

[ ORIGINAL ARTICLE ]

# The Association between the Establishment of a General Internal Medicine Department and an Increased Number of Blood Cultures in Other Departments: An Interrupted Time Series Analysis

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## Abstract:

**Objective** The establishment of a department of general internal medicine (GIM) has been shown to improve the clinical outcomes among patients treated in GIM departments but the effect on practice patterns in other departments remains unclear. We evaluated the association between the establishment of a GIM department and the use of blood cultures, an indicator of quality of care of infectious diseases, in other departments.

**Methods** This study was conducted between 2013 and 2017 in a community hospital which established a new GIM department in 2015, with a mandate to improve the quality of care of the hospital including infectious disease management. The primary outcome was the change in the number of blood culture episodes per calendar month in other departments before and after establishment of the GIM department. The secondary outcome was the change in the blood culture episodes per month, indexed to 1,000 patient-days, during the same time. Using 2015 as the phase-in period, interrupted time series analyses were used to evaluate the change in the outcome variables.

**Results** In departments other than GIM, there were 284 blood cultures prior to the establishment of the GIM department (2013-2014) and 853 afterwards (2016-2017). The number of blood culture episodes in other departments increased by 10.7 (95%CI: 0.39-21.0,  $p=0.042$ ) per calendar month after the establishment of the GIM department; blood culture episodes/calendar month/1,000 patient-days increased by 0.55 (95%CI: 0.03-1.07  $p=0.037$ ).

**Conclusion** These results indicate that a GIM department in a community hospital can improve the quality of care in other departments.

**Key words:** general internal medicine, hospitalist, blood culture, interrupted time series

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## Introduction

In Japan, subspecialty training has been the standard in the development of physicians. However, with the aging of society and the growing imbalance of doctors between urban and rural areas, recognition of the need for more general in-

ternal medicine (GIM) physicians, who deliver patient-centered care and who are more likely to work in underserved areas, has increased (1, 2). GIM physicians not only provide comprehensive clinical care for adults but are also expected to improve quality of care in other clinical departments by serving as hospitalists (1, 3). There are few infectious disease specialists in Japan (4). For this reason, GIM

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physicians often manage patients with infectious disease, such as pneumonia, urinary tract infection, or skin and tissue infection. Moreover, they provide consultations on the management of these problems in patients cared for by subspecialty physicians. In addition to consultation on individual patients, GIM physicians implement optimal infection disease management across the hospital.

A recent Japanese study showed that establishing a GIM department was associated with a shorter length of hospitalization among pneumonia patients (5). However, it evaluated only patients cared for by GIM physicians. Whether GIM physicians influence infectious disease management by physicians in departments other than GIM is unknown.

Blood cultures are an essential step in the evaluation of fever in hospitalized patients, especially when sepsis or a blood stream infection is suspected (6-8). Drawing duplicate cultures from more than one site is recommended to improve the sensitivity of detecting blood stream infection (9). Thus, use of blood cultures, and drawing duplicate cultures, are indicators of the quality of infectious disease management. Blood cultures are underutilized in Japan. A study of 6 Japanese hospitals revealed that the median number of blood cultures was 25.2 sets/1,000 patient-days (range: 10.4-64.2) (10). The American Society of Microbiology (ASM) guidelines recommend a rate of 103-188 sets/1,000 patient-days as optimal (9). In this study, we evaluated the association between the establishment of a department of GIM and use of blood cultures by members in other clinical departments.

## Materials and Methods

### Setting

This retrospective cohort study was conducted from January 2013 to December 2017 at Hashimoto Municipal Hospital, a 300-bed secondary care hospital containing about 50 physicians located in Wakayama, a rural area of Japan. The catchment area of the hospital has a population of around 100,000 people. Prior to the founding of the department of GIM, Hashimoto Municipal Hospital had 18 departments, including: medical departments (cardiology, gastroenterology, respiratory medicine, and endocrinology and metabolism) and non-medical departments (general surgery, neurosurgery, obstetrics and gynecology, orthopedics, urology, cardiovascular surgery, respiratory surgery, dermatology, emergency medicine, pediatrics, anesthesiology, radiology, pathology, and dental oral surgery).

