A Hybrid Electronic Health Record System Integrating Electronic and Paper-based Records

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Abstract

Objectives: Ordinary electronic health record (EHR) systems have difficulty managing paper-based medical records because digitized paper-based records must be browsed with a viewer other than the main display for the EHR system. Because of this "fragmentation" of electronic and paper information, it is difficult to combine keyboard/mouse input with handwriting input in a clinical setting. We developed a new EHR system to address this problem.

Methods: We revised a commercial EHR system to function as a progress note system that integrates keyboard/mouse-based electronic records with digitized paper-based records, both of which can be viewed in a page-turning style. In this system all records, including paper-based records, are arranged in relation to the time they were written, even when they were digitized later at a scanning center. These features of the system allow for combined use of handwritten and keyboard/mouse input, without fragmentation. We investigated the impact of the introduction of the first EHR system in the ophthalmology department at our hospital, which had long resisted implementation of an EHR system.

Results: The number of ophthalmology outpatients did not significantly decrease after introduction of the system. The ophthalmologists in our hospital accepted the first EHR system without negative reactions, and a gradual transition from handwritten input to keyboard/mouse input was noted.

Conclusions: The present system enables users to produce flexible medical documentation, by using both keyboard/mouse and handwriting inputs, without reducing medical efficiency or safety. This is a cost-efficient, true hybrid digital–analog EHR system.

Keywords

Electronic health records; Paper-based record; Handwriting; Ophthalmology

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1 Introduction

Adoption of electronic health record (EHR) systems has been rapidly accelerating because of the potential for such systems to improve delivery, quality, and efficiency of health care [1]. However, a fundamental shortcoming of EHR systems is the difficulty in managing paper-based medical records such as handwritten medical charts, interview sheets, referral forms by other medical institutions, and informed consent forms with patient signatures [2]. Paper-based records are usually digitized by a scanner and browsed with a viewer other than the main display for the EHR system [3]. In other words, keyboard/mouse-based electronic records and paper-based records cannot be viewed in the same way, a situation referred to as "fragmentation" of electronic and paper information (Figure 1). Because this situation reduces the efficiency and safety of health care, it is difficult to combine keyboard/mouse input with handwriting input in clinical settings [4].

Some doctors still prefer classical handwriting input to keyboard/mouse input in medical documentation and

are reluctant to use an EHR system. As a method of producing narrative progress notes, handwritten input has definite advantages over keyboard/mouse input. Keyboard input is slower than handwriting [5, 6]. In addition, keyboard/mouse input records are inherently more restrictive as compared with handwritten sketches or diagrams on paper; therefore, keyboard/mouse input progress notes often have fewer graphic representations [5, 6, 7, 8]. Electronic records are more likely to include copied and repetitive notes [5, 9]. Some reports indicate that constant use of a keyboard and a mouse results in less eye-to-eye contact between doctors and patients [4, 10, 11]. Therefore, some physicians consent to the adoption of an EHR system only if it permits handwriting on paper.

C-Note (FINDEX Inc., Tokyo, Japan) is a progress note system developed to respond to such doctors' requests, in which various types of medical records can be viewed in a page-turning style [12]. On the pages we can type text, draw illustrations, import data and images from external testing equipment, and make annotations on an image by using a mouse or a pen-tablet device as if we are writing on paper. Although this system offers various methods for inputting medical documentation with a paper-like interface, fragmentation of electronic and paper information remains a problem (Figure 2). A simple solution to this problem is immediate scanning of paper-based records, followed by manual pasting of the digitized images onto a progress note page during the patient's care. This is an unrealistic solution in the busy setting of outpatient care because timely manual manipulation of records by doctors and clinical clerks is not always possible. Additionally, in large hospitals, paper-based records are often collected and digitized at a scanning center at least several hours, or possibly a day, after the records are created. In such cases, keyboard/mouse-based electronic records and digitized paper-based records are sometimes not arranged in the order they were written, which can result in miscommunication of patient information among medical staff.

2 Objectives

To address the problems described above, we developed a new EHR system by revising C-Note. The new system integrates keyboard/mouse-based electronic records with digitized paper-based records, which can both be viewed in page-turning style. All records, including paper-based records, are arranged in relation to the time they were written, even when they were later digitized at a scanning center. Finally, the system allows for combined use of handwritten and keyboard/mouse input, without fragmentation of electronic and paper information. To verify the effectiveness of the system, we investigated the impact of introducing the first EHR system to the ophthalmology department at our hospital.

