Quality metrics and outcomes among critically ill patients in China: results of the national clinical quality control indicators for critical care medicine survey 2015–2019

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Abstract

Background: It is crucial to improve the quality of care provided to ICU patient, therefore a national survey of the medical quality of intensive care units (ICUs) was conducted to analyze adherence to quality metrics and outcomes among critically ill patients in China from 2015 to 2019.

Methods: This was an ICU-level study based on a 15-indicator online survey conducted in China. Considering that ICU care quality may vary between secondary and tertiary hospitals, direct standardization was adopted to compare the rates of ICU quality indicators among provinces/regions. Multivariate analysis was performed to identify potential factors for in-hospital mortality and factors related to ventilator-associated pneumonia (VAP), catheter-related bloodstream infections (CRBSIs), and catheter-associated urinary tract infections (CAUTIs).

Results: From the survey, the proportions of structural indicators were 1.83% for the number of ICU inpatients relative to the total number of inpatients, 1.44% for ICU bed occupancy relative to the total inpatient bed occupancy, and 51.08% for inpatients with Acute Physiology and Chronic Health Evaluation II scores ≥15. The proportions of procedural indicators were 74.37% and 76.60% for 3-hour and 6-hour surviving sepsis campaign bundle compliance, respectively, 62.93% for microbiology detection, 58.24% for deep vein thrombosis prophylaxis, 1.49% for unplanned endotracheal extubations, 1.99% for extubated inpatients reintubated within 48 hours, 6.38% for unplanned transfer to the ICU, and 1.20% for 48-hour ICU readmission. The proportions of outcome indicators were 1.28‰ for VAP, 3.06‰ for CRBSI, 3.65‰ for CAUTI, and 10.19% for in-hospital mortality. Although the indicators varied greatly across provinces and regions, the treatment level of ICUs in China has been stable and improved based on various quality control indicators in the past 5 years. The overall mortality rate has dropped from 10.19% to approximately 8%.

Conclusions: The quality indicators of medical care in China's ICUs are heterogeneous, which is reflected in geographic disparities and grades of hospitals. This study is of great significance for improving the homogeneity of ICUs in China.

Keywords: Medical quality; ICU; China; Epidemiological survey

Background

In recent years, medical quality and patient safety have emerged as major goals for doctors, nurses, and hospital managers. The "Institute of Medicine: Crossing the Quality Chasm: A Next, Health System for the 21st Century"[1] and "To Err Is Human: Building a Safer Health System"[2] showed that medical errors are common and adversely affect patient outcomes. An intensive care unit (ICU) is a hospital unit with substantial levels of risk for morbidity and mortality. In addition to intrinsic risks (eg, underlying disease or pathophysiologic derangements), ICU patients face extrinsic risks related to the care process itself.

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ICU patients experience an average of 1.75 medication errors each day.[3] In the ICU, nearly 20% of medication errors are life-threatening to patients, and 40% of these errors require treatment. It is crucial to improve the quality of care provided to ICU patients, especially in the COVID-19 pandemic. Relevant quality control standards for critical care medicine (CCM) have been recommended in some countries and regions.[4–6] However, these standards vary greatly due to the diversity of quality control systems.[4–6] To address the need for improved care quality, the quality improvement of critical care (QICC) program, led by the China National Critical Care Quality Control Center (China-NCCQC), was initiated in 2015. To date, an annual survey has been ongoing for 5 years. For each of these 5 years, the China-NCCQC group has carried out corresponding rectification and improvement based on the data. This makes the ICU a specialty with strong quality control in China and resilient to the impact and challenges associated with the COVID-19 pandemic. Through these data, we show the full indicators of the Chinese ICU quality control system and basically describe and analyze the *status quo* of Chinese critical care quality, including its geographical characteristics and outcomes among patients with critical illnesses.

Methods

Organization of quality control survey

Peking Union Medical College Hospital was the National CCM Quality Control Center authorized by the National Health Commission, China. The China-NCCQC was responsible for issuing CCM quality control indicators and notified different grades of hospitals across the country through administrators. The database of the National Clinical Improvement System was designed, and detailed ICU-level data regarding these quality control indicators were collected. ICUs in hospitals that received the China-NCCQC notification logged into the system and filled in information as required from September to October every year. Then, their information was uploaded to the China-NCCQC after being reviewed and approved by the Medical Administration Department at the local hospital. After data collection, the Department of CCM, Peking Union Medical College Hospital, supervised by China-NCCQC, performed the data cleaning, conducted the analysis, and issued the Quality Annual Report. The surveys were approved by the Institutional Research and Ethics Committee of Peking Union Medical College Hospital and were updated and audited every year.

Definitions of the Chinese clinical quality control indicators for critical care medicine

The Chinese Society of CCM (CSCCM) was established in 2005 and released guidelines on the construction and management of China's ICUs in 2006.[7] The guidelines relate to basic requirements, scale, staffing, professional requirements, medical management principles, ward construction standards, and equipment for ICUs. In general, the establishment of ICUs in China follows these guidelines. Details are provided in Supplementary Material Document 1, http://links.lww.com/CM9/A885.

In 2015, China-NCCQC released the 15 specific National Clinical Quality Control Indicators for CCM, which can be classified into three categories: structural indicators (the proportion of ICU patients relative to the total number of inpatients, the proportion of ICU bed occupancy relative to the total inpatient bed occupancy, and the proportion of patients with Acute Physiology and Chronic Health Evaluation II (APACHE II) scores ≥15 relative to all ICU patients), procedural indicators (3-h surviving sepsis campaign [SSC] bundle compliance, 6-h SSC bundle compliance, rate of microbiology detection before administration of antibiotics, proportion of ICU patients given deep vein thrombosis [DVT] prophylaxis, proportion of unplanned endotracheal extubations, proportion of extubated patients reintubated within 48 h, proportion of patients with unplanned ICU transfers, and 48-h ICU readmission rate), and outcome indicators (incidences of ventilator-associated pneumonia [VAP], of catheter-related bloodstream infection [CRBSI], of catheter-associated urinary tract infection [CAUTI], and of ICU mortality).

The criteria for VAP diagnosis included manifestation of new infiltrates on chest radiographs after 48 to 72 hours of endotracheal intubation and the presence of at least two of the following: fever (temperature $>38°C$ or higher than basal temperature), abnormal white blood cell (WBC) count ($\geq 10{,}000/\mu L$ or $<4000/\mu L$), and purulent respiratory tract secretions. The pulmonary infection identification score was based on the clinical pulmonary infection score system.[8,9]

CRBSI is usually suspected when a patient uses a central venous catheter (CVC) and has fever or chills, unexplained hypotension, and no other localizing sign. A confirmed diagnosis of a CRBSI requires that the same organism grows from at least one percutaneous blood culture and a culture of the catheter tip or that two blood samples be drawn (one from a catheter hub and the other from a peripheral vein) and meet the CRBSI criteria for quantitative blood cultures or differential time to positivity (DTP) when cultured. For quantitative blood cultures, a colony count of microbes grown from blood obtained through the catheter hub that is at least threefold greater than the colony count from blood obtained from a peripheral vein best defines a CRBSI. For DTP, the growth of microbes from a blood sample drawn from a catheter hub at least 2 hours before microbial growth is detected in a blood sample obtained from a peripheral vein best defines a CRBSI.[10,11]

CAUTI in patients with indwelling urethral, indwelling suprapubic, or intermittent catheterization is defined by the presence of symptoms or signs compatible with a urinary tract infection with no other identified source of infection along with $\geq 10^3$ colony forming units/mL of ≥1 bacterial species in a single catheter urine specimen or in a midstream voided urine specimen from a patient whose urethral, suprapubic, or condom catheter was removed within the previous 48 hours.[12]

Definitions of all of the aforementioned parameters are presented in Supplementary Material Document 2, http://links.lww.com/CM9/A886.

