$ 1,750, $p < 0.01$).

Conclusions: In the current study, the severity of sepsis did not correlate with ICU costs. Moreover, ICU staffing patterns were not associated with healthcare costs and daily costs for patients with sepsis in critical care units. Compared to lack of CCPs, allocation of a CCP might reduce these costs in patients with sepsis, irrespective of the level of intensivist care. Therefore, further research is necessary to determine the effect of CCPs on ICU costs for patients with sepsis.

Physician Staffing Patterns and Costs for Septic Patients in Intensive Care Units

Takeshi Umegaki, MD, Miho Sekimoto, MD, PhD, MPH, and Yuichi Imanaka, MD, PhD, MPH.

Department of Healthcare Economics and Quality Management, Kyoto University Graduate School of Medicine, Kyoto, Japan

Corresponding Author: Yuichi Imanaka

Tel: +81-75-753-4454

FAX: +81-75-753-4455

E-mail: imanaka-y@umin.net

Affiliation: Department of Kyoto University Graduate School of Medicine,

Yoshida Konoe-cho, Sakyo-ku, Kyoto 606-8501, Japan

Key Words: healthcare costs; intensive care units; economics; sepsis; multicenter study

ABSTRACT

Objective: Sepsis is a serious disease from both clinical and economical perspectives. In 2002, the Surviving Sepsis Campaign was initiated to achieve better clinical outcomes, but patients with sepsis still have high mortality, with 7.3 deaths due to sepsis per 100,000 population in Japan in 2007. The cost of sepsis is also a serious burden for the healthcare system. Costs of intensive care unit (ICU) stays are associated with both the underlying disease and the high incidence of severe sepsis in critical care patients. However, healthcare costs vary between hospitals and it is difficult to determine the difference between hospital and ICU costs at different institutions. In this study, we used patient classification data to evaluate the relationship between physician staffing patterns and healthcare costs for patients with sepsis in ICUs in Japan.

Design: An observational cross-sectional study was performed between January 1, 2007, and December 31, 2008. The Institutional Review Board of the Faculty of Medicine at the Graduate School of Medicine of Kyoto University approved the study.

Setting: Forty-nine ICUs in 49 acute-care hospitals in Japan.

Patients: Cases of sepsis were identified from administrative data based on coding for bacterial, fungal, viral, and obstetric sepsis in the International Classification of Diseases (10^{th} version). A total of 797 patients with a diagnosis of sepsis were included in the analysis, after exclusion of those aged less than 20 years old.

Interventions: None.

Measurements and Main Results: The Quality Indicator/Improvement Project database was used to collect data from a large population in a short period of time for assessment of healthcare costs and daily costs in the ICU. The administrative information included Diagnosis Procedure Combination data and detailed claims data, including information

on medical care, daily resource use, and healthcare costs. Based on ICU staffing patterns, the 49 ICUs were classified into high-intensity ICUs (n=18, 303 cases), in which critical care physicians (CCPs) had primary responsibility or consultation with CCPs was mandatory; and low-intensity ICUs (n=31, 494 cases), in which consultation with CCPs was optional or there was no CCP involved in care. Age, gender, and reason for admission did not differ significantly between the two ICU models. Healthcare costs during ICU stays (total ICU costs) were calculated from ICU admission to ICU discharge. Daily ICU costs were calculated by dividing the total ICU cost by the length of ICU stay (in days). All costs were converted to US dollars at the 2008 exchange rate (¥102=US $1). Correlations of total and daily ICU costs were examined with the predicted mortality rate calculated using the Critical Care Outcome Prediction Equation (COPE) model, since this has no requirement for physiological data. There were no significant differences in total ($9,937 vs. $10,264; $p = 0.987$) and daily ($1,761 vs. $1,688; $p = 0.461$) ICU costs between the low- and high-intensity ICU models. However, subgroup analysis in the low-intensity ICU model showed that the total and daily ICU costs in the no-CCP group (3 ICUs, 19 cases) were significantly higher than those in the optional consultation group (total ICU costs, $35,730 vs. $9,853, $p < 0.05$; daily ICU costs, $3,970 vs. $1,750, $p < 0.01$).

