Original Article

The mortality of patients with sepsis increases in the first month of a new academic year

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Objective Many studies have examined the July effect. However, little is known about the July effect in sepsis. We hypothesized that the July effect would result in worse outcomes for patients with sepsis.

Methods Data from patients with sepsis, collected prospectively between January 2018 and December 2021, were analyzed. In Korea, the new academic year starts on March 1, so the "July effect" appears in March. The primary outcome was 30-day mortality. Secondary outcomes included adherence to the Surviving Sepsis Campaign bundle. Outcomes in March were compared to other months. A multivariate Cox proportional hazard regression was performed to adjust for confounders.

Results We included 843 patients. There were no significant differences in sepsis severity. The 30-day mortality in March was higher (49.0% vs. 28.5%, P<0.001). However, there was no difference in bundle adherence in March (42.2% vs. 48.0%, P=0.264). The multivariate Cox proportional hazard regression showed that the July effect was associated with 30-day mortality in patients with sepsis (adjusted hazard ratio, 1.925; 95% confidence interval, 1.405–2.638; P<0.001).

Conclusion The July effect was associated with 30-day mortality in patients with sepsis. However, bundle adherence did not differ. These results suggest that the increase in mortality during the turnover period might be related to unmeasured in-hospital management. Intensive supervision and education of residents caring for patients with sepsis is needed in the beginning of training.

Keywords Sepsis; Medical education; Patient safety; Precision medicine

Capsule Summary

What is already known
Many studies have examined the July effect. However, little is known about the July effect in sepsis.

What is new in the current study
The July effect is associated with 30-day mortality in patients with sepsis. However, bundle adherence did not differ. These results suggest that the increase in mortality during the turnover period might be related to unmeasured in-hospital management.

INTRODUCTION

Sepsis is a dysregulated host response to infection that leads to life-threatening organ dysfunction [1]. Sepsis and septic shock have high mortality rates of approximately 10% and 30%, respectively [2–4]. It is known that initial treatment is important in patients with sepsis, and the Surviving Sepsis Campaign (SSC) guidelines specifically recommend antibiotic administration and fluid resuscitation for the initial 1 or 3 hours [5]. Improper administration of fluids and delayed administration of antibiotics increase mortality rates [6]. Therefore, it is important to recognize sepsis early and treat it appropriately based on the sepsis bundle [5]. It can be assumed that the prognosis of patients with sepsis will deteriorate if a doctor who lacks experience in the turnover period between academic years does not recognize sepsis quickly and proper treatment is delayed.

In teaching hospitals, there is an inevitable transition period during which new residents, fellows, and staff join the front line. During this transitional period, relatively inexperienced doctors enter hospitals. The safety issue for patients associated with the beginning of a new academic year for residents in training is usually called the July effect in the United States. Various studies have been conducted on the prognosis of patients who visit teaching hospitals during this period [7]. One study reported an increase in mortality rates among patients of internal medicine admitted to a general ward or intensive care unit (ICU) via the emergency department (ED) on the first Wednesday after the beginning of a new academic year [8]. Another study showed that the July effect could be associated with in-hospital cardiac arrest requiring resuscitation attempts [9]. However, another study found no increase in mortality rates among patients admitted to the ICU during the beginning of a new academic year [10].

The July effect on emergency physician practice behavior has also been studied. One study reported that less experienced physicians had a longer average time from patient intake to initial evaluation and a longer average time to disposition [11]. However, another study reported consistently longer ED lengths of stay at teaching hospitals than at non-teaching hospitals but did not find a July effect [12].

Sepsis is a critical condition that requires early recognition and aggressive management [13]. However, the association between the academic turnover period and the mortality rate of sepsis has rarely been studied. Given that in-hospital mortality from medical disease was higher and initial evaluations were delayed in July, we hypothesized that the mortality rate of patients with sepsis would be higher in the first month of a new academic year than in other periods. Additionally, we investigated differences in sepsis bundle adherence throughout the study period.

METHODS

Ethics statement

The study was approved by the Institutional Review Board of Korea University Ansan Hospital, with a waiver of informed consent (No. 2022AS0280). The requirement for informed consent was waived because the study involved no more than minimal risk due to its retrospective nature. The study was performed in accordance with the Declaration of Helsinki.

Study design and setting

This retrospective observational study used data from a prospectively collected sepsis registry. This research was conducted at the ED of Korea University Ansan Hospital (Ansan, Korea), which is a tertiary teaching hospital with approximately 50,000 ED visits per year.

In Korea, postgraduate medical education consists of a 1-year internship followed by 3 or 4 years of residency. Fellowships for 1 or 2 years are optional. New trainees and staff members begin their duties on March 1st. Therefore March, not July, is the period during which the so-called "July effect" occurs in Korea. Because both describing it as the July effect (even though it happens in March) and calling it the March effect could cause confusion in interpretation, we describe it as academic turnover or the turnover effect. In our ED, initial assessment and resuscitation are performed by residents under the guidance and supervision of at least one board-certified emergency medicine staff member, as per the SSC guidelines. However, consultations with intensivists or board-certified infectious disease experts are generally performed after admission to the ICU or general ward.

