



Health Economics

— Effect of Electronic Medical Record Systems on Cardiovascular Disease Outpatient Consultation Time —

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Because electronic medical record systems may affect productivity of clinical practice, we examined the effects of different types of medical record systems on consultation time and total fee claims for outpatient consultation for cardiovascular cases. We investigated consultation time (i.e., the sum of practice time and work-up time) and total fee claims by 13 cardiovascular physicians for 862 outpatients. The means of consultation time and total fee claims were calculated for 3 types of medical records: electronic, paper-based, and hybrid. No difference in mean consultation time was seen between the electronic and paper-based medical record groups (paper based, 11.4 ± 0.3 min/case; electronic, 12.7 ± 0.8 min/case; hybrid, 13.5 ± 0.5 min/case). In contrast, the electronic group had the highest mean practice time (10.9 ± 0.6 min/case) and the lowest mean work-up time (1.7 ± 0.4 min/case). There was no difference in total fee claims between the 3 medical record groups. The total fee claims per practice time was lower for the electronic group than the paper-based (67.5 ± 52.8 vs. 108.8 ± 108.1 points/min, $P < 0.001$). The findings suggest that physicians using the electronic medical record system can be more directly involved with patients due to higher productivity, as reflected in the lower work-up time.

Key Words: Cardiovascular case; Consultation time; Electronic medical record; Fee claim; Health economics

In developed countries with high-quality medical systems, reforms are needed for clinical functions to remain sustainable due to recent developments such as the increasing complexity of clinical demand and shortage of medical resources. To realize these reforms, the use of medical resources (e.g., health professionals and materials) has to be adapted to the aforementioned developments. This means that, in order to optimize clinical and economic outcomes with limited medical resources, efficiency in the use of these resources will have to be improved.¹

One of the purposes of advances in medical information science, such as electronic medical record (EMR) keeping, is to change how medical resources are used in order to improve efficiency. EMR in particular is expected to reduce the work load for record keeping and the organization and documentation of health professionals and to encourage sharing the work load in clinical practice.² It has been suggested, however, that the EMR system may not reduce physician work-up time for documentation.^{3,4} It is therefore of major importance to evaluate the net benefits derived from advances in medical information science, including improvement in the overall required workload at medical institutions and the economic effect on other sectors (i.e., the inter-departmental effect) as well as on the management system of the institutions.

To evaluate physician productivity with regard to the

maximization of clinical and economic outcome at clinics, the effect of a given medical information system such as the EMR system on the clinical practice of physicians in terms of medical management (i.e., control of medical resources) would need to be investigated. Some Japanese studies have reported on the effect of EMR systems on the clinical practice of physicians,^{5,6} but these studies were based on questionnaires and simulation studies, and none of them carried out a parallel comparison of the effect of different medical record types based on clinical outcomes measured in 1 clinic over the same time period.

Thus, to evaluate physician productivity associated with different medical information technology (IT) systems, we examined the relationship between medical record systems and consultation time as well as total fee claims for outpatient consultation at an institution where physicians can choose the type of medical record systems they prefer and optimize their use of the system for their clinical practice.

In this study, we used old observational data, given that this was an assessment of EMR history and, hence, of its progress.