3 Methods

3.1 Revision of the C-Note System

In our hospital, MegaOakHR (NEC Corp., Tokyo, Japan)

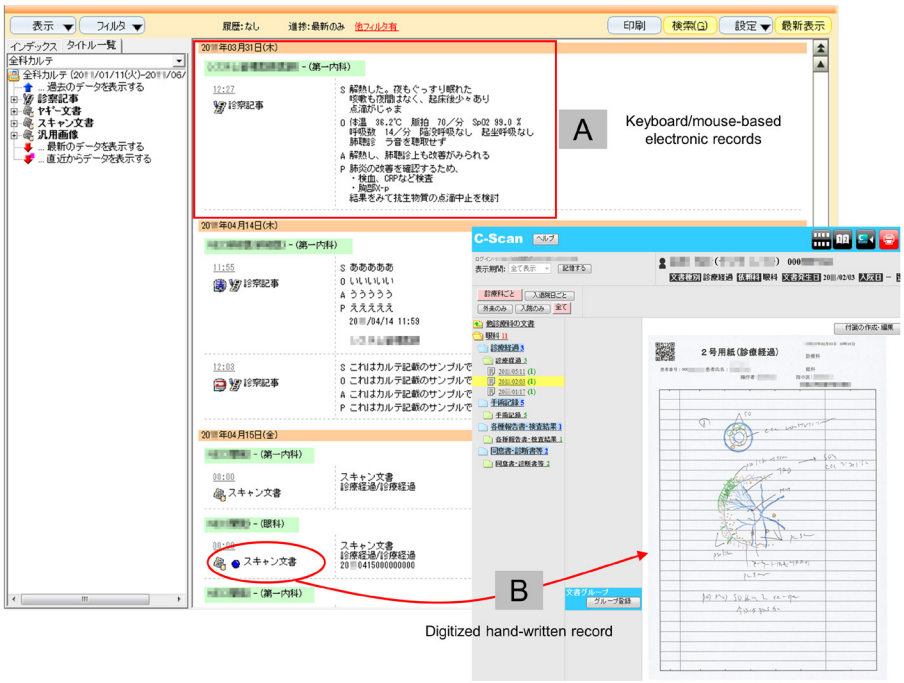

Figure 1: Example of "fragmentation" of electronic and paper information.
When using an ordinary EHR system, keyboard/mouse-based electronic records are browsed in the main system display (A). However, a separate display is needed in order to view digitized paper-based records (B).

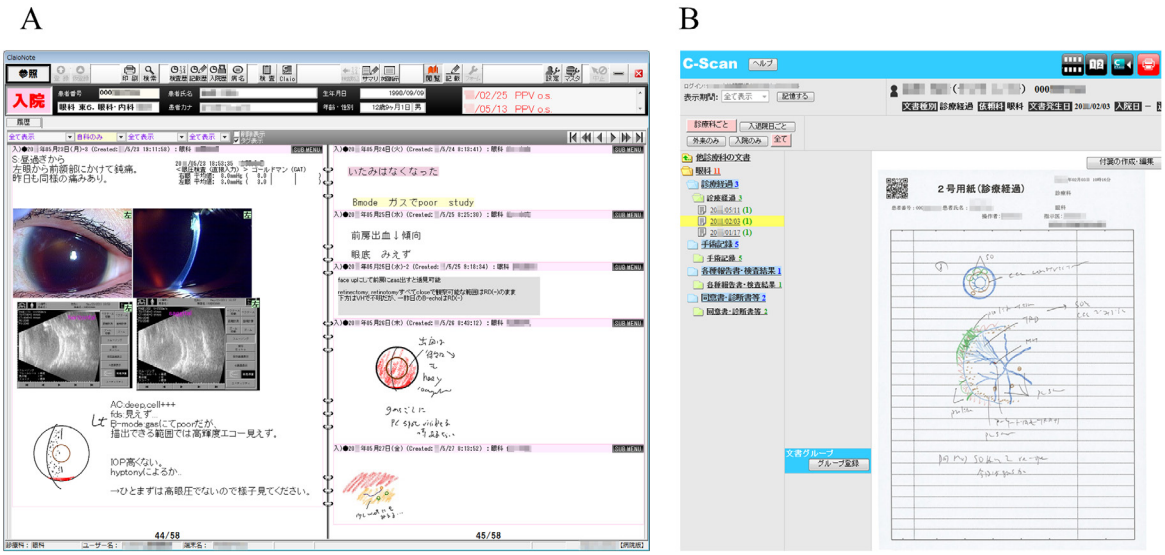

Figure 2: Original progress note system.
C-Note (FINDEX Inc.) is a progress note system in which medical records can be created and then browsed in a page-turning style (A). However, the original version requires a separate display to view digitized paper-based records (B).