Selection of participants

We used data from adult patients aged ≥ 18 years who were entered in the sepsis registry between January 2018 and December 2021. Every patient who visited the hospital in February was excluded from the analysis because some of their hospitalization period might have overlapped with the turnover period in March. Patients with a do not attempt resuscitation (DNAR) order before ED presentation were excluded from the analysis as well.

Our institution uses the quick Sepsis-related Organ Failure Assessment (qSOFA) as a screening tool for operating the Intelligent Sepsis Management System [14]. The system automatically screens qSOFA-positive patients and informs physicians about

the possibility of sepsis. The physicians then confirm the presence of an infection and organ dysfunction. The Sepsis-3 criteria, defined as an increase in SOFA scores of 2 or more from baseline, are used to define organ dysfunction. If the baseline SOFA score is unknown, enrollment is based on a SOFA score of ≥2. Septic shock is also defined based on the Sepsis-3 definition as the need for inotropes and a lactate level of >2 mmol/L despite adequate fluid resuscitation.

Outcome measures

The primary outcome measure was 30-day mortality. The secondary outcomes were SSC bundle adherence and the lengths of the ED, hospital, and ICU stays. The 30-day mortality, SSC bundle adherence, and hospitalization days were compared between the turnover and non-turnover periods. Bundle adherence was assessed based on whether each component was completed within 3 hours of ED presentation. Antibiotics were assessed for a door-to-administration time within 3 hours. Fluid resuscitation was defined as 30 mL/kg administered within 3 hours of arrival if the systolic blood pressure was less than 100 mmHg or lactate was greater than 4 mmol/L. Lactate follow-up was considered adherent if an initial lactate level of ≥2 mmol/L was remeasured within the ED stay. Overall, bundle adherence was considered when each component was completed on time.

Statistical analysis

The normality of the variables was evaluated using the Shapiro-Wilk test. To compare clinical variables, continuous variables are presented as the median and interquartile range and were compared using the Mann-Whitney U-test when the variables did not follow normality. If the variables followed normality, we show the average and standard deviation and compared them using Student t-test. Categorical variables are presented as numbers and percentages and were compared using either the chi-squared or Fisher exact test, as appropriate.

Sepsis severity was compared using SOFA and Acute Physiology and Chronic Health Evaluation (APACHE) II scores and the initial lactate concentration. SOFA is a marker for sepsis diagnosis and severity that indicates the extent of organ failure. It is based on six organs from the respiratory, cardiovascular, liver, bone marrow, kidney, and central nervous systems [15]. APACHE II is a severity scoring system for critically ill patients that is applied within 24 hours of hospitalization [16]. It considers epidemiologic factors, medical history, vital signs, and laboratory results.

The association between the turnover period and bundle adherence was assessed using a logistic regression. Survival was

analyzed using Kaplan-Meier curves and log-rank tests for 30-day mortality in the turnover and non-turnover periods. To determine the effect of the turnover period on 30-day mortality, we used a Cox regression model. Univariate Cox regression modeling was used to identify individual variables that correlated with 30-day mortality. Variables that were statistically significant in the univariate analysis were selected for the multivariate Cox regression analysis used to calculate the adjusted hazard ratio (aHR) of the academic turnover effect after adjusting for confounders.

We calculated the aHR of the turnover effect by performing a multivariate Cox regression in each subgroup using the variables identified in the previous multivariate Cox regression model. Subgroups were divided based on the presence of septic shock, disposition (ICU or general ward), initial systolic blood pressure, initial lactate concentration, SOFA score, and whether mechanical ventilation was applied. Statistical analyses were performed using IBM SPSS ver. 25.0 (IBM Corp) and MedCalc ver. 19.8 (MedCalc Software).

RESULTS

Demographic results

Between 2018 and 2021, 981 patients were enrolled, of whom 87 were excluded because they visited the hospital in February. The 51 patients with sepsis who had documented DNAR orders prior to their ED visits were also excluded from the analysis. Therefore, 102 and 741 patients in the turnover and non-turnover periods, respectively, were included in the analysis (Fig. 1). The included
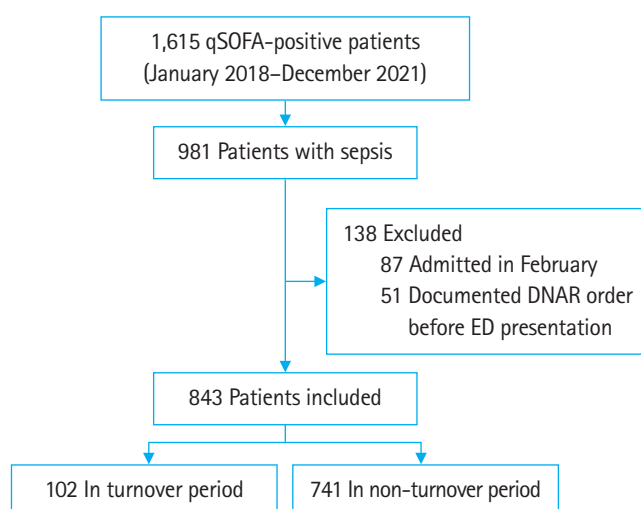

Fig. 1. Flowchart of the number of included and excluded patients. qSOFA, quick Sepsis-related Organ Failure Assessment; DNAR, do not attempt resuscitation; ED, emergency department.

patients had no statistically significant differences in sex, age, or comorbidities between the two periods. The rate of septic shock did not differ between the two periods, and the APACHE II and SOFA scores did not differ between the periods either. The outcomes show that 7-, 14-, and 30-day mortality were all significantly higher in the turnover period. However, SSC bundle adherence did not differ significantly (Table 1). The lengths of the ED, hospital, and ICU stays did not differ significantly either. The logistic regression analysis of SSC bundle adherence during the turnover period showed no statistical significance (odds ratio [OR], 0.788; 95% confidence interval [CI], 0.519–1.198; P = 0.265).

