A study of user requests regarding the fully electronic health record system at Seoul National University Bundang Hospital: Challenges for future electronic health record systems

Sooyoung Yoo, Seok Kim, Seungja Lee, Kee-Hyuck Lee, Rong-Min Baek, Hee Hwang*

Center for Medical Informatics, Seoul National University Bundang Hospital, Republic of Korea

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ABSTRACT

Objective: Although the adoption rates for Electronic Health Records (EHRs) are growing, significant opportunities for further advances in EHR system design remain. The goal of this study was to identify issues that should be considered in the design process for the successful development of future systems by analyzing end users’ service requests gathered during a recent three-year period after a comprehensive EHR system was implemented at Seoul National University's Bundang Hospital in South Korea.

Methods: Data on 11,400 service requests from end users of the EHR system made from 2008 through 2010 were used in this study. The requests were categorized as program modification/development, data request, insurance-fee identification/generation, patient-record merging, or other. The authors further subcategorized the requests for program modification/development into the following nine areas of concern: (1) indicators and statistics, (2) patient safety and quality of care, (3) special task-oriented functionalities, (4) ease of use and user interface, (5) system speed, (6) interoperability and integration, (7) privacy and security, (8) customer service, and (9) miscellaneous. The system users were divided into four groups—direct care, care support, administrative/insurance, and general management—to identify each group’s needs and concerns.

Results: The service requests for program modification/development, data request, insurance-fee identification/generation, patient-record merging, and other issues constituted approximately 49.2%, 33.9%, 11.4%, 4.0%, and 1.5% of the total data set, respectively. The number of data-request service requests grew over the three years studied. Different groups of users were found to have different concerns according to their activities and tasks. Within the program-modification/development category, end users were most frequently concerned with ease of use and user interface (38.1% of the total) and special task-oriented functionalities (29.3% of the total) in their use of the EHR system, with increasing numbers of requests in both categories over the three years. Users in the direct-care group differed from the other groups in that they most frequently submitted requests related to ease of use and user interface, followed by special functionalities, patient safety and quality care, and customer service, while users in other groups submitted requests concerning ease of use and user interface and special functionalities with a similarly high frequency.

* Corresponding author at: Center for Medical Informatics, Department of Pediatrics, Seoul National University Bundang Hospital, 166 Gumi-ro, Bundang-gu, Seongnam-si 436-707, Republic of Korea. Tel.: +82 31 787 7284; fax: +82 31 787 4054.

E-mail address: neuroandy@snubh.org (H. Hwang).

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1. Introduction

A comprehensive electronic health record (EHR) system has the ability to integrate and streamline the healthcare delivery process, thereby improving the quality of care, increasing efficiency and reducing the cost of healthcare delivery, as well as to support research [1–3]. Although the adoption rates for EHRs are on the rise [4], rate for the use of comprehensive EHRs is still low worldwide. HIMSS Analytics [5], the authoritative source on EHR adoption trends, scored hospitals on their progress in completing 8 stages of adoption, from 0 for hospitals that do not have any EHR functionality installed through 7 for hospitals that have fully functional paperless EHR systems. As of December 2011, only 66 hospitals worldwide (approximately 1.1% of U.S. hospitals) had achieved level 7. Seoul National University’s Bundang Hospital (SNUBH) in South Korea was the first stage-7 hospital outside the U.S.

SNUBH opened in May 2003 as a fully digital general hospital with an in-house integrated EHR system. It was the first hospital in South Korea to adopt a paperless EHR system. It currently has 910 beds and 23 operating rooms. There were 1,054,738 outpatient visits and 96,708 emergency-room visits in 2011. The hospital employs 1838 staff (including 218 professors of medicine, 324 physicians, 919 nurses, 76 administrative-staff members, and various other healthcare professionals). The current total IS operating budget is 12.6 million dollars.

After the EHR system was adopted at SNUBH, maintenance and enhancement were outsourced. Because the system’s usability and its fit within the organizational culture and processes are significant factors in the successful implementation of EHRs [6], the SNUBH system has been continuously modified and updated since 2003 to meet the end users’ ongoing demands, and by 2007, it had evolved into a complete EHR system that was interoperable and capable of advanced reporting. The ongoing process of maintaining and improving the system based on end users’ requests has been one of the key factors in successfully encouraging end users to use it more effectively and allowing them to use it more easily. We have now begun to develop the next generation of our EHR system.