is used as the main EHR system, including a computerized provider order-entry system in all departments [13]. Just before writing a paper-based record, the user must print a page with a QR code for the patient, which is generated by the main system. The documents written by the user are later picked up, taken to a scanning center, and then digitized on the same day or the next morning. The QR code contains patient information, the name and department of the user, the time of printing (approximately equal to the time of writing), and document type (eg, progress note, results of laboratory tests, certificates). Use of QR codes ensures that data from digitized paper-based records are registered to the database of all scanned documents in our hospital.

We modified the C-Note system so that all data from a digitized paper-based record are also automatically registered in the system database. Each paper-based record corresponds to one page of the system display. Every time the system database is updated (including modifications or deletions of already registered data), the registered data are rearranged in the order of writing, and the double-page view of the system is reconstructed. Therefore, keyboard/mouse-based electronic records and paper-based records are arranged in the order they were written and can be browsed chronologically in a page-turning style (Figure 3). To ensure that records remain arranged in the order they were originally created, already registered paper-based records cannot be edited, e.g., by adding annotations.

3.2 Adoption of the First Ophthalmic EHR in Our Hospital

Adoption of an EHR system in an ophthalmology department is one of the most demanding challenges in medical record management, because of the unique characteristics of ophthalmic outpatient care, which include the need for many intradepartmental examinations, the necessity of documentation that emphasizes graphical representation of examination findings, unique outpatient workflows, and high clinical volumes [7, 14, 15, 16]. An ophthalmic medical record may contain various data types, such as texts, drawings, photographs, images, graphs, waves, and schematic diagrams. Additionally, the time for writing such records is limited because, as compared with other departments, more patients are evaluated and the durations of evaluations are shorter. Therefore, the ophthalmology department in our hospital had long declined EHR implementation, although several EHR systems specially designed for ophthalmic medical record keeping had been proposed [17, 18]. However, we repeatedly explained the unprecedented features of the revised C-Note system to the department, which finally agreed to introduce the system—the first ophthalmic EHR system in our hospital.

To examine how the system was used, we calculated the ratio of the numbers of paper-based to keyboard/mouse-based records. All medical records produced by 28 ophthalmologists during the 8 months after the system was introduced were categorized as keyboard/mouse-based or paper-based records. Then, the numbers of paper-based and keyboard/mouse-based records were counted. The count ratios of keyboard/mouse-based to paper-based records (keyboard/paper) were monitored during these 8 months. We

