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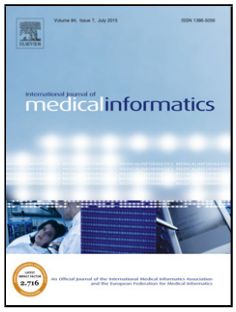

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Interface design dividing physical findings into medical and trauma findings facilitates clinical document entry in the emergency department: a prospective observational study

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HIGHLIGHTS

・The interface design and its effect on workflow are key determinants of the usability of electronic medical records, and poor user interface design has been reported to pose a threat to patient safety.

・Dividing the interface design of physical findings into medical and trauma findings was effective for shortening the time for clinical documentation for trauma patients.

・None of the other factors, such as electrocardiography, blood tests, imaging studies, and/or procedures, changed during the study period, suggesting that dividing the interface design of physical findings into medical and trauma findings may help increase the time of direct patient care.

Abstract

Purpose

The interface design and its effect on workflow are key determinants of the usability of electronic medical records (EMRs) in the emergency department (ED). However, whether the overall clinical care can be improved by dividing the interface design of physical findings into medical and trauma findings is unknown. We previously developed an EMR system in which the checkpoints were separated into different sections according to the body part. Herein, we modified this EMR system by remaking the interface design specifically for trauma patients, and evaluated its performance.

Methods

This study was undertaken in a single-center ED between October 2014 and September 2015. In the modified EMR system, all trauma findings are displayed together on the screen, according to the Japan Advanced Trauma Evaluation and Care. We compared the time to final documentation entry and the length of ED stay between the previous (used in the first 6 months) and current systems (used in the latter 6 months). Furthermore, we stratified the patients by triage levels.

Results

The study involved 2141 patients (934 and 1207 assessed using the previous and modified EMR systems, respectively). The modified EMR in trauma patients significantly decreased the time to final documentation entry from 131.5 [interquartile range, 86.8-207.3] to 115 [78.8-161] min (p=0.049). When stratifying trauma patients by triage level, significantly shorter clinical documentation times were observed with the modified EMR system in levels 2 (emergency) and 3 (urgent).

Conclusions

Using different interfaces for trauma findings shortened the time for clinical documentation for trauma patients.

Keywords: emergency care systems, patient support, prehospital care, critical care transport

Abbreviations: ED, emergency department; EMR, electronic medical record; IQR, interquartile range.

1. Introduction

Promptly available high-quality electronic medical records (EMRs) and information-sharing after a patient encounter are essential in the emergency department (ED) [1, 2], because they facilitate the clinical evaluation process, management, and medical decision-making, thereby leading to increased efficiency and patient safety [3, 4].

Recently, ED care has become increasingly complex with the growing demands for multidisciplinary care, high efficiency, high quality, and timely patient treatment; however, malpractice claims are also becoming more common [5], indicating the need for high-quality EMRs in the ED. As a result, EMRs now take up a large proportion of the physicians' working time [6-9]. Thus, it is critically important to satisfy the need for high-quality efficient EMRs that can be completed by ED physicians simultaneously while performing a number of clinical examinations. However, there has been almost no formal research on developing appropriate and more effective EMR systems [10].

We previously developed an EMR system focusing on clinical documentation to efficiently enter detailed patient information, including vital signs, medical history, present illnesses, and physical and/or neurological findings, and this information was monitored and shared among the ED staff. Moreover, we recently introduced and integrated this EMR system at a hospital where an existing, standard EMR system was already in use, and our pilot study showed that our EMR system shortened the time for clinical documentation and was associated with a high degree of physician satisfaction [11].

The interface design and its effect on workflow are key determinants of usability, and poor user interface design has been reported to pose a threat to patient safety [12]. In fact, the user interface is one of the most important factors influencing the

willingness of physicians to use the EMR system and to follow the intended use, which is assumed to promote safe habits. Thus, this is an extremely important, although oft-ignored, aspect of EMR deployment that has important consequences for both the physician's wellness and the patient safety.

In the ED, patients often have not only trauma, but also associated medical problems (e.g. head trauma after syncope). Our previous EMR system was developed according to the physical examination findings, with physical findings first grouped according to region (e.g. head, eye, ear, neck, and chest), irrespective of whether they were medical- or trauma-related (Figure 1). In the present study, we modified our previous EMR system, focusing specifically on trauma, by creating a "trauma button." When this button is tapped, a separate screen shows all trauma findings at the same time in a matrix (Figure 2). Subsequently, we evaluated the differences in the time to the final documentation entry and the length of ED stays using the previous and new systems over a long time period.