Conclusions: In the current study, the severity of sepsis did not correlate with ICU costs, and ICU staffing patterns were not associated with total and daily ICU costs for patients with sepsis in critical care. However, staffing of a CCP may reduce these costs regardless of the level of intensive care, which suggests that further research is needed to determine the effect of CCPs on ICU costs for patients with sepsis.

INTRODUCTION

Sepsis is a serious disease from both clinical and economic perspectives. From 2002, the Surviving Sepsis Campaign guidelines have been used in an attempt to achieve better clinical outcomes, but patients with sepsis still have a high mortality. The reported deaths due to sepsis were 7.3 and 240.4 per 100,000 population in Japan and the United States (1), respectively, and the mortality rate in sepsis in critical care is estimated to be 30-40% (2-4). In addition to the challenge of improving clinical outcomes, the cost of sepsis is a serious burden for the healthcare system, costs of intensive care unit (ICU) are associated with the high incidence of severe sepsis in critical care patients, and the costs of the septic patient were the highest in critical care illness (5). The cost of severe sepsis worldwide was estimated to be $22,100 in 1995 (6) and a study of an integrated sepsis treatment protocol found that costs for patients with septic shock ranged from $30,000 to $40,000 (7).

It is suggested that healthcare costs of critical care patients vary between intensivists (8), so those varied between ICUs. The ICU organizational model was available when outcome evaluation among different ICUs was performed. Therefore, in the present study, we used patient classification data to evaluate the relationship between physician staffing patterns and healthcare costs for patients with sepsis in ICUs in Japan.

METHODS

Study Design and Hospitals

An observational cross-sectional study was performed in 49 ICUs in 49 acute-care hospitals in Japan between January 1, 2007, and December 31, 2008. Data were

obtained from the Quality Indicator/Improvement Project, which collected detailed administrative claim data including information on medical care, daily resource use and daily healthcare costs from voluntary participating institutions. This is a large population database that facilitates rapid collection of Diagnosis Procedure Combination data. The study was approved by the Institutional Review Board of the Faculty of Medicine at the Graduate School of Medicine of Kyoto University.

Organization of ICUs

In a prior investigation of ICU staffing patterns, we divided the 49 ICUs into two groups: high-intensity ICUs, in which critical care physicians (CCPs) had primary responsibility or consultation with CCPs was mandatory; and low-intensity ICUs, in which consultation with CCPs was optional or there was no CCP.

Case Selection

Cases of sepsis were identified from administrative claim data using the 10th Version of the International Classification of Diseases. Sepsis was defined as the coding series related to bacterial, fungal, viral, and obstetric sepsis (Table 1), with exclusion of patients aged less than 20 years old. The administrative data did not include scores for the severity of critically ill patients, such as those from the Acute Physiology and Chronic Health Evaluation (APACHE), the Mortality Prediction Model (MPM) and the Simplified Acute Physiology Score (SAPS). Therefore, we calculated the predicted mortality rate (severity of illness) using the Critical Care Outcome Prediction Equation (COPE) model, since this is based on administrative data and does not require physiological data (9).

Cost calculation

The administrative data were used to assess healthcare costs and daily costs in the

ICU. Healthcare costs during ICU stays (total ICU costs) were calculated from the day of ICU entry to the day of ICU discharge, daily ICU costs were calculated by dividing the all healthcare costs during the ICU stay by the length of ICU stay (in days), and so these described costs from the 3rd payer's perspective. All costs were converted to US dollars at the 2008 exchange rate (¥102=US $1). We did not include costs incurred after ICU discharge, since we focused on the resource use during ICU stays. And we did not include indirect costs, such as productivity loss and other nonmedical expenses.

Statistical Analysis

Data for comparison of the two ICU staffing models were analyzed using Dr. SPSS Version 2 (SPSS Inc.). All data are shown as means ± SD, medians with ranges, or percentages. A Student *t* test was used for continuous variables, and a chi-square test or Fisher exact test was used for categorical variables. $P < 0.05$ was considered to be significant.

RESULTS

Data were obtained for 665,442 patients discharged from 49 hospitals. Among these patients, 801 (0.1%) were identified as cases of sepsis and 4 (0.5%) matched the exclusion criteria, leaving 797 (99.5%) for inclusion in the analysis: 303 cases from 18 high-intensity ICUs and 494 cases from 31 low-intensity ICUs.

