospitals	11	75 127	4.51 (4.46–4.57)	2 (0.5–17)	1.00 (0.99–1.01)	1.07 (1.01–1.14)
Compliance according to follow-up activity						
In-patients at hospitals having a return-visit[b]	11	103 677	4.75 (4.70–4.80)	2 (0.5–18)	1.00	1.00
In-patients at hospitals submitting documentation	9	96 785	4.31 (4.26–4.35)	1 (0.5–17)	1.09 (1.08–1.10)	1.12 (1.01–1.24)
In-patients at hospitals with no follow-up (fully accredited)	11	75 127	4.51 (4.46–4.57)	2 (0.5–17)	1.04 (1.03–1.05)	1.13 (1.04–1.23)
Compliance with four standards combined						
In-patients at non-compliant hospitals[b]	10	119 570	4.68 (4.64–4.73)	2 (0.5–18)	1.00	1.00
In-patients at compliant hospitals	21	156 019	4.42 (4.38–4.45)	2 (0.5–17)	1.05 (1.04–1.06)	1.12 (1.03–1.21)
Compliance with standards individually						
Organizational standards: Documentation and monitoring of nosocomial infections						
In-patients at non-compliant hospitals[b]	3	28 012	5.46 (5.35–5.57)	2 (0.5–19)	1.00	1.00
In-patients at compliant hospitals	28	247 577	4.43 (4.40–4.46)	2 (0.5–17)	1.15 (1.14–1.17)	1.20 (1.07–1.34)
General patient pathway standards: Pain assessment and treatment						
In-patients at non-compliant hospitals[b]	6	79 145	4.37 (4.32–4.43)	1 (0.5–17)	1.00	1.00
In-patients at compliant hospitals	25	196 444	4.59 (4.56–4.63)	2 (0.5–18)	0.98 (0.97–0.99)	1.00 (0.93–1.09)
Organizational standards: Timely reaction to test results						
In-patients at non-compliant hospitals[b]	3	36 489	4.13 (4.05–4.20)	1 (0.5–16)	1.00	1.00
In-patients at compliant hospitals	28	239 100	4.59 (4.56–4.62)	2 (0.5–18)	0.94 (0.93–0.95)	0.94 (0.87–1.02)
Observation and follow-up on critical observation results						
In-patients at non-compliant hospitals[b]	3	33 366	5.16 (5.06–5.25)	2 (0.5–19)	1.00	1.00
In-patients at compliant hospitals	28	242 233	4.44 (4.41–4.48)	2 (0.5–17)	1.11 (1.10–1.12)	1.25 (1.09–1.44)

[a]Adjusted for age, gender, comorbidity, primary diseases, marital status, type of admission and a within-hospital clustering.
[b]Reference group.

combined with the fact that the overall level of compliance was awarded based on all eligible standards any potential misclassification would most likely to be of a non-differential nature and bias the results towards the null. Furthermore, we cannot rule out the risk of residual or unmeasured confounding by the use of a non-randomized design, despite adjusting for a range of patient-related characteristics and stratifying for hospital-related characteristics. The DNRP does not obtain information on the severity of disease, which might prolong LOS and increase AR; thus, we were not able to adjust for this factor. In addition, our data did not include the specific time of admission and discharge (hour and minute), which could have provided more accurate information on LOS. Also geographical variation in re-admission patterns according to traditions and resources available in the primary care sector as well as variation in the registration of in-patient information among hospital staff must be considered as components for potential misclassification. However, any differences in the severity of disease, LOS by the hour, or variation in readmission patterns and data collection were expected to be equally distributed among in-patients at fully and partially accredited hospitals and therefore considered to be non-differential and most likely bias the association towards the null.

The differences in the crude mean LOS between in-patients admitted at fully and partially accredited hospitals were negligible (fully: 4.51 days; partially: 4.54 days). After adjusting for potential confounding factors, however, the measure reached statistical significance and equalled a 7% decrease of the mean LOS. A difference of this size may have potential clinical and economic implications at population level if it reflects a true causal difference. However, the practical consequence at unit level is not answered by this study design and, thus, remains to be further clarified.

Although no previous study had examined the association between compliance with accreditation and LOS, and AR like ours, other studies have used designs of 'accredited vs non-accredited' or 'before vs after implementation' and looked at specific patient groups [8–12]. A shorter LOS was found in favour of accreditation in three of the four studies implying like our findings that implementation of accreditation standards is associated with shorter LOS. The findings regarding AR were inconsistent with either a higher risk (odds ratio 2.82; 95% CI: 1.46–25.44) or a lower risk of AR ($P = 0.003$), and combined with our neutral finding, the association between accreditation and AR remains unclear [8, 12].

Our neutral finding on AR could be explained by the first version of DDKM mainly focussed on quality improvements within hospitals and not between hospitals or other collaborators. Still, the quality improvement process initiated was anticipated to transfer to other areas not included, but this seems not to be the case. Not without reason has AR been challenged as an accurate measure to qualify hospital performance as progress of disease, organization of the healthcare system and socioeconomic factors have been highlighted as factors increasing the patients risk of being acute readmitted – all factors beyond hospital

Table 3 Acute readmission and HR for in-patients admitted at accredited Danish hospitals according to the first version of DDKM for hospitals