Methods

Subjects

This study was carried out by a team of physicians at the

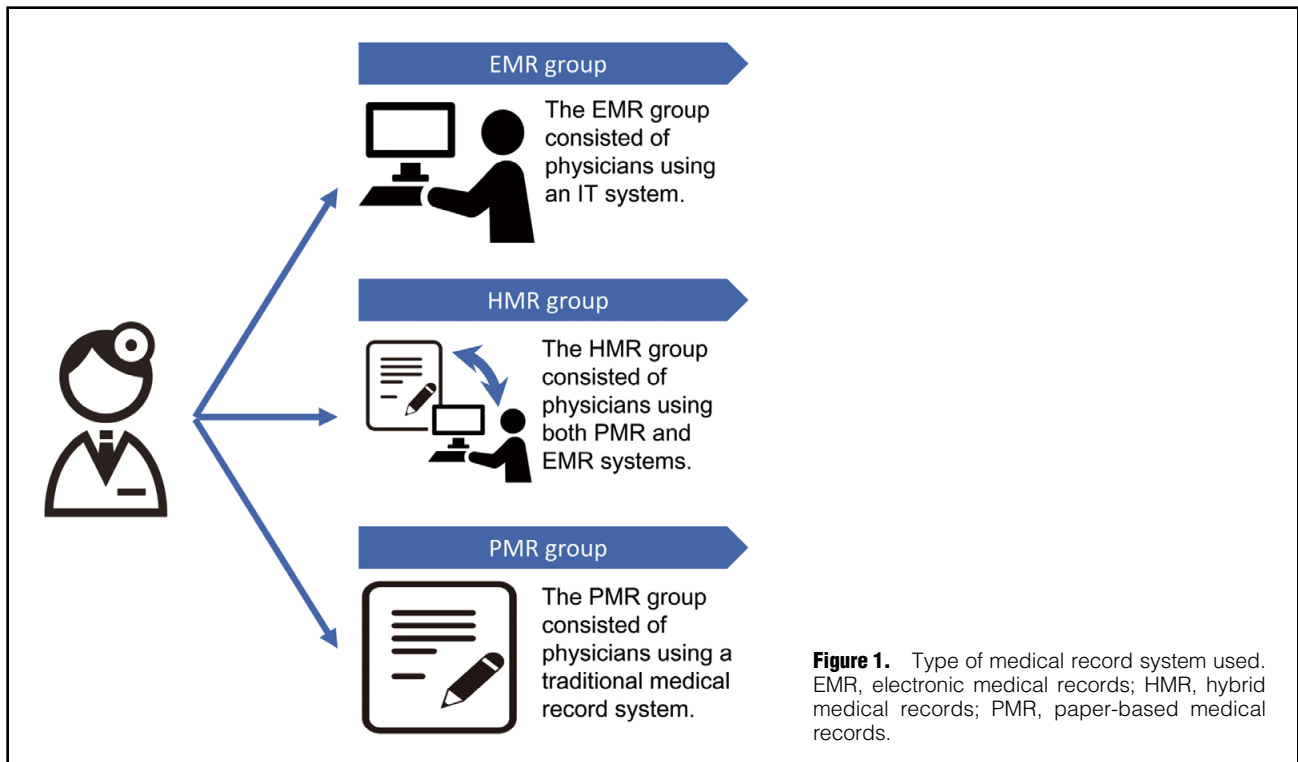
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outpatient department of a medical institution specializing in cardiovascular disease (Sakakibara Heart Institute Clinic), during a 1-week period (consisting of 5 weekdays) in October 2006. The team consisted of 13 physicians (10 men, 3 women) with 10 years or more experience in clinical practice, who worked at least once during the study period in the outpatient department. We prospectively examined a total of 862 outpatient consultations performed by these 13 physicians. A total of 44 patients made a first visit and 818 patients made a return visit. The 862 outpatients consisted of 526 men with a mean age of 72.1 ± 11.6 years and 336 women with a mean age of 74.2 ± 12.0 years. A total of 18.7% of the outpatients were diagnosed with hypertension, followed by 12.8% with angina, 6.8% with arrhythmia, 4.9% with old myocardial infarction (MI), and 3.0% with valvular disease. Because all patients were initially diagnosed and treated by a single cardiovascular physician in the outpatient department, there were no cases of overlap between the physicians.

Informed consent was obtained to conduct the study based on the guidelines of the Council for International Organizations of Medical Science.⁷ The Board Committee of the Sakakibara Heart Institute approved this study.