Patient characteristics

The patients' characteristics are shown in Table 2. The mean age was 71.3 years old, 486 patients were males (61.0 %), and the reasons for ICU admission were internal medical disease (48.8%), emergency surgery (21.8%) and scheduled surgery (29.4%). The overall predicted mortality rate was 20.7%. The background data did not differ

significantly between the groups with the different ICU staffing models.

Cost evaluation

For all cases, there was no correlation between total or daily ICU costs and severity of illness (p=0.13 and p=0.98, respectively). The total and daily ICU costs for each ICU staffing model are shown in Table 3. There were no significant differences in the total ICU costs ($9,937 vs. $10,264; $p = 0.987$) or daily ICU costs ($1,761 vs. $1,688; $p = 0.461$) between the low- and high-intensity models. However, subgroup analysis among the low-intensity ICUs showed that total and daily ICU costs in the no-CCP group (19 cases from 3 ICUs) were significantly higher than those in the optional consultation group (total costs, $35,730 vs. $9,853, $p < 0.05$; daily costs, $3,970 vs. $1,750, $p < 0.01$) (Figs. 1 and 2).

DISCUSSION

The investigation of ICU staffing models presented the differences in mortality and length of stay as an indicator of ICU performance. Previous studies of the association between ICU staffing patterns and outcomes (10-13) have suggested that high-intensity ICU physician staffing models are associated with reduced hospital and ICU mortality and lengths of stay. Although ICUs had serious economical burden and septic patients had especially high costs, few investigations of their costs in organization model had been performed. So we focused on the evaluation of the costs of septic patients between different ICU staffing models.

Although there were no significant differences in ICU costs between two staffing models, we found that the costs of sepsis in the no-CCP group were the twice or more as high as those in the optional consultation group. It was indicated that the staffing of

CCPs had some effects on ICU costs of sepsis. Pronovost et al. [14] reported that existence of intensivist led to cost saving in adult intensive care units, and our result was consistent with their study.

In the present study, the median total ICU cost of $9,803 (range: $916-$234,818) appears to be lower than that in other recent studies (6, 7). However, these ICU costs do not distinguish between sepsis, severe sepsis and septic shock, and costs incurred after ICU discharge are not included. In addition, costs in the present study were different from accounting cost. These may explain why the ICU costs in our analysis were lower than those in previous studies.

The limitations of the study were as follows. First, not all septic patients may be identifiable using the ICD-10 code, due to miscoding or lack of coding by doctors. These potential errors in the administrative data have not been examined and therefore we performed the study without taking such errors into account. Second, the no-CCP group included a very small number of hospitals and cases, and we cannot conclude with certainty that the ICU costs in the no-CCP group were higher than in other groups. Finally, we did not group the patients into survivors and non-survivors or high and low severity groups since these analyses were not consistent with the principle aim of the study.

In summary, there was no difference in healthcare costs between staffing patterns for critically ill patients with sepsis. However, the finding that almost all patients with extremely high ICU costs were treated in a no-CCP ICU suggests that CCPs have an important role in reducing healthcare costs for septic patients in critical care. Further research is needed to determine the effect of CCPs on ICU costs for patients with sepsis, since we include small number of septic patients in a few no-CCP ICUs.

Conflict of Interest

We declare no conflicts of interest.

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FIGURE LEGENDS

Figure 1. Total ICU costs in the optional consultation and no-CCP sub-groups

Figure 2. Daily ICU costs in the optional consultation and no-CCP sub-groups

Table 1. ICD-10 codes used in the study

Condition	Code
Salmonella septicaemia	A02.1
Septicaemic plague	A20.7
Anthrax septicaemia	A22.7
Erysipelothrix septicaemia	A26.7
Listerial septicaemia	A32.7
Streptococcal septicaemia	A40
Other septicaemia	A41
Actinomycotic septicaemia	A42.7
Disseminated herpesviral disease	B00.7
Candidal septicaemia	B37.7
Disseminated coccidioidomycosis	B38.7
Disseminated histoplasmosis capsulati	B39.3
Disseminated blastomycosis	B40.7
Disseminated paracoccidioidomycosis	B41.7
Disseminated sporotrichosis	B42.7
Disseminated aspergillosis	B44.7
Disseminated cryptococcosis	B45.7
Disseminated mucormycosis	B46.4
Puerperal sepsis	O85