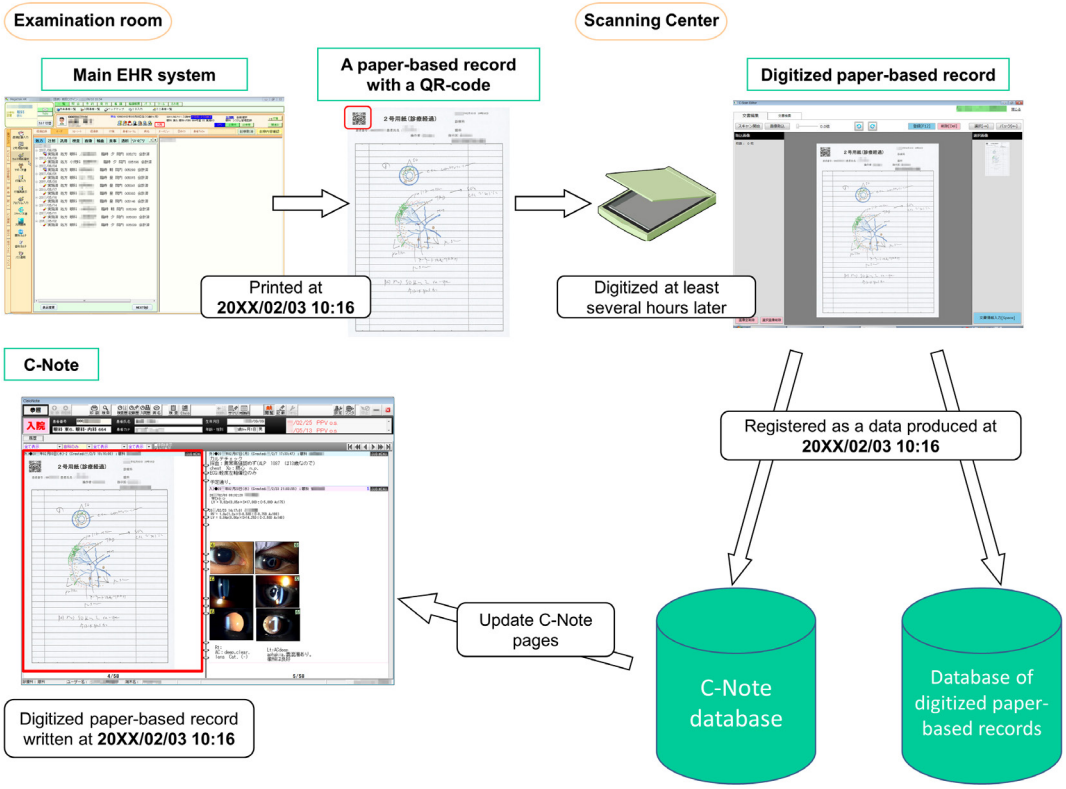

Figure 3: The revised progress note system integrates electronic and paper-based medical records.

When a paper-based record with a QR code is later digitized at a scanning center, the digitized data are also automatically registered to the system database as data produced at the time of writing. The double-page view is reconstructed every time the system database is updated. Therefore, keyboard/mouse-based electronic records and digitized paper-based records are arranged in the system in the order they were written.

also counted the numbers of ophthalmic outpatients seen during the periods 6 months before and 6 months after implementing the system.

4 Results

Before implementing the system, the department used only handwritten paper-based medical records, including more than 20 types of ophthalmic charts, interview records, and informed consent forms. When the system was introduced, we converted these paper-based documents to templates with QR codes stored in the main EHR system. Representative templates are shown in Figure 4. In the system, both keyboard/mouse-based electronic records and digitized paper-based records can be browsed in the same page-turning style (Figure 5).

Therefore, a doctor sometimes used these paper-based templates for handwritten input and other times produced records with a keyboard/mouse input. Figures 6 and 7 shows the actual proportions of the usage of these two input methods during the 8 months after system implementation. As shown in Figure 6, the count ratio of keyboard/mouse-based to paper-based records increased from 1.58 to 2.02 during the 8-month period, which suggests a gradual transition from handwriting input to keyboard/mouse input. However, the count ratio varied widely by doctor (Figure 7). Some doctors mostly used keyboard/mouse input from the beginning (Drs. A and B in Figure 7; a transient decrease in the keyboard/paper ratio for the two doctors in June was due to a temporary increase in their request for digitizing documents of new outpatients referred by other medical institutions), while other doctors predominantly used handwritten input (Drs. F and G in Figure 7) throughout the observation period. Despite differences in uptake among physicians, our results show that the ophthalmologists accepted the new EHR system without negative reactions, which resulted in a gradual transition from handwritten input to keyboard/mouse input.

Figure 8 shows the number of ophthalmic outpatients seen per day during the 6 months before and after introduction of the system. Although there was an almost 10% decrease in the number of outpatients during the 1–2 months after introducing the system, the number returned to the usual level at 3 months after the system was introduced. The average numbers of ophthalmic outpatients per day 6 months before and after implementing the revised system were 122 and 114,