Medical Record Systems

The medical information system of Sakakibara Heart Institute consists of a reservation system, a management system (e.g., appointments, practice, prescriptions, and tests), and a fee claim system, which are based on the Act Concerning Protection of Personal Information of Japan and the Health Insurance Portability and Accountability Act of 1996 (HIPAA), Privacy and Security Rules of the United States. The EMR system was rated as level 3 (reclassification 3-3) according to the Japanese Association of Healthcare Information System Industry (JAHIS) crite-

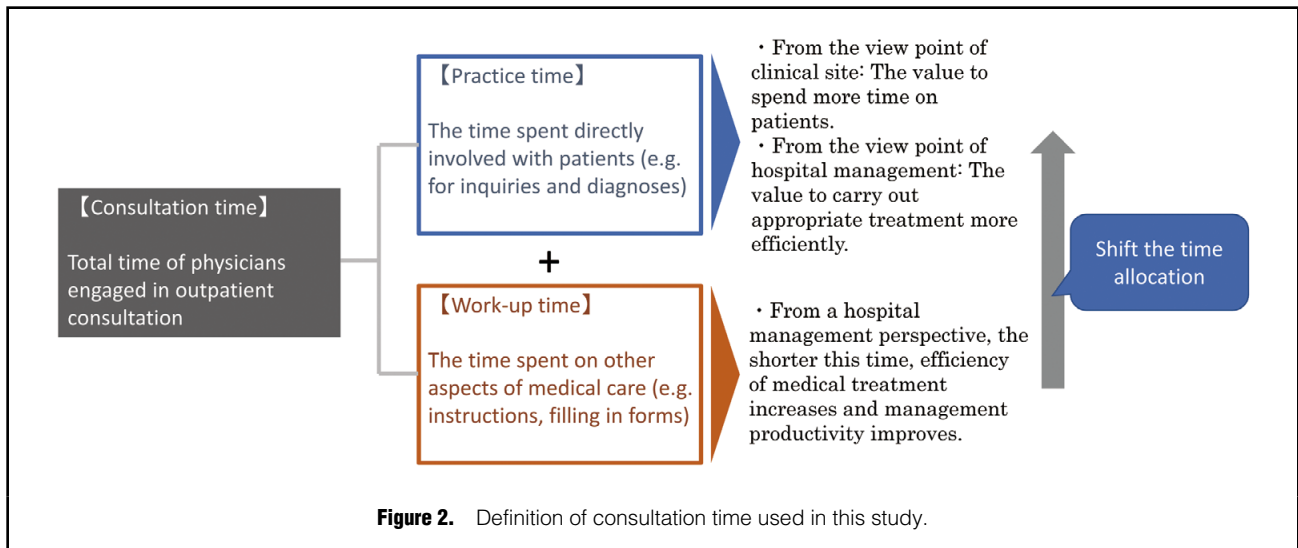
ria.⁸ All physicians selected the type of medical record system they wanted to use, so that the selection of EMR depended on the practice style of each physician.

Measurement of Indicators

We classified the type of medical records into 3 groups. The first group consisted of physicians using a traditional medical record system and was named the paper-based medical record (PMR) group (Figure 1). These physicians gave oral orders for clinical matters to a medical secretary (e.g., ordering laboratory tests making out prescriptions). The second group consisted of physicians using an IT system and was named the EMR group. The third group consisted of physicians using both PMR and EMR systems, and was named the hybrid medical record (HMR) group. This group used an EMR system for ordering laboratory tests and a PMR system for keeping a record of clinical findings.

Consultation time for outpatients was measured in minutes by observers of the physicians engaged in outpatient consultation. This observation was performed in a time study. Consultation time consisted of practice time, that is, time directly involving patients (e.g., for inquiries and diagnoses) and work-up time, that is, time spent on other aspects of medical care (e.g., instructions, filling in forms, ordering laboratory tests and making out prescriptions). This means that work-up time serves as an indicator of operational efficiency of the medical institute (Figure 2).

Total fee claim (i.e., income from health services) was measured as economic output, and consisted of (1) physician fee claims for technical aspects of treatment (e.g., consultation, instructions, diagnoses and testing); and (2) other fee claims for items indirectly involved in treatment (e.g., costs of drugs and materials). Therefore, the total fee claim represents medical income from outpatient consultation (i.e., economic output of clinical practice), and reflects



the complexity and severity of each cardiovascular case. Total fee claims were obtained from medical accounts for individual cases.

Statistical Analysis

We examined the differences in consultation time (practice time and work-up time) and total fee claims between the 3 types of medical record systems (EMR group, PMR group and HMR group).