Table 2. Characteristics of the patients in the study

	High-intensity ICU (n = 303)	Low-intensity ICU (n = 494)	*P* value
Age (years)	70.7±13.0	71.7±13.0	0.271
Sex (male) (%)	60.4	61.3	0.792
Predicted mortality rate (%)	21.3±19.5	20.0±17.9	0.322
Mortality rate (%)	46.9	46.8	0.9
Reason for ICU admission† (%)			
Internal medical disease	53.5	46.0	
Emergency surgery	20.5	22.7	0.074
Scheduled surgery	26.1	31.4	

†: Scheduled surgery: surgery performed before ICU entry, except for emergency surgery

Emergency surgery: surgery performed on the day of ICU entry or the day before ICU entry

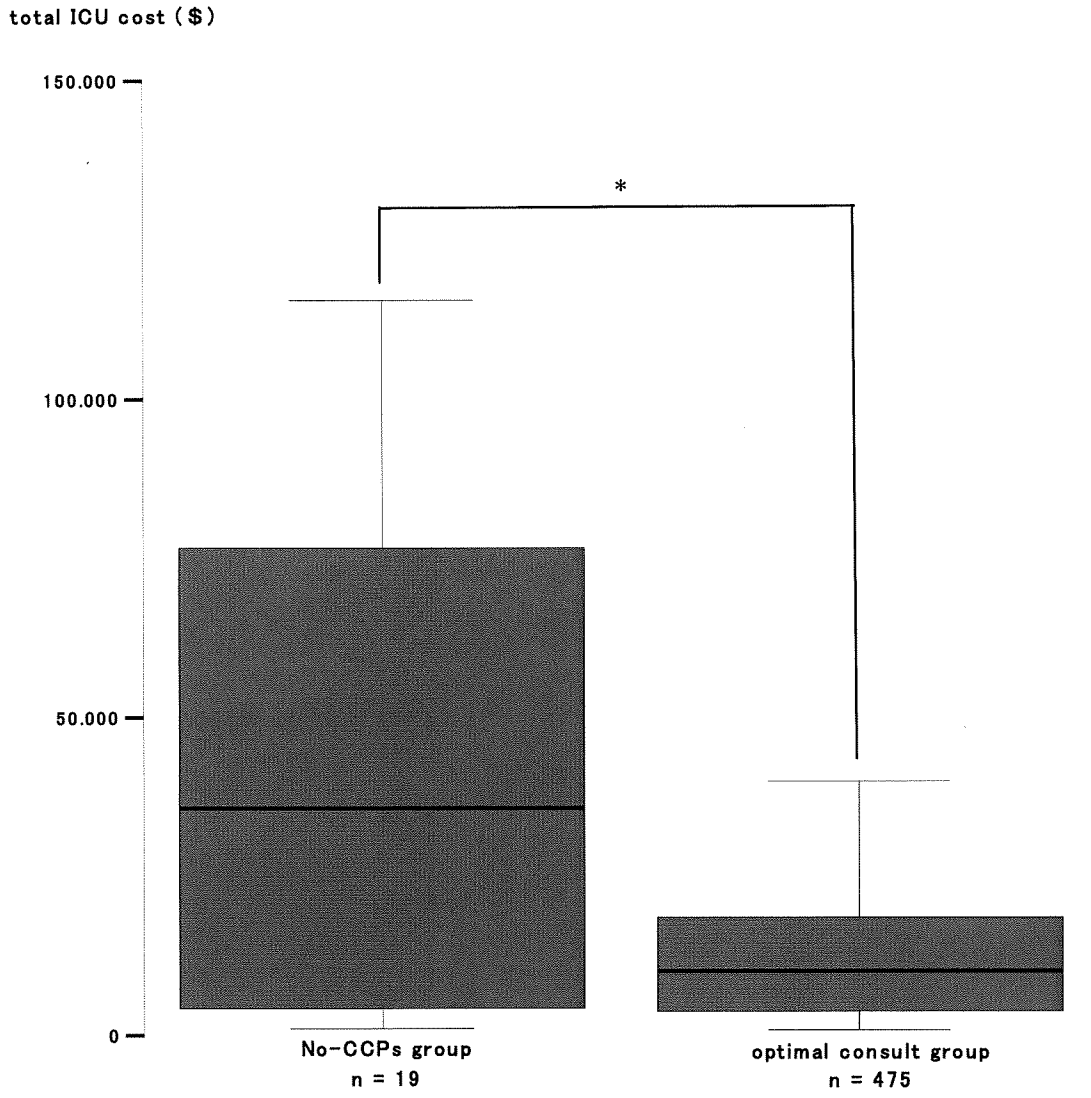
Continuous variables: mean ± SD; categorical variables: percentage; *: $p < 0.05$; **: $p < 0.01$