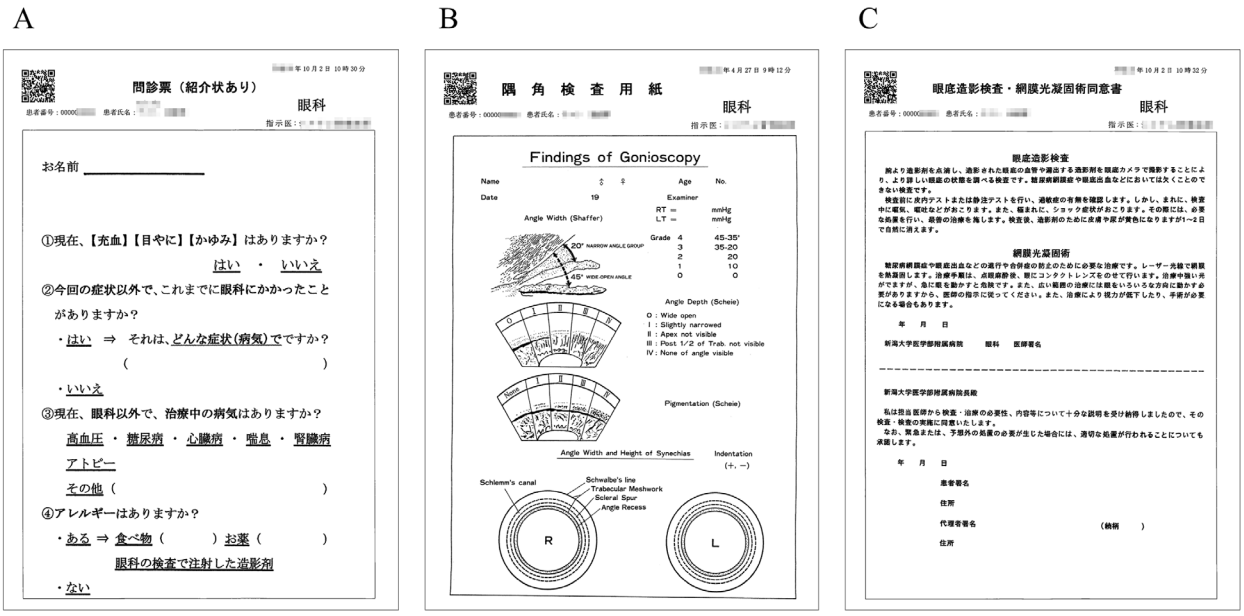

Figure 4: Representative templates (with QR codes) used in our hospital for paper-based records.

When the revised progress note system was introduced, we registered to the system more than 20 types of handwritten paper-based templates with QR codes for ophthalmic charts, interview records, and informed consent forms. The three representative templates shown are an interview record for a new patient (A), a record of an ophthalmic examination (B), and an informed consent document (C).

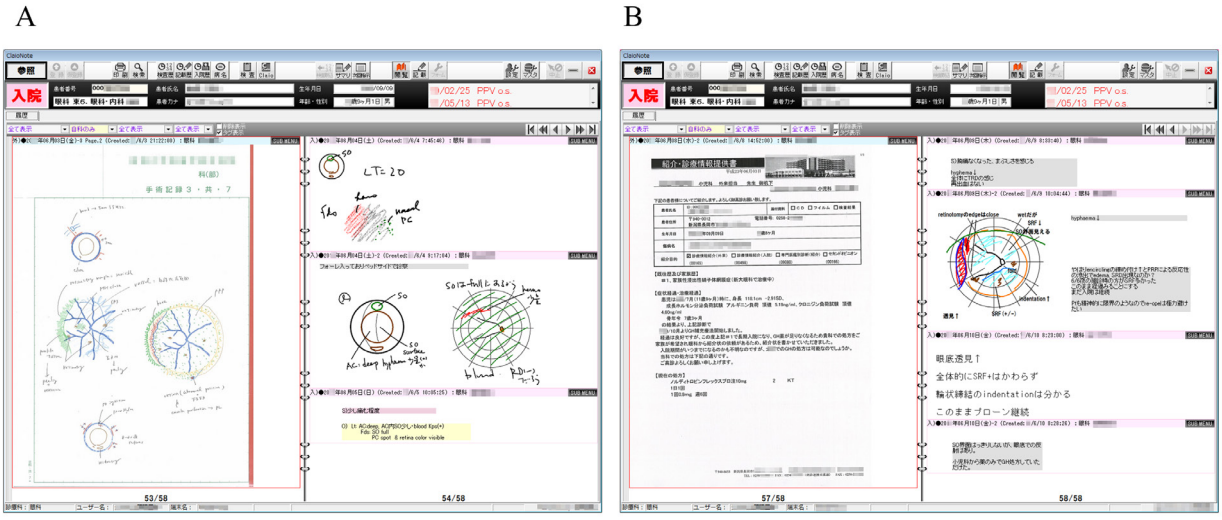

Figure 5: Representative double-page views from the revised progress note system.

In this system, both keyboard/mouse-based electronic records and digitized paper-based records can be browsed in a page-turning style. The examples from the revised progress note system are a handwritten record of a surgical procedure and an electronic record (A) and a paper-based referral form from another hospital and an electronic record (B).