	No. of hospitals ($N = 31$)	No. of patients ($N = 266\,532$)	Acute readmission (%) (95% CI)	Acute readmission HR (95% CI)	
				Crude	Adjusted[a]
Compliance with accreditation					
In-patients at partially accredited hospitals[b]	20	193 790	12.72 (12.57–12.86)	1.00	1.00
In-patients at fully accredited hospitals	11	72 742	13.70 (13.45–13.95)	1.08 (1.06–1.11)	1.01 (0.92–1.10)
Compliance according to follow-up activity					
In-patients at hospitals having a return-visit[b]	11	99 861	12.21 (12.01–12.42)	1.00	1.00
In-patients at hospitals submitting documentation	9	93 929	13.25 (13.03–13.46)	1.09 (1.06–1.12)	1.07 (0.96–1.19)
In-patients at hospitals with no follow-up (fully accredited)	11	72 742	13.70 (13.45–13.95)	1.13 (1.10–1.16)	1.04 (0.92–1.17)
Compliance with three standards combined					
In-patients at non-compliant hospitals[b]	9	98 635	12.21 (12.00–12.41)	1.00	1.00
In-patients at compliant hospitals	22	167 897	13.44 (13.28–13.61)	1.11 (1.08–1.13)	1.05 (0.97–1.14)
Compliance with the standards individually					
Pain assessment and treatment					
In-patients at non-compliant hospitals[b]	6	76 408	12.34 (12.11–12.57)	1.00	1.00
In-patients at compliant hospitals	25	190 124	13.24 (13.09–13.40)	1.08 (1.05–1.10)	1.05 (0.96–1.15)
Timely reaction to test results					
In-patients at non-compliant hospitals[b]	3	35 239	12.59 (12.25–12.94)	1.00	1.00
In-patients at compliant hospitals	28	231 293	13.04 (12.91–13.18)	1.04 (1.00–1.07)	1.04 (0.95–1.13)
Medicine reconciliation					
In-patients at non-compliant hospitals[b]	5	32 004	12.45 (12.08–12.81)	1.00	1.00
In-patients at compliant hospitals	26	234 528	13.06 (12.92–13.20)	1.05 (1.02–1.09)	0.93 (0.71–1.23)

[a]Adjusted for age, gender, comorbidity, primary diseases, marital status and type of admission and a within-hospital clustering.
[b]Reference group.

influence [26, 27]. Thus, further research may profitably be restricted to clinical outcomes within hospital influence.

Throughout the years, hospitals have invested substantial resources in the implementation of quality improvement programmes including accreditation in the effort to deliver high-quality patient care. Our findings support the hypothesis that compliance with accreditation was associated with shorter LOS, without an increase in AR. Difference in LOS does on the other hand not necessarily indicate that accreditations standards *per se* were responsible for the in-patients being discharged earlier at fully accredited than partially accredited hospitals [28]. Other concomitantly national initiatives have focussed on reducing LOS and the numbers of AR. In 2009, compulsory healthcare agreements were introduced between regions (hospitals owners) and the surrounding municipalities (primary care owners) with the focus to ensure efficient transfers by addressing access and capacity of outpatient health services for discharged in-patients. Another national initiative introduced was continuous indicator monitoring and auditing through clinical quality databases covering major disease areas including stroke, heart failure, diabetes and hip fracture as a strategy to improve patient outcome. It is likely that these initiatives may have had a direct effect on lowering LOS, but since all hospitals, fully as well as partially accredited, were encompassed by these programmes any inherent variation was unlikely to explain the relative differences in LOS revealed. It seems more likely that the ability to implement such programmes effectively may also play a role when implementing accreditation standards in the organization.

Alternatively, high compliance with accreditation standards may just be a marker of high-performing hospitals delivering high quality of care including lower 30-day mortality risk and shorter LOS without an increase in AR. In this light, compliance with accreditation could in the future be used as a proxy for identifying hospitals delivering high quality of care, potentially. Before such use, however, further investigations on this relationship are needed to be able to draw a firm conclusion.

Conclusion

Admissions at hospitals fully accredited by the first version of the DDKM were associated with a significantly shorter LOS than admissions at partially accredited hospitals, although the difference was modest. There was no difference in all-cause AR within 30 days after discharge between admissions at fully and partially accredited hospitals.

Funding

This work was supported by Center for Quality in the Region of Southern Denmark, Department of Clinical Epidemiology, Aarhus University Hospital, and the Institute of Quality and Accreditation in Healthcare (IKAS). IKAS had no role whatsoever regarding study design, data collection, analysis, decision to publish or preparation of the manuscript. All authors are independent researchers without any financial interest in the results presented.

Ethics approval

The study was approved by the Danish Data Protection Agency. According to Danish law, ethical approval is not needed for registry-based studies.

Authors' contributions

A.M.F.J. and S.P.J. designed and conceived the study; collected, managed, analysed and interpreted the data; contributed to manuscript

drafting and revision; following The STROBE guideline. All other authors were responsible for study design, interpretation of data and critical manuscript revision and approval. A.M.F.J., S.P.J. and H.J.L. had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Data sharing

Codebook and statistical code (in Danish) are available from the corresponding author at amfj@clin.au.dk.

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35. Vera Ehrenstein: Association of Apgar score and postterm delivery with neurologic morbidity: Cohort studies using data from Danish population registries. PhD thesis. *2007*.

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40. Asbestose og kræft i lungehinderne. Danmark 1977-2005. *2008*.

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47. Jette Bromman Kornum: Obesity, diabetes and hospitalization with pneumonia. PhD thesis. *2009*.

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105. Kathrine Dyhr Lycke: Preadmission use of antidepressants and quality of care, intensive care admission and mortality of colorectal cancer surgery – a nationwide population-based cohort study. Research year report. *2015*.

106. Louise Bill: Hyponatremia in acute internal medicine patients: prevalence and prognosis. PhD thesis. *2015*.

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