The department of GIM was established in January 2015 with the hiring of three physicians who had just completed residency programs at academic teaching hospitals designed to train GIM physicians and hospitalists. Their roles included working as hospitalists with a mandate to improve the quality of care for patients hospitalized on every service, including implementation of optimal infectious disease care. They established an educational program about the impor-

tance of blood cultures for physicians in all department. This program was delivered through consultations on individual patients and lectures on optimal management of infectious diseases. A key point was that blood cultures are indicated to detect or rule out bloodstream infection or sepsis. GIM staff members also helped to increase access to blood culture bottles, establish a microbiology laboratory, and improve the electronic health record to facilitate ordering of blood cultures. GIM physicians also worked with the Infection Control Team (ICT) to provide training in the optimal procedure for performing blood cultures and to implement a system to check for, and alert providers to, positive blood culture results.

### Outcome Definition

Patients who had at least one set of blood cultures obtained between January 1, 2013 and December 31, 2017 were identified using the electronic medical records. A blood culture was defined as a set of an aerobic and an anaerobic culture bottles submitted to the laboratory for culture. A blood culture episode was defined as blood cultures sets that were drawn from the same patient on the same day. For example, if a patient had two or more sets of blood cultures on the same day, it was counted as 1 blood culture episode. Excluded were episodes in which blood cultures were within 60 days of the index episode; ordered by the staff of the department of GIM; or, drawn based on consultation with the GIM department. Blood cultures based on consultation with the GIM department were defined as blood cultures obtained on the day of, or the following day of the consultation and were excluded because the purpose of the study was to assess the practice patterns of physicians outside the department of GIM.

The outcome variable for this analysis was the number of total blood culture episodes per month in clinical departments other than GIM. The primary analysis used the number of total blood culture episodes per calendar month as the outcome. In order to take into account differences in the duration and patient census by month, the secondary analysis used number of blood culture episodes per calendar month per 1,000 patient-days. For hospitalized patients, this was defined as the number of total blood culture episodes per calendar month divided by the total of the number of occupied bed-days, standardized to 1,000. For outpatients, outpatient visits per calendar month were used as the denominator. Data from inpatients and outpatients were combined for the analysis of both outcome variables.

### Descriptive analyses

We conducted descriptive analyses of the percentage of positive blood culture episodes per calendar year and percentage of blood culture episodes with multiple sets per calendar year. A positive blood culture episode was defined as bacterial growth in any of multiple blood culture sets drawn on the same day. For example, if two of four blood cultures in a single blood culture episode were reported as showing

growth, then that episode was classified as positive. The percentage of positive blood culture episodes was calculated by dividing the number of positive episodes per calendar year by the number of total blood culture episodes per calendar year. The percentage of positive blood cultures is an indicator for the appropriateness of blood culture sampling and should be within 5-15% according to the ASM guidelines (9).

Two or more sets of blood cultures are recommended to improve the detection of blood stream infections (8, 11, 12). For this study, a blood culture episode with multiple sets was defined as a blood culture episode with two or more sets of blood cultures drawn from the same patient on the same day.

We also reviewed positive blood culture episodes in other departments to investigate whether an increased number of blood cultures had a positive impact on the clinical practice pattern. We defined appropriate antimicrobial changes within seven days based on positive blood culture episodes as follows; de-escalation; starting susceptible antimicrobials; or changing from resistant antimicrobials to susceptible antimicrobials. De-escalation was defined as a decreased number of antimicrobials or lower ranks of antimicrobials in the following rank order; carbapenem, antipseudomonal  $\beta$ -lactam, third-generation cephem, ampicillin with  $\beta$ -lactamase inhibitor, and other  $\beta$ -lactam (13). Susceptible or resistant antimicrobials were determined based on the findings of antimicrobial susceptibility tests.

