Effect of certified training facilities for intensive care specialists on mortality in Japan

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The impact of intensive care physicians on patient outcomes is widely debated. Critical care represents a large percentage of health care spending, and improving the quality of care in intensive care units is essential, given that medical needs will increase as the population ages rapidly. However, as of August 2011, Japan had only 878 critical care specialists certified by the Japanese Society of Intensive Care Medicine (JSICM; referred to as "board-certified" intensivists) — only 0.3% of the total number of physicians.[1] This suggests that the majority of patients who need intensive care are treated by non-board-certified physicians. JSICM certifies training facilities for intensive care specialists. According to their rules for certification,[2] an ICU that is a certified facility (CF) has at least one board-certified intensivist. The question of whether more intensivists are needed must be addressed immediately, as intensivist training takes 5 to 10 years after graduation from medical school, and medical demand is estimated to peak in 2025 in Japan; however, it is difficult to answer this question, because few studies have investigated the impact of board-certified intensivists in Japan.

The purpose of our study was to investigate the impact of board-certified intensivists in Japan, using administrative data. The study was approved and registered by the Kyoto University Graduate School and Faculty of Medicine Ethics Committee.

Methods

Data source

Data were obtained from the Diagnosis Procedure Combination (DPC) database, which is the national administrative database of a casemix classification system for acute inpatient care, developed in Japan and used since 2003.[3] The database consists of summarised clinical information and detailed health care claim data. Clinical information comprises key patient information on age, sex, primary diagnosis, comorbidities (as classified by the International Classification of Diseases, 10th revision), complications, surgeries, and the DPC code. The DPC code is a 14-digit code used for reimbursement, where the first two digits represent the 18 major diagnosis categories (MDC) comprising diseases that require the most medical resource expenditure. Health care claim data include detailed medical resources use, indexed in

ABSTRACT

Objective: To compare patient outcomes in hospitals certified by the Japanese Society of Intensive Care Medicine (JSICM) as training facilities for intensive care specialists with patient outcomes in hospitals not certified by the JSICM (non-CFs).

Design: A retrospective case–control study using administrative data.

Main outcome measure: Inhospital mortality.

Results: 164 803 intensive care unit admissions were identified between 1 April 2008 and 31 March 2010, of which 159 540 were for adults (≥ 18 years). A total of 50 875 patients in 125 hospitals were admitted to certified facilities (CFs) and 108 665 patients in 309 hospitals were admitted to non-CFs. Inhospital mortality rates were 9.9% and 10.6% in CFs and non-CFs, respectively ($P < 0.001$). After adjusting for age, emergency admission, admission route, use of vasopressors, mechanical ventilation, and renal replacement therapy, the odds ratio for hospital mortality in CF-treated patients was 0.81 (95% confidence interval, 0.78–0.85). The c statistic of the model was 0.881.

Conclusions: Patients admitted to the intensive care unit in CFs had better outcomes. To improve patient outcomes, more board-certified intensivists are required in Japan.

the original Japanese codes,[4] including diagnostic tests, all surgical or interventional procedures, medications, and the specified hospitalisation fees.

Hospital selection

All hospitals in the DPC database with at least one patient admitted to the ICU were included in this study. A list of CFs was obtained from the JSICM website.[5]

Patient selection

From all patients who were discharged between 1 April 2008 and 31 March 2010 we selected patients who were admitted to an ICU at any point during their hospitalisation. To focus on adult intensive care, patients younger than 18 years of age were excluded.

