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Impact of a New Medical Record System for Emergency Departments Designed to Accelerate Clinical Documentation

A Crossover Study

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Abstract: Recording information in emergency departments (EDs) constitutes a major obstacle to efficient treatment. A new electronic medical records (EMR) system focusing on clinical documentation was developed to accelerate patient flow. The aim of this study was to examine the impact of a new EMR system on ED length of stay and physician satisfaction.

We integrated a new EMR system at a hospital already using a standard system. A crossover design was adopted whereby residents were randomized into 2 groups. Group A used the existing EMR system first, followed by the newly developed system, for 2 weeks each. Group B followed the opposite sequence. The time required to provide overall medical care, length of stay in ED, and degree of physician satisfaction were compared between the 2 EMR systems.

The study involved 6 residents and 526 patients (277 assessed using the standard system and 249 assessed with the new system). Mean time for clinical documentation decreased from 133.7 ± 5.1 minutes to 107.5 ± 5.4 minutes with the new EMR system ($P < 0.001$). The time for overall medical care was significantly reduced in all patient groups except triage level 5 (nonurgent). The new EMR system significantly reduced the length of stay in ED for triage level 2 (emergency) patients (145.4 ± 13.6 minutes vs 184.3 ± 13.6 minutes for standard system; $P = 0.047$). As for the degree of physician satisfaction, there was a high degree of satisfaction in terms of the physical findings support system and the ability to capture images and enter negative findings.

The new EMR system shortened the time for overall medical care and was associated with a high degree of resident satisfaction.

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Abbreviations: ED = emergency department, EMR = electronic medical record.

INTRODUCTION

Overcrowding in emergency departments (EDs) has become a global problem.[1–4] Long lengths of stay in EDs are associated with a low degree of patient satisfaction[5] and poor prognosis.[6] For these reasons, medical personnel have searched for efficient and safe ways to dispense medical care in EDs.[7]

Electronic medical record (EMR) systems have the potential to improve the quality of health care, streamline workflows, and increase efficiency.[8,9] Accordingly, EMR systems have recently begun to be adopted not only in outpatient departments or wards, but also in EDs,[7] and their introduction is also underway in Japan.[10–12] However, when emergency physicians switched from a paper record system to an EMR system, the EMR entries reportedly took more time than paper record entries,[13] and the degree of satisfaction was low.[14]

We have previously shown that 81.4% of hospitals listed as accredited training institutions had EMR systems, and that the desired outcome of using EMR systems in EDs was to shorten the time for clinical documentation.[15] However, we also found that all previous EMRs used in Japan do not focus on clinical documentation. Accordingly, because of the high rate of EMR implementation, we developed an EMR system focusing on clinical documentation to efficiently enter detailed patient information including vital signs, history, present illness, and physical or neurological findings. We introduced and integrated this newly developed EMR system at a hospital where an existing, standard EMR system was already in use. We then evaluated the change in time for overall medical care, length of stay in ED, and degree of physician satisfaction using the new EMR system.

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METHODS

Subjects and Setting

This study was conducted at the JR Tokyo General Hospital on all patients visited at the ED during working hours from October 1, 2014 to November 31, 2014. The study was approved by the Ethics Committee of JR Tokyo General Hospital.

JR Tokyo General Hospital has 2 nonisolation beds and 2 isolation beds in the ED, and 6 nonisolation beds in follow-up observation rooms. During working hours (ie, Monday through Friday, and every alternate Saturday from 8:30 to 17:00 hours), patients who came as walk-ins or via an ambulance were attended by 3 residents and 1 emergency physician who provided supervision. At other times, such as public holidays or days off, 3 specialist physicians from each department and 2 residents were in charge of emergency treatment.

In Japan, emergency hospitals are divided into primary, secondary, and tertiary. Ambulatory patients are usually examined at primary hospitals. If an ambulance is called, patients are transferred to secondary or tertiary hospitals depending on the degree of severity.[16,17] JR Tokyo General Hospital is in charge of primary/secondary emergencies, has 350 to 400 ambulance conductions, and visits 300 to 400 walk-in patients who are examined at the ED each month.

JR Tokyo General Hospital is a catchment area that has a daytime population of approximately 750,000 individuals and is located near Shinjuku Station, which boasts the highest passenger capacity in Japan, with approximately 3,500,000 individuals per day. In addition, there are 6 tertiary hospitals and 6 secondary hospitals in the vicinity.[18]

Software

JR Tokyo General Hospital uses the most standard EMR system in Japan (IBM, NY), which only documents the subjective, objective, assessment, and plan sections of clinical documentation.