### Interrupted Time Series analyses

An interrupted time series (ITS) analysis is a quasi-experimental study design to evaluate the effectiveness of health interventions. An ITS is useful when there are clear pre- and post- intervention time periods without an external control group. In an ITS analysis, the change in the level, as well as trend, of the outcome before and after the intervention are analyzed using a segmented regression model to evaluate the effect of the intervention (14, 15).

In this study, we used ITS for both the primary and secondary analysis. The study period was divided into the pre-GIM establishment period (January 2013 to December 2014) and post-GIM establishment period (January 2016 to December 2017). The year of GIM establishment (January to December 2015) was defined as the phase-in period. We confirmed no apparent autocorrelation for both primary and secondary analyses based on the Durbin-Watson test and used a segmented linear regression model without adjusting for autocorrelation. The change in the number of total blood culture episodes per calendar month in departments other than GIM prior to, and after, the establishment of the GIM department was evaluated in the primary analysis. We also analyzed the change in the number of blood culture episodes per calendar month after stratification by medical departments or non-medical departments as subgroup analyses. The change in blood culture episodes per 1,000 patient-days, by calendar month, in departments other than GIM before

and after the establishment of the GIM department was evaluated in the secondary analysis.

Stata 15 (StataCorp, College Station, USA) and R 3.6.2 (The R Foundation for Statistical Computing Platform, Vienna, Austria) was used to complete the statistical analyses. *p* values <0.05 were considered to indicate statistically significant differences.

### Ethical considerations

This study was approved by the ethics committee of Hashimoto Municipal Hospital. According to ethical guidelines for medical and health research involving human subjects in Japan, written informed consent was not required because this study was retrospective and none of the findings could be used to identify specific individuals.

## Results

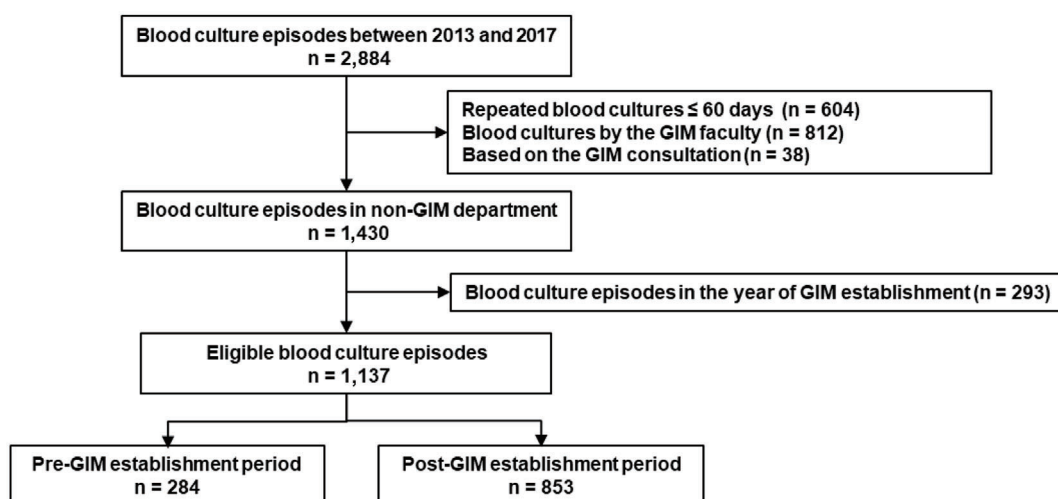
### Characteristics of blood culture episodes

Between January 2013 and December 2017, 2,884 blood culture episodes were identified. After excluding blood cultures drawn within 60 days of the index episode (604 episodes), by faculty of the department of GIM (812 episodes), or within a day following consultation by the GIM department (38 episodes), 1,430 episodes were identified as the number of blood culture episodes in departments other than GIM. The 1,430 blood culture episodes were comprised of 2,708 blood culture sets from 1,333 unique patients. During pre-GIM establishment period, 284 blood culture episodes were observed while 853 blood culture episodes were observed during the post-GIM establishment period and included in the ITS analysis. The 293 episodes occurring in the phase-in period were excluded (Fig. 1).