2. Methods

2.1. Subjects and setting

In Japan, emergency hospitals are divided into primary, secondary, and tertiary hospitals. Ambulatory patients are usually examined at primary hospitals. If an ambulance is called, the patients are generally transferred to a secondary or tertiary hospital depending on the severity of their condition [13-15]. This study was conducted at a single hospital in charge of primary/secondary emergencies. This hospital handles approximately 350–500 ambulance transfers per month. All patients, transported via ambulance, who visited the ED during working hours (i.e., Monday through Friday, and every alternate Saturday from

8:30 to 17:00 h) from October 1, 2014 to September 30, 2015, were included in this study. These patients were attended by three residents and one emergency physician who provided supervision. The resident program includes a three-month rotation in the ED.

The study was approved by the Ethics Committee of our hospital. During the study period, the single emergency physician, nurses, shifts of the staff, and trauma care did not change.

2.2. Study design

We have previously developed an EMR system focusing on clinical documentation [11]. This previous system includes 3 specific functions. First, the chief complaint is tapped in on one page, and the system supports the physician by showing the necessary physical exams in red-colored body parts and red-colored text (Figure 1). This system does not force the physician to input the necessary physical exams, but rather provides support. Second, this system supports 60 primary complaints. In addition, for residents, we also created a table of differential diagnoses, divided into three categories, namely “Critical”, “Emergency”, and “Non-emergency”, as a means to avoid any diagnosis being overlooked. Finally, the physician can operate this system while at the patient’s bedside by using an iPad. After the patient information is entered into the system, the system automatically creates a clinical documentation.

In the modified system, a “trauma button” shows all trauma findings at once (Figure 2). The trauma findings were categorized according to the Japan Advanced Trauma Evaluation and Care, which has been converted from The Advanced Trauma Life Support.

Herein, the previous EMR system was first used, followed by the modified EMR system, for 6 months each. There were no trial periods for using the previous and modified EMR systems before the initiation of this study.

2.3. Data analysis and outcome parameters

To ensure that patients documented using the previous and modified EMR systems had similar baseline characteristics, the age, sex, admission rate, and triage level of the patients each day were compared. The main outcome parameters were the time to final documentation entry and the length of ED stay.

The start of documentation entry was defined as the time when a patient arrived at the hospital; thus, the time to final documentation entry was measured from the start of a patient's arrival until the final entry was made. The length of stay in the ED was measured from the time of patient arrival until the patient had completed ED care and was discharged/expired/transferred to another department for inpatient care. All residents working in the ED during the study period had three month's training in the ED, and had attended a trauma lecture in their first week of ED training.

First, we stratified the patients by medical and trauma groups. When a patient presented with both medical and trauma problems, we classified them into the trauma group. Second, as the time to final documentation entry and length of ED stay may differ according to the patients' level of triage, we moreover stratified and examined the 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 [16-18].

2.4. Statistical analysis

Continuous parameters are expressed as the mean and standard deviation, compared using independent t-tests, or as the median [interquartile range (IQR)], compared using the Wilcoxon-Mann-Whitney test. For categorical variables, the proportions of patients in each category were calculated and the groups were compared using Pearson's chi-squared test. All analyses were performed with STATA 13.1 software (Stata Corp., College Station, Texas, United States). The threshold for significance was set at $p < 0.05$.

3. Results

3.1. Patient characteristics

A total of 2141 patients were included in this study, including 934 assessed using the previous EMR system and 1207 assessed using the modified system (Table 1). The number of days examined were 106 and 134 days, respectively. The two groups had comparable characteristics.

3.2. Impact of the interface design splitting physical findings into medical and trauma findings in medical and trauma patients

In trauma patients, the modified EMR system saved approximately 15 min of documentation entry time compared to the previous EMR system (115 [IQR, 78.8-161] vs. 131.5 [IQR, 86.8-207.3] min, $p = 0.049$; Table 2). Analysis based on stratifying the trauma patients by level of triage revealed significantly shorter times for the overall clinical care with the modified EMR system in level 2 (emergency) and 3 (urgent) patients (108 [IQR, 73-163] vs. 165 [IQR, 110-353] min, $p = 0.049$; 120 [IQR, 90-158] vs. 172 [IQR, 104-248] min, $p < 0.001$, respectively).

In medical patients, the time to final documentation entry was significantly shorter in level 2 patients (130.3 [IQR, 100-185.5] vs. 171 [119-208] min, p = 0.015). The length of ED stay in both medical and trauma patients did not significantly differ in any of the triage levels.

4. Discussion

4.1. Summary of findings

The modified EMR system for trauma patients in the ED was shown to reduce the time to final documentation entry, especially for level 2 (emergency) and 3 (urgent) patients. To the best of our knowledge, this is the first study dividing the overall physical findings into medical and trauma findings, and evaluating a modified EMR system according to this interface design in an ED.