The new EMR system was created to record the information in accordance with the patient flow in the emergency room, namely ambulance team information, followed by emergency triage, initial physician assessment, primary complaints, history of present illness, past medical history, physical findings, neurological examination, laboratory data and imaging tests, assessment, plan, and outcome. A function was included to display the required physical exams, past history, and medication when enter the primary complaint, and there were simultaneously viewing at the patient's bedside. The system automatically records the login and input completion time, as well as the times when records are changed. This software was created by RI over 3 years and revised by SI.

The system supports 60 primary complaints, based on the advice of 4 emergency medical specialists (RI, KS, MG, and NY). A function was added to record weather patient history, physical examination, or neurological examination is positive or negative by clicking on a screen. In addition, emergency physicians are often interrupted by new patients or urgent treatments. Therefore, when re-entering the information after completing another duty, we provided users with an overview of areas that had already been completed by simply pressing the summary button.

To incorporate the merits of paper records, we also maintained a handwriting function. Furthermore, we designed the system to capture photographs because these are often important in emergency treatment. The system was created using Filemaker 13 Pro advanced (FileMaker, Inc., CA). In addition, for residents, we also created a table of diseases that should not be overlooked for primary complaints encountered in the ED, and it was divided into ''Critical,'' ''Emergency,'' and ''Nonemergency'' according to the degree of urgency. Only 10 differentiations according to the degree of urgency are described in emergency medicine documents.[19,20] Therefore, we created this table taking into account the opinions of emergency medical specialists (RI, KS, MG, and NY).

Hardware

A FileMaker server was installed on a computer running Windows (HP Elite Desk 800 G1 TWR) as well an iPad (iPad Air, Apple Inc.) equipped with a wireless internet connection. Patient records input via the iPad could also be printed as paper copies and uploaded to the new system in PDF format using a scanner. The records could then be directly uploaded into the hospital's current EMR system. At our hospital, Sugoi Cable Easy Pro (System Talks Inc., Tokyo, Japan) is used to exchange shared files, and records made in the new EMR system preserves the Word (Microsoft Corporation, Washington, DC) format in shared files. EMRs made in the new system were simply copied into the existing EMR system.

Study Design

The time required to enter clinical data of a patient into the EMRs, and for the overall medical care, depends on the experience of each physician. Therefore, a crossover design was adopted whereby residents who had been training for 1 month in the ED were randomly divided into 2 groups. Group A used the existing EMR system first, followed by the newly developed system, for 2 weeks each. Group B used the newly developed EMRs first, followed by the existing EMR system, for the same duration. The 6 residents who participated in the study had a mean age of 26 ± 6 years, were predominantly male (5/6, 83.3%), and had trained for a mean period of 10.7 ± 4.4 months after the start of residency. A trial period using the new EMR system was not provided.

Data Analysis and Outcome Parameters

To ensure that patients documented using the standard EMR system and the new EMR system had comparable baseline characteristics, they were compared for age, sex, illness, admission conditions, and triage level.

The main outcome parameters under investigation were time for overall medical care and degree of physician satisfaction. The secondary outcome parameters were rate of admission in order to determine whether the new system significantly improved patient flow and reduced overcrowding in EDs, as well as the number of specialist consultations, admission rate, and mortality at 28 days after hospitalization.

The overall medical care and length of stay in ER may differ according to the patient's level of triage. Accordingly, in this study, we decided to stratify and examine patients by triage level. We used the Japanese Triage and Acuity Scale to assess the degree of severity, which is based on the Canadian Triage and Acuity Scale.[21–23]

The start of medical treatment was defined as the time when a patient arrived at the hospital just after a resident briefly performed triage and interviewed the patient. Time for overall medical care was measured from the start of medical treatment until the final entry was made in clinical documentation. Length of stay in the ED was measured from the start of medical

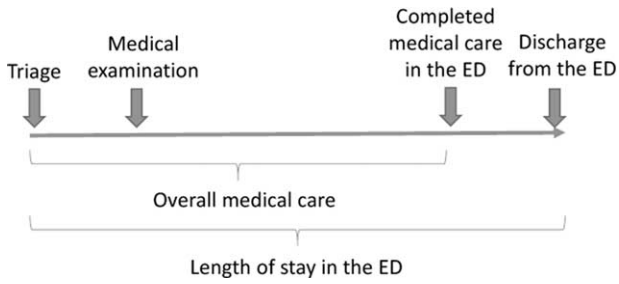

FIGURE 1. Patient flow, definition of overall medical care, and length of stay in the emergency department.

treatment until the patient was discharged from the ED (Figure 1).

All 6 residents were asked to compile a questionnaire after 1 month training in the ED. The questionnaire was created in reference to previous reports[24,25] using a five-point Likert scale, whereby a score of 1 indicated a low level of satisfaction and a score of 5 indicated a high level of satisfaction.