The mortality trend by month of patient visit is shown in Fig. 2A. The turnover period (March) had the highest mortality, which was similar for patients with and without septic shock. However, the monthly SSC bundle adherence rates showed a similar pattern in the turnover and non-turnover periods (Fig. 2B). The survival analysis using a Kaplan-Meier curve and log-rank test between the turnover and non-turnover periods is shown in Fig. 3. In patients with sepsis, a significant turnover effect was observed between the two periods, and it was more clearly observed in patients with septic shock.

Main results

The results of the univariate Cox hazard regression analysis for each variable associated with 30-day mortality are shown in Table 2. The turnover period was significantly associated with 30-day mortality (HR, 1.925; 95% CI, 1.405–2.638; P < 0.001). The multivariate Cox proportional hazard regression showed that the turnover period was associated with 30-day mortality in patients with sepsis after adjusting for all confounders (aHR, 1.990; 95% CI, 1.444–2.743; P < 0.001) (Table 3). The results of the subgroup analysis are shown in Fig. 4. When subgroups were analyzed according to shock status, both septic shock and sepsis showed an academic turnover effect in both the subgroup with an initial systolic blood pressure ≥ 100 mmHg and the subgroup with initial systolic blood pressure < 100 mmHg. However, when the subgroup analysis was performed by disposition, the academic turnover effect was significant in ICU patients but not in general ward patients. The academic turnover effect was significant in the subgroup with lactate concentrations ≥ 4 mmol/L but not in the subgroup with lactate concentrations < 4 mmol/L. The academic turnover effect was significant in the subgroup with a SOFA score of ≥ 8 but not in the subgroup with a SOFA score of < 8.

Table 1. Comparison of characteristics of patients with sepsis in the turnover and non-turnover periods between 2018 and 2021 (n=843)

Characteristic	Turnover period (n = 102)	Non-turnover period (n = 741)	P-value
Male sex	61 (59.8)	429 (57.9)	0.714
Age (yr)	77 (68–85)	77 (66–83)	0.286
Underlying disease			
Diabetes mellitus	39 (38.2)	298 (40.2)	0.702
Hypertension	49 (48.0)	395 (53.3)	0.318
Chronic liver disease	8 (7.8)	45 (6.1)	0.490
Chronic kidney disease	12 (11.8)	90 (12.1)	0.912
Chronic respiratory disease	16 (15.7)	131 (17.7)	0.619
Cardiovascular disease	14 (13.7)	142 (19.2)	0.185
Malignancy	24 (23.5)	162 (21.9)	0.703
Suspected infection source			
Genitourinary infection	36 (35.3)	280 (37.8)	0.626
Respiratory infection	63 (61.8)	485 (65.5)	0.464
Gastrointestinal infection	12 (11.8)	63 (8.5)	0.278
Other infection source	8 (7.8)	44 (5.9)	0.453
Multiple infection sources	25 (24.5)	185 (25.0)	0.920
Presence of shock	39 (38.2)	259 (35.0)	0.516
Severity			
APACHE II score	20 (15–24)	19 (15–23)	0.339
SOFA score	9 (6–11)	8 (6–11)	0.245
Initial serum lactate (mmol/L)	3.5 (1.9–7.3)	2.9 (1.9–5.5)	0.120
Adherence to SSC bundle			
Overall bundle adherence	43 (42.2)	356 (48.0)	0.264
Fluid administration in 3 hr	68 (66.7)	512 (69.1)	0.620
Antibiotics administration in 3 hr	73 (71.6)	576 (77.7)	0.166
Time to antibiotics (min)	129 (71–202)	115 (71–181)	0.140
Lactate measurement	101 (99.0)	741 (99.6)	0.429
Lactate follow-up	87 (85.3)	660 (89.1)	0.248
Time to vasopressor if indicated (min)	137 (45.8–293.5)	132 (67.5–240.0)	0.978
Primary outcome			
7-day Mortality	32 (31.4)	123/736 (16.7)	< 0.001
14-day Mortality	44 (43.1)	170/727 (23.4)	< 0.001
30-day Mortality	48/98 (49.0)	202/709 (28.5)	< 0.001
Secondary outcome			
Length of ED stay (min)	689 (488.5–1,330.3)	625 (413.0–1,171.0)	0.114
Length of hospital stay (day)	11 (4–28)	13 (7–23)	0.213
Length of ICU stay (day)	8 (4–14)	9 (4–17)	0.386

