Nursing staff capacity plays a crucial role in compliance to empiric antibiotic treatment within the first hour in patients with septic shock

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To the Editor: Sepsis and septic shock are a leading cause of intensive care unit (ICU) admissions and induce significant morbidity and mortality.[1,2] Early propitiate antibiotics administration is significantly associated with improved survival in sepsis and septic shock[3,4] which is recommended by the international guidelines.[5] However, the compliance to sepsis protocols remains very low.[6] Nurses, who play a vital role in carrying out physician orders, are likely associated with the compliance to empiric antibiotic administration. Phua *et al*[7] showed that nurses occupy an essential and conscious position as brokers of doctors' antibiotic decisions. In addition, other studies also demonstrated that nurse-led protocols were an effective, safe, and sustainable method for achieving early antibiotic administration in patients with suspected febrile neutropenia.[8] Therefore, we performed a retrospective cohort study to confirm the effect of nursing staff capacity on the compliance of nurses to empiric antibiotic treatment in patients with septic shock.

This was a retrospective cohort study which was approved by Independent Ethics Committee for Clinical Research of Zhongda Hospital, affiliated to Southeast University with protocol number 2017ZDSYLL005-p01. All adult patients aged 18 years or older who were admitted to the ICU due to septic shock between January 1, 2015, and February 29, 2016, were included in this study. All the included patients were diagnosed by the consultation of our ICU physicians and then transfer to ICU. The exclusion criteria included pregnancy; patients diagnosed with septic shock by clinicians of other departments and already received antimicrobials before ICU admission. Because we want to find the compliance of antimicrobial treatment of ICU nurse, and the consultation time cannot be found, we define the time when participants admitted in the ICU as the time of sepsis diagnosis and look at if the patients received antimicrobials with 1 hour after ICU admission.

Capacity of nursing staff was defined based on educational background and work experience. Nursing staff was classified into 4 levels (N0-N3, where means from lower to superior grade): N0 were nurses who had a college degree or above, nurse qualification certificate, and work experience of <1 year; N1 was defined as those who had a nurse qualification certificate and had worked for 1 to 3 years; N2 was defined as those who had a nurse practitioner qualification and had worked for >3 years; and N3 was defined as those with nurse-in-charge qualifications or professional critical care nurse qualifications at the provincial level for >1 year. Nursing shifts were formulated by our hospital to arrange nursing work in the ICU. Day shift begins at 08:00 and ends at 16:00; afternoon shift begins at 16:00 and ends at 22:30; night shift begins at 22:30 and ends at 08:00 the next day. Shifting of duty occurs from 07:00 to 09:00, 15:00 to 17:00, and 21:30 to 23:30.

The time of initial empiric antibiotic treatment of all patients was recorded. Details of the capacity for nursing staff and nursing shift were also collected. We also collected demographic characteristics and clinical variables. We reviewed other medical information that was possibly associated with compliance. We classified all patients by the different capacities of nursing staff or nursing shift and calculated the compliance to empiric antibiotic treatment within 1 hour in these different groups.

We also designed a questionnaire to evaluate nurses' subjective assessment of the importance of empiric antibiotic treatment within an hour after the diagnosis of septic shock. It was a scale ranging from 1 to 10 in which a higher score meant more importance of empiric antibiotic treatment within an hour for patients with septic shock.

A total of 1458 patients were admitted to the ICU from January 1, 2015, to February 29, 2016, among which 255 patients were diagnosed as septic shock. Totally, 214

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Table 1: Multivariate analysis of the risk factors of antibiotic use within 1 hour after sepsis diagnosis

Items	Odds ratio	SE	*P* value	95% CI
Age	1.000	0.010	0.964	0.981–1.021
Gender	1.037	0.334	0.911	0.551–1.949
SOFA	1.025	0.041	0.548	0.947–1.109
Nurse level				
N0	Reference			
N1	1.367	0.596	0.474	0.581–3.213
≥N2	5.453	3.698	0.012	1.443–20.605
Different shifts				
Day shift	Reference			
Afternoon shift	0.989	0.396	0.978	0.451–2.169
Night shift	2.288	1.121	0.091	0.876–5.978
Shifting of duty	0.668	0.275	0.328	0.298–1.498
Type of antibiotics				
Carbapenems	Reference			
Enzyme inhibitor compound	0.352	0.114	0.001	0.186–0.665
Cephalosporin	0.683	0.702	0.711	0.091–5.124
Others	0.152	0.112	0.011	0.036–0.646

SOFA: Sequential organ failure assessment; SE: Standard error; CI: Confidence interval.

patients with septic shock were included in the analyses [Supplementary Figure 1, http://links.lww.com/CM9/A9]; 110 (51.4%) received empiric antibiotic treatment within 1 hour. There was no significant difference in baseline characteristics and outcome between patients with timely and delayed empiric antibiotic treatment [Supplementary Table 1, http://links.lww.com/CM9/A9].