Data collection

In 2015,1174 hospitals were involved in China's ICU Medical Quality Survey. A total of 756 of these hospitals had ICUs (89 newly built ICUs were excluded). In the following 4 years, 2016–2019,1404, 2419, 1843, and 3035 ICUs joined the survey, respectively. The annual survey is from January 1 to December 31 of the previous year.

The level of the hospital and the area where the hospital is located was also included in our analysis. In China, hospitals are graded according to a 3-tier system that recognizes a hospital's ability to provide medical care and medical education and conduct medical research. Accordingly, hospitals are graded as primary, secondary, or tertiary institutions[13] A primary hospital is typically a township hospital that contains < 100 beds. They are tasked with providing preventive care, minimal healthcare, and rehabilitation services. Secondary hospitals tend to be affiliated with a medium-sized city, county, or district and contain > 100 beds but < 500 beds. They are responsible for providing comprehensive health services and medical education and conducting research in local areas. Tertiary hospitals are comprehensive or general hospitals at the city, provincial, or national level with a bed capacity exceeding 500. They are responsible for providing specialist health services and play a larger role in medical education and scientific research. They serve as medical hubs providing care to multiple regions. Given the potential disparities in the quality of care provided in hospitals at different levels, both secondary and tertiary facilities were surveyed. Additionally, China was geographically divided into seven regions: Southwest (Sichuan Province, Guizhou Province, Yunnan Province, Chongqing, and Tibet Autonomous Region), Northwest (Shaanxi Province, Gansu Province, Qinghai Province, Ningxia Hui Autonomous Region, and Xinjiang Uygur Autonomous Region), South (Guangdong Province, Guangxi Zhuang Autonomous Region, and Hainan Province), East (Shanghai, Jiangsu Province, Zhejiang Province, Anhui Province, Fujian Province, Jiangxi Province, and Shandong Province), North (Beijing, Tianjin, Hebei Province, Shanxi Province, and Inner Mongolia Autonomous Region), Northeast (Liaoning Province, Jilin Province, and Heilongjiang Province), and Central (Henan Province, Hubei Province and Hunan Province).

Statistical analysis

Considering that ICU care quality may vary between secondary and tertiary hospitals, direct standardization was adopted to compare the rates of ICU quality indicators among provinces/regions. The pooled data of all analyzed hospitals were used as the standard population, and the rates in each province or region were standardized according to the distribution of hospital grades, which included tertiary and secondary hospitals. The theory and methods for standardization have been reported in previous studies.[14,15] To explore the quality indicators related to outcomes in ICUs (in-hospital mortality and nosocomial infection), multivariate logistic analyses were performed using the data from 2015 as representative data, and the unit for analysis was the ICU. As the binary response data were grouped, we fitted a binary logit model to identify predictors for outcome indicators using the variable selection method. Potential factors for in-hospital mortality were mainly hospital information (area and hospital grade) and structural and procedural indicators in the ICU. Due to a lack of common and well-established indicators for ICU outcomes, factors were determined by stepwise selection with the forward selection at an alpha of 0.05 and a backward elimination criterion of 0.05. In the multivariate analyses, the proportion of unplanned endotracheal extubations, unplanned transfers to VAP, and CRBSI were dichotomized into < 0.012 or ≥ 0.012, < 0.011 or ≥ 0.011, and < 0.0016 or ≥ 0.0016 according to their medians to estimate effects with clinical significance. Additionally, multivariate regression analyses were performed for factors related to VAP, CRBSI, and CAUTI. All statistical analyses were performed in SAS 9.4 (SAS Institute, Inc., Cary, NC, USA). Statistical significance was established at a two-tailed $P < 0.05$.

Results

The general characteristics of the clinical quality control indicators for critical care

All ICUs participating in these surveys were comprehensive ICUs that treated all types of patients and illnesses (ie, they were not disease- or service-specific ICUs, such as medical ICUs, surgical ICUs, neurological ICUs, or cardiac ICUs). Illogical or erroneous data (Supplementary Table 1, http://links.lww.com/CM9/A882) were regarded as missing data, and the proportions of missing data are summarized in Supplementary Table 2, http://links.lww.com/CM9/A885. The overall quality management and quality control are presented [Table 1].

Structural indicators and geographic differences

Standardized rates of structural indicators were compared among provinces/regions to demonstrate geographic disparities in basic information on ICU admission. Here, Figure 1 shows the 2015 data as an example. Variations across the map and regions revealed that the proportion of ICU patients relative to the total number of inpatients and the proportion of ICU bed occupancy relative to total inpatient bed occupancy were highest in Midwest and South China. The proportion of ICU patients with APACHE II scores ≥15 was highest in South China and exceeded the national level (51.08%). In Northwest China, the rates of ICU admissions and bed occupancy were highest, but the proportion of patients with APACHE II scores ≥15 was lowest among the seven regions of China. As shown on the map, the standardized rates of patients with APACHE II scores ≥15 in Xinjiang, Gansu, Qinghai, and Ningxia were <47.87%. In contrast, the rate of bed occupancy and the proportion of APACHE II scores ≥15 were highest in South China, whereas the ICU admission rate was lowest in this area [Figure 1].

Table 1: Overall data on national clinical quality control indicators for critical care for the whole country in 2015–2019.

Indicators	Rates for 2015	Completion rate (%)	Rates for 2016	Completion rate (%)	Rates for 2017	Completion rate (%)	Rates for 2018	Completion rate (%)	Rates for 2019	Completion rate (%)
The proportion of ICU in total inpatients (%)	1.83	89.32	1.80	91.23	1.86	92.14	2.22	91.06	2.06	90.11
The proportion of ICU in total inpatient bed occupancy (%)	1.44	86.77	0.87	89.42	1.18	88.76	3.13	89.21	1.60	88.67
The proportion of APACHE II score ≥15 in all ICU inpatients (%)	51.08	76.84	50.59	79.25	51.43	80.25	46.33	83.22	47.37	84.25
3-h SSC bundles compliance (%)	74.37	66.32	77.20	72.35	78.83	79.55	79.94	80.23	80.65	81.66
6-h SSC bundles compliance (%)	76.60	66.32	66.93	68.25	68.17	70.11	68.3	69.27	71.09	71.46
Microbiology detection rate before antibiotics (%)	62.93	75.64	69.75	78.69	72.73	80.15	82.56	82.11	78.14	81.24
The proportion of DVT prophylaxis (%)	58.24	78.95	58.64	80.15	60.49	81.56	54.92	82.31	59.66	80.98
The proportion of unplanned endotracheal extubations (%)	1.49	77.74	2.07	80.21	2.23	83.21	2.29	82.57	1.81	81.55
The proportion of reintubation within 48 h (%)	1.99	76.69	2.31	79.24	2.67	81.26	2.58	82.35	2.44	80.66
Unplanned transfer to ICU (%)	6.38	72.93	8.26	73.56	6.75	71.59	8.97	74.68	8.64	73.26
ICU re-admission rate within 48 h (%)	1.20	90.08	1.46	95.68	1.39	94.59	1.59	94.68	1.22	96.58
VAP (per 1000 ventilator days) (‰)	12.77	87.22	14.42	89.54	14.54	90.22	10.50	91.47	9.58	93.45
CRBSI (per 1000 catheter days) (‰)	3.06	86.32	2.93	90.24	3.66	92.58	2.19	93.74	2.07	94.55
CAUTI (per 1000 catheter days) (‰)	3.65	86.32	3.97	87.56	4.41	88.21	2.97	89.25	2.70	90.11
In-hospital mortality (%)	10.19	81.95	8.70	88.67	8.68	91.22	8.09	92.87	8.30	93.45

CAUTIs: Catheter-associated urinary tract infections; CRBSI: Catheter-related bloodstream infection; DVT: Deep vein thrombosis; ICU: Intensive care unit; SSC: Surviving sepsis campaign; VAP: Ventilator-associated pneumonia.