For this analysis, we also calculated correlations between consultation time and total fee claims stratified by type of medical record in order to determine the production efficiency according to type of medical record for outpatient consultation. Incidentally, we also calculated total fee claims per practice time (as cost-benefit) by type of medical record.

Differences were analyzed with the Wilcoxon rank sum test, and associations, with the Spearman rank correlation coefficient. All statistical tests were 2-sided, and $P < 0.05$ was regarded as statistically significant. SAS, version 9.13 (SAS Institute, Cary, NC, USA) was used for all statistical analyses.

Results

Outpatient Characteristics

We examined the difference in consultation time of cardiovascular physicians according to age, gender and main outpatient disease, and confirmed no statistically significant differences (**Table 1**). The R-squared between age and consultation time was -0.03 ($P=0.31$), and the consultation time per case was 12.4 ± 6.9 min for male patients and 12.3 ± 7.4 min for female patients ($P=0.40$). The respective consultation time was 12.5 min for hypertension, 10.2 min for angina, 12.1 min for atrial flutter, 12.5 min for old MI and 11.9 min for mitral regurgitation ($P=0.29$).

Number of Consultations

Table 2 lists the characteristics of the 3 medical record groups. The mean number (\pm SE) of outpatient consultations per physician was 77.8 ± 14.5 for the PMR group, 34.7 ± 11.4 for the EMR group and 72.8 ± 32.4 for the HMR group.

| Table 1. Patient Characteristics vs. Consultation Time | | |
|--|-----------------|----------------------|
| | Mean \pm SD | P-value |
| Population | | |
| Patients (n) | 862 | |
| Male | 60.1 | |
| Female | 38.9 | |
| Age (years) | 72.3 \pm 11.9 | |
| Male | 72.1 \pm 11.6 | |
| Female | 74.2 \pm 12.0 | |
| Main disease (%) | | |
| Hypertension | 18.7 | |
| Angina | 12.8 | |
| Arrhythmia | 6.8 | |
| Old MI | 4.9 | |
| Valvular disease | 3.0 | |
| Consultation time (min/case) | | |
| Age | | |
| All patients | 12.2 \pm 7.4 | (0.31 [†]) |
| Sex | | |
| Male | 12.4 \pm 6.9 | 0.40 [‡] |
| Female | 12.3 \pm 7.4 | |
| Main disease | | |
| Hypertension | 12.5 \pm 8.9 | 0.29 [§] |
| Angina | 10.2 \pm 4.6 | |
| Atrial flutter | 12.1 \pm 9.7 | |
| Old MI | 12.5 \pm 5.8 | |
| Mitral regurgitation | 11.9 \pm 6.5 | |

Data given as mean \pm SD or %. [†]Spearman rank correlation coefficient; [‡]Wilcoxon signed-rank test; [§]Kruskal-Wallis test. MI, myocardial infarction.

Consultation Time

There were no differences in consultation time between the EMR and PMR groups, but the HMR group had a longer consultation time than either the EMR or the PMR group (**Table 3**): the mean \pm SE (P-value in comparison to the PMR group) of consultation time was 11.4 ± 0.3 min/case

| Table 2. Physician Characteristics | | | | |
|------------------------------------|-----------|-----------|-----------|-----------|
| | PMR group | EMR group | HMR group | Total |
| No. physicians | 6 | 3 | 4 | 13 |
| No. outpatient consultations | 467 | 104 | 291 | 862 |
| No. consultations per physician | 77.8±14.5 | 34.7±11.4 | 72.8±32.4 | 66.3±19.3 |

Data given as n or mean±SE. EMR, electric medical records; HMR, hybrid medical records; PMR, paper-based medical records.

| Table 3. Consultation Time vs. Type of Medical Record System | | | |
|--|-----------|-----------|-----------|
| | PMR group | EMR group | HMR group |
| Consultation time (min/case) | 11.4±0.3 | 12.7±0.8 | 13.5±0.5 |
| P-value | 0.87 | | <0.05 |
| | <0.01 | | |
| Practice time (min/case) | 8.4±0.3 | 10.9±0.6 | 9.3±0.5 |
| P-value | <0.01 | | <0.05 |
| | <0.01 | | |
| Work-up time (min/case) | 2.9±0.1 | 1.7±0.4 | 4.2±0.2 |
| P-value | <0.01 | | <0.01 |
| | <0.01 | | |

Data given as mean±SE.