Statistical Analysis

Statistical analysis was designed to compare the standard and new EMR systems. Continuous parameters were expressed as mean and standard deviation or extreme values, and independent *t* tests were conducted to compare groups. Categorical variables were expressed as frequencies and percentages, and chi-squared tests were conducted to compare the groups. All analyses were performed with STATA 13.1 (Stata Corporation, College Station, TX). The threshold for significance was set at $P < 0.05$.

RESULTS

Patient Characteristics

A total of 526 patients were included in this study, including 277 assessed using the standard EMR system and 249 assessed using the new system (Table 1). The 2 groups had comparable characteristics in terms of age, sex, type of admission, and triage profile.

Impact of the Newly Developed EMR System

Table 2 shows that on average, residents saved about 25 minutes of overall medical care using the new EMR system compared to the existing EMR system (133.7 ± 5.1 vs 107.5 ± 5.4, $P < 0.001$). An analysis based on stratifying patients by level of triage revealed significantly shorter times for overall clinical care with the newly developed EMR system in all groups, except level 5 (nonurgent).

In general, the length of stay in the ED was not significantly affected by the type of EMR system ($P = 0.295$). However, the length of stay in ED was significantly decreased with the new EMR system (184.3 ± 13.6 vs 145.4 ± 13.6, $P = 0.0473$) for level 2 (emergency).

Satisfaction Questionnaire

The questionnaire compiled by the 6 residents showed that, in most cases, the new EMR system was assessed favorably. In particular, there was a high degree of satisfaction in terms of a support system for physical findings and the ability to capture images and enter negative findings (Table 3). In addition, their responses indicated willingness to use the system in the future because of potential reduction in oversights, its utility in training, and the presence of a differential diagnosis table. Some responders indicated that the time needed to perform physical examination increased.

Patient Outcomes

There were no significant differences between the standard and newly developed EMR system in the proportion of consultations (16.3% vs 17.7%, $P = 0.663$), admissions (13.7% vs 16.1%, $P = 0.450$), or 28-day mortality rate (0.7% vs 0.4%, $P = 0.622$).

DISCUSSION

Summary of Findings

The newly developed EMR system for EDs was shown to reduce the time needed for overall medical care of patients entering the ED and had a high degree of user satisfaction. To the best of our knowledge, this is the first study investigating the integration and implementation of a newly developed EMR system in an ED.

Furthermore, in terms of level 2 (emergency) patients, the EMR system was associated with a decrease in the time needed for overall medical care, in addition to length of stay in ED. Such a system would be extremely useful in EDs that handle more severe patients, especially considering that patients in this category have increased mortality during longer emergency room stays.[26,27]

TABLE 1. Baseline Characteristics of Patients Assessed With the Standard and New Electronic Medical Record (EMR) Systems

Variable	Patients Assessed by Standard EMR	Patients Assessed by New EMR	*P*
Number enrolled	277	249	
Consultation days	25	21	
Median age (years) (mean ± SD)	52.8 ± 1.48	49.8 ± 1.56	0.160
Sex (male, %)	123 (44.4)	131 (52.6)	0.060
Ambulance/walk-in patients	178/99	177/72	0.095
Triage category			0.206
Level 1 (resuscitation)	0	0	
Level 2 (emergency)	31	32	
Level 3 (urgent)	146	136	
Level 4 (less urgent)	62	61	
Level 5 (nonurgent)	38	20	

TABLE 2. Comparison of the Standard and New Electronic Medical Record (EMR) Systems

	Standard EMR (min, mean ± SD)	New EMR (min, mean ± SD)	*P*	Reduction in Time (min, mean ± SD, %)
Time for overall medical care, min	133.3 ± 5.0	107.5 ± 5.4	<0.001	25.8 ± 7.4 (19.4)
Triage category				
Level 2 (emergency)	168.0 ± 12.9	124.0 ± 13.1	0.020	44.0 ± 18.4 (26.2)
Level 3 (urgent)	148.9 ± 6.6	127.6 ± 6.9	0.026	21.4 ± 9.5 (14.4)
Level 4 (less urgent)	124.3 ± 10.8	76.0 ± 10.9	0.002	48.3 ± 15.4 (38.9)
Level 5 (nonurgent)	61.1 ± 10.9	47.1 ± 15.1	0.456	14.0 ± 18.7 (22.3)
Length of stay in emergency department, min	119.5 ± 4.4	112.8 ± 4.7	0.295	6.7 ± 6.4 (5.6)
Triage category				
Level 2 (emergency)	184.3 ± 13.6	145.4 ± 13.6	0.047	38.8 ± 19.2 (21.1)
Level 3 (urgent)	133.5 ± 5.7	128.8 ± 6.0	0.575	4.6 ± 8.3 (3.4)
Level 4 (less urgent)	96.2 ± 7.7	83.7 ± 7.8	0.255	12.5 ± 10.9 (13.0)
Level 5 (nonurgent)	51.2 ± 6.5	42.9 ± 9.0	0.456	8.3 ± 11.1 (16.2)

SD = standard deviation.