Table 3. Total ICU costs and daily ICU costs

	High intensity ICU (n = 303)	Low intensity ICU (n = 494)	*P* value
Total ICU costs ($)	10,264 (1,057-234,818)	9,937 (916-115,698)	0.987
Daily ICU costs ($)	1,688 (301-18,063)	1,761 (312-34,010)	0.461

Data are shown as medians with ranges in parentheses

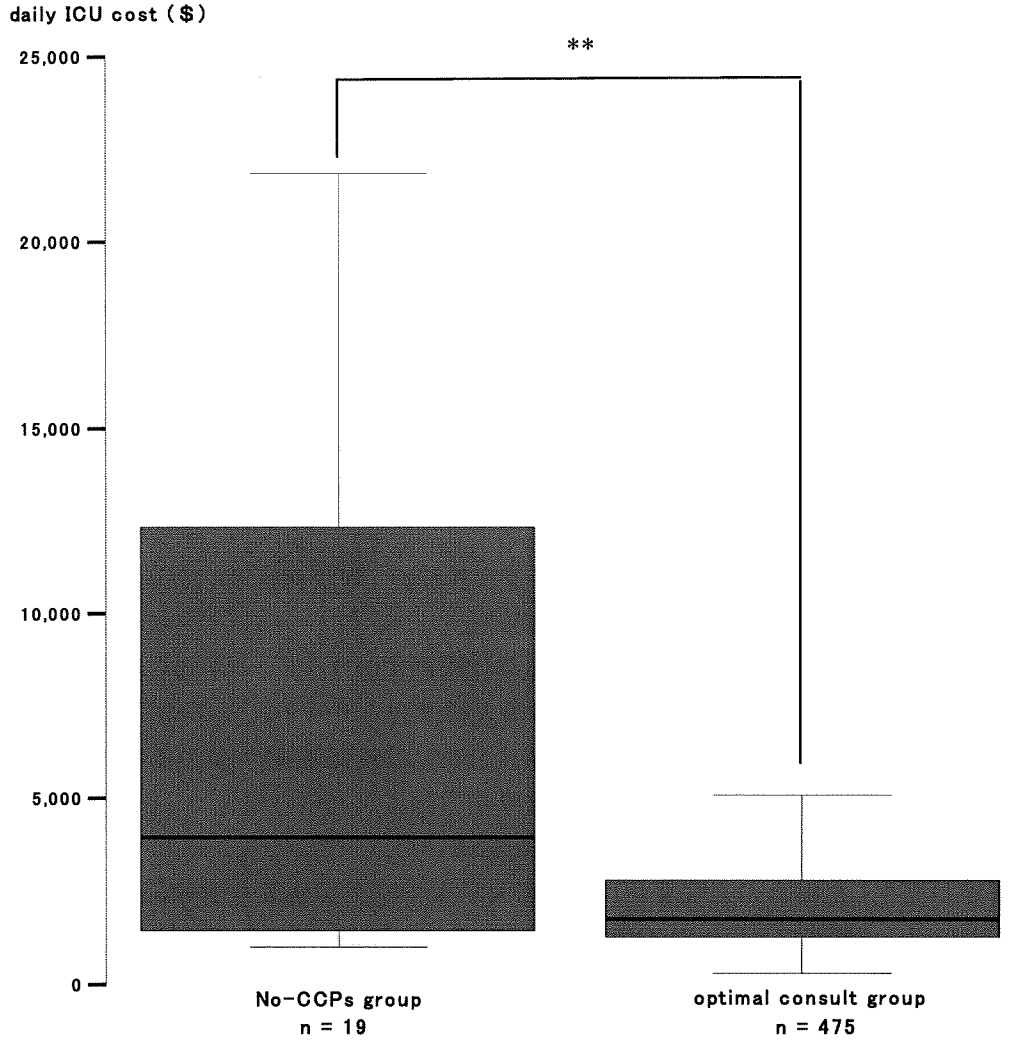
Figure 1



CCPs: critical care physicians

*: $p < 0.05$

Figure 2



**: $p < 0.01$

妊娠・分娩にかかる個人および社会全体の費用の検討

【目的】

我が国の少子高齢化は急速に進行し、今後の社会保障のあり方に大きな影響を及ぼしている。政府は妊婦本人に対して妊婦健診費用に対する助成や出産一時金の増額という形で少子化対策を進めている。しかし、助成は本来それに伴う費用に対する補償として行われるべきものであるが、一人の女性が妊娠した際の個人や社会全体の負担がどの程度かという検討はほとんど行われていない。そこで我が国の少子化対策の議論を行う上での一助とすべく、妊娠における個人および社会全体の費用を算出した。

【方法】

研究デザイン cost-of-illness study

分析の視点 個人および社会

解析方法とデータソース decision-tree model を用いた決断分析を行い 1 妊娠あたりの費用および生児数を計算した。

費用は社会では直接費用として妊婦健診および分娩に伴う費用，合併症の発生により入院加療を行った際の医療費を、間接費用として機会費用を算出した。個人では直接費用として妊婦健診，分娩，合併症による入院加療を行った際の窓口負担から公的助成金を差し引いた額を、間接費用として機会費用を算出した。

1 妊娠あたりの生児数は妊娠初期合併症(流産，子宮外妊娠，胞状奇胎)および子宮内胎児死亡の場合 0 、多胎妊娠は 2 、その他は 1 として計算した。

decision-tree model における妊娠合併症の発生率は国内におけるデータが得られるものについては厚生労働省の統計データベース，日本産科婦人科学会のデータを、その他は文献検索から得られた値を用いた。初期解析には平均値を、感度分析には最低値-最大値の幅を利用した。