Values are presented as number (%) or median (interquartile range).
APACHE, Acute Physiology and Chronic Health Evaluation; SOFA, Sepsis-related Organ Failure Assessment; SSC, Surviving Sepsis Campaign; ED, emergency department; ICU, intensive care unit.
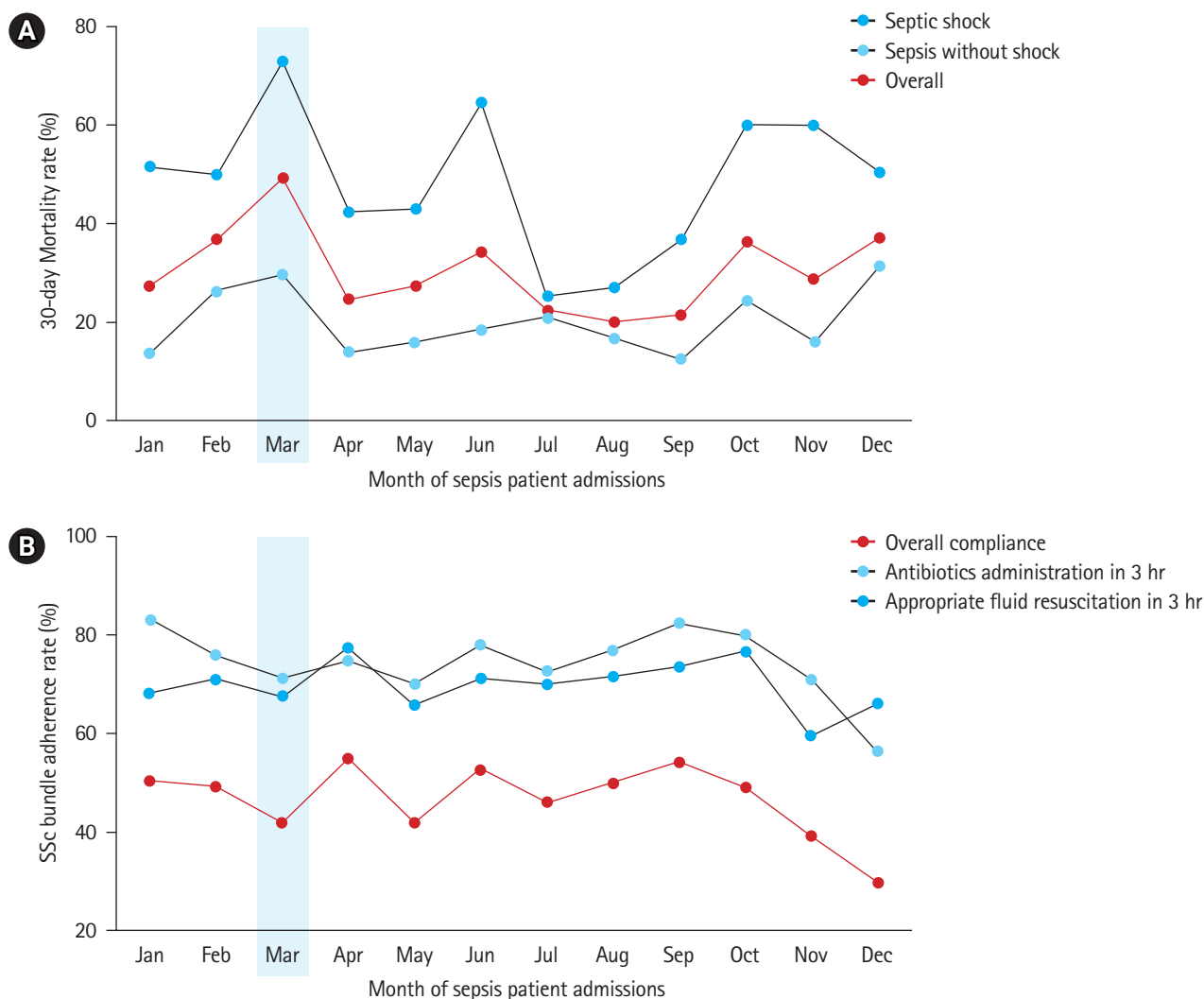
Fig. 2. Monthly trend for patients with sepsis who visited the hospital between 2018 and 2021. (A) The 30-day mortality rate. (B) The Surviving Sepsis Campaign (SSC) bundle adherence rate.

DISCUSSION

In this study, we found that the turnover period was an independent risk factor for 30-day mortality (HR, 1.925; 95% CI, 1.405–2.638; P < 0.001). Academic turnover can play a significant role in the in-hospital mortality of patients with sepsis. However, no significant differences were observed in SSC bundle adherence or the lengths of the ED, hospital, and ICU stays. From October to December, a downward trend appeared in the rates of antibiotic administration and overall compliance within 3 hours that was mainly attributed to the fourth wave of the COVID-19 pandemic in 2021 [17]. The mortality rate rose sharply and SSC bundle adherence dropped sharply from October to December 2021 (Fig. 5). Because of the additional quarantine process, triage was

time-consuming, and antiviral agents were often administered rather than antibiotics. Those were the main reasons for decreased bundle adherence in that period.