Table shows the total number of patient visits or hospitalizations in departments other than GIM. The average numbers of patient encounters in other departments in the periods before establishment of the GIM department were 234,689 (in-patients: 81,552, out-patients: 153,137). After the establishment of the GIM department, the number was similar, 226,492 (in-patients: 81,782, out-patients: 144,710). The mean ages of the patients were 70.3 years in the pre-establishment period and 72.9 years in the post-establishment period.

### Descriptive analysis: positive blood culture episodes, blood culture episodes with multiple sets, and appropriate antimicrobial changes based on the blood culture results

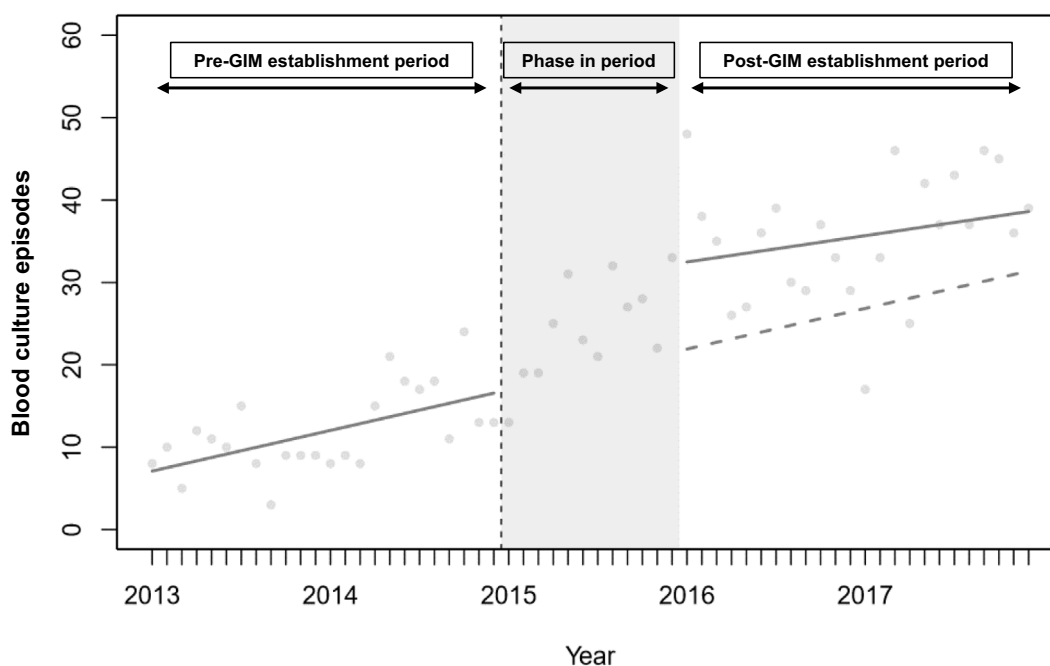
The percentage of positive blood culture episodes, the percentage of blood culture episodes with multiple sets and the appropriate antimicrobial changes based on blood culture results are shown in Table. Over the study, the percentage of positive blood culture episodes decreased from 28.4% in 2013 to 10.8% in 2017. The percentage of blood culture episodes with multiple sets increased from 78.0% in 2013 to



**Figure 1.** Flow diagram of blood culture episodes. A total of 2,884 episodes were identified during the study period. Repeat blood culture episodes within 60 days (604 episodes), by the department of GIM (812 episodes), or in a day or a following day of consultation to the GIM department (38 episodes) were excluded and 1,430 episodes were identified as a number of blood culture episodes in other departments. 284 episodes were observed during the pre-GIM establishment period and 853 episodes were observed during the post-GIM establishment period. GIM: general internal medicine