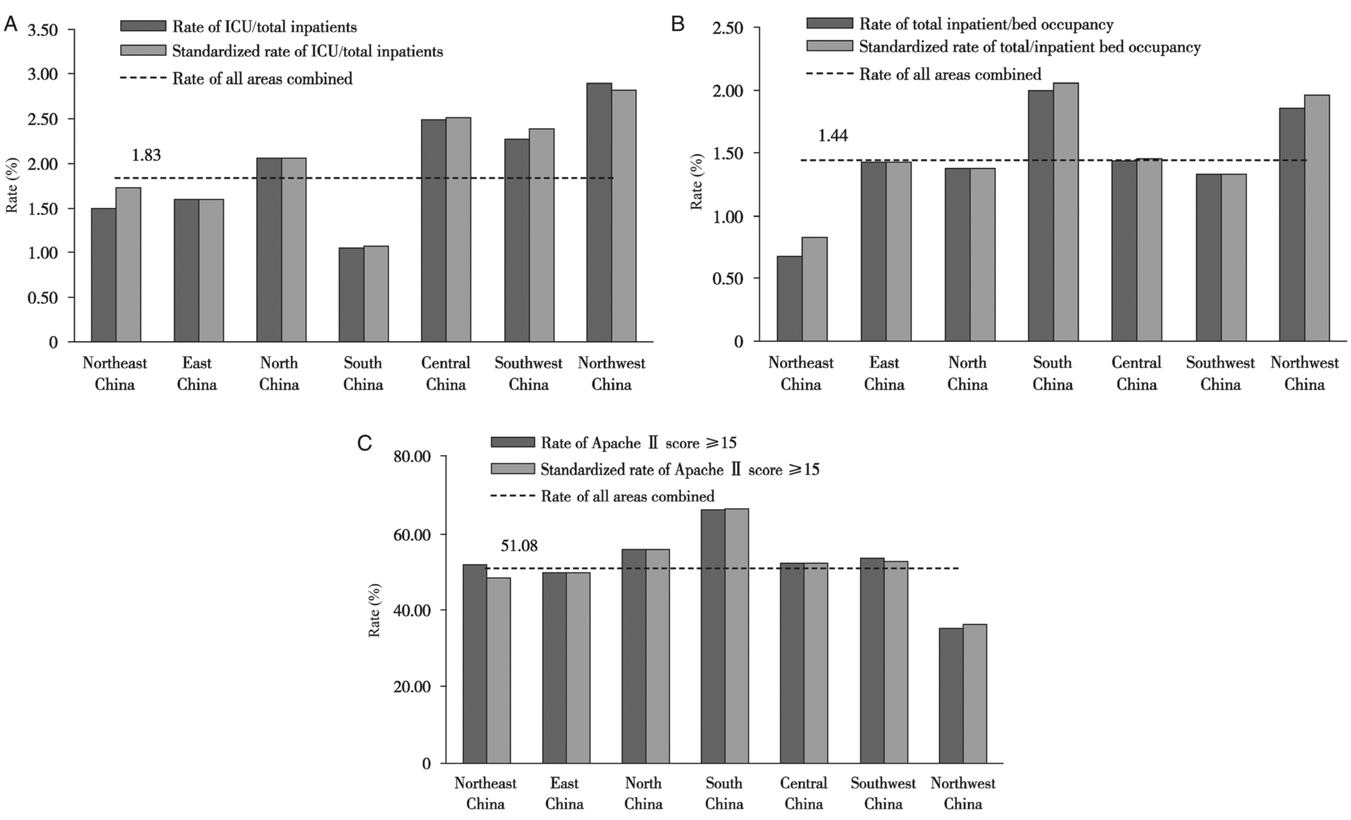

Figure 1: Basic information regarding ICU admission. (A) The proportion of total inpatients in the ICU, (B) the proportion of total Inpatient beds accounted for by the ICU, and(C) represents the proportion of ICU patients with APACHE II scores ≥15. APACHE II: Acute Physiology and Chronic Health Evaluation II; ICU: Intensive care unit.

Throughout the 2015–2019 data, the proportion of ICU patients relative to the total number of inpatients was 1.8% to 2.22%, the proportion of ICU bed occupancy relative to the total inpatient bed occupancy was 0.87% to 3.13%, and the proportion of patients with APACHE II scores ≥15 relative to all ICU patients was 46.33% to 51.43%.

Procedural indicators and geographic differences

The indicators for the diagnosis and treatment of septic shock from the 2015 survey are shown in Figure 2. The incidence rates of septic shock in Southwest, South, North, and Northeast China were above the average rate of