Degree of Satisfaction for Physicians

The overall degree of satisfaction for physicians with the new EMR system was high. In addition to providing a shorter time for clinical documentation, user satisfaction is extremely important.[14] There was an extremely high degree of satisfaction in terms of the ability to enter negative findings. In fact, one of the unique functions of our new system was the ability to easily enter negative findings (ie, no abnormalities in examination results or physical findings).

EMR systems used to date have included positive findings (ie, abnormalities identified during physical examination). However, emergency physicians are usually time-constrained, and although they identify negative findings during physical

TABLE 3. Results of Questionnaires Used to Evaluate Satisfaction of Residents Regarding the New Electronic Medical Record (EMR) System*

System Quality	Mean ± SD
The new system was easy to use	3.3 ± 1.2
The new system shortened the time of overall medical care	4.0 ± 0.63
The new system increased the efficiency of medical care	4.2 ± 0.75
The support system for physical examination was useful	4.7 ± 0.52
The function allowing insertion of photographs was useful	5.0 ± 0.0
The ability to use handwriting was useful	4.2 ± 0.98
Recording of negative findings was useful	4.2 ± 0.98
The ability to access previously input information in 1 step by sliding the screen was useful	4.5 ± 0.55
User satisfaction	
I am generally satisfied with new EMR system	4.3 ± 0.52
Mistakes can be reduced with the new system	4.5 ± 0.55
The new system is useful for training	4.7 ± 0.52
I would like to use the new system in the future	4.3 ± 0.82
Use of information	
The differential diagnosis table was useful	4.5 ± 0.84
I often use the previous patient search function	3.7 ± 0.82
Individual attributes	
The nature of consultations has changed through the use of the new system	3.7 ± 0.52
Time until diagnosis has been shortened by the new system	3.5 ± 0.55
Patient conversations have increased with the new system	3.0 ± 0.89
Patient examination time has increased with the new system	3.7 ± 1.0
Time for physical examination has increased with the new system	4.2 ± 0.75
Organizational impact	
Conversations between medical staff have increased with the new system	4.0 ± 0.89
Handovers between medical staff have become more streamlined with the new system	4.0 ± 0.89

SD = standard deviation.
* A score of 1 indicates a low level of satisfaction and a score of 5 indicates a high level of satisfaction.

examination, they do not usually mention this in clinical records.[28] This gap in documentation may, on occasion, cause subsequent problems during inquiry into a medical accident because the examination results were not committed as evidence.[29] Accordingly, this new ability to enter negative findings in the EMR system is extremely important to emergency physicians who have limited time.

Furthermore, we added a function to the new system that displayed physical findings to be noted with a particular primary complaint. This was done not only for physician satisfaction, but also for contributing to patient safety. In combination with the differential diagnosis table, this tool may be useful for both training of interns and in clinical studies. In addition, this system has now been developed for nurses.

Patient Outcome

No significant differences were observed between patient outcomes using the existing and new systems. However, the purpose of this study was to chronologically investigate the introduction of a new EMR system by evaluating changes in physician performance and differences in patient outcomes. Future investigations involving multiple institutions, longer duration, and larger sample size will be required to assess whether the increase in physician performance seen herein is associated with actual improvement in patient outcomes.

Costs and System Integration

We built the EMR system with a focus on clinical documentation using FileMaker. If a personal computer and wireless environment are available for the FileMaker server, the overall costs are low. Even including several iPads, printers, and scanners, the system can be built for less than 5000 US dollars, and it can easily be connected to the readymade EMR with a cable. In addition, emergency medical care varies depending on the hospital, thus EMR needs will also vary. The low cost of implementing quick changes to the system is considered a huge benefit.

LIMITATIONS

There are some limitations to this study. First, the study was conducted at a single center, and in the future, multiple centers will be needed for better evaluation of the new EMR system. Second, the investigative period and number of residents who participated in the study were both low. The impact of the new system could thus be better understood by increasing the study duration and number of residents participating in the study. Third, the resident questionnaire may have increased bias toward the new EMR, and the number of participating residents was low; accordingly, additional external validation is needed. However, once residents used the new EMR system, they preferred to use it compared with the existing system. Finally, because the study did not specifically investigate improvements in patient outcomes, this needs to be assessed by long-term and large-scale studies.

CONCLUSIONS

This pilot study supports the use of this new EMR system that acquires clinical data using FileMaker. The new EMR system considerably shortened the time required to record clinical data and provide appropriate treatment to most patients admitted to the ER.

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