**Table.** Characteristics of Blood Culture Episodes and Descriptive Analyses.

	Pre-GIM establishment		GIM establishment -phase in period-	Post-GIM establishment	
	2013	2014	2015	2016	2017
Year	2013	2014	2015	2016	2017
Number of patient visits in other departments	235,606	233,772	230,617	229,819	223,164
in-patients <sup>†</sup>	79,991	83,113	79,867	81,708	81,856
out-patients <sup>‡</sup>	155,615	150,659	150,750	148,111	141,308
Age, mean (SD) <sup>¶</sup>	71.7 (21.6)	68.8 (23.8)	73.1 (20.8)	71.2 (22.2)	74.6 (21.9)
Male, n (%) <sup>¶</sup>	63 (57.8)	99 (56.6)	159 (54.3)	220 (54.1)	228 (51.1)
Number of blood culture episodes in other departments					
Total	109	175	293	407	446
Medical	64	69	108	94	136
Non-medical	45	106	185	313	310
Rate of blood culture episodes / 1,000 patient-days in other departments	0.46	0.75	1.27	1.77	2.00
Average number of blood culture episodes per calendar month in other departments	10.05	16.27	25.79	34.98	39.08
Average rate of blood culture episodes / 1,000 patient-days per calendar month in other departments	0.512	0.825	1.341	1.817	2.097
Positive blood cultures, %	28.4	20	22.5	16.2	10.8
Multiple sets of blood cultures, %	78	82.9	89.1	91.7	91.7
Appropriate antimicrobial changes based on the blood culture results in other departments / 1000 patient-days					
Total	0.042	0.013	0.056	0.157	0.134
De-escalation	0.013	0.000	0.017	0.052	0.054
Starting antimicrobials	0.008	0.004	0.009	0.004	0.013
Changing from resistant to susceptible antimicrobials	0.021	0.009	0.030	0.100	0.067



**Figure 2.** Change in the number of blood culture episodes per calendar month in departments other than GIM. After the establishment of GIM, the number of blood culture episodes in departments other than GIM significantly increased by 10.7 (95% CI: 0.39 to 21.0,  $p=0.042$ ) episodes per calendar month. Point: the number of blood culture episodes in departments other than GIM in a month. Solid line: regression estimation of monthly numbers of blood culture episodes in departments other than GIM. Dotted line: estimation of the counterfactual if the trend in pre-GIM establishment period remained to post-GIM establishment period. GIM: general internal medicine

91.7% in 2017. The appropriate antimicrobial changes based on the blood culture results increased from 0.04 episodes/1,000 patient-days in 2013 to 0.13 episodes/1,000 patient-days in 2017.

#### Primary analysis: association between the establishment of a GIM department and the monthly number of blood culture episodes in other departments

Fig. 2 shows number of blood culture episodes per calendar month in departments other than GIM during the study periods. The average monthly number of blood culture episodes in other departments was 13.2 episodes in pre-GIM establishment period and 37.0 episodes in post-GIM establishment period. According to the ITS analysis, the number of blood culture episodes in other departments increased by 10.7 (95%CI: 0.39 to 21.0,  $p=0.042$ ) episodes per calendar month after the GIM establishment. The trend in number of blood culture episodes per calendar month in other departments decreased slightly after the establishment of the GIM department, but it was not statistically different from period one [-0.14 (95%CI: -0.66 to 0.37,  $p=0.574$ )].