We analyzed the capacity of nursing staff and nursing shift in administering timely empiric antibiotic treatment, the results of which are shown in Supplementary Figures 1 and 2, http://links.lww.com/CM9/A9. The compliance to empiric antibiotic treatment administered during the shifting of duty was significantly lower compared with night shift (42.4% *vs.* 63.9%, $P=0.042$) [Supplementary Figure 2, http://links.lww.com/CM9/A9]. Further, differences in capacity of nursing staff represent differences in compliance. The compliance of three groups was 44.8%, 48.7%, and 78.3% in N0, N1 and N2, and N3 level, respectively. Compared with N0 and N1, the compliance to antibiotic treatment in N2 and N3 was significantly higher (N2 and N3 *vs.* N0, $P=0.015$; N2 and N3 *vs.* N1, $P=0.008$) [Supplementary Figure 3, http://links.lww.com/CM9/A9]. However, after multivariate analysis, only N2 was associated with increased compliance of antibiotic management [Table 1].

The type of antibiotic significantly affected the compliance. The proportion of carbapenems was significant higher as well as enzyme inhibitor compound was lower in empiric antibiotic treatment within an hour group compared to the delayed empiric antibiotic treatment group [Supplementary Table 1, http://links.lww.com/CM9/A9]. Multivariate analysis showed that cabapenems were significantly associated with increased compliance of antibiotic management [Table 1].

In total, 113 nurses of our ICU finished the questionnaire. Differences in capacity of nursing staff meant different scores in the scale. The scores of N0, N1, N2 and superior staff were 6.91, 8.90, and 9.79, respectively. Nurses from higher nursing staff were more inclined to approve the importance of empiric antibiotic treatment within 1 hour (N0 *vs.* N1, $P=0.002$; N1 *vs.* N2 and N3, $P<0.001$; N0 *vs.* N2 and N3, $P<0.001$) [Supplementary Figure 4, http://links.lww.com/CM9/A9].

In the present study, we found that the compliance to empiric antibiotic treatment within 1 hour in patients with septic shock (51.4%) was not satisfactory in our ICU. Capacity of nursing staff was associated with the low compliance.

Numerous studies showed that early antibiotic administration is vital in patients with sepsis or septic shock. As nurses play a crucial role in the management of sepsis patients, research increasingly focuses on nurses' contribution to patients' safety and quality of medical care in the ICU.[9] Mattison and his colleagues reported that low-grade professional level means lower medical quality to a great extent[9] which was confirmed by our study.

We found that compliance to empiric antibiotic treatment was lowest during the shifting of duty. Nurses needed to communicate patients' major medical issues and treatment plans and handle many other affairs during this period. However, after adjust other confounders, we did not find work shift was associated with the compliance of antibiotic management.

Better training of nursing staff may help improve medical quality.[10] The questionnaire results showed that nurse with low level are lack the knowledge of the importance of empiric antibiotic treatment within an hour after septic shock diagnosis. All of our results indicated that strengthening professional training, especially for low-grade nurses during shifting of duty, may be a good solution to improve compliance to empiric antibiotic

treatment. In addition, reasonable arrangement of nurses may also be a solution to this problem.

A single-center retrospective study, small sample size and other confounding factors not included in final analysis were limitations of this study. In addition, the situation that was either busy or not in the hospital was not considered in this study, that might also induce study bias. To confirm the effect of nursing staff on the compliance of antibiotic treatment within 1 hour after septic shock diagnosis, a further, larger, prospective, clinical trial needs to be performed.

In conclusion, the compliance to empiric antibiotic treatment within 1 hour in patients with septic shock was low in our ICU. Capacity of nursing staff was associated with the low compliance.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

None.

Author contributions

Yang Y is the corresponding author and responsible for the concept, data analysis and interpretation, revision and approval of this manuscript. Li XQ participated in the design of the study, data analysis and interpretation, coordination, and drafting of the manuscript. Xie JF participated in the design of the study, data analysis and interpretation, and coordination and drafting of the manuscript. Zhu YP was responsible for the data collection, data analysis, and interpretation. Zhou J was responsible for the data collection, data analysis, and interpretation. Qian SY was responsible for the data collection, data analysis, and interpretation. Sun Q performed the statistical analysis and helped to revise the manuscript. Pan C performed the statistical analysis and helped to revise the manuscript. Qiu HB participated in the design of the study, data analysis and interpretation, and manuscript revision. All authors read and approved the final manuscript.

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