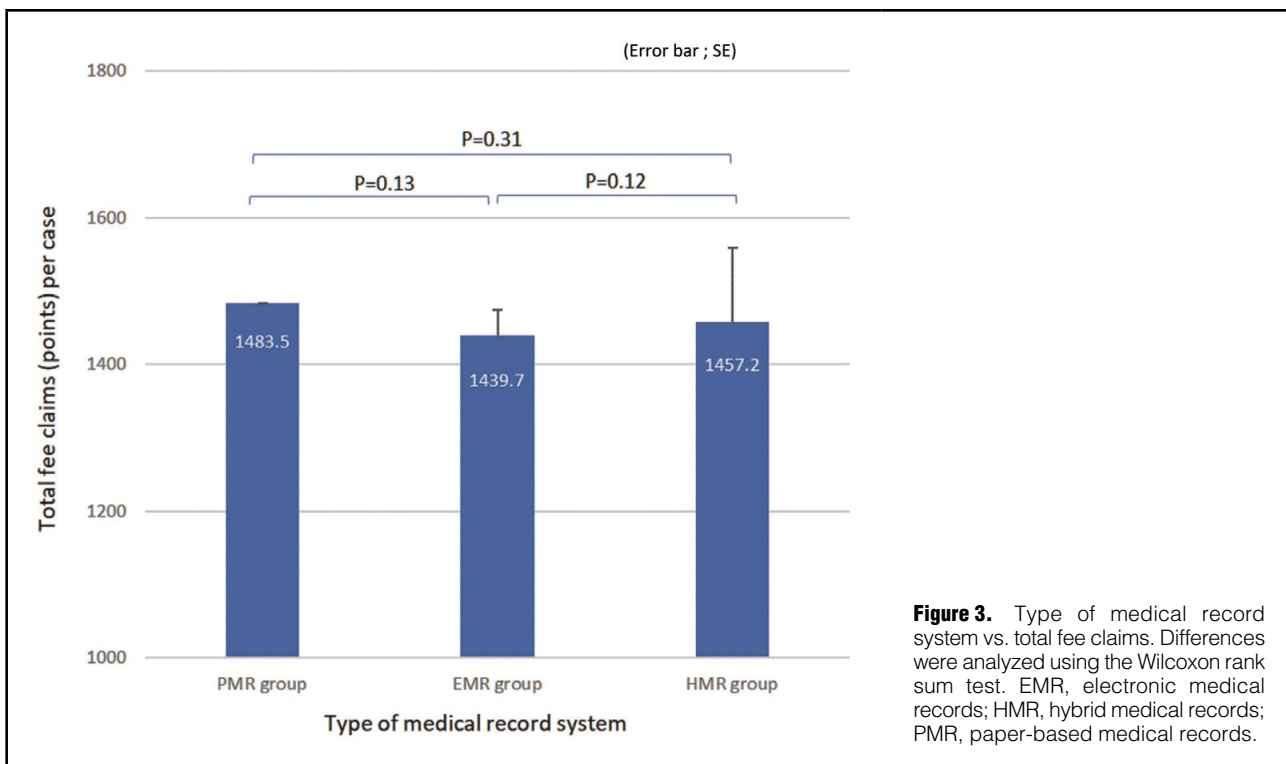


Figure 3. Type of medical record system vs. total fee claims. Differences were analyzed using the Wilcoxon rank sum test. EMR, electronic medical records; HMR, hybrid medical records; PMR, paper-based medical records.

(reference) for the PMR group, 12.7±0.8 min/case (P=0.87) for the EMR group, and 13.5±0.5 min/case (P<0.01) for the HMR group. In contrast, the EMR group had a higher mean practice time (10.9±0.6 min/case) compared with the PMR group (8.4±0.3 min/case; P<0.01) and the HMR group (9.3±0.5 min/case; P<0.05). Moreover, the EMR group had the lowest mean work-up time (1.7±0.4 min/case).