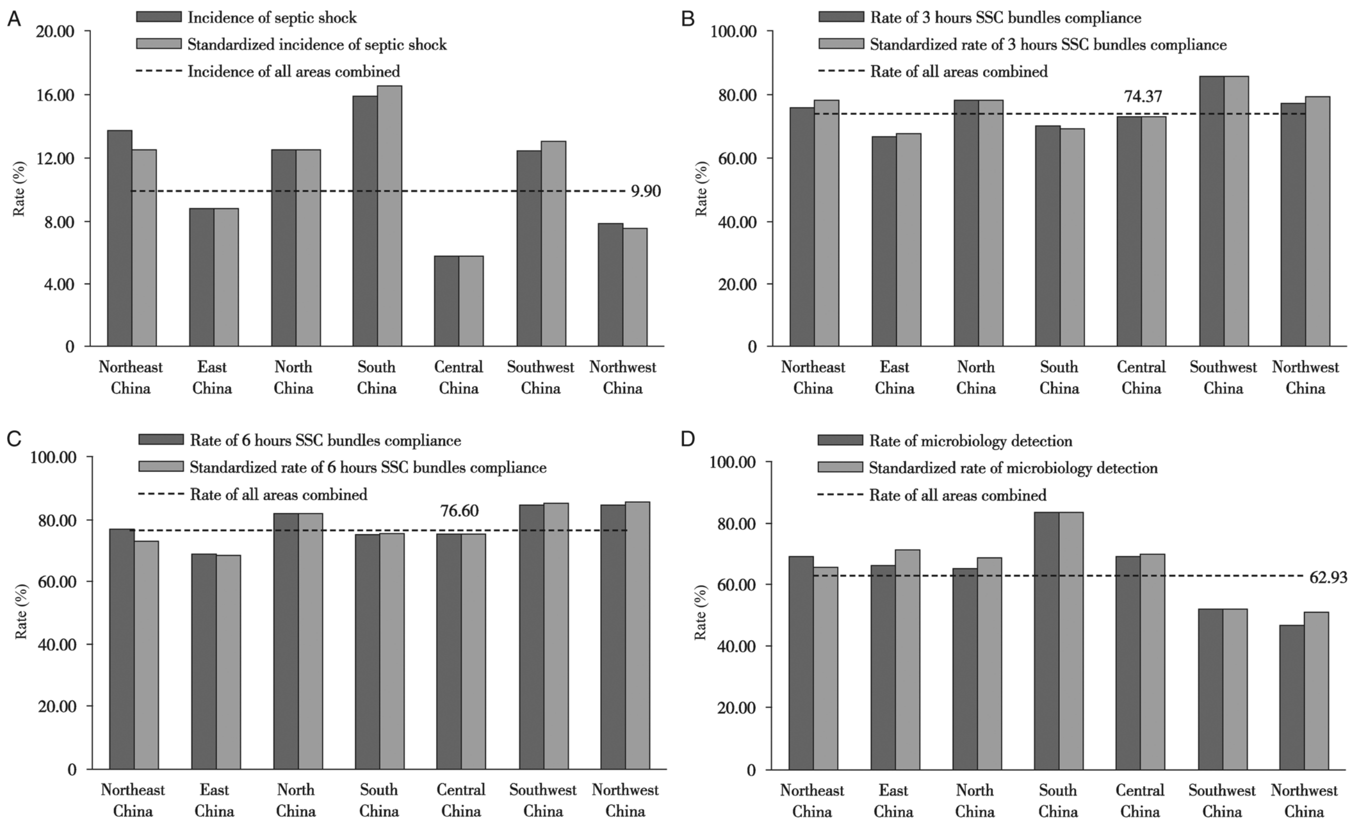

Figure 2: Parameters for septic shock and sepsis bundle compliance. (A) The Incidence of septic shock; (B and C) the 3-hour and 6-hour bundle compliance rates, and (D) demonstrates the rate of microbiological specimen submission before antibiotic administration.

9.90%. The rates of 3-hour and 6-hour bundle compliance were approximately equal to the average rates (74.37% and 76.60%), regardless of the province or regional economic development level. The rate of microbiology detection before antibiotic administration was highest in South China, suggesting good ICU performance in the region. Some provinces in South (Hainan, Fujian, Guangxi, Yunnan), Central (Hunan), and East (Zhejiang) China as well as Qinghai Province had rates > 84.16%. In contrast, the rate of microbiology detection was lower in Southwest and Northwest China, but the rates of 3-hour and 6-hour SSC bundle compliance were similar across regions. On the map of China, the standardized rate of microbiology detection and 3-hour and 6-hour SSC bundle compliance were highest in Hainan (95.40%), Shaanxi (92.60%), and Guizhou (93.33%), respectively [Figure 2]. From this 5-year survey, the national incidence of septic shock was 8.26% to 9.90%. The completion rate of the 3-hour bundle for septic shock treatment increased from 74.37% to 80.65%. However, the completion of the 6-hour bundle dropped from 76.60% to 71.09%.

The unplanned endotracheal extubation rates in 2015 in ICUs ranged from 0.66% to 4.33% (standardized rate 0.84%–4.37%) across provinces, with an average of 1.49%. This indicator in South China surpassed the average level [Figure 3A]. The 5-year data fluctuated between 1.49% and 2.29%. The proportion of reintubations within 48 hours of 2015 across provinces ranged from 0.76% to 5.08% (standardized rate 0.76%–5.11%). The proportions in Northeast (standardized rate 2.53%) and Central China (standardized rate 2.67%) were significantly higher than the average level (1.99%), whereas they were lowest in the West, including in Southwest and Northwest China. In addition, the unplanned extubation rate was lowest in Southwest China [Figure 3A and 3B]. The 5-year data fluctuated between 1.99% and 2.67%.

There was a large gap in the proportion of unplanned transfers to the ICU (6.38%–8.97%) and the ICU readmission rate within 48 hours after discharge (1.20%–1.59%) across provinces/regions from the 5-year data. The 2015 data were used to show that the standardized proportion reached a high of 17.46% in Qinghai and a low of 2.01% in Heilongjiang [Figure 3C]. The ICU readmission rate within 48 hours after discharge varied from 0.59% to 3.09% across provinces (standardized rate 0.59%–3.16%). The national average was 1.20% in 2015. Northeast China had a considerably higher rate than other regions, whereas the rate was lowest in North China [Figure 3D].

The national average proportion of ICU patients who received DVT prophylaxis was 58.24% in 2015. The proportion was over 80% in Chongqing and Shandong Provinces (standardized rates were 88.75% and 80.50%, respectively). However, Shanghai and Hainan Provinces had lower rates, with < 30% of ICU patients receiving

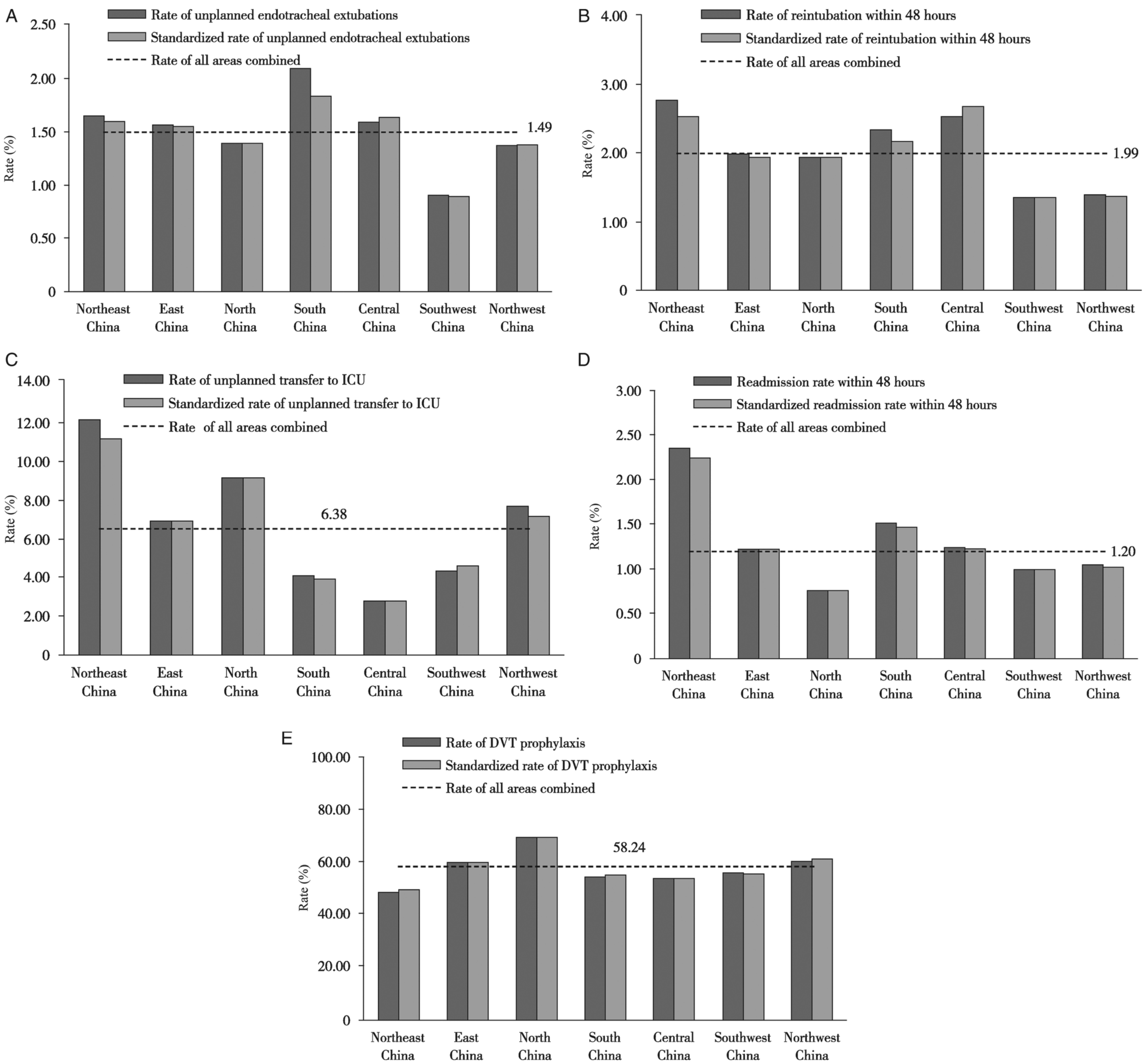

Figure 3: The parameters for the (A) proportion of unplanned endotracheal extubations, (B) proportion of reintubations, (C) proportion of ICU patients with unplanned transfers, (D) ICU readmission rate within 48 hours of ICU discharge, and (E) the proportion of ICU patients given DVT prophylaxis. DVT: Deep vein thrombosis; ICU: Intensive care unit.