Table 1. Background of patients, by type of intensive care facility in Japan

	CFs ($n = 50\,875$)*	Non-CFs ($n = 108\,665$)*	$P^{\dagger}$
No. of hospitals	125	309	
Age (years)	67.2 (14.0)	68.3 (14.4)	< 0.001
Male	31 950 (62.8%)	64 306 (59.2%)	< 0.001
Emergency admission	24 042 (47.3%)	59 063 (54.4%)	< 0.001
Admission route to ICU			< 0.001
Post scheduled surgery	27 516 (54.1%)	52 716 (48.5%)	
Post emergency surgery	8 540 (16.8%)	18 483 (17.0%)	
Medical indication	14 819 (29.1%)	37 466 (34.5%)	
Major diagnosis category			< 0.001
Nervous system	6 314 (12.41%)	17 055 (15.7%)	
Eye	12 (0.02%)	20 (0.02%)	
Ear, nose, mouth and throat	572 (1.12%)	852 (0.78%)	
Respiratory system	4 461 (8.77%)	10 059 (9.26%)	
Circulatory system	20 601 (40.49%)	33 601 (30.92%)	
Digestive system	9 362 (18.4%)	23 765 (21.87%)	
Musculoskeletal system	1 203 (2.36%)	4 092 (3.77%)	
Skin and subcutaneous tissue	48 (0.09%)	89 (0.08%)	
Breast	58 (0.11%)	442 (0.41%)	
Endocrine and metabolic system	849 (1.67%)	1 789 (1.65%)	
Kidney and urinary system	2 114 (4.16%)	3 843 (3.54%)	
Female reproductive system	597 (1.17%)	1 546 (1.42%)	
Blood and immunological disorders	985 (1.94%)	1 603 (1.48%)	
Congenital disease	220 (0.43%)	262 (0.24%)	
Paediatric disease	25 (0.05%)	82 (0.08%)	
Injuries, burns and poisoning	1 756 (3.45%)	6 261 (5.76%)	
Psychiatry	36 (0.07%)	251 (0.23%)	
Others	1 657 (3.26%)	3045 (2.8%)	
Uncoded	5 (0.01%)	8 (0.01%)	

CFs = hospitals certified as training facilities for intensive care specialists by the Japanese Society of Intensive Care Medicine. ICU = intensive care unit.

* Categorical variables are given as no. of cases (%); continuous variable is given as mean (SD). † χ^2 test for categorical variables; Student t-test for continuous variables.

Patient outcomes

We evaluated ICU mortality and hospital mortality and compared patients who were treated in CFs with those who were treated in non-CFs.

We evaluated the impact of CFs on mortality using a two-step analysis. First we generated two models using multivariate logistic regression to adjust for casemix. One model (model A) included the variables age, emergency admission, admission source, treatments carried out in the ICU, such as mechanical ventilation, renal replacement therapy, and use of vasopressors. The other model (model B) included primary diagnosis in addition to the variables in model A. The forced-entry method was used in both models. In model B, MDCs constituting more than 1% of the total cases were selected, and the MDC

"circulatory system" was used as the reference category. To check the discriminatory ability of the models, c statistics were calculated.

After calculating c statistics of the models, a binary variable was assigned to indicate the group to which the patient belonged. The c statistics of the models were calculated again.

Statistical analyses

Data were compared using the χ^2 test for categorical variables and the unpaired Student t-test for continuous variables. Data are expressed as mean (standard deviation [SD]) or number (%). $P < 0.05$ was considered significant. All statistical analyses were performed using SPSS 11.0J (SPSS Inc).

Table 2. Treatments and outcomes of patients, by type of intensive care facility in Japan

	CFs (*n* = 50 875)*	Non-CFs (*n* = 108 665)*	*P*
Vasopressor	24 147 (47.5%)	43 738 (40.3%)	< 0.001
Mechanical ventilation	14 503 (28.5%)	21 786 (20.0%)	< 0.001
Renal replacement therapy	2 420 (4.8%)	3 443 (3.2%)	< 0.001
Blood transfusion	11 688 (23.0%)	17 908 (16.5%)	< 0.001
Tracheostomy	1 843 (3.6%)	2 548 (2.3%)	< 0.001
Length of ICU stay (days)	3.1 (3.4)	3 (3.3)	< 0.001
Length of hospital stay (days)	28.8 (26.4)	27.7 (27.1)	< 0.001
Discharge to other hospitals	6 172 (12.1%)	15 351 (14.1%)	< 0.001
ICU mortality	2 407 (4.7%)	5 744 (5.3%)	< 0.001
Inhospital mortality	5 046 (9.9%)	11 540 (10.6%)	< 0.001

CFs = hospitals certified as training facilities for intensive care specialists by the Japanese Society of Intensive Care Medicine. ICU = intensive care unit.
* Categorical variables are given as no. of cases (%); continuous variables are given as mean (SD).