4.2. Impact of our modified EMR system

We found that the modified EMR system could shorten the time to final documentation entry, especially for high triage level trauma patients. In contrast, the length of ED stay, which includes physical examination, electrocardiography, blood tests, imaging studies, and/or procedures, in trauma patients did not significantly differ in any of the triage levels. As none of these factors changed during the study period, our findings indicate that the modified system decreased the time needed for clinical documentation, because these factors are rate-determining steps.

In addition, in the previous system, the residents would not complete the physical exam charting until after the trauma patient left, when they had some free time. With the modified system, they could complete the physical exam documentation in real-time during the trauma care.

The fact that the modified EMR did not change the length of stay is important to note. The greatest threats to patient safety have been reported to occur during the initial implementation of a system [19]. Recent studies showed that a newly introduced EMR in the ED required more time than paper record entries [20], and that the degree of satisfaction was low [21]. Thus, we consider our modified EMR to have simple and intuitive data displays.

Further, more time for direct patient care is critically important. As some reports have stated that patient satisfaction is related to increased communication and longer physical examinations, this may play a role in improving the patient–physician relationships and reduce medical malpractice claims [22]. Our previous questionnaire-based study evaluating satisfaction showed that the time for physical examination increased with the previous EMR system [11]. Thus, our modified system may help further decrease the time for clinical documentation and help increase the time of direct patient care.

4.3. Impact of the interface design splitting physical findings into medical and trauma findings

We found that dividing the interface design of physical findings into medical and trauma findings was effective. In the ED, patients often have not only trauma, but also medical problems, and we had therefore previously grouped the physical findings according to

each region; however, in the present study, we found that, for trauma cases, having all physical findings in full view was very effective for ED physicians.

In addition, for medical patients, we found that the time to final documentation entry was significantly shorter times in level 2 patients. By separating the medical and trauma physical finding screens, the physician may more easily tap the target physical findings button in patients in severe condition.

The user interface is one of the most important factors influencing the willingness of physicians to interact with EMRs and to follow the intended use, which is assumed to promote safe habits [19]. Thus, the interface design is a key determinant of usability and patient safety.

4.4. Costs and system integration

Currently, commercial electronic health record systems (including EMR, order, and clinical decision support systems) designed by the health industry are commonly used, and modifications of these will likely be required to meet the needs of health professionals; however, this is associated with immeasurable costs and an enormous amount of time. In the present study, we created the modified system using FileMaker 13 Pro advanced (FileMaker, Inc., Santa Clara, California, United States), which can both be promptly changed by requests of the ED staff and is associated with low costs. In addition, emergency medical care varies between hospitals, and the EMR needs will hence also vary. The low cost of implementing quick changes to the system is considered a huge benefit of the above approach. The EMR system is used to exchange shared files within a hospital, and records made in the modified EMR system preserve the Word format of the shared files; moreover, the EMRs created in the modified system were simply copied

into the preexisting EMR system. Thus, when integrating the hospital EMRs, the time for clinical documentation is further decreased using our modified system.

4.5. Limitations

There are some limitations to this study. First, the study was conducted at a single center, and, in the future, multi-center studies will be needed to better evaluate the modified EMR system, especially in tertiary hospitals. Accordingly, we recently introduced this system to a tertiary hospital, and are currently awaiting the results. Second, this study did not specifically investigate improvements in the patient outcomes, and this needs to be assessed by long-term and large-scale studies in the future. Third, there may be seasonal differences. However, there were no differences in the number of patients and triage categories between the two study periods in the present study. In addition, the residents' training period was started in April, while the study was initiated in October, meaning that the residents did not work only in the ED and that there was no trial period for using the modified EMR system. Nevertheless, this study showed that the modified EMR system can reduce the time for overall clinical care in trauma patients.

4.6. Conclusion

In summary, we here showed that our modified EMR system shortened the time for clinical documentation, especially in level 2 and 3 trauma patients. The use of different interfaces of physical findings for medical and trauma findings was effective.

Authors' contributions:

R.I. conceived the study. R.I., M.I., and H.S. performed the statistical analyses. R.I. wrote the first draft of the study. R.I. and S.I. modified the electronic medical record system. R.I., H.M., S.I., Y.Y., T.A., and M.Y collected the data. K.N., K.D., and N.M. critically reviewed the manuscript. All authors contributed to the design, interpretation of the results, and critical revision of the article for intellectually important content.

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Declarations of interest: None.

Summary points

What was already known on the topic?

・The interface design and its effect on workflow are key determinants of the usability of electronic medical records, and poor user interface design has been reported to pose a threat to patient safety.