DVT prophylaxis [Figure 3E]. The 5-year overall prevention rate was 54.92% to 60.49%.

Outcome indicators and geographic differences

With respect to nosocomial infection in 2015, Qinghai Province had the highest incidence rate of VAP (26.38 cases/1000 days for mechanical ventilation), and the rate ranged between 10 and 20 cases/1000 days for mechanical ventilation in most provinces. The national average incidence rate was 12.77 cases/1000 days for mechanical ventilation [Figure 4A]. During these 5 years, the incidence rate of VAP rose from 12.77 cases/1000 days for mechanical ventilation to a high of 14.54 cases/1000 days for mechanical ventilation in 2017 and then dropped to 9.58 cases/1000 days for mechanical ventilation in 2019. Hubei, Guangdong, and Yunnan Provinces had the highest CRBSI incidence. The comparing rates among the seven regions, the highest rate was 19.55 cases/1000 days for CVC placement in Northwest China. In general, Central China had a strikingly high incidence of CRBSI, which was much higher than the national average of 3.06 cases/1000 days for CVC placement [Figure 4B]. The CRBSI incidence showed the same trend for the past 5 years, from 3.06 cases/1000 days for CVC placement in 2015 to 3.66 cases/ 1000 days for CVC placement in 2017 and 2.07 cases/ 1000 days for CVC placement in 2019. The incidence of CAUTI was considerably higher in Yunnan and Gansu. The national average urinary catheter placement was 3.65 cases/1000 days [Figure 4C]. The incidence of CAUTI also dropped from a high of 4.1 cases/ 1000 days for urinary catheter placement in 2017 to

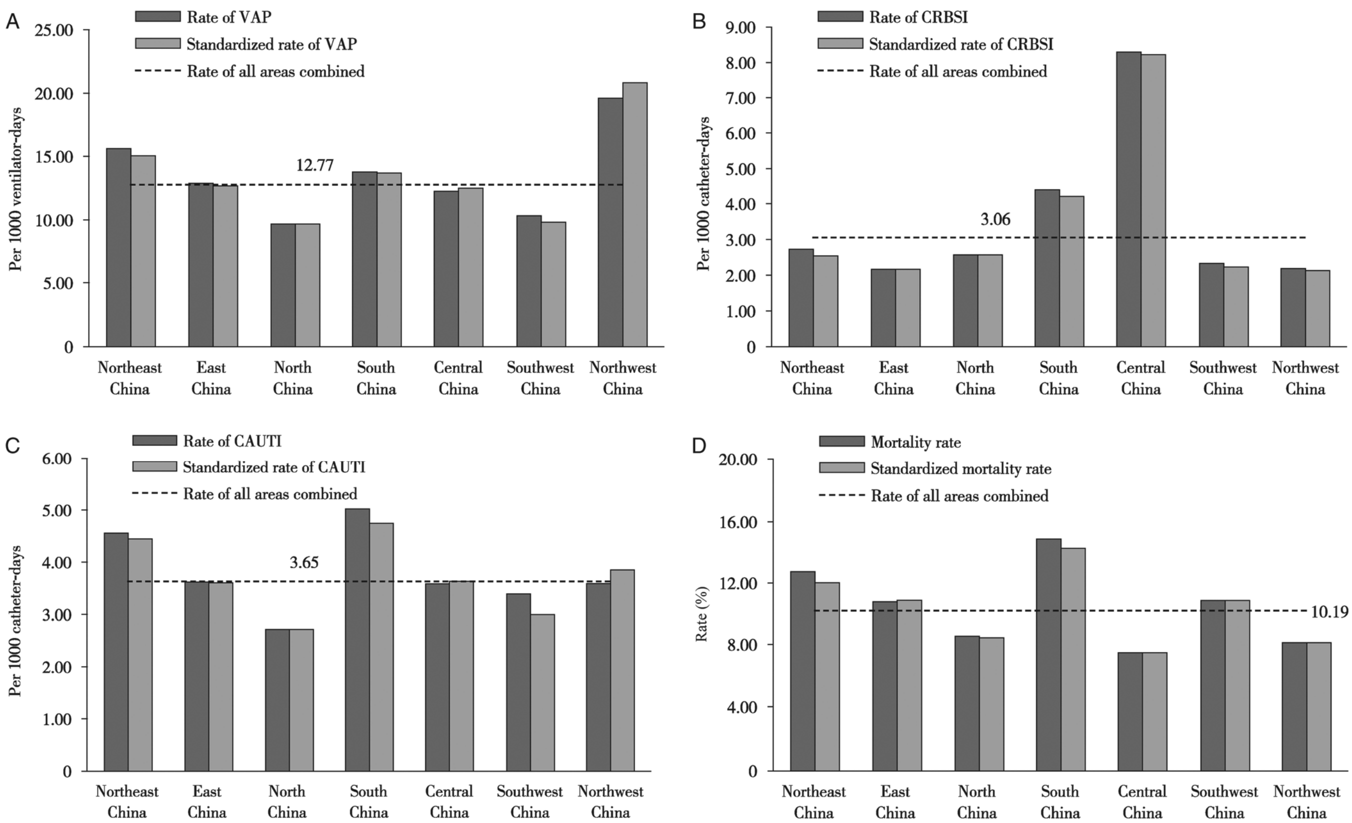

Figure 4: The ICU nosocomial infections (VAP [A], CRBSIs [B], and CAUTIs [C]) and ICU mortality rates [D] in different regions. CAUTIs: Catheter-associated urinary tract infections; CRBSIs: Catheter-related bloodstream infections; ICU: Intensive care unit; VAP: Ventilator-associated pneumonia.

2.7 cases/1000 days for urinary catheter placement in 2019.

ICU mortality rates across the provinces and regions in 2015 are displayed in Figure 4D. The rates varied substantially across the country, with the highest rate being 18.39% in Ningxia Province and the lowest rate being 5.37% in Gansu. The national average rate of ICU mortality was 10.19%. In the past 5 years, the national ICU case fatality rate has declined and stabilized at approximately 8%.

Quality indicators related to outcomes

In further analyses of the quality indicators related to ICU mortality and ICU nosocomial infection, we thoroughly analyzed the 2015 data and observed that in certain regions (South, East, North, Northeast, and Central), the proportion of ICU patients with APACHE II scores ≥15, 3 hour SSC bundle compliance, microbiology detection before antibiotic administration, unplanned endotracheal extubations, unplanned transfers to the ICU, VAP, and CRBSIs were significantly associated with poor outcomes. In particular, unplanned transfer to the ICU and higher APACHE II scores were associated with increased odds of ICU mortality (odds ratio [OR] = 3.863 and OR = 4.539, respectively). Location (North and Central China) and the 3-hour SSC bundle compliance rate were associated with reduced mortality in the ICU (OR = 0.567, OR = 0.598, and OR = 0.618, respectively) [Table 2]. The factors related to ICU nosocomial infection were as follows [Table 3]. Tertiary hospitals were consistently associated with decreased odds of VAP and CAUTI but increased odds of CRBSI (OR = 0.869, 0.827, 1.154). The proportion of ICU patients relative to the total inpatient bed occupancy was associated with a higher incidence of VAP and CAUTI (OR = 31.236, OR = 23.670). The ICU readmission rate within 48 hours (OR = 143.662) was associated with a higher incidence of CRBSI.