An EHR system cannot simply be used “out of the box” [7]. Different groups of users, such as physicians, nurses, other healthcare professionals, administrators, computer professionals, and patients, are involved in the multidisciplinary field of healthcare. Users carry out many complex and time-consuming activities that “complement” the system. Such complementary activities have been found to be critical in generating benefits from new technology [7,8]. EHR systems should also be adjusted according to user feedback to effectively support the users’ complex tasks.

EHR users have valuable first-hand knowledge of what EHR features and functionalities they need in their work environments that can be used in developing and improving EHR systems. Tracing and change management of the user needs provide the understanding needed to anticipate issues and ensure the continuous quality of systems [9]. One of the challenges in the development and planning of EHR systems is taking into account the needs and requirements of different users [10]. A review of studies on barriers to and facilitators of EHR systems [11] found that each group of users had a unique perspective on the implementation process that needed be taken into account, though the study also highlighted important similarities between groups.

The present study categorized and empirically analyzed three years’ worth of user requests from all different user groups that had been gathered in the process of maintaining a complete EHR system at SNUBH. Users can provide more concrete and specific requests regarding what features they are really looking for while they are using the system. Because there has been little study of user requests or needs after they have adopted EHR systems, we used our data to investigate how the EHR system has progressed and evolved through consistent user requests during routine use and which features different users have sought for the EHR system. The goal was to identify issues that should be considered in the design process and strategies for successful development of the next-generation EHR system.

2. Methods

Since implementing its EHR system in May 2003, SNUBH has been collecting service requests related to the system from users in all departments, including requests related to Electronic Medical Records (EMRs), Computerized Physician Order Entries (CPOEs), Clinical Decision Support (CDS), Electronic Medical Administration Records (EMARs), Administration/Claims, Laboratory, Pharmacy, Data Warehouse (DW), and Health Information Exchange (HIE). Requests were electronically submitted to the EHR operating team using a service-request application that included the name of the requesting department or subspecialty, a short title, the purpose of the request, and a detailed description. The user could choose one of the following categories to describe the purpose: program modification/development, data request, insurance-fee identification/generation, patient-record
merging, or other. The requests were then considered by the EHR operating team and implemented in the system according to their priority level. Compliance with legal and regulatory requirements was usually prioritized first, in accordance with SNUBH policy.

At SUNBH, request data were only available from May 2007 onward. We therefore used the 11,400 requests submitted in the recent three years from 2008 to 2010 in this study. Two of the authors inspected the data and subcategorized the requests for program modification/development more specifically to determine which EHR features end users have been asking for in their routine use. Table 1 gives the subcategorization criteria that were empirically derived by the authors for classifying the purpose of program-modification/development requests. Nine sets of criteria were defined in terms of system-design factors that would largely be considered in EHR development.

For the purposes of this study, we divided EHR users into four groups: direct care, care support, administrative/insurance, and general management. The direct-care group consisted of clinicians, surgeons, and nurses from the medical departments. The care-support group included radiologists, radiology technicians, pharmacists, laboratory technicians, and other healthcare professionals from the care-support departments. The administrative/insurance group included the administrative and insurance staff. The general-management group included other staff in quality assurance, business planning, general affairs, education and research support, distribution and asset management, and other administrative departments.

### 3. Results

#### 3.1. General statistics

Table 2 gives the overall statistics on service requests during the three years of the study. The total numbers of service requests for program modification/development, data request, insurance-fee identification/generation, patient-record merging and others constituted approximately 49.2%, 33.9%, 11.4%, 4.0%, and 1.5% of the requests, respectively. Program modifications or development was requested more than 1400 times in 2008 and more than 2000 times in 2009 and 2010. There were more than 1000 data requests every year; interestingly, the number increased each year. Because insurance regulations have been changing constantly, insurance-fee-identification and generation requests have been submitted with high frequency, at rates of several hundred every year. Patient-record merging was requested more than 100 times each year. In our current system, merging of patient records can be performed only by system developers, not by end users; these data indicate that merging functionality for end users would be required in future EHR systems to meet users’ needs in a timely manner.