妊婦健診，分娩の費用および公的助成金の額は厚生労働省研究班の報告から各都道府県別の値の平均値を初期解析に用い、その幅を感度分析に用いた。

妊娠合併症が発生した場合の入院費用は、京都大学大学院医学研究科医療経済学分野で行っている DPC データ解析プロジェクト QIP(Quality Indicator/Improvement Project)で収集した入院患者の DPC データから当該合併症疾患が主病名とコードされている産科入院患者の DPC データを抽出し、その診療報酬点数の中央値を初期解析に、10%-90%タイルを感度分析に利用した。

妊娠，出産に伴う機会費用は厚生労働省のデータベースより妊婦の就職率および同年代女性の平均賃金を取得し、それに妊婦健診および産休による休職日数を乗じて算出した。

感度分析:各疾患の発生率，費用について確率的感度分析を行った。

【結果】

初期解析: 1 妊娠あたりの生児数は 0.84 人であり、費用は個人では 370,366 円(うち直接費用は 92,261 円)、社会全体では 872,993 円であった。

感度分析: 10,000 回試行の結果は 1 妊娠あたりの生児数が 0.84 人[95%信頼区間 0.8358-0.8367]、費用は個人では 388,825 円[同 388,406-389,244](うち直接費用は 108,943 円)、社会全体では 896,587 円[同 895,903-897,270]であった。

【考察】

日本における妊娠にかかる費用について、妊娠に伴う合併症も含めて算出した。個人の費用は助成金を差し引いても 37-38 万円、社会全体ではおよそ 90 万円の負担であった。妊娠，分娩が

自費診療であるとはいえ、個人が 4 割程度を負担しており、妊娠が多い比較的若年の世代においてはそれなりの負担であることが判明した。
この研究の限界として日本人における正確な合併症の罹患率が把握できない、社会の視点で考えた際、診療報酬は必ずしも本当の費用ではない、出生した児が NICU など入院した際にかかった費用を算出していないという点が挙げられる。さらに、個人にとって出生後の児にかかる費用が大きいことが、出産を躊躇させている一因であることは間違いない。
しかしながら、少子高齢化にあえぐ我が国の今後の少子化対策を考える際、この研究が個人と社会がどの程度その費用の負担を分け合うのかという議論の一助となることを期待したい。