Results

A total of 164 803 ICU admissions in 434 hospitals were identified, of which 5266 cases (3.2%) were excluded because the patients were under 18 years of age. A total of 159 540 cases were included in our analysis.

A total of 50 875 patients in 125 hospitals were treated in CFs and 108 665 patients in 309 hospitals were treated in non-CFs. The two groups were not substantially different with respect to disease categories; however, a higher proportion of CF patients exhibited diseases and disorders of the circulatory system (*P* < 0.001) (Table 1).

The proportions of patients who needed special treatments in the ICU were higher in CFs than in non-CFs (Table 2). ICU mortality and inhospital mortality were slightly higher in non-CFs (ICU mortality: 4.7% in CFs, 5.3% in non-CFs; inhospital mortality: 9.9% in CFs, 10.6% in non-CFs).

Results of the logistic regression analysis are presented in Table 3. In the first step, both models exhibited a good discriminatory ability. In the second step, among CF-treated patients the odds ratios for ICU mortality were 0.78 in both models and the odds ratios for hospital mortality were 0.81 and 0.85 in models A and B, respectively.

Discussion

This is the first large-scale study to document the use of ICUs and focus on board-certified intensivists in Japan. According to the Ministry of Health, Labour and Welfare, 806 hospitals were equipped with ICUs in 2008;[6] therefore, these data are from more than half (53.8%) of the ICUs in Japan. Among the patients who needed critical care in our study, admission to hospitals whose ICUs were certified as training facilities for intensive care specialists had a positive effect on patient mortality, after risk adjustment.

Administrative data are easier and less expensive to collect than clinical data and are increasingly used in a variety of specialties. However, whether administrative data are suitable for risk adjustment in critically ill patients is debatable. A comparison between the performance of a model based on clinical data (customised Simplified Acute Physiology Score [SAPS] II) with that of a model based on administrative data (customised hospital standardised mortality ratio) in a Dutch ICU population showed that the clinical data-based model outperformed the administrative data-based model, particularly for high-risk patients.[7] On the other hand, a comparison between several models based on administrative data with three physiology-based scores (Acute Physiology and Chronic Health Evaluation [APACHE] II, SAPS II and SAPS III) concluded that the Charlson comorbidity index[8] combined with other administrative data predicted short- and long-term mortality in ICU patients as effectively as the physiology-based scores.[9]

In Japanese ICUs that are not certified as training facilities, physiological scores are not available for all patients, because there are no critical care specialists or such requirements. In general, physiological scores, such as the Sequential Organ Failure Assessment (SOFA) score[10] and APACHE II,[11] are preferred for clinical decision making, standardising research and comparing the quality of patient care across ICUs. We adjusted for the difference in casemix using ICU treatments because in our view each treatment reflects the severity of illness. The SOFA score comprises six elements: respiratory, renal, hepatic, cardiovascular, haematological and neurological. The predictive power of each element has been reviewed previously.[12] Entry criteria for each treatment vary somewhat between clinicians; some ICU treatments may be used as surrogates of the physiological score. For example, in the SOFA score, the use of mechanical ventila-

