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

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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

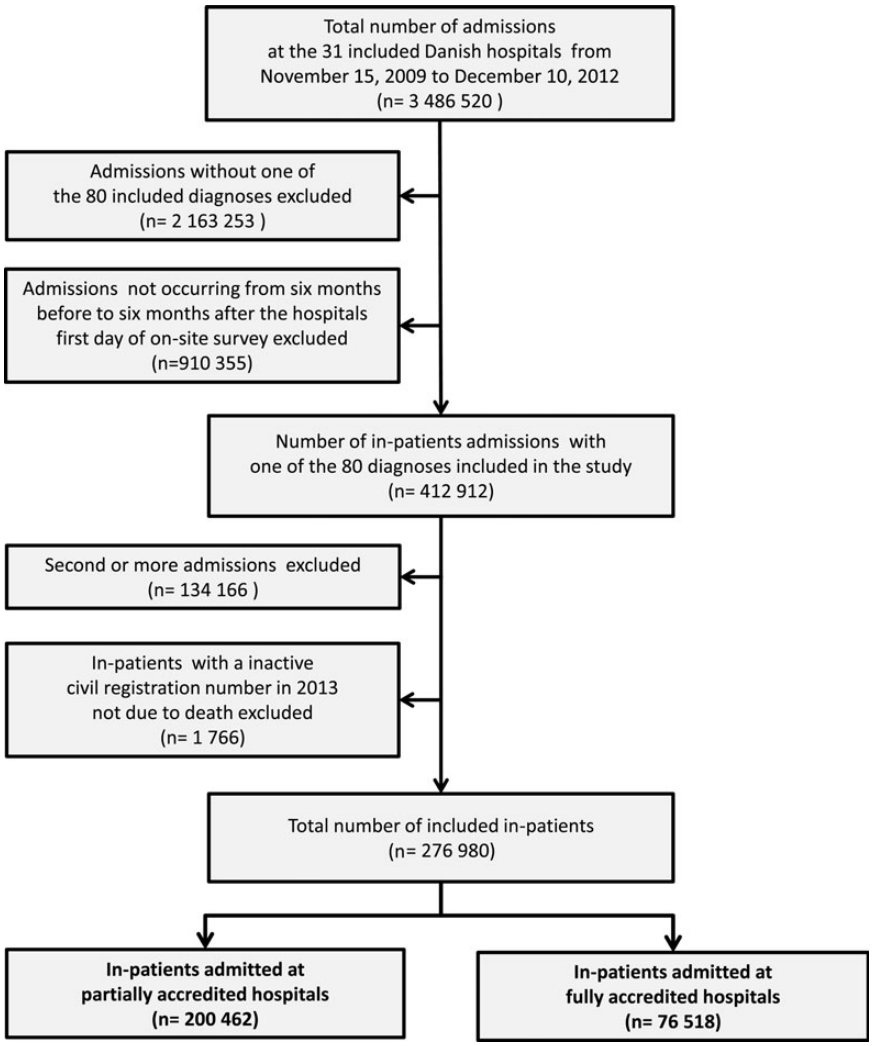

Figure 1 Flowchart of in-patients included in the study.

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.

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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.

References

1. Alkhenizan A, Shaw C. Impact of accreditation on the quality of healthcare services: a systematic review of the literature. *Ann Saudi Med* 2011;**31**: 407–16.
2. Flodgren G, Pomey MP, Taber SA *et al.* Effectiveness of external inspection of compliance with standards in improving healthcare organisation behaviour, healthcare professional behaviour or patient outcomes. *Cochrane Database Syst Rev* 2011;CD008992.
3. Greenfield D, Braithwaite J. Health sector accreditation research: a systematic review. *Int J Qual Health Care* 2008;**20**:172–83.