Total Fee Claim

No significant differences were observed in total fee claims between the 3 medical record groups (**Figure 3**): the mean total fee claim was 1,483.5±34.0 points for the PMR group, 1,439.7±101.7 points for the EMR group, and 1,457.2±58.9 points for the HMR group.

Analysis of associations between consultation time and total fee claim according to type of medical record system

Table 4. Total Fee Claims and Consultation Time vs. Type of Medical Record System

| | Correlation between consultation time and total fee claim (R) | P-value | Total fee claims per practice time (points/min) | P-value |
|-----------|---|---------|---|---------|
| PMR group | -0.0084 | 0.84 | 108.8±108.1 | <0.001 |
| EMR group | 0.3411 | <0.01 | 67.5±52.8 | |
| HMR group | 0.0045 | 0.95 | 89.1±78.1 | |

Data given as n or mean ± SD. EMR, electric medical records; HMR, hybrid medical records; PMR, paper-based medical records.

identified a positive association ($r_s=0.341$; $P<0.01$) only for the EMR group (Table 4). Furthermore, on cost-benefit evaluation (total fee claims per practice time), the EMR group (67.5 ± 52.8 points/min, $P<0.001$) outperformed the PMR group (Table 4).

Discussion

The present study provides quantitative evidence that the EMR group had a higher mean practice time and lower mean work-up time than either the PMR or the HMR groups, and there were no differences in consultation time or total fee claims between the EMR and PMR groups. Moreover, we identified a statistically significant association between total fee claims and consultation time only for the EMR group, which indicates that this group has a production function related to economic efficiency. It should be noted, however, that the data used in this manuscript were obtained more than 10 years ago, and also that the current EMR has undergone significant evolution.⁹ Hence, further research is necessary, using contemporary data, to show how the EMR system has progressed and advanced.

Effects of EMR System

For the past quarter of a century, rapid advancements in medical information science have been made. The aim of this advancement was to “help free the physician to concentrate on the tasks that are uniquely human such as the application of bedside skills, the management of the emotional aspects of disease, and the exercise of good judgment in the non-quantifiable areas of clinical care” given that the computer would be “well equipped to store large volumes of information and ingeniously programmed to assist in decision making”.² In fact, a previous questionnaire study suggested that the EMR system leads to an improvement in hospital management through an increase in mobility (i.e., reduction in waiting time and rapid return of clinical reports) and an improvement in hospital finances through an increase in total fee claims and hospital management.¹⁰ Some more recent studies, however, have suggested that use of the EMR system could lead to an increase in time directly involving patients as a result of drastic changes in physician work.^{3,4} It was also suggested that it was important to evaluate the overall effect on hospital management, as well as to evaluate any reduction in the time that physicians use indirectly for patients (e.g., time for maintaining case records). In other words, we have to evaluate the overall effect on the institution, including outcomes of medical services and intangible work product of physicians, and not only the effect of work sharing. Few studies, however, have evaluated the overall effect of use of an EMR system on hospital management.

In short, when evaluating overall optimization, it is important to first focus on administration of the inter-

departmental role of the medical institution, followed by an evaluation of production efficiency of the overall medical resources.

Positioning of the Study

The aim of this study was to examine the effect of the use of EMR on consultation time and total fee claims in order to investigate of the productivity of physicians with regard to outpatient consultation. We therefore looked for associations between type of medical record system and production efficiency in a hospital where physicians themselves select the type of medical record system they use, suggesting that the physicians optimize their use of the medical record system of their choice. Although we found no difference in consultation time between the EMR and PMR systems, we need to further interpret the results on the basis of general management of the medical institution (e.g., restructuring of overall consultation time), as discussed in the previous section.

In terms of management, the current study was conducted in 1 department focusing on outpatient consultation, which results in little variation in clinical treatment and clinical support unrelated to diagnosis, compared with hospitals with several departments. This means that we could not examine the inter-departmental effect of EMR (e.g., effect on work burden in other departments), although the effect on medical professionals other than physicians may be small. Moreover, we could not examine the effect of medical record systems on outcomes of health services and intangible work product of physicians. Further studies are needed to examine these effects of medical record systems on physician productivity.