Discussion

To the best of our knowledge, this was a longitudinal study to quantitatively evaluate the current medical quality of adult ICUs in China over the past 5 years. This study also included the largest number of hospitals to date in the world and showed the panoramic view of ICU quality control in China. The data revealed great heterogeneity in the medical quality of ICUs in China atthe level ofthe ICU. This study also revealed some gaps between Chinese ICUs and the ICUs of developed countries. The survey results remind us that unplanned transfer to the ICU and higher APACHE II scores were related to higher mortality rates in the ICU. Treatment in certain regions and 3-hour SSC bundle compliance were associated with lower mortality and may benefit critically ill patients. Therefore, we have been improving quality control in the medical process since the first survey in 2015. The mortality rate of ICU patients in China is declining, and the incidence of nosocomial infections is improving. These efforts have laid the

Table 2: Multivariable analysis for factors related to ICU mortality based on the 2015 survey.

Variables	P value	OR	95% CI
Region (ref. = Southwest)			
Northwest	0.3020	1.033	(0.971, 1.098)
South	<0.0001	1.621	(1.521, 1.727)
East	<0.0001	1.141	(1.083, 1.203)
North	<0.0001	0.567	(0.531, 0.606)
Northeast	<0.0001	1.315	(1.236, 1.400)
Central	<0.0001	0.598	(0.564, 0.635)
Proportion of patients with APACHE II scores ≥15 within all ICU patients	<0.0001	4.539	(4.303, 4.788)
3-h SSC bundle compliance	<0.0001	0.618	(0.581, 0.657)
Microbiology detection rate before antibiotics	<0.0001	1.380	(1.300, 1.466)
Unplanned endotracheal extubation (ref. = <0.012)†	<0.0001	1.072	(1.043, 1.102)
Unplanned transfer to ICU	<0.0001	3.863	(3.416, 4.369)
VAP (ref. = 0 ≤ VAP < 0.011)*	<0.0001	1.128	(1.097, 1.159)
CRBSI (ref. = 0 ≤ CRBSI < 0.0016)*	0.0001	1.057	(1.028, 1.088)

* To meet the assumption of logistic regression and examine the effect with clinical significance, we dichotomized the rate of unplanned endotracheal extubation, VAP incidence, and CRBSI incidence in the ICU into binary variables according to their medians. APACHE II: Acute Physiology and Chronic Health Evaluation II; CI: Confidence interval; CRBSI: Catheter-related bloodstream infection; DVT: Deep vein thrombosis; ICU: Intensive care unit; OR: Odds ratio; SSC: Surviving sepsis campaign; VAP: Ventilator-associated pneumonia.

foundation for us to manage the COVID-19 pandemic, which is why we want to widely report these developments and experiences of Chinese ICUs over the past 5 years.

The development of CCM in China began in the 1980s when the first ICU with a single bed was opened in 1982 at Peking Union Medical College Hospital, which then opened the first department of CCM in 1984 with a seven-bed ICU. CCM was acknowledged as a medical specialty in China in 2008. Until now, there has been no survey of the quality of ICUs in China. Du *et al*[16] provided a general clinical review of CCM in China in 2010, noting that the limited data suggested that critical care resources, especially ICU beds, were insufficient compared with those in developed countries. After 10 years of rapid development in critical care, China's ICUs have been the subject of much clinical and teaching research. Amid the COVID-19 pandemic, Chinese ICU doctors have demonstrated rapid response capabilities, standardized ICU treatment procedures, and professional qualities. The results of this study showed the data of the Chinese ICU quality control system before COVID-19. Although there is no standard for ICU quality control indicators in the world,[4–6,17] we find that the overall ICU mortality rate in China is similar to that of developed countries (13.5 ± 9.9 *vs.* 14.3 ± 6.8 from Table 2). Some indicators, such as readmissions within 48 hours, are lower in ICUs in China than in ICUs in North America (3.3 ± 1.4% *vs.* 2.3 ± 6.5%). However, the extubation failure rate/reintubation within 48 hours, the incidence of central-line bloodstream infection (CLBSI)/ 1000 line days (‰), and especially the incidence of VAP/1000 ventilator days (‰) were higher. These findings expose ICU management issues and work priorities.

Unnecessary iatrogenic damage should be avoided during ICU treatment. This requires a consensus on relevant issues and strengthened training and medical practices. Of course, we also learned that the lack of ICU bed resources and the lack of configuration of doctors and nurses remain serious based on the data of the proportion of ICU patients relative to the total number of inpatients and the proportion of ICU bed occupancy relative to the total inpatient bed occupancy. Hospital and ICU provisions vary greatly across the country. Indeed, we see achievements in China's ICU development, but there is still a long way to go. Therefore, the National Health Commission of R.R.C and the Chinese Society of CCM have been working hard to narrow the gap between China and developed countries in the past 5 years.

Mortality rates vary across different regions. A possible explanation may be that Central and North China have many universities and large hospitals, which have good resources and infrastructure and talented people. In contrast, West China is less developed, and some areas still maintain traditional ideas and customs. The imbalance in regional resource allocation may be a core issue affecting the quality of China's medical care. However, it is interesting that Gross Domestic Product did not have any statistical correlation with ICU mortality or nosocomial infection (VAP, CRBSI, and CAUTI) [Supplementary Figure 1, http://links.lww.com/CM9/A885]. For the other indicators, interestingly, two indicators (rates of ICU admissions and bed occupancy and the proportion of patients with APACHE II scores ≥15) in Northwest and South China have the opposite relationship. South China could allocate ICU resources to treat more severe patients. As expected, there was a clear divergence in Northwest China. There is undeniably much room for improvement in the rational use of ICU resources. In the past 5 years, we have accelerated the homogenization of the national intensive care professional level through the organization of learning training, grassroots activities in lower and higher hospitals, and the deployment of medical supplies and equipment. Now, in a county or a town in China, ICU wards and doctors are basically deployed.

For some specific indicators, our quality improvements over the past 5 years are as follows. The completion rate of

Table 3: Multivariable analyses for factors related to nosocomial infection based on the 2015 survey.