We found no academic turnover effect in patients with low-severity sepsis. However, we did find an academic turnover effect in patients with higher severity sepsis, although there was no decrease in SSC bundle adherence. There was an academic turnover effect for patients with sepsis of higher severity who required ICU admission, had a high initial serum lactate concentration, and had multiorgan failure. This suggests that new physicians might be less capable than more experienced physicians of treating patients with higher severity sepsis after bundle therapy. In addition, this study qualitatively assessed compliance with the bundle. Even if bundle compliance is good, it is possible that inappropri-
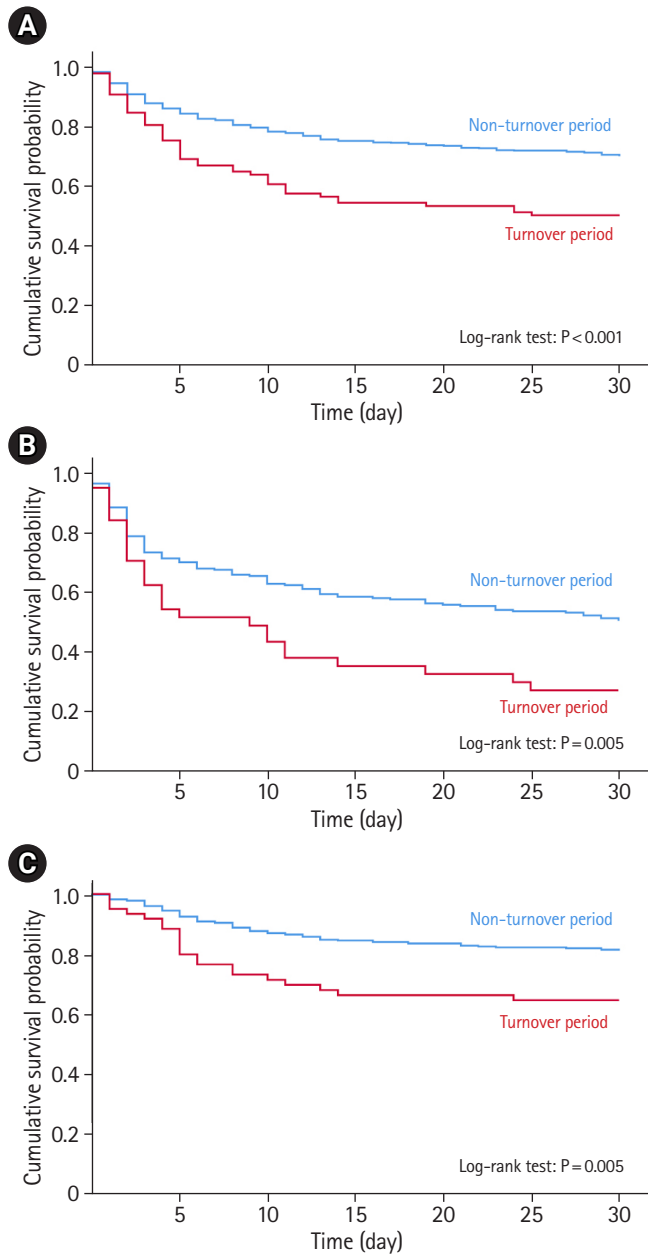
Fig. 3. Kaplan-Meier curve and log-rank test between the turnover and non-turnover periods. (A) Overall patients with sepsis. (B) Patients with septic shock. (C) Sepsis without shock.

Table 2. Univariable Cox proportional hazard regression analyses of 30-day mortality

Variable	HR (95% CI)	P-value
Sex		
Male	1 (Reference)	-
Female	1.123 (0.874–1.442)	0.365
Age (yr)	1.023 (1.012–1.034)	<0.001
Underlying disease		
Diabetes mellitus	1.196 (0.931–1.536)	0.161
Hypertension	1.000 (0.780–1.282)	0.999
Chronic liver disease	1.325 (0.839–2.092)	0.228
Chronic kidney disease	1.008 (0.692–1.469)	0.967
Chronic respiratory disease	1.242 (0.917–1.682)	0.162
Cardiovascular disease	0.884 (0.638–1.224)	0.457
Malignancy	1.970 (1.516–2.561)	<0.001
Suspected infection source		0.294
Genitourinary infection	1 (Reference)	-
Respiratory infection	1.451 (0.975–2.159)	0.066
Gastrointestinal infection	1.433 (0.750–2.738)	0.277
Other infection source	1.613 (0.947–2.749)	0.079
Multiple infection sources	1.571 (1.027–-2.403)	0.037
Presence of shock	3.219 (2.506–4.136)	<0.001
Severity		
APACHE II score	1.088 (1.068–1.109)	<0.001
SOFA score	1.171 (1.131–1.211)	<0.001
Initial serum lactate	1.170 (1.139–1.203)	<0.001
Admission in turnover period	1.925 (1.405–2.638)	<0.001
Adherence to SSC bundle		
Overall bundle adherence	0.775 (0.603–0.997)	0.047
Fluid administration in 3 hr	0.817 (0.630–1.061)	0.129
Antibiotics administration in 3 hr	0.878 (0.661–1.166)	0.369
Lactate follow-up	0.831 (0.568–1.218)	0.343

HR, hazard ratio; CI, confidence interval; APACHE, Acute Physiology and Chronic Health Evaluation; SOFA, Sepsis-related Organ Failure Assessment; SSC, Surviving Sepsis Campaign.