In subgroup analyses, the number of blood culture episodes in non-medical departments significantly increased by 9.6 (95%CI: 2.1 to 17.0,  $p=0.013$ ) episodes per calendar month after the GIM establishment, while the number of blood culture episodes in medical departments was not substantially different [1.1 (95%CI: -4.3 to 6.6,  $p=0.675$ ) episodes per calendar month]. The trends in the number of

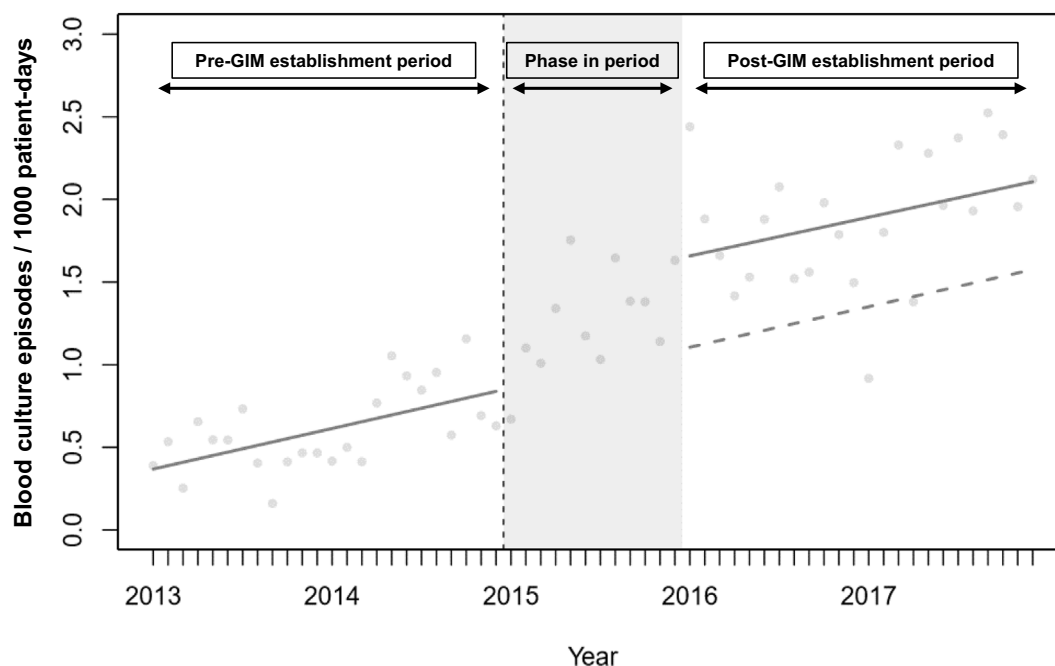
blood culture episodes per calendar month in both of medicine and non-medicine departments showed no significant change after the establishment of the GIM department [0.14 (95%CI: -0.13 to 0.41,  $p=0.304$ ) and -0.29 (95%CI: -0.66 to 0.08,  $p=0.121$ ), respectively].

#### Secondary analysis: association between the establishment of a GIM department and the rate of blood culture episodes in other departments

The number of blood culture episodes per 1,000 patient-days per calendar month in departments other than GIM during the study period is described in Fig. 3. The average rate of blood culture episodes in other departments was 0.67 episodes per 1,000 patient-days prior to establishment of the GIM department and 1.96 episodes per 1,000 patient-days afterwards. Similar to the primary analysis, the rate of blood culture episodes in other departments increased significantly by 0.55 (95%CI: 0.03 to 1.07,  $p=0.037$ ) episodes per 1,000 patient-days between pre- and post-GIM establishment. The trend of the monthly number of blood culture episodes per 1,000 patient-days in other departments was not significantly different after the establishment of the GIM department [-0.001 (95%CI: -0.07 to 0.02,  $p=0.943$ )].