Table 3. Multiple logistic regression analysis of inhospital and ICU mortality

	Inhospital mortality, by model				ICU mortality, by model			
	A	A + certified status	B	B + certified status	A	A + certified status	B	B + certified status
Age	1.03*	1.03*	1.03*	1.03*	1.02*	1.02*	1.02*	1.02*
Emergency admission	2.20*	2.17*	2.13*	2.10*	2.09*	2.05*	2.01*	1.97*
Admission route								
Post scheduled surgery	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Post emergency surgery	2.11*	2.12*	2.05*	2.05*	3.93*	3.94*	3.70*	3.71*
Medical indication	6.01*	5.98*	5.18*	5.16*	9.22*	9.17*	9.17*	9.14*
ICU treatment								
Vasopressor	4.39*	4.41*	5.12*	5.13*	4.75*	4.78*	5.19*	5.20*
Mechanical ventilation	3.77*	3.85*	3.60*	3.65*	4.45*	4.55*	4.51*	4.62*
Renal replacement therapy	3.52*	3.57*	3.51*	3.54*	2.12*	2.15*	2.27*	2.30*
Major diagnosis category								
Nervous system			3.04*	3.00*			1.59*	1.56*
Respiratory system			2.46*	2.43*			0.71*	0.70*
Circulatory system			1.00	1.00			1.00	1.00
Digestive system			1.58*	1.57*			0.93	0.91*
Musculoskeletal system			1.28*	1.27*			0.61*	0.60*
Endocrine and metabolic system			1.47*	1.46*			0.78	0.78
Kidney and urinary system			1.32*	1.31*			0.71*	0.70*
Female reproductive system			1.41	1.4			0.53	0.52
Blood and immunological disorders			5.17*	5.19*			1.27*	1.28*
Injuries, burns and poisoning			1.67*	1.65*			1.23*	1.21*
Others			2.68*	2.67*			0.92	0.92
Other diagnosis categories†			1.01	1.02			0.56*	0.56*
Certified ICU, odds ratio (95% CI)		0.81 (0.78–0.85)		0.85 (0.81–0.88)		0.78 (0.74–0.82)		0.78 (0.73–0.82)
c statistic	0.881	0.881	0.892	0.892	0.892	0.881	0.902	0.902

ICU = intensive care unit. * $P < 0.05$. † Includes seven major diagnosis categories (eye; ear, nose, mouth and throat; skin and subcutaneous tissue; breast; congenital disease; paediatric disease; psychiatry), each of which consisted of less than 1% of total cases.

tion is about equivalent to a respiratory score of > 2, the use of renal replacement therapy is equivalent to a renal score of ≥ 3, and the use of vasopressors is equivalent to a cardiovascular score of ≥ 2. The c statistics for our models were high. Therefore, the use of ICU treatments as risk-adjustment variables is one option for countries where physiological scores are unavailable for evaluating the quality of care in a critical care setting.

Suitable physician staffing in ICUs is widely debated. High-intensity ICU physician staffing has been shown to be associated with reduced hospital mortality.[13] However, it has also been reported that patients managed by critical care physicians had higher hospital mortality than those who were not.[14]

In our study, overall mortality was relatively low compared with that of other countries. An investigation of international variation in critical care services across North America and Western Europe found an inverse correlation between ICU beds per capita and hospital mortality.[15] In the United States, less than one-third of patients admitted to the ICU are from an operating room or related sources.[16] By contrast, in our study, about half of the patients in both groups were admitted to the ICU after a scheduled operation. Admission route has already been shown to be a risk factor for inhospital mortality,[17,18] so casemix may explain the fact that overall mortality among ICU patients is relatively low in Japan considering the number of ICU beds. However, this fact raises a new question: where are the other patients who suffer from severe diseases and need to be treated in the ICU?

The reason why better outcomes were achieved in CFs is unclear from this study, but possible explanations include implementation of best clinical practices, such as evidence-based treatments for acute lung injury and sepsis; preven-

tion of ICU complications;[19] the educational role of ICU staff;[20] and quick responses to emergency situations.

Limitations

This study has several limitations. First, we did not consider the intensity of care provided by each physician, which may influence the result. The 24-hour availability of a consultant-level intensivist is considered ideal,[21] but in Japan physicians were not present in 21% of ICUs.[22] These variations in the intensity of care may decrease the effect. We used mortality as the outcome, but mortality alone is not sufficient to measure the quality of ICUs.[23] Activities of daily living after hospital discharge, the care process and costs should be evaluated in the future.

Second, the administrative data included information on a calendar-day basis rather than an hourly basis. We were therefore unable to distinguish between death in the ICU and death in the ward immediately after ICU discharge. But these deaths appear to indicate poor quality of care, given that a significant rate of readmission to the ICU within 48 hours is considered to indicate suboptimal clinical care.[21] Therefore, inclusion of these deaths in ICU mortality is not germane to our discussion.

Conclusion

In Japan, models that use administrative data to adjust for the casemix of ICU patients provide good discriminatory ability, and we have shown that ICUs that are certified as training facilities for intensive care specialists have a positive effect on mortality in Japan.

Competing interests

None declared.

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