4. Hinchcliff R, Greenfield D, Moldovan M *et al*. Narrative synthesis of health service accreditation literature. *BMJ Qual Saf* 2012;**21**:979–91.
5. Braithwaite J, Greenfield D, Westbrook J *et al*. Health service accreditation as a predictor of clinical and organisational performance: a blinded, random, stratified study. *Qual Saf Health Care* 2010;**19**:14–21.
6. Chen J, Rathore SS, Radford MJ *et al*. JCAHO accreditation and quality of care for acute myocardial infarction. *Health Aff (Millwood)* 2003;**22**: 243–54.
7. Chandra A, Glickman SW, Ou FS *et al*. An analysis of the Association of Society of Chest Pain Centers accreditation to American College of Cardiology/American Heart Association non-ST-segment elevation myocardial infarction guideline adherence. *Ann Emerg Med* 2009;**54**:17–25.
8. Gratwohl A, Brand R, Niederwieser D *et al*. Introduction of a quality management system and outcome after hematopoietic stem-cell transplantation. *J Clin Oncol* 2011;**29**:1980–6.
9. Lichtman JH, Allen NB, Wang Y *et al*. Stroke patient outcomes in US hospitals before the start of the Joint Commission Primary Stroke Center certification program. *Stroke* 2009;**40**:3574–9.
10. Rajamani K, Millis S, Watson S *et al*. Thrombolysis for acute ischemic stroke in Joint Commission-certified and -noncertified hospitals in Michigan. *J Stroke Cerebrovasc Dis* 2013;**22**:49–54.
11. Pedersen CB. The Danish Civil Registration System. *Scand J Public Health* 2011;**39**:22–5.
12. International Society for Quality in Health Care. http://isqua.org/accreditation/accreditation (4 April 2014, date last accessed).
13. Institut for Kvalitet og Akkreditering i Sundhedsvæsenet. 2014, Denmark. http://www.ikas.dk/ (4 April 2014, date last accessed).
14. *Den danske kvalitetsmodel: akkrediteringsstandarder for sygehuse: 1. Version*. 2nd edn. Århus: Institut for Kvalitet og Akkreditering i Sundhedsvæsenet, 2011.
15. Institut for Kvalitet og Akkreditering i Sundhedsvæsenet. Vurderingsprincipper i DDKM af 2012 - vejledning til surveyors og akkrediteringsnævn. 9 November 2013, Denmark. http://www.ikas.dk/Regler/Vurderingsprincipper.aspx (8 October 2013, date last accessed).
16. Papanikolaou PN, Christidi GD, Ioannidis JP. Patient outcomes with teaching versus nonteaching healthcare: a systematic review. *PLoS Med* 2006;**3**:341.
17. Ayanian JZ, Weissman JS. Teaching hospitals and quality of care: a review of the literature. *Milbank Q* 2002;**80**:569–93.
18. Andersen TF, Madsen M, Jorgensen J *et al*. The Danish National Hospital Register. A valuable source of data for modern health sciences. *Dan Med Bull* 1999;**46**:263–8.
19. Jarman B, Gault S, Alves B *et al*. Explaining differences in English hospital death rates using routinely collected data. *BMJ* 1999;**318**:1515–20.
20. Charlson ME, Pompei P, Ales KL *et al*. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;**40**:373–83.
21. Thygesen SK, Christiansen CF, Christensen S *et al*. The predictive value of ICD-10 diagnostic coding used to assess Charlson comorbidity index conditions in the population-based Danish National Registry of Patients. *BMC Med Res Methodol* 2011;**11**:83-2288-11-83.
22. Greenfield D, Pawsey M, Naylor J *et al*. Researching the reliability of accreditation survey teams: lessons learnt when things went awry. *HIM J* 2013;**42**:4–10.
23. Greenfield D, Pawsey M, Naylor J *et al*. Are accreditation surveys reliable? *Int J Health Care Qual Assur* 2009;**22**:105–16.
24. Shaw CD. Evaluating accreditation. *Int J Qual Health Care* 2003; **15**:455–6.
25. Rothman KJ. Six Persistent Research Misconceptions. *J Gen Intern Med* 2014;**29**:1060–4.