### Conclusion

This retrospective cohort study showed that the establishment of a GIM department was associated with an increased



**Figure 3.** Change in the monthly number of blood culture episodes/1,000 patient-days in departments other than GIM. After the GIM establishment, the number of blood culture episodes/1,000 patient-days in departments other than GIM significantly increased by 0.55 (95% CI: 0.03 to 1.07,  $p=0.037$ ) episodes/1,000 patient-days in a month. Point: the number of blood culture episodes/1,000 patient-days in departments other than GIM in a month. Solid line: regression estimation of monthly numbers of blood culture episodes/1,000 patient-days in departments other than GIM. Dotted line: estimation of the counterfactual if the trend in the pre-GIM establishment period remained until the post-GIM establishment period. GIM: general internal medicine

number of blood cultures performed in other departments. This association was shown for both number of blood cultures per calendar month and the number of blood cultures per patient-days. To our knowledge, this is the first study showing the association between the GIM establishment and an improvement in the practice patterns in other departments.

In a previous study, the establishment of a GIM department was associated with a reduction of the length of hospitalization in pneumonia patients (5). Other studies have also shown that patients cared by hospitalists had a shorter length of hospitalization than those who were cared for by non-hospitalists (16-18). The current study adds new evidence that establishing a GIM department, with the staff members carrying out a hospitalist role (1), improves the quality of practice in other departments.

The establishment of the GIM department may have contributed to an increased number of blood cultures in other departments through several factors, such as education of the importance and the optimal procedure of blood cultures, making access to bottles of blood culture easier, improving the ordering system, requesting the establishment of a bacterial laboratory, and implementing a system -- with ICT -- to check blood cultures and alert providers of positive results. Education about the importance and optimal procedure to collect blood cultures has been reported to contribute to the ideal sampling volume of blood cultures and reducing time

to positivity of blood cultures (11, 19, 20). Improving the ordering system of blood cultures combined staff education has also been shown to increase the proportion of multiple sets of blood cultures (21). The establishment of a microbiological laboratory and implementation of a system to check the results and alert providers of positive results of blood cultures also likely contributed to transporting sampled blood cultures to the laboratory within two hours and rapid reporting of blood culture results which are recommended in the ASM guidelines (9).

During the study period, the proportion of positive results of blood cultures decreased and the proportion of multiple sets of blood cultures increased. In the ASM guidelines, a positive rate of blood cultures more than 15% or less than 5% triggers a recommendation to investigate whether blood cultures are appropriately conducted (9). In the present study, the percentage of positive blood culture episodes declined from very high, 28.4%, to an acceptable level, 10.8%, at the last year of the study period. Generally, at least 2 sets of blood cultures should be performed to improve the sensitivity of detecting blood stream infections (8, 11, 12). In the present study, the percentage of blood culture episodes with multiple sets of blood cultures increased from 78.0% to 91.7% during the study period. The reduction in positive blood cultures and the increased use of multiple sets of blood cultures and number of blood cultures drawn in other departments demonstrates an improvement of the practice

pattern after the establishment of the GIM department.

The present study is associated with four limitations. First, we did not have clinical data on why the blood cultures were drawn. However, the number of patients in departments other than GIM did not substantially change during the study period, and we assume that disease patterns and patient population did not change during this relatively short period. Second, this study did not collect data on the physicians in other departments during the study period. The studied hospital is a city hospital cooperating with medical universities. Around 20-40% of the physicians in the departments other than GIM change every year. If the knowledge base or other characteristics of these physicians differed over the study period, it might affect clinical decision-making regarding use of blood cultures. Third, because the intervention to increase the utilization of blood cultures in other departments was multifactorial, the specific aspects of the intervention that were responsible for the positive outcome cannot be determined. Fourth, this study was conducted in a single institution in Japan, so the generalizability of this result to other hospitals may be limited. Additional studies in other institutions are needed to confirm these results.

In conclusion, this is the first study to show an association between the establishment of a GIM department and a clinically important increase in number of blood cultures in other clinical departments. Establishing a GIM department with a hospitalist service can be used as an intervention to improve clinical practice patterns in other departments and positively influence quality of patient care throughout the entire hospital.

**The authors state that they have no Conflict of Interest (COI).**

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