Table 3. Multivariate Cox proportional hazard regression analysis of 30-day mortality

Variable	aHR (95% CI)	P-value
Age (yr)	1.026 (1.014–1.037)	<0.001
Malignancy	1.758 (1.347–2.293)	<0.001
Presence of shock	1.594 (1.143–2.222)	0.006
SOFA score	1.088 (1.041–1.137)	<0.001
Initial serum lactate	1.113 (1.077–1.151)	<0.001
Overall bundle adherence	0.765 (0.592–0.988)	0.040
Admission in turnover period	1.990 (1.444–2.743)	<0.001

aHR, adjusted hazard ratio; CI, confidence interval; SOFA, Sepsis-related Organ Failure Assessment.

ate treatment was administered to patients. For example, if 30 mL/kg of fluid resuscitation is administered, the bundle is adhered to, but if the patient is still dehydrated and should have received more fluid, the treatment might still be associated with death despite bundle adherence. Therefore, more intense supervision is required during the turnover period.

Our research results contradict those of previous studies. The academic turnover effect (so-called "July effect") has been stud-ied in various fields to date. One systematic review reported that 113 studies on the academic turnover effect had been published as of 2019 [7]. Only 21 of them (18.6%) showed a statistically or partially significant academic turnover effect.

Few studies have examined the effects of academic turnover in sepsis or critical care. To the best of our knowledge, only one pre-
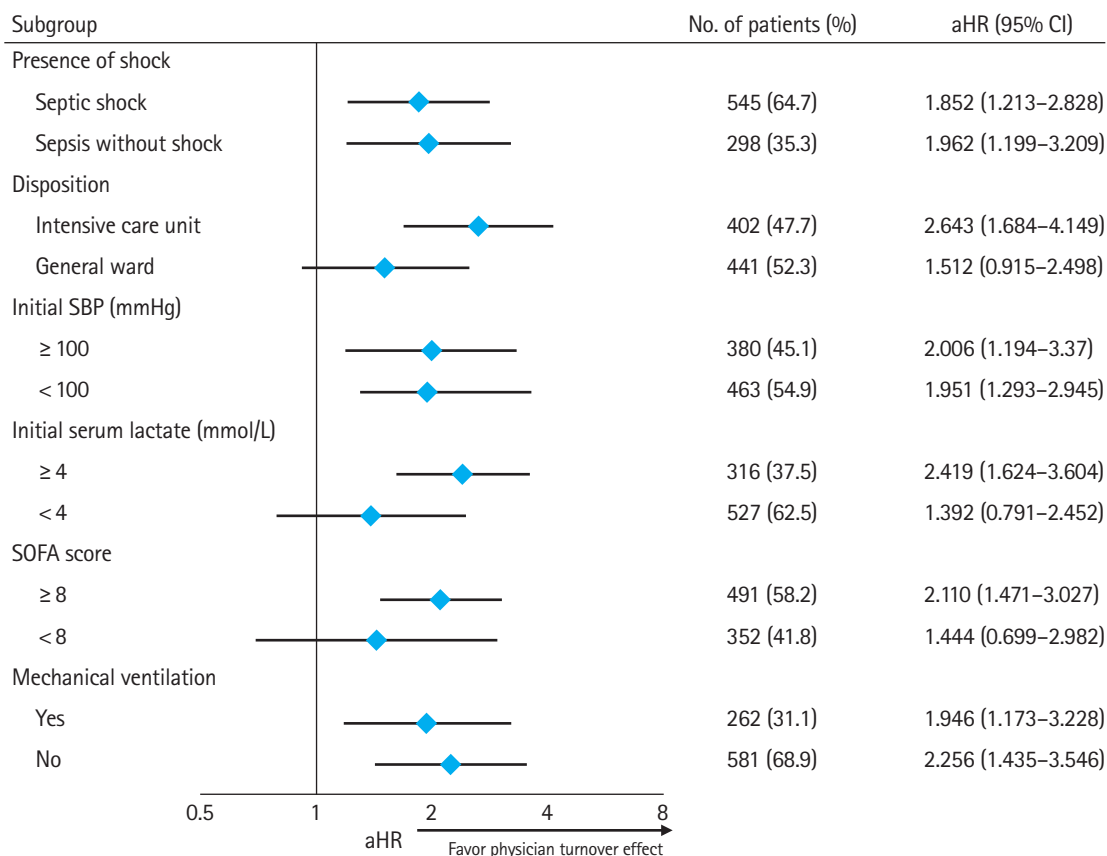
Subgroup	No. of patients (%)	aHR (95% CI)
Presence of shock		
Septic shock	545 (64.7)	1.852 (1.213–2.828)
Sepsis without shock	298 (35.3)	1.962 (1.199–3.209)
Disposition		
Intensive care unit	402 (47.7)	2.643 (1.684–4.149)
General ward	441 (52.3)	1.512 (0.915–2.498)
Initial SBP (mmHg)		
≥ 100	380 (45.1)	2.006 (1.194–3.37)
< 100	463 (54.9)	1.951 (1.293–2.945)
Initial serum lactate (mmol/L)		
≥ 4	316 (37.5)	2.419 (1.624–3.604)
< 4	527 (62.5)	1.392 (0.791–2.452)
SOFA score		
≥ 8	491 (58.2)	2.110 (1.471–3.027)
< 8	352 (41.8)	1.444 (0.699–2.982)
Mechanical ventilation		
Yes	262 (31.1)	1.946 (1.173–3.228)
No	581 (68.9)	2.256 (1.435–3.546)

aHR — Favor physician turnover effect (0.5, 1, 2, 4, 8)

Fig. 4. Subgroup analysis of adjusted hazard ratios (aHRs) for 30-day mortality in the turnover period. Adjusted confounders were age, malignancy, presence of shock, Sepsis-related Organ Failure Assessment (SOFA) score, initial serum lactate, and overall bundle adherence. CI, confidence interval; SBP, systolic blood pressure.

vious study has investigated the effects of academic turnover on sepsis. Saqib et al. [18] attributed a lack of a turnover effect in their study to adherence to a protocol-based practice and watchful supervision by senior staff. A limitation of that study is that it performed a subgroup analysis based on premorbidity but not based on sepsis severity.