Table 3 gives the average number of days taken to process service requests (from request receipt to request completion), with standard deviations. Interestingly, the average processing time decreased for both program modification and development and data request. This decrease indicates that the

| Table 1 – Categorization criteria for program-modification/development service requests. |
|---------------------------------------------|------------------|
| **Category**                               | **Definition**   |
| Indicators and statistics                  | Program modifications or additions to monitor, manage, and/or report clinical or performance indicators or statistical data for daily work activities or hospital accreditation |
| Patient safety and quality of care         | Program modifications or additions to improve quality of care and patient safety in terms of effectiveness, such as adding alerts, reminders, critical pathways, or patient-safety reports or managing the quality of medical records |
| Special task-oriented functionalities      | Program modifications or additions to improve productivity or make changes to work processes in terms of efficiency that are specific to the requesting department or subspecialty |
| Ease of use and user interface             | Program modifications or additions to increase ease of use and improve the user interface, such as rearrangement of the user-interface layout and buttons or changes to sorting, filtering, or program-page linking functions |
| System speed                               | Program modifications or additions to improve response times, such as increasing the speed of data searches, saving, printing, or exporting |
| Interoperability and integration           | Program modifications or additions to interface and/or integrate with external systems in a standardized way, including standardization of terminology, device interfacing, and application of standard medical codes |
| Privacy and security                       | Program modifications or additions to enforce patient privacy, confidentiality, and security, such as access control, data encryption, or managing printing and deletion privileges |
| Customer service                           | Program modifications or additions to increase patients’ convenience and satisfaction, such as customer-relations management, SMSs for schedule reminders, electronic signboards in outpatient and surgery rooms, or providing postvisit information guides for next steps and precautions |
| Other                                      | Miscellaneous other program modifications including fixing system errors, managing online questionnaires, and handling server changes and software-version upgrades, as well as requests for multiple services |

EHR system has been optimized for rapid change management. Fig. 1 shows that the number of Science Citation Index (SCI)/Science Citations Indication Expanded (SCIE) publications affiliated with SNUBH increased over the three years as the number of data requests increased, indicating that the EHR

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system is capable of being used for research support. In the future, research can be better supported if naive end users can easily retrieve data as well as program developers can.

3.2. Analysis of the results for service requests by different groups of users

Table 4 gives the percentage of service requests of each type for each group of users. As can be seen, the groups had different concerns, in accordance with their activities and tasks. The direct-care group requested services the most frequently, submitting 38.8% of the total service requests. Their requests mostly concerned program modification or development and data request, with similar ratio between the two categories. The ratio was similar for the administrative/insurance group and the general-management group; however, for the care-support group, those two categories constituted 78.1% and 20.5% of the requests, respectively. This difference indicates that the care-support departments have much more of a need for and concern about the EHR features that support their activities than those that support the use of data. The insurance-fee identification/generation requests and patient-record-merging requests mostly came from the administrative/insurance group because of the particular characteristics of their departmental activities. These results suggest that all groups of users need to be considered in both system maintenance and the design of future systems to provide for their different interests and concerns.

3.3. Statistics on the subcategories of program modification/development requests

Table 5 gives the results for specific purposes within the program-modification/development requests according to the categories defined in Table 1.

Overall, it can be seen that end users were most frequently concerned with ease of use and user interface (38.1% of the total for program modification/development) and special task-oriented functionalities (29.3% of the total) in their use of the EHR system, with an increasing number of requests in both categories over the three years of the study. It seems that the end users frequently sought to make the EHR system more user-friendly and productive in their daily work.