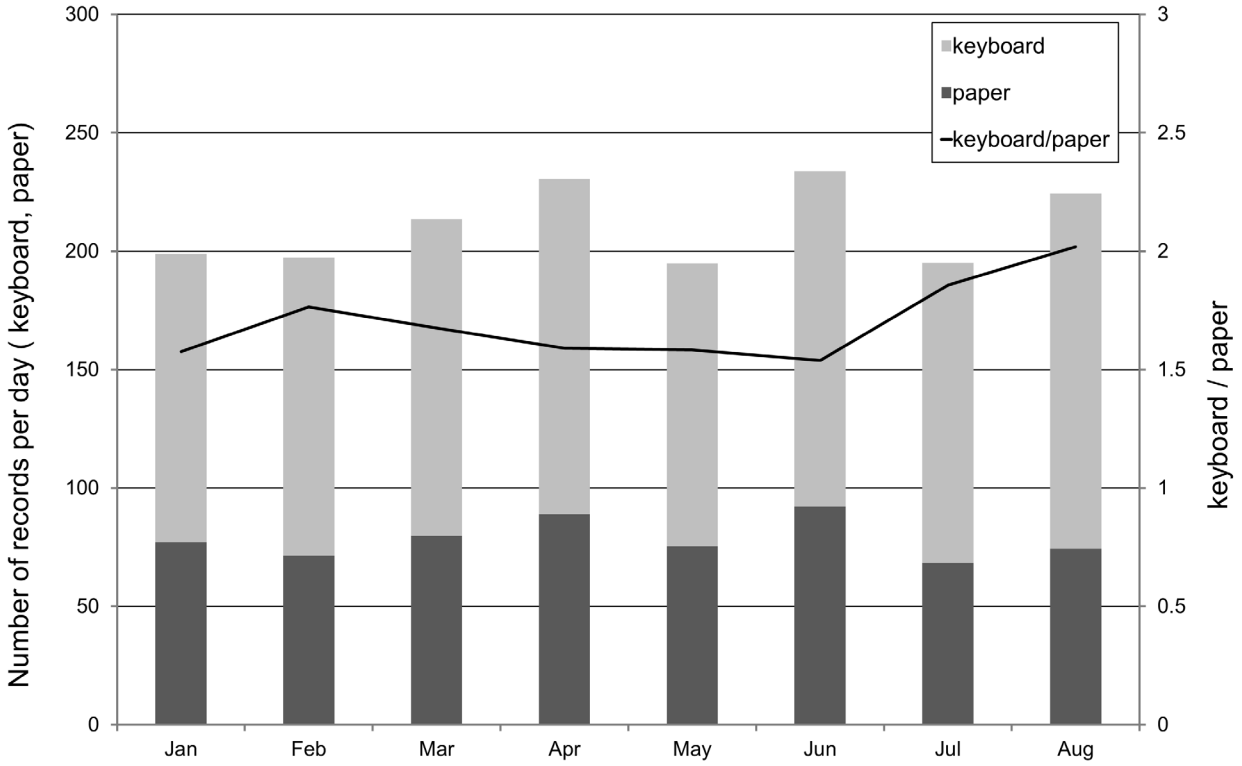

Figure 6: The numbers of keyboard/mouse-based (keyboard) and paper-based (paper) records and their count ratio (keyboard/paper). The keyboard/paper ratio was calculated by using data collected from 28 ophthalmologists during the 8-month period after the system was implemented. The ratio increased from 1.58 to 2.02 during the 8-month observation period, which suggests a gradual transition from handwritten to keyboard/mouse input.