Residual Confounding

We described the effect of EMR on outcomes of clinical practice, which then led to an evaluation of the production efficiency of physicians. There may thus be residual confounding in the present results related to clinical practice and production efficiency of physicians.

First, production efficiency of physicians may be affected by their characteristics (e.g., experience and specialty) and environment (e.g., working conditions, support and management system), and especially by case mixture (e.g., socioeconomic background and type of symptoms). In this study, the average number of cases per physician was smaller only in the EMR group, which might have influenced the present results. For example, the characteristics of physicians (experience and specialty) have been shown to be associated with consultation time.¹¹ To evaluate the production efficiency of EMR systems for outpatient consultation, we need to take into account the length and extent of experience with a particular medical record system as well as other components of management systems (e.g., medical administration).

Second, to accurately evaluate physician clinical practice, we need to take into account the characteristics of patients, region and institution (e.g., environment of medical record systems and secretarial support) and human resources (e.g., experience and specialty). In other words, we need to match the bias related to the various characteristics with different medical record systems. Given that the current study was conducted in only 1 department, it does not account for any variations in characteristics of the region or the institution. The characteristics of patients and human resources, however, should also be taken into consideration.

With regard to patient characteristics, the present study was conducted in an outpatient department specializing in cardiovascular cases, which involved few variations in case mixture. Hence, we found no difference in consultation time according to age, gender or main disease of outpatients. In clinical practice, outpatients were randomly assigned to a physician at their first visit, which reduces bias related to patient selection. We found that there was no difference in total fee claims associated with clinical practice between the 3 medical record systems: the total fee claims per case were 1,483.5 points for PMR, 1,439.7 points for EMR and 1,457.2 points for HMR. This indicated that there may be little bias related to patient characteristics between the medical record groups.

With regard to human resources, this study was conducted with a physician team consisting of 13 cardiovascular physicians who had ≥ 10 years' experience in clinical practice, which again would result in little bias related to experience and specialty.

As for use of the medical record and other management systems (e.g., medical administration), the physicians themselves selected the medical record system (i.e., they can be assumed to optimize the use of the medical records based on their approach to clinical practice). Thus, the system used may have little effect on the results.

Interpretation of the Findings

We examined associations between medical record systems and consultation time and fee claims for outpatient consultation to determine which system results in the highest production efficiency of physicians engaged in outpatient consultation. We found the following quantitative evidence.

First, EMR may not have any effect on consultation time or total fee claims, but EMR was associated with longer practice time than PMR. Second, the EMR group had shorter work-up time, and there was a strong association between total fee claims and practice time for the EMR group. On the presupposition of a closer examination of the patient's condition, this might suggest that the cost-benefit of the EMR group was superior, although the lower fee claims was not cost-effective for the hospital management. In addition, analysis function related to economic efficiency can be introduced in medical record systems.

The present EMR group had longer practice time than the PMR group, in contrast to a previous study.¹² The latter compared findings before and after introduction of the EMR system, whereas we conducted a parallel comparison of an EMR group and a PMR group during the same period, which may have resulted in a reduction in bias related to time. In contrast, we felt that it was necessary to use a cross-over design for the reason of case mixture. In Japan, there have been no studies using the aforementioned approach, and future research is therefore necessary.

Conclusions

The EMR system was associated with longer practice time than the PMR system, but the type of medical record keeping may not have a major effect on consultation time and total fee claims. We have presented, however, quantitative evidence that physicians using EMR had higher mean practice time and lower mean work-up time compared with physicians using PMR or HMR, whereas there was no difference in consultation time or total fee claims between the EMR and the PMR groups. Physicians using EMR can therefore be more directly involved with patients, as reflected in the lower work-up time.

Acknowledgments

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Disclosures

T.T. is affiliated with an endowed department sponsored by Chugai Pharmaceutical. H.I. declares no conflicts of interest.

Author Contributions

T.T. conceived of and designed the study, and carried out analysis and interpretation of data, and drafting of the manuscript and provided statistical expertise. H.I. participated in acquisition of data, and in drafting of the manuscript and critical revision of the manuscript.

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