Our institution also has supervision by at least one board-certified emergency medicine staff member in the ED, and the ICUs are staffed by intensivists with day and nighttime duties. The intensivists provide general intensive care to patients. The medical critical care unit is covered by two postgraduate year 2 (PGY-2) internal medicine residents during the day and one PGY-2 or higher resident at night. Residents of internal medicine spend their first year training on the general wards and begin their first ICU duty in March of their second year. They work 12-hour shifts and care for critically ill patients under the supervision of attending physicians. Bundle adherence did not differ significantly between the turnover and non-turnover periods. In addition, our institution uses an Intelligent Sepsis Management System to warn

emergency physicians about the possibility of sepsis, and it leads to early recognition and increased SSC bundle adherence, which results in improved survival [14]. As a result, we observed higher bundle adherence, even during the academic turnover period, than the overall SSC bundle adherence suggested by a recently published Korean multicenter cohort study [19]. Therefore, the fact that the turnover period was significantly associated with 30-day mortality independent of SSC bundle adherence highlights the need to investigate other potential causes of the increased mortality.

It is possible that the mortality rate increased because of inadequate detection of clinical deterioration during hospitalization. An observational study of the academic turnover effect on in-hospital cardiac arrest reported an increase in the incidence of in-hospital cardiac arrest during this period [9]. Those researchers suggested that inexperienced new trainees failed to recognize the signs preceding cardiac arrest. Patients with sepsis often exhibit rapid deterioration during hospitalization. Delayed recognition of deterioration in patients with sepsis in in-hospital settings
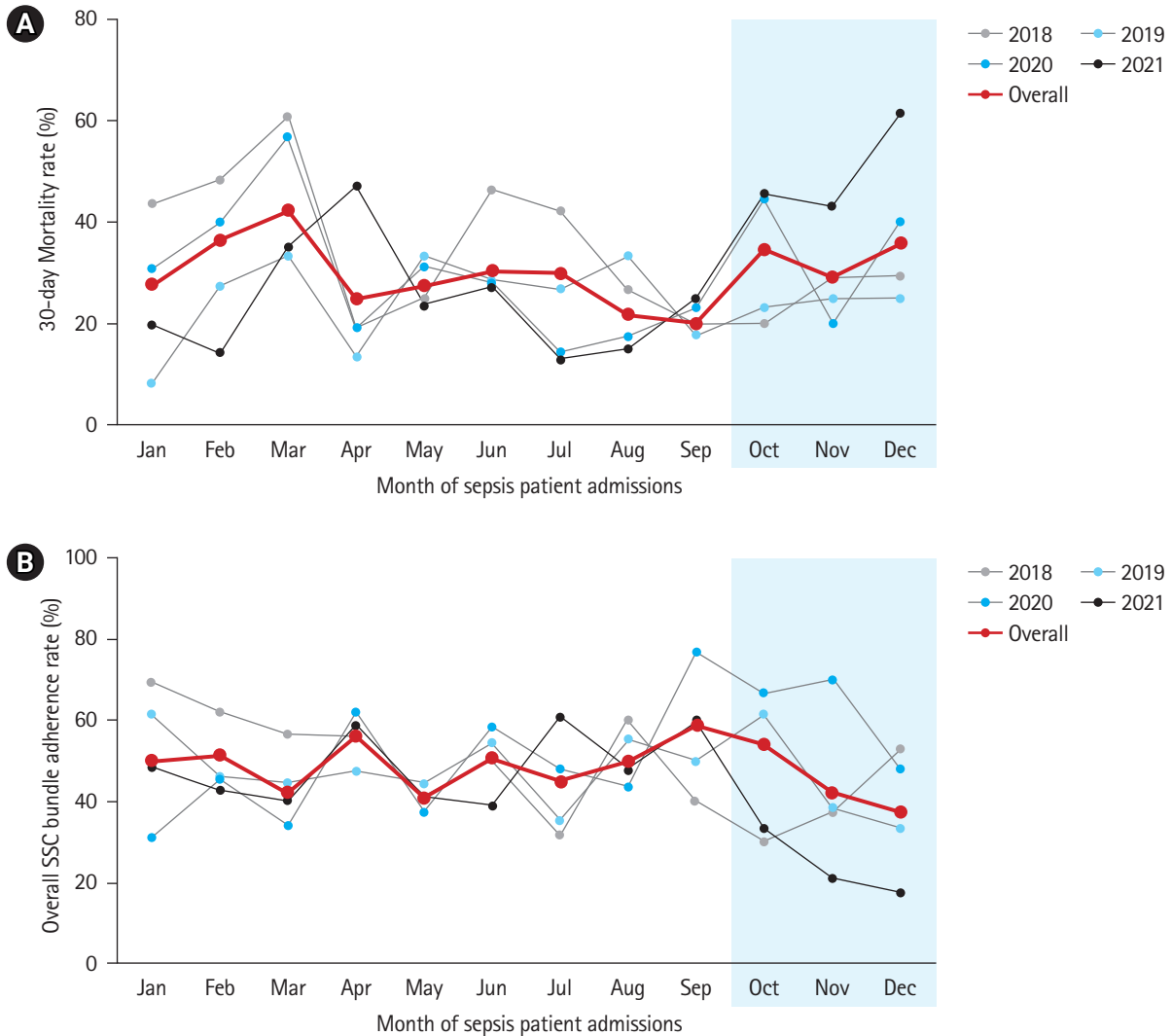
Fig. 5. Monthly trend for patients with sepsis who visited the hospital by year. (A) The 30-day mortality rate. (B) The Surviving Sepsis Campaign (SSC) bundle adherence rate.