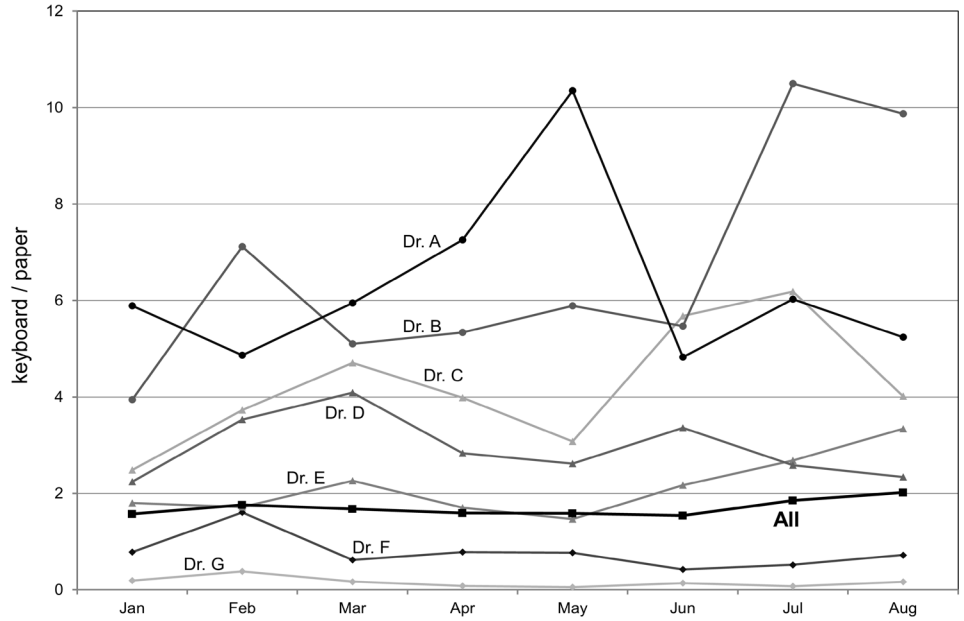

Figure 7: Count ratios of keyboard/mouse-based to paper-based medical records (keyboard/paper) for eight representative doctors.

Keyboard/paper ratio varied widely among the physicians. Some doctors used mostly keyboard/mouse input from the beginning (Drs. A and B), while others predominantly used handwritten input (Drs. F and G) throughout the observation period.