Variables	*P* value	OR	95% CI
Factors related to VAP			
Region (ref. = Southwest)			
Northwest	<0.0001	1.525	(1.370, 1.697)
South	0.1925	1.078	(0.963, 1.207)
East	<0.0001	1.597	(1.469, 1.737)
North	<0.0001	1.260	(1.136, 1.396)
Northeast	<0.0001	1.822	(1.631, 2.035)
Central	<0.0001	1.525	(1.385, 1.680)
Hospital grade (ref = secondary)	<0.0001	0.869	(0.819, 0.922)
Proportion of ICU bed occupancy within total inpatient bed occupancy	<0.0001	31.236	(20.433, 47.75)
Microbiology detection rate before antibiotics	<0.0001	0.659	(0.604, 0.719)
Proportion of reintubation within 48 h	0.0025	0.452	(0.270, 0.756)
Unplanned transfer to ICU	<0.0001	0.219	(0.176, 0.274)
ICU re-admission rate within 48 h	<0.0001	4.601	(3.072, 6.891)
Factors related to CRBSI			
Region (ref. = Southwest)			
Northwest	0.1525	0.856	(0.692, 1.059)
South	<0.0001	0.619	(0.508, 0.753)
East	−0.1964	0.822	(0.713, 0.947)
North	0.3475	1.083	(0.917, 1.280)
Northeast	0.0092	0.760	(0.618, 0.934)
Central	<0.0001	4.728	(4.103, 5.448)
Hospital grade (ref = secondary)	0.0171	1.154	(1.026, 1.298)
Proportion of ICU inpatients within total inpatients	<0.0001	0.001	(0.001, 0.001)
Proportion of ICU bed occupancy within total inpatient bed occupancy	0.0046	0.132	(0.032, 0.534)
Proportion of patients with APACHE II scores ≥15 within all ICU patients	<0.0001	2.136	(1.809, 2.523)
Microbiology detection rate before antibiotics	<0.0001	2.176	(1.779, 2.662)
Unplanned transfer to ICU	<0.0001	2.794	(2.126, 3.671)
ICU re-admission rate within 48 h	<0.0001	143.662	(85.926, 240.193)
Factors related to CAUTI			
Region (ref. = Southwest)			
Northwest	<0.0001	0.595	(0.517, 0.684)
South	<0.0001	0.686	(0.593, 0.794)
East	<0.0001	1.210	(1.104, 1.325)
North	<0.0001	0.699	(0.618, 0.791)
Northeast	0.5530	0.957	(0.827, 1.107)
Central	0.0241	0.886	(0.797, 0.984)
Hospital grade (ref = secondary)	<0.0001	0.827	(0.771, 0.886)
Proportion of ICU bed occupancy within total inpatient bed occupancy	<0.0001	23.670	(14.748, 37.989)
Proportion of patients with APACHE II scores ≥15 within all ICU patients	<0.0001	2.524	(2.249, 2.833)
Microbiology detection rate before antibiotics	<0.0001	0.233	(0.212, 0.256)
Unplanned transfer to ICU	<0.0001	0.303	(0.228, 0.402)

APACHE II: Acute Physiology and Chronic Health Evaluation II; CAUTI: Catheter-associated urinary tract infection; CI: Confidence interval; ICU: Intensive care unit; OR: Odds ratio; VAP: Ventilator-associated pneumonia.

sepsis bundles was similar across the country, but the rate of microbiological specimen submission before antibiotic administration varied greatly. This suggests that in the area of standardized anti-infection treatment, it is necessary to further strengthen supervision to promote improvement so that the application of antibiotics is more scientific and accurate. The rate of microbiological specimen submission before antibiotic administration rose from 62.93% in 2015 to 82.56% in 2018. The unplanned endotracheal extubation rates and the proportion of reintubations within 48 hours were higher in South, Northeast, and East China. This suggested that further training on basic clinical indications for extubation/intubation and airway management should be provided to ICUs in areas with particularly poor care quality. We have strengthened training related to these issues. Additionally, unplanned transfer to the ICU and the ICU readmission rate within 48 hours of ICU discharge were highest in Northeast China. Improvements had been made in these hospitals on how to rationally allocate hospital resources, ensure safe medical operations, and develop ICU transfers. Regarding DVT prophylaxis, the rate was low overall, with a rate of <60%, which caused China-NCCQC to be highly attended to and valued. Currently, national action is being taken for DVT prevention in critically ill patients. Considering the high incidence of VAP in the Northwest, the high incidence of CRBSI in the Central region, and the high incidence of

CAUTI in the South, China-NCCQC has already fed back these results to regional quality control centers and, together with these regional centers, analyzed the reasons, developed improvement plans, and carried out special quality improvement actions. From the overall data of the past 5 years, these indicators have all been improved.

In this survey, unplanned transfer to the ICU was related to ICU mortality and was often due to the lack of early identification of critically ill patients. We say that for a patient, there is no sudden change in the condition, rather the change in the condition is suddenly discovered by the doctor. Early recognition of critical illness with prompt admission to an ICU would result in an improvement in outcomes.[18–20] However, the appropriate diagnosis was always delayed, which was multifactorial, such as a lack of beds, unrecognized critical illness, or impending deterioration in clinical practice. Using the Project IMPACT database, >50,000 patients in 120 heterogeneous ICUs and hospital centers were evaluated. Being held in the emergency department for 6 hours or longer before transfer to the ICU increased in-hospital mortality rates by 4.5%.[21] Therefore, the early identification of critically ill patients and their timely transfer to the ICU are very important for improving patient prognosis. In this survey, the proportion of ICU patients with APACHE II scores ≥15 was associated with increased in-hospital mortality. A large number of clinical studies have confirmed that higher scores correspond to more severe disease and a higher risk of death. A higher score indicated an increased risk of patient mortality, which justified the use of the score as a risk factor. Our results also reflected this issue very well. Among the identified factors that were related to mortality, the 3-hour SSC bundle compliance rate reflected a very important aspect of care for critically ill patients. In the ICU, the 3-hour SSC bundle includes measuring lactate levels, obtaining blood cultures before the administration of antibiotics, administering broad-spectrum antibiotics, and administering 30 mL/kg crystalloids or 4 mmol/L lactate for hypotension. The 3-hour SSC bundle has been recommended for clinical use in the SSC guidelines since 2008.[22,23] The 3-hour and 6-hour SSC bundles clearly outline the clinical path for the resuscitation of patients with sepsis, and they have been widely accepted and promoted over the past 10 years. In a global prospective observational quality improvement study of SSC bundle compliance for patients with either severe sepsis or septic shock, a 40% reduction in the odds of dying in the hospital was observed when the ICU was in compliance with the 3hour bundle.[24] Another study revealed that 3-hour SSC bundle compliance was associated with improved survival and cost savings.[25] All the evidence highlights the importance of medical quality control for critical care. For critically ill patients, timely implementation oftargeted treatment can improve their prognosis. A low target implementation rate or a compromised quality of medical care will directly affect the outcomes of the treatment. All the above details have been the focus of our work in recent years.

In addition, we compared the relevant parameters between Chinese ICUs and North American ICUs. A retrospective review of the literature on quality control in CCM was performed by Chrusch and Martin[6] in Canada in 2015. Five performance metrics were compared between the previous research and our data for 2015 [Table 4]. We were unable to find data in the EU context.[17] There were significant differences in extubation failure and the incidence of VAP and CLBSI, but the ICU mortality rates were similar.

There were several limitations in this study. First, this was a longitudinal study that was led by the National Health Commission of China and carried out on a provincial basis. As the standards of data collection and hardware configurations in each province and hospital were inconsistent, this survey collected data on each quality indicator at the ICU level and did not obtain individual patient information. Data on basic demographics of patients, ICU features, and hospital characteristics both nationally and within the provinces were unavailable. After this national survey, the National Health Commission of China established a medical quality control committee dedicated to the development, collection, analysis, and application of national data. At present, a nationally unified database is being formed, and a data visualization platform is imminent, which includes survey data from 2015 to 2018. Big data and artificial intelligence are also being pursued. Second, it was difficult to achieve uniformity in quality control indicators in different countries. Compared with Canada, we are not as good at controlling and managing nosocomial infections in the ICU (VAP and CRBSIs). Relevant data from other countries are needed to compare the current status of

Table 4: Summary of performance metrics for care quality in ICU.

Quality indicators in studies	Chrusch and Martin[6] 2016*	Data from survey 2015
Numbers of units/hospitals	18	665
Readmissions within 48 h (%)	3.3 ± 1.4	2.3 ± 6.5
ICU mortality (%)	14.3 ± 6.8	13.5 ± 9.9
Extubation failure rate/reintubation within 48 h (%)	2.7 ± 1.5	4.0 ± 8.9
Incidence VAP/1000 ventilator days (‰)	4.2 ± 2.0	21.6 ± 48.3
Incidence CLBSI/1000 line days (‰)	1.1 ± 0.9	4.4 ± 17.1

Data are presented as *n*, mean ± standard deviation. * Comparison with previous literature was limited to Chrush's study because values of quality indicators were provided in this study. In some other papers on quality indicators for ICU care, relevant data were unavailable, for example, Flaatten.[17] CLBSI: Central-line blood-stream infection; ICU: Intensive care unit; SD: Standard deviation; VAP: Ventilator-associated pneumonia.