could be a cause of high mortality.

Oh et al. [10] reported finding no academic turnover effect in the ICU of a tertiary hospital in Korea, independent of intensivist coverage. That report differs from our study, in which the turnover period was associated with higher mortality among patients admitted to the ICU. Oh et al. [10] did not perform any subgroup analysis by disease; therefore, time-dependent conditions, such as sepsis, might have been masked by other diseases. Their study also showed a trend toward increased mortality around the time of ICU extension. Those results provide indirect evidence that environmental changes are associated with in-hospital mortality.

Increased mortality without changes in adherence to the SSC bundle could be a result of usual care that is not covered by the bundle or unmeasured in-hospital management after initial re-

suscitation in the ED. Further research is required to investigate whether inadequate fluid balance persists after hospitalization, whether nosocomial infections occur, and whether proper nutrition is delivered. In addition, we should consider the possibility that less experienced doctors might not be able to provide individualized treatment that is not specifically covered by the guidelines.

There might be an academic turnover effect in certain phenotypes of sepsis or on the composition of the phenotype. Recently, efforts have been made to classify sepsis phenotypes and individualize treatments [20–22]. Seymour et al. [22] classified sepsis into four phenotypes and reconstructed previous sepsis-related randomized trials to show how the outcomes differed according to the phenotype composition. For example, they simulated the

ProCESS (Protocolized Care for Early Septic Shock) trial and showed that early goal-directed therapy improved survival in the alpha type but worsened survival in the delta type [22,23]. Ma et al. [20] further categorized septic shock into several phenotypes, and for one of them fluid administration increased in-hospital mortality.

The subgroup analysis in our study shows that the academic turnover effect was statistically significant among patients with high lactate concentrations (≥4 mmol/L) and high SOFA scores (≥8), which are specific features of the delta phenotype. In our study, SSC adherence was higher than that reported in other multicenter studies conducted in Korea [19], but the mortality rate was rather high. According to a recent study, precision medicine is needed to account for each patient's condition [13]. Less experienced doctors might not be able to adopt a personalized approach and instead rely solely on guidelines. For certain phenotypes, the SSC bundle might be associated with harmful outcomes, so further research is required.

This study had several limitations. First, because of its retrospective design, we could not completely control potential confounding factors, and we can show only an association, not causation. Vulnerability to selection bias might also have confounded the results. Second, because our study was conducted in a single tertiary teaching hospital, the generalizability of our results, including the composition of sepsis phenotypes, remains uncertain. Third, although the study design cannot completely rule out a seasonal effect, we did our best to rule it out by statistically demonstrating that the suspected infection source and severity (APACHE II, SOFA) did not differ between March and the rest of the year. Increased 30-day mortality was observed despite no differences in bundle adherence rates, and the reason for that is unknown because the influence of in-hospital interventions has not been investigated. Many variables related to posthospitalization care might have had a significant effect, and further research is needed. Another limitation was that we included only patients with positive qSOFA scores upon admission to the ED. When the Sepsis-3 definition was published, screening for sepsis with qSOFA was recommended, and that is what we used in this study; however, the SSC guidelines revised in 2021 do not recommend screening for sepsis with qSOFA alone. Our choice might thus have resulted in selection bias. Nevertheless, this is the first study to report an academic turnover effect in patients with sepsis. Larger multicenter studies are required for external validation.

In summary, academic turnover was associated with high 30-day mortality in patients with sepsis. However, SSC bundle adherence in the ED did not differ significantly between the turnover

and non-turnover periods. These results suggest that the increase in mortality during the turnover period might be related to unmeasured in-hospital management.

ARTICLE INFORMATION

Author contributions
Conceptualization: JHP; Data curation: SL, SK, HC, SM; Formal analysis: SL, SA, HC, SM; Funding acquisition: JHP; Investigation: SL, SK, YDC; Methodology: SL, SA, JHP, YDC; Supervision: HC, SM; Validation: JHP; Visualization: JHP; Writing–original draft: SL; Writing–review & editing: all authors. All authors read and approved the final manuscript.

Conflicts of interest
The authors have no conflicts of interest to declare.

Data availability
Data analyzed in this study are available from the corresponding author upon reasonable request.

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