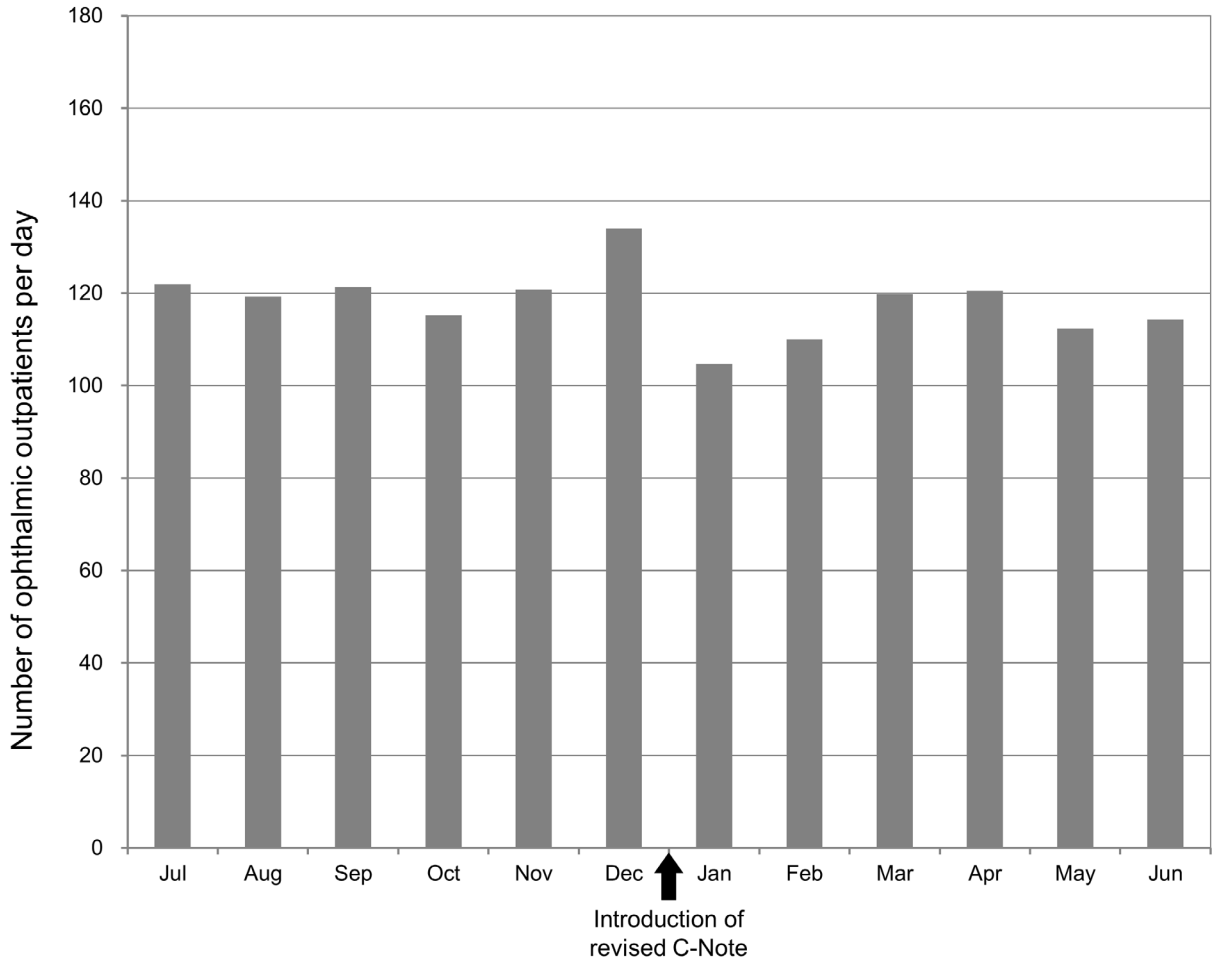

Figure 8: Number of ophthalmic outpatients per day 6 months before and after introduction of our system.

Although there was an almost 10% decrease in the number of outpatients during the 1–2 months after introducing the system, the number had increased to normal volume at 3 months after system introduction.

respectively. These results indicate that there was a minimal and transient decrease in the number of outpatients seen per unit of time after implementing the system.

5 Discussion

The present results show that the first ophthalmic EHR implementation in our hospital was successful. The decrease in clinical volume was minimal and transient; thus, the clinical outflow in the ophthalmology department was hardly affected by EHR implementation. That contrasts strikingly with previous studies reporting the opposite effect [19, 20]. The ophthalmologists accepted the new EHR system, and the system utilization rate increased in relation to their satisfaction with the system. Nevertheless, most ophthalmologists still have concerns regarding the potential adverse effects on productivity and efficiency in ophthalmology practice [18, 19, 21]. Furthermore, a recent survey found that ophthalmologists' rate of satisfaction with their EHR has decreased [17]. We believe that the success in our hospital is strong evidence of the effectiveness of our revised EHR system.

The most important advantage of our system is the coexistence of electronic and paper-based records. The system offers complete browsing compatibility for the two types of records, which are arranged in the order they were written rather than by the time of registration. Therefore, in this system, classical handwriting in paper is accepted as an equivalent input method to keyboard/mouse input, and there is no communication gap between electronic and paper information. We believe that this is the best solution for doctors reluctant to use an EHR system. Even users who are unfamiliar with the system, e.g., part-time and temporary employees, can utilize the system by mainly using handwriting input from the first day. The transition from handwritten to keyboard/mouse input can then occur gradually, in accordance with users' computer literacy and understanding of the system. Users can take advantage of the respective benefits of handwritten and keyboard input.

Similar systems or devices that aim for coexistence of electronic and paper-based records have important practical

limitations. First, electronic document management systems (EDMSs) are software programs that manage the creation, storage, and control of documents electronically and can integrate scanned documents [22, 23]. However, unlike an EHR system, an EDMS is only used for reference and is not suitable for creating progress notes. Second, to our knowledge, only one other EHR system (MegaOak-NEOCIS, NEC Corp., Tokyo, Japan [24]) developed for large Japanese hospitals is based on concepts similar to those guiding the development of our system. However, the initial cost of the MegaOak-NEOCIS is at least five times that of our system. Furthermore, our system allows for easy handling of medical records from ophthalmology, otorhinolaryngology, and gynecology departments, without a supplementary system. Third, in contrast to digital pens, digital writing boards, and tablets or sheets of exclusive paper optimized for scanning, our system does not require additional devices or supplies, the ongoing costs of which are usually much higher than expected, especially for a large hospital such as ours. Therefore, we think our system is the most feasible choice in a general hospital.

As discussed above, in the Introduction, similar results can be achieved by clinical clerks who scan paper by hand and insert it into the appropriate place of an EHR. However, this method will likely limit flexibility regarding when and where doctors write records. Furthermore, it requires many additional workers in a large hospital, where multiple doctors use the EHR system simultaneously. A future controlled study that compares the original system with on-site processing and our revised system with posteriori automatic registration would help confirm the benefits of the latter. We hope this limitation will be addressed soon.

8 Conclusion

The present system enables users to produce flexible medical records with keyboard/mouse and handwriting input methods, without fragmentation of electronic and paper information. This system is a cost-efficient, true hybrid digital–analog EHR system.

9 Acknowledgement

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10 Conflict of Interest

K Terajima recieved lecture fees from FINDEX Inc.

11 Author Contribution

K. Terajima has contributed to the conception and design of research and drafted the article, N. Negishi and H. Hasegawa have developed the system, K. Maruyama and H. Hasegawa have analyzed the results of the research and K. Akazawa has approved the system introduction and supervised the research. All authors have given approval of the final version to be published.

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