What this study added to our knowledge?

・Dividing the interface design of physical findings into medical and trauma findings was effective for shortening the time for clinical documentation for trauma patients.

・None of the other factors, such as electrocardiography, blood tests, imaging studies, and/or procedures, changed during the study period, suggesting that dividing the interface design of physical findings into medical and trauma findings may help increase the time of direct patient care.

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Figure Legends

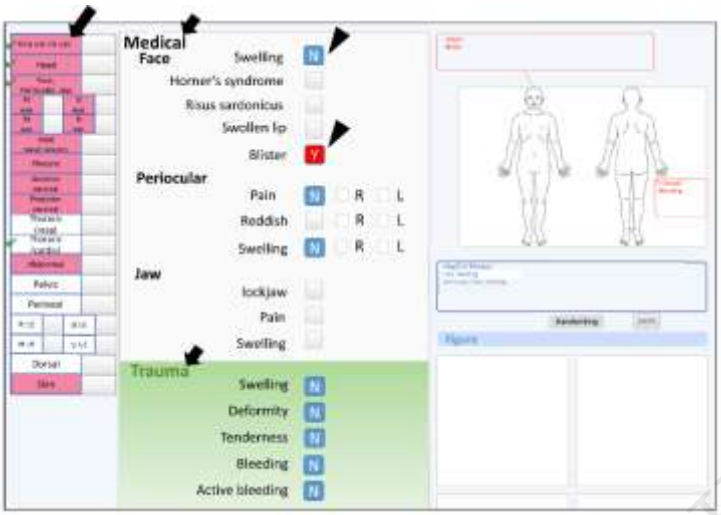

Figure 1.

Representative image of the previously developed electronic medical record (EMR) system. When you tap a region (e.g. the head, eye, ear, neck, or chest) (long arrow), the physical findings of medical and trauma are subsequently separated within each list (short arrows). The physical findings are labeled as positive or negative by clicking on the screen (arrowheads). Usually, the system is written in Japanese.

Figure 2.

The modified electronic medical record (EMR) system. When you tap the "trauma button," a separate screen shows all trauma findings at the same time in a matrix.

Table 1. Characteristics of the Patients Assessed with the Previous and Modified Electronic Medical Record (EMR) Systems

	Previous EMR	Modified EMR	P-value
Number enrolled	934	1207	
Number of days examined	106	134	
Patients each day			
Number (mean ± SD)	8.8 ± 0.2	9.0 ± 0.3	0.59
Medical	6.5 ± 0.2	6.5 ± 0.2	0.82
Trauma	2.3 ± 0.2	2.6 ± 0.2	0.29
Age (years, mean ± SD)	53.4 ± 1.1	50.9 ± 0.9	0.077
Male (%)	48.5	50.5	0.44
JTAS (median, [IQR])	3 (2.5-4)	3 (2.5-4)	0.62
Admissions (mean ± SD)	1.7 ± 0.1	2.0 ± 0.1	0.072

JTAS; Japanese Triage and Acuity Scale; IQR, interquartile range; SD, standard deviation.

Table 2. Comparison of the Previous and Modified Electronic Medical Record (EMR) Systems

	Medical			Trauma		
	Previous EMR (min, median [IQR])	Modified EMR (min, median [IQR])	P-value	Previous EMR (min, median [IQR])	Modified EMR (min, median [IQR])	P-value
Time for overall clinical care						
All	145.5 (98.4-199)	133.9 (98-188)	0.23	131.5 (86.8-207.3)	115 (78.8-161)	0.049
Triage category						
Level 2 (Emergency)	171 (119-208)	130.3 (100-185.5)	0.015	165 (110-353)	108 (73-163)	0.049
Level 3 (Urgent)	150.8 (119.9-204.2)	146.9 (111.1-190)	0.73	172 (104-248)	120 (90-158)	< 0.001
Level 4 (Less urgent)	105 (68-157)	107 (104-181.5)	0.74	96 (67-159)	103 (75.5-166)	0.38
Time for ED stay						
All	132.9 (10-173.7)	138.5 (108.7-171)	0.37	118 (84.5-168.5)	121 (86-162)	0.90
Triage category						
Level 2 (Emergency)	147.5 (119.7-198)	144 (119-200)	0.93	113.5 (74-171)	164 (117-195)	0.17
Level 3 (Urgent)	144.5 (118.5-173.7)	145.6 (125.4-173.7)	0.41	150.8 (115-192.8)	130 (103.3-178)	0.13
Level 4 (Less urgent)	89.6 (76-127)	109.5 (88-140.5)	0.051	99 (61-137.5)	109 (65-159.5)	0.45

ED, emergency department; IQR, interquartile range.