In the service request for ease of use and user interface, we also found that the end-users, especially the direct-care group, sought the functional capabilities of personalized configuration settings that allowed end-users to set up the default method of sorting, filtering, and inquiring conditions; for example, the configuration of the default inquiry condition for viewing an outpatient’s visiting history to the patient’s current encounter department or all departments, and the
configuration of the default inquiry organization name (i.e., network clinic’s name) and the department name for searching a patient’s test results. In addition, users wanted to input and retrieve data in a lump fashion, for example, the input of pain assessment on a single page in a nursing department, and viewing patient’s various types of test results, including radiology studies, laboratory studies, and functional studies, in a lump. As shown in Fig. 2, the number of service requests on ease of use and user interface from the direct-care group were much higher than those from other user groups, however, the average time for processing those request from direct-care group was greatly decreased over time, indicating the reduce of the complexity of those requests (see Fig. 2(a)). It seems that the EMR capabilities of personalized configuration settings that provide flexible user interface would be the important features to reach the various types of healthcare users’ requests.

There seemed to be growing unmet needs, especially for the group of care-support and general management users, in terms of special task-oriented functionalities, as both the number of those requests and the average processing time tended to increase for two groups (see Fig. 2(b)). For example, pharmacy department requested the development of Total Parenteral Nutrition (TPN) calculation program for pediatric patients that supports calculating injection volume, filling out replying document, creating order, and printing TPN

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Table 4 – Distribution of service requests across user groups.

<table>
<thead>
<tr>
<th>Category</th>
<th>2008 (N = 3334)</th>
<th>2009 (N = 4154)</th>
<th>2010 (N = 3912)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct-care group</td>
<td>37.5</td>
<td>40.8</td>
<td>37.8</td>
<td>38.8</td>
</tr>
<tr>
<td>Program modification/development</td>
<td>52.9</td>
<td>57.5</td>
<td>48.8</td>
<td>53.3</td>
</tr>
<tr>
<td>Data request</td>
<td>38.7</td>
<td>39.1</td>
<td>47.1</td>
<td>41.6</td>
</tr>
<tr>
<td>Insurance-fee identification/generation</td>
<td>1.0</td>
<td>0.8</td>
<td>1.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Patient-record merging</td>
<td>0.5</td>
<td>0.7</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Other</td>
<td>6.9</td>
<td>2.0</td>
<td>2.2</td>
<td>3.4</td>
</tr>
<tr>
<td>Care-support group</td>
<td>12.4</td>
<td>14.4</td>
<td>17.0</td>
<td>14.7</td>
</tr>
<tr>
<td>Program modification/development</td>
<td>74.5</td>
<td>77.3</td>
<td>81.0</td>
<td>78.1</td>
</tr>
<tr>
<td>Data request</td>
<td>22.8</td>
<td>21.2</td>
<td>18.5</td>
<td>20.5</td>
</tr>
<tr>
<td>Insurance-fee identification/generation</td>
<td>2.4</td>
<td>0.7</td>
<td>0.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Patient-record merging</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Other</td>
<td>0.2</td>
<td>0.8</td>
<td>0.0</td>
<td>0.4</td>
</tr>
<tr>
<td>Administrative/insurance group</td>
<td>31.5</td>
<td>27.1</td>
<td>22.5</td>
<td>26.8</td>
</tr>
<tr>
<td>Program modification/development</td>
<td>19.4</td>
<td>26.1</td>
<td>32.6</td>
<td>25.7</td>
</tr>
<tr>
<td>Data request</td>
<td>20.0</td>
<td>15.1</td>
<td>26.0</td>
<td>20.2</td>
</tr>
<tr>
<td>Insurance-fee identification/generation</td>
<td>45.2</td>
<td>44.8</td>
<td>27.7</td>
<td>40.0</td>
</tr>
<tr>
<td>Patient-record merging</td>
<td>14.4</td>
<td>13.9</td>
<td>13.3</td>
<td>13.9</td>
</tr>
<tr>
<td>Other</td>
<td>0.1</td>
<td>0.1</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>General-management group</td>
<td>18.7</td>
<td>17.7</td>
<td>22.7</td>
<td>19.7</td>
</tr>
<tr>
<td>Program modification/development</td>
<td>51.8</td>
<td>50.8</td>
<td>52.4</td>
<td>51.7</td>
</tr>
<tr>
<td>Data request</td>
<td>46.8</td>
<td>48.5</td>
<td>46.7</td>
<td>47.3</td>
</tr>
<tr>
<td>Insurance-fee identification/generation</td>
<td>0.8</td>
<td>0.5</td>
<td>0.3</td>
<td>0.5</td>
</tr>
<tr>
<td>Patient-record merging</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>Other</td>
<td>0.6</td>
<td>0.1</td>
<td>0.3</td>
<td>0.4</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: The percentages given for each category of service request are the proportions within each user group.

Table 5 – Statistics on the purposes of program-modification/development service requests over the three years of the study.

<table>
<thead>
<tr>
<th>Year (units: number, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Indicators and statistics</td>
</tr>
<tr>
<td>Patient safety and quality of care</td>
</tr>
<tr>
<td>Special task-oriented functionalities</td>
</tr>
<tr>
<td>Ease of use and user interface</td>
</tr>
<tr>
<td>System speed</td>
</tr>
<tr>
<td>Interoperability and integration</td>
</tr>
<tr>
<td>Privacy and security</td>
</tr>
<tr>
<td>Customer service</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

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dispense label in one-step in order to reduce the time of pharmacist’s TPN consultation tasks. Administrative department asked the development of scan program for a patient’s identification card in order to simplify their copy process of the identification card. The results highlight the necessity for taking into account the growing unmet needs on special task-oriented functionalities from the care-support and general management user groups in further system design.

Patient safety and quality of care were also considered to be important by end users over the study period. It is necessary to be continually concerned with providing safe, high-quality care to patients. In Table 5, the number of programming requests related to these issues increased by over

Fig. 2 – The number of service requests and the number of average processing time over three years: (a) ease of use and user interface, (b) special task-oriented functionalities, (c) patient safety and quality of care, and (d) indicators and statistics.
one hundred in 2009 because, at that time, SNUBH was preparing for a national healthcare accreditation process that primarily examined patient safety and quality of care; this resulted in more program modification/development requests regarding those issues. As can be seen in Fig. 2(c), the requests seemed to be continuous and important to support the activities of patient safety for the care-support user group, such as pharmacy, laboratory, infection control, quality assurance departments, and care departments. For example, the development of the application of patient safety management that allows all hospital staffs to report rapidly any accidents related to patient safety, the development of documental templates for injection control activities to surgery site, alert for incompatible infusion orders, and alert for contrast CT orders if patients have taken metformin for recent six months were requested from care-support departments. Physicians requested the development of spine clinical pathway to standardize care process and to improve patient safety, and that of SMS notification to reply any consults. Those requests indicate the importance and necessity of an integrated management method of various types of the growing alert, reminders and rules from various departments in further system design.

The number of requests related to indicators and statistics also increased consistently over the years of the study, constituting an average of 6.6% for all program-related requests for the entire period (see Table 5). It seems that features related to data extraction and reporting are also becoming more important due to internal and external needs, such as formally reporting on the hospital’s performance. Especially, care-support user group increasingly needed the features as the number of those requests and the average processing time has increased over time, emphasizing the importance of understanding and analyzing those group’s unmet needs. For example, various indicators in regards to the incidence of a decubitus, clean surgery antibiotics, and nutrition were asked to be developed by care-support departments in the study period.

The customer-service-related requests constituted approximately 4.3% of the total (see Table 5). For example, the following patients programs were requested and developed; printing the guide information about where-to-go path and indications for next treatment after seeing a doctor, and the electronic boards for displaying patient’s waiting time and calling at outpatient clinics and emergency rooms, and for educating patients at a dental clinic. This fact indicates that the EHR system has evolved to support patient-centered services by providing patients with the administrative or clinical information they need. Because most hospitals want to provide a positive patient experience and patient-centered services, customer service will be a high-ranking feature in future EHR systems. In our hospital, various departments, such as nursing, health promotion center, emergency medicine, dentistry, radiation oncology, pharmacy, diagnostic radiology, physiologic diagnostic laboratory, administration, and promotion team, asked those request, indicating the further needs to develop an integrated, consistent service for patient through the analysis of unmet needs from various departments.

System speed improvements were not often requested by end-users. It is likely that this is because system speed was a top priority in our system-maintenance policy, so the system was maintained with the goal of it being able to respond within a few seconds. The response speed seems to have satisfied the end users, resulting in a low number of requests regarding system speed.

Fig. 3 shows the cumulative distribution of specific program-modification/development-request purposes for the four groups of users, with data for all three years. It can be
seen that the different groups of users had different distributions of needs and concerns, depending on their activities and tasks. In particular, users in the direct-care group differed from the other groups in that they most frequently submitted programming requests related to ease of use and user interface, followed by requests concerning special functionalities, patient safety and quality care, and customer service. In contrast, other groups of users were concerned about ease of use and user interface and special functionalities with a similarly high frequency. The general-management group requested two or three times more program modifications or development services related to indicators and statistics than did other groups of users because their activities are closely related to the hospital’s finances and management.

4. Discussion

Health information systems are in a phase of rapid development, with many questions still unresolved in terms of architecture, functionality and management [12]. In this study, we analyzed long-term users’ service requests for our university hospital’s in-house EHR system to examine those end users’ needs and issues in terms of use and management of the EHR system. Interestingly, the end users have continually submitted requests regarding the EHR system, which has made the system more complex but resulted in it fitting better into their daily work.

4.1. Common service requests from all EHR-user groups

All users’ needs for information for research or clinical work have increased over time. It has previously been established that unmet research needs are one of the factors that prevent deployment and use of EHRs [13]. Although we had a DW system from which users could retrieve EHR data by themselves, users tended to submit requests for the data to our system-management team. Because it was the easiest way to obtain the exact data they were interested in, they preferred to request the data directly rather than use the DW system, which required some skill to use. It is certain that some of the most important features of future EHR systems will be those that easily support users’ use of EHR data in their research or clinical work.

In requests for improvements to the EHR programs, users in all of the groups most frequently requested EHR features and functionalities that would improve the system’s usability and efficiency, such as improving the user interface to make it easier to use and expanding the functionalities to accommodate new or modified work processes, as well as features that would improve the quality of care and patient safety. Those requests accounted for approximately 79% of all program-related requests.

A similar study was conducted by [14], in which the researchers analyzed end-user requests for EMRs and CPOEs over a period of three years, between 2006 and 2008, using the following nine categories: (1) improving quality of care, (2) evaluation of clinical quality, (3) customer service, (4) compliance with government regulations, (5) business aspects, (6) statistics, (7) education, (8) clinical research, and (9) miscellaneous. The researchers reported that improving quality of care was the most frequent type of request, at 73%. Although the categorization criteria used in the present study were different, having been defined more in terms of system-design strategies, all of the groups of EHR users most frequently sought EHR features and functionalities related to usability, productivity, and quality of care.

4.2. Characteristics of service requests by different user groups

Users in the direct-care group, such as physicians and nurses, were especially concerned about the EHR system’s usability. They are the main users of EHR systems who routinely perform complex medical processes in their daily work. They need to be able to quickly review complex medical data to make decisions on a tight schedule and to record any changes in a patient’s progress and status. Understandably, they were therefore continually trying to make the EHR system easy to use so that it could effectively support their clinical activities and work process. SNUBH’s EHR system seems to have improved and evolved to become more user-friendly by continuously incorporating those user requests over time. Such user-friendly features can cause EHR users to perceive the systems as easy to use and as valuable tools for facilitating work processes [11,15,16].

In contrast, administrative/insurance and general-management users most frequently requested customized functionalities for their own work on the EHR system and had fewer concerns about usability. Because they were dealing with administrative data on multiple patients that were less complicated than the clinical data and because there were frequent changes in regulations, government policies, and the work flow, these groups appeared to prioritize their customized functionalities over usability in seeking to increase their productivity and work performance.

4.3. Features of the next generation of EHR systems

SNUBH has been improving its EHR system by meeting the many constantly changing requests from all EHR users. However, there are both internal and external demands on the development of the next-generation EHR system. Internally, users want an EHR system that is much more user-friendly and flexible to enable them to easily organize and view data and to personalize the program settings. Externally, the EHR system was increasingly required to adapt to the rapidly changing health IT environment, including the growing demand for integration with outside systems and frequent changes to legal and regulatory policies. The EHR system was also expected to easily comply with various international and national healthcare-accreditation systems. SNUBH’s system was not originally designed with sufficient flexibility to incorporate such changes quickly.

Based on our eleven years of experience in EHR-system operation and this analysis of long-term end users’ requests in the context of a complete EHR system, we believe that the following issues should be considered in the EHR-system-design process if new systems are to be successfully implemented in
the future. First, innovative new user-interface technologies will be necessary to meet the increasing demands for ease of use and the ability to set preferences, especially among healthcare professionals, as shown in this study. Designing easy-to-use software for knowledge workers is a challenge that the entire software industry faces, not just developers of healthcare software [7,17]. It is known that EHR user interfaces and data entry procedures are a major obstacle to healthcare professionals’ use and acceptance of EHRs; meeting this design challenge is the most important factor that will influence future success [18]. The presentation of information in terms of layout and structure is important because it can influence data retrieval, interpretation, and clinical decision making in, at times, fundamental ways [18,19]. Grams [20] emphasized changing the focus of the system-design process by making physicians key players in the process. A study of the user experiences of different types of healthcare professionals will be required to develop an EHR system that will organize complex clinical activities according to their mental models. State-of-the-art user-interface technologies, such as ASP.net’s AJAX, the Windows Presentation Foundation (WPF), and Silverlight, provide tools for implementing a rich user experience and innovative interactive user interfaces. By adopting such techniques, in combination with adaptive interface technologies such as voice recognition, future EHR systems will enable users to quickly and easily locate, view, navigate and enter information.

Second, a process of gathering, analyzing, and coordinating data on special requirements from all different types of users and subspecialties should be undertaken as part of the system design process. Each medical department or center has specific unmet needs; meeting these needs could facilitate clinical and administrative activities specific to the unique workflow and data management of that department or center, as was demonstrated by the increase in user requests for task-specific functionalities over the course of our study. Other studies have also examined specific unmet needs and function gaps in current EHR systems used in, for example, congenital heart disease centers [21], ophthalmology [22], and pediatrics [23]. The recognition and implementation of specific functions and niche capabilities to meet the needs of all departmental subspecialties will be one of the key features of future systems.

Third, a powerful function for easily searching, filtering, analyzing, reporting, and exporting EHR data should be developed to meet the increasing demand for information for research purposes that has been shown in this study. It is noteworthy that there has been a shift in the use of information from being more related to patient care and administrative functions to being more extensively related to clinical research [12]. The need to utilize data is becoming more important as the amount of data increases. Increased use of data can lead to improved research outcomes. In our experience of operating and maintaining the current DW system for research support, we found that, although the system has full functionality for searching EHR data using various options such as searching by diagnosis or by clinical observations as well as a user-defined free search, usage levels are extremely low due to difficulties with making and using queries. Tools will be required that will allow naive EHR users to easily and intuitively search both structured and unstructured data in a secure way. In addition, our results on the growing requests on indicators and statistics, especially from the care-support user group, highlighted the importance of discovering and analyzing unmet needs of the user group in the future system.

Fourth, as EHR systems grow more complex, they will require a new system architecture that is flexible enough to adapt to constant changes in users’ needs, regulations, business requirements, and the IT environment, like developing new services using IT has consistently created for patients over the course of our study. In addition, advances in IT technology and the aging of the society demand that EHR systems be integrated with more outside systems, such as other institutions’ EHR systems and home-health-monitoring systems, to provide a continuum of care. Service-Oriented Architecture (SOA) is one possible solution for the challenges of interoperability and integration of diverse systems [24]. The implementation of SOA provides consumers with seamless access to the different services available within the architecture. The adoption of SOA can accelerate a healthcare enterprise by reducing the gap between changes in strategies and processes on the one hand and their supporting IT systems on the other [25]. The development of an EHR system based on SOA would be a successful change-management strategy in the rapidly changing healthcare environment, though questions remain about how to define and delineate services in an EHR system.

Lastly, it will be necessary to design and implement new platforms for improving patient-directed functionalities in the future EHR system, such as functions that allow patients to access their medical records, fill out prior questionnaires online, facilitate the use of their data in clinical and epidemiological research, and communicate with healthcare professionals about their current health status in a timely fashion, as can be expected from the growing end-user’s requests on customer services in our results. Features that facilitate the sharing of EHRs with patients have the potential to improve efficiency, quality of care, and patient satisfaction and to reduce costs [26]. Previous efforts have been made to give patients access to their medical records [27–30]; however, it is still a challenge to carefully consider the complex issues related to the contradictory needs and concerns of patients and providers, the specific requirements of particular medical specialties, security and confidentiality concerns, and cultural differences in the design of patient-centered EHR platforms. We believe that patient-directed EHR capabilities will become more important as the adoption of EHRs increases.

4.4. Limitations of this study

The classification of users’ service requests for EHR programming according to their purpose involved some adjustment by the authors, both because some users tended not to clearly specify their purpose in their requests and because some users tended to name multiple purposes to emphasize the importance of their requests. However, we believe that these adjustments will not directly effect the results or the findings because of the relatively large volume of data collected.

In this study, we analyzed end users’ service requests collected in a university-hospital setting, at SNUBH in South Korea. There is a possibility that particular organizational
and cultural characteristics may have been relevant to users’ needs and requirements. SNUBH has actively invested in and strongly supported the adoption of IT; it is a leader in healthcare IT in South Korea. These policies have encouraged employees to use IT to continuously increase their work efficiency and their patients’ safety.

5. Conclusions

Interest in and issues with the adoption of full-EHR systems is growing worldwide. Although progress has been made in the adoption of such systems, significant opportunities remain for further advances in future EHR systems. In our study of end-user requests across three recent years regarding the full-EHR system at SNUBH in South Korea, we found that users have continued to inform us of their needs and requirements and that the EHR system has evolved to become optimized for ease of use and for special functionalities for various groups of users and medical subspecialties. End users’ requests to obtain EHR data increased over the three years of the study, indicating a need for research-support capabilities in EHR systems.

Based on our experiences maintaining the full-EHR system, we suggest that the key factors to be considered in the development of future EHR systems are innovative new user-interface technologies; special extended functions for each type of users’ specific-task-oriented requirements; powerful, easy-to-use functions for research support; new flexible system architecture; and patient-directed functions. To successfully meet these challenges in the next generation of EHR systems, EHR vendors should actively involve representative users from all departments and subspecialties in the entire process of system development, from user-requirement analysis to design, implementation, and usability testing. Vendors should also consider an advanced new system architecture that is both flexible enough to adapt to the rapidly changing healthcare IT environment and quickly responsive to consistent user’s needs and requirements.

Authors’ contributions

S. Yoo designed the study and drafted the manuscript; S. Kim and S. Lee contributed to the data categorization and analysis; and K. Lee, R. Baek, and H. Hee contributed to the discussions of data and reviewed the manuscript.

Conflict of interest

There is no conflict of interest that could inappropriately influence the authors’ findings.

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Summary points

What was already known

- The adoption rate of comprehensive EHRs is still low worldwide.
- Graphical-user-interface design quality and feature functionality have been shown to affect EHR implementation outcomes.
- Unmet research needs are known to be one of the basic factors that prevent the deployment and use of EHRs in the healthcare industry, in addition to financial factors and the immaturity of available products.
- There is little information about end users’ needs and requirements that arise during the routine use of full-EHR systems after implementation.

What this study added

- After adopting and implementing a full-EHR system, end users continued to make suggestions about their needs and requirements for the system as their activities and tasks and the other technologies were tightly integrated with the system and have been changed.
- The direct-care user group most frequently concerned ease of use and user interface. EMR capabilities of personalized configuration settings that provide flexible user interface would be the important features to reach the various types of healthcare users’ requests.
- There seemed to be growing unmet needs, especially for the group of care-support and general management users, in terms of special task-oriented functionalities, highlight the necessity for taking into the unmet needs from the user groups in future system design.
- Service requests on patient safety and quality of care seemed to be continuous and important to support the activities of patient safety for the care-support user group, such as pharmacy, laboratory, infection control, quality assurance departments, as well as direct-care departments.
- Developers of future EHR systems should consider the following factors in the design process: innovative new user-interface technologies; special extended functions for each type of user’s specific task-oriented requirements; powerful, easy-to-use functions for research support; new flexible system architecture; and patient-directed functions.

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