China's ICUs. However, relevant data were lacking. In the future, it may be necessary to form uniform standards for ICU specifications. Indicators for the global versatility of ICU quality control have yet to be established. In addition, there could be potential bias in reporting due to missing data for some quality indicators. This may weaken the representativeness of participating hospitals and the generalizability of the findings. We will improve data collection and its completeness in ongoing surveys of ICU quality nationwide in the future. Last but not least, we reiterate that this study was performed based on the unit of analysis, which may well be mortality at the level of the ICU rather than the patient. We included these associations, a correlation between unit-level characteristics (eg, VAP rates), and unit-level mortality in Supplementary Table 3, http://links.lww.com/CM9/A885, which may make it clearer that this is an association.

Conclusions

The quality of medical care in China's ICUs was heterogeneous, particularly in terms of geographic differences and grades of hospitals. The identification of critically ill patients and the implementation of appropriate and timely treatment interventions are of great importance to enhance the overall level of critical care in China. Since 2015, we have been committed to improving the quality management of ICUs based on these surveys. Some good results have been obtained. The critical care quality control system played a major role in addressing the COVID-19 pandemic. However, we should pay attention to the gaps in technology, talent, and resources in different regions of China. There is still considerable room for improvement in China'sICU construction. In the future, the China-NCCQC will focus on improving the quality of critical care programs throughout the entire country. Using these data, the medical quality levels of ICUs in China will be improved.

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Conflicts of interest

None.

References

1. Rivers E, Nguyen B, Havstad S, Ressler J, Muzzin A, Knoblich B, *et al*. Early goal-directed therapy in the treatment of severe sepsis and septic shock. N Engl J Med 2001;345:1368–1377. doi: 10.1056/NEJ-Moa010307.
2. Kohn LT, Corrigan JM, Donaldson MS. To err is human; building a safer health system. Washington, DC: 2000.
3. Rothschild JM, Landrigan CP, Cronin JW, Kaushal R, Lockley SW, Burdick E, *et al*. The critical care safety study: the incidence and nature of adverse events and serious medical errors in intensive care. Crit Care Med 2005;33:1694–1700. doi: 10.1097/01.CCM.0000171609.91035.BD.
4. Rhodes A, Moreno RP, Azoulay E, Capuzzo M, Chiche JD, Eddleston J, *et al*. Prospectively defined indicators to improve the safety and quality of care for critically ill patients: a report from the task force on safety and quality of the european society of intensive care medicine (ESICM). Intensive Care Med 2012;38:598–605. doi:10.1007/s00134-011-2462-3.
5. Ray B, Samaddar DP, Todi SK, Ramakrishnan N, John G, Ramasubban S. Quality indicators for ICU: ISCCM guidelines for ICUs in India. Indian J Crit Care Med 2009;13:173–206. doi: 10.5005/ijccm-13-4-173.
6. Chrusch CA, Martin CM. The Quality Improvement In Critical Care Project. Quality improvement in critical care: selection and development of quality indicators. Can Respir J 2016;2016: 2516765. doi: 10.1155/2016/2516765.
7. CSCCMGuidelines for the construction and management of intensive care unit (ICU) in China (2006) (in Chinese). Chin Crit Care Med 2006;18:387–388.
8. American Thoracic SocietyInfectious diseases society of America. guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med 2005;171:388–416. doi: 10.1164/rccm.200405-644ST.
9. (CSCCM) CSoCCMGuidelines for the diagnosis, prevention and treatment of ventilator-associated pneumonia (2013). Chin J Intern Med 2013;52:524–543.
10. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, *et al*. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. Clin Infect Dis 2009;49:1–45. doi:10.1086/599376.
11. Medicine (CSCCM) CSoCCGuidelines for the prevention and treatment of intravascular catheter-related infections (2007). Chin J Intern Med 2008;28:413–421.
12. Hooton TM, Bradley SF, Cardenas DD, Colgan R, Geerlings SE, Rice JC, *et al*. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America. Clin Infect Dis 2010;50:625–663. doi: 10.1086/650482.
13. Li X, Huang J, Zhang H. An analysis of hospital preparedness capacity for public health emergency in four regions ofChina: Beijing, Shandong, Guangxi, and Hainan. BMC Public Health 2008;8:319. doi: 10.1186/1471-2458-8-319.
14. Piechota M, Cywiński J, Piechota A, Kusza K, Siemionow M, Moreno R. Is the unadjusted ICU mortality a good indicator of quality of ICU care? Intensive Care Med 2018;44:127–128. doi: 10.1007/s00134-017-4903-0.
15. Standardization: a classic epidemiological method for the comparison of, rates. Epidemiol Bull 2002;23:9–12.
16. Du B, Xi X, Chen D, Peng J, China Critical Care Clinical Trial G. Clinical review: critical care medicine in mainland China. Crit Care 2010;14:206. doi: 10.1186/cc8222.
17. Flaatten H. The present use of quality indicators in the intensive care unit. Acta Anaesthesiol Scand 2012;56:1078–1083. doi: 10.1111/j.1399-6576.2012.02656.x.
18. Escarce JJ, Kelley MA. Admission source to the medical intensive care unit predicts hospital death independent of APACHE II score. JAMA 1990;264:2389–2394. doi: 10.1001/jama.1990.03450180053028.
19. Parkhe M, Myles PS, Leach DS, Maclean AV. Outcome ofemergency department patients with delayed admission to an intensive care unit. Emerg Med (Fremantle) 2002;14:50–57. doi: 10.1046/j.1442-2026.2002.00286.x.
20. Renaud B, Santin A, Coma E, Camus N, Van Pelt D, Hayon J, *et al*. Association between timing of intensive care unit admission and outcomes for emergency department patients with community-acquired pneumonia. Crit Care Med 2009;37:2867–2874. doi: 10.1097/CCM.0b013e3181b02dbb.
21. Chalfin DB, Trzeciak S, Likourezos A, Baumann BM, Dellinger RP. DELAY-ED study group. Impact of delayed transfer of critically ill patients from the emergency department to the intensive care unit.

Crit Care Med 2007;35:1477–1483. doi: 10.1097/01.CCM.0000266585.74905.5A.
22. Dellinger RP, Levy MM, Rhodes A, Annane D, Gerlach H, Opal SM, *et al*. Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock: 2012. Crit Care Med 2013;41:580–637. doi: 10.1097/CCM.0b013e31827e83af.
23. Dellinger RP, Levy MM, Carlet JM, Bion J, Parker MM, Jaeschke R, *et al*. Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock: 2008. Crit Care Med 2008;36:296–327. doi: 10.1097/01.CCM.0000298158.12101.41.
24. Rhodes A, Phillips G, Beale R, Cecconi M, Chiche JD, De Backer D, *et al*. The surviving sepsis campaign bundles and outcome: results from the International Multicentre Prevalence Study on Sepsis (the IMPreSS study). Intensive Care Med 2015;41:1620–1628. doi: 10.1007/s00134-015-3906-y.
25. Leisman DE, Doerfler ME, Ward MF, Masick KD, Wie BJ, Gribben JL, *et al*. Survival benefit and cost savings from compliance with a simplified 3-hour sepsis bundle in a series of prospective, multisite, observational cohorts. Crit Care Med 2017;45:395–406. doi: 10.1097/CCM.0000000000002184.

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