User-centered Approach to Developing Solutions for Electronic Medical Records: Extending EMR Data Entry

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Abstract: The rapid advancement of technology presents the opportunity to digitize practice management. With a doctor to patient ratio of 1:33,000, digitizing health records in the Philippines is seen as one solution in providing more efficient health care services. With the deployment of EMRs in the Philippines at its infancy, there is a need to initiate studies on feasibility, usability and user perception. This paper reports findings on usability of EMRs in a developing economy. Specifically, a system usability scale (SUS) was used to assess the usability of an EMR and interviews were conducted to acquire user feedback. Results of the survey indicated an overall mean SUS score of 70.76 with age and confidence in technology being key deciding factors. Further observations and future research to streamline the heavy task of encoding on an EMR during patient-physician consultation are explained.

1 INTRODUCTION

The World Health Organization (WHO) suggests that the desirable doctor-patient ratio is 1:1000 (Kumar and Pal, 2018) but last 2008, a doctor to patient ratio of 1:28,000 was reported in the Philippines (Villar Jr., 2008). As of 2016, the country had further increased its doctor to patient ratio to an alarming 1 doctor for every 33,000 patients (Sandoval, 2016), a far cry from the WHO recommended standard.

To curb the staggering proportion of doctors and patients, the recently promulgated Universal Health Care Act (UHC) aims to provide policies and infrastructure that improves the situations of both health service provider and health-seeking individual (Congress of the Philippines, 2018). The UHC law also cites a number of government programs that aim to increase human resources for health. These programs include the National Health Human Resource Master Plan, scholarships, training programs, and a return service agreement where graduates of health-related courses who are recipients of government-funded scholarships are required to work in the public health sector for at least three years.

This study builds its foundation from section 36 of the act which states that health service providers are required to maintain a complete health information system, a component of which is the electronic medical record (EMR). To increase adoption to the technology, public health clinics who submit patient profiles and patient encounters to the Philippine Health Insurance Corporation (PhilHealth) via EMRs are entitled to receive cash incentives. The EMR is also an avenue for receiving incentives for clinics that provide health care services that are of high priority by the Department of Health including maternal care and new born care.

This study zooms in on the crossroads Philippine doctors find themselves in through the Universal Health Care Act. On one end, the continuously rising number of Filipinos pushes the need for faster patient turnaround times while the nation's doctor-patient ratio is being improved. On another end, physicians are pressured to implement EMRs in their practice for more efficient facilitation of electronic claims.

As of date, there has been no comprehensive study on the utilization of EMRs since its initial implementation in 2015. Implementing and deploying EMRs without focus on users and usability has been proven to hinder adoption and further development of the technology (Force, 2011). Solutions and features currently being developed whether for existing EMRs or as new software may be rendered ineffectual once shipped out without being grounded in user feedback and without including the user within the center of the design process.

The challenge to adopt and adapt to new and unfamiliar technology in the face of high work demand

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may be a task too heavy for any user and may be counterproductive to the goals the UHC set out. This paper describes an application of user-centered methods to ideate and create solutions for EMRs. The surge in EMR usage and adoption in the country brought about by the UHC has presented an opportunity to survey and acquire the feedback of the users of existing EMRs. In response, research materials such as a demographics questionnaire and the system usability scale were produced and modified for distribution to EMR users. A research team conducted a week-long survey that covered a number of clinics hundreds of kilometers apart.

2 USABILITY AND USER-CENTERED DESIGN FOR EMRs

User-centered or Human-centered design is defined by the International Organization for Standardization as an "approach to systems design and development that aims to make interactive systems more usable by focusing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques (ISO Central Secretary, 2019)." Improved productivity, enhanced user well-being, avoidance of stress, increased accessibility, and reduced risk of harm are some of the benefits user-centered design brings to systems (ISO Central Secretary, 2019). This study takes inspiration from the goal of user-centered design which is to optimize the user's experience of a system by including the user and the user's perspective in all stages of the system's development. Development of the research materials used in the study were guided by user-centered design philosophy.

User-centered design highlights the importance of and is heavily concerned with the subject of usability. The Handbook of Usability Testing explains that a product or a system is usable when users are able to perform tasks they expect to be able to do without any barriers or hindrances (Rubin and Chisnell, 2008). In the scope of EMR usability, Belden et al. (2009) enumerated key methods in evaluating the usability of a system by assessing its effectiveness, efficiency, and satisfaction provided to users. Given how this study deals with EMRs that have already been shipped for production and distributed to the market, this study focused on acquiring user feedback data to determine if these systems were able to pass expected criterion.

Page and Schadler (2014) explored how to increase the efficiency, effectiveness, and satisfaction of the nursing interface of the University of Kentucky Healthcare EMR. The study aimed to create systems that made it easy to tell patient stories and reflect nursing practices through rapid iterative methods in design, prototyping, and user testing that spanned two years segmented into 4 phases. A defining factor in the whole process was using iterative development phases that was guided by cognitive nurse workflow, tangible requirements from work teams, and future state user workflow. Including the users within the design motivates them to continue using the technology and become part of what drives the technology to be better.

Rose et al. (2005) examined the results management module of the Longitudinal Medical Record (LMR) web-based EMR through two qualitative studies conducted among the EMR's users. The study used task analyses and focus groups as its main methodologies to address usability factors in the system. Prevalent issues in both studies included information overload and poor organization, disruptive effects to physician workflows, and lack of visual cues and feedback. Focusing on the user's workflow in their busiest time was a key recommendation moving forward. This supports the motivation behind meeting users face-to-face in order to be able to personally observe what they really need from a system.

With regards to the system usability scale, Kavuma (2019) surveyed and scored EMR systems in 19 reviewed publications based on efficiency, effectiveness, ease of learning, cognitive load, and user satisfaction using a 5-point rating system inspired by the usability evaluation criterion of the Healthcare Information and Management Systems Society (HIMSS). The study aimed to evaluate the usability of EMRs in sub-Saharan Africa and to find out how much usability enabled or hindered EMR implementation in the region. Findings showed that user satisfaction was the key factor that pulled the general usability score down. Moreover, it was observed that ease of learning was correlated to effectiveness as a number of systems simultaneously had high scores in both metrics. The study recommended that EMR systems providers pay special attention to user satisfaction when implementing EMRs.

Furthermore, Shah et al. (2013) developed an EMR system catered to palliative care providers in low-resource areas of sub-Saharan Africa and evaluated its usability using the system usability scale. The study aimed to provide palliative care to Africans in response to rampant diseases such as HIV/AIDS, tuberculosis, and cancer. The results from the system usability scale showed a positive overall median of 77.5, well above the accepted threshold of 70 to be deemed usable. Participants, however, were con-

fused by the difference between ”agree” and ”strongly agree” and likewise ”disagree” and ”strongly disagree”. This may suggest the merging of the two positive and negative answers as the difference warranted no significant effects to the overall result.

EMR usability is a rising field of study in many nations and with the UHC, it is high time that EMRs in the Philippines are also examined.

3 DATA COLLECTION

An open ended survey was constructed to measure user experience including: what types of users are there, how they perceive their EMR, how they use their EMR, what features they like and dislike, what their pain points are in using their EMR, what they would like added or taken away, and what can be done to improve their experience on their EMR. The SUS was slightly modified to fit the context of the research without sacrificing too much of the original essence. Specifically, the word ”system” was replaced with ”EMR”, the verb tenses were changed from past tense to present tense, and complex words such as ”cumbersome” were replaced with simpler alternatives. Small changes like these were also made by previous studies and had shown no significant effect to the result (Finstad, 2006; Bangor et al., 2009). Additionally, an interview script was created to allow further elaboration of answers and for the participants to be able to fully express their opinion.

These materials were primarily distributed to the users and clients of the SHINEOS+ EMR service as an initial survey population. SHINEOS+ is a web and mobile-based EMR service that caters to a network of health establishments and health professionals in the Philippines (The Secured Health Information Network Exchange, 2019).

Data collection was performed during a five-day trip that covered three provinces in the Western Visayas region of the Philippines. A mixture of allied health professionals including midwives, nurses, doctors-to-the-barrios, and municipal health officers were asked to participate in a one-on-one session to answer the research materials and be interviewed personally. Each session took an estimated 45 minutes to an hour including the interview. Before each session, compliant with modern ethical standards, participants were oriented on details such as what the purpose of the survey was, why they were asked to participate, and if they could withdraw from interview at any point. The survey proper started with the demographics questionnaire, followed by a usability assessment through the system usability scale, and concluded with the interview.

The demographics questionnaire was created to find out what kind of users implement the EMR at work. Occupation, gender, and age were the standard questions asked while literacy and confidence in technology were also assessed. Furthermore, participants were also asked how long they have been using the EMR, how often they use the EMR, and in what period of a work day do they interact with the EMR the most.

A version of the system usability scale was created in order to attain a qualitative level of the usability of the EMR based on its user’s perspective. The system usability scale is a tool that yields a provisional measure of a usability through a 10-item Likert-scale questionnaire (Brooke et al., 1996). For the case of this research, a total of 15 more items were added to the SUS and the whole questionnaire was adapted to fit the EMR context. The extra items were included to encompass other areas such as technology stress but for the purpose of this study, only the items concerning the baseline SUS will be evaluated. In total however, the participants were asked to score 25 statements based on the degree of which the statement pertains to them.

An interview was held in order to allow users free speech on their opinion of the EMR as well as to be able to further expound on their answers. The participants answered a total of 12 questions that were carefully formulated such that they were structured to keep the topic within bounds of the EMR conversation but without being too leading as to provoke specific answers. The participants were asked questions in English but were given free reign to use whatever language they were most comfortable speaking.

Interview questions as well as SUS items were meticulously formulated to map to a specific aspect of usability, whether efficiency, effectiveness, or satisfaction. Through this, participant answers are more tangible, the survey is more more organized and consistent, and data acquired is easier to classify. Table 1 illustrates the mapping of interview questions and modified SUS items to specific usability factors.

Each one-on-one session was conducted in a separate room in order to minimize noise and establish a more private setting. In both written and oral surveys, no identifying information were collected in order to preserve user anonymity. The demographics questionnaire and modified system usability scale were answered by the participants with a pen on paper. The interview was recorded using the interviewer’s mobile phone and the audio recordings were stored on a privately hosted repository on the cloud. Interviewers were also advised to take notes as backup and imme-

diate sources of information.

After completion of all one-on-one sessions, data from the demographics questionnaire and system usability scales were tallied on a Google Sheets spreadsheet while transcription from the interviews were collated on a separate spreadsheet. A coding manual providing a mapping of fields to descriptions, data types, and sample values was created for a more structured encoding and more readable results.

4 RESULTS AND DISCUSSION

4.1 Demographics Results

A total of 15 regional health units and clinics were visited at the end of the trip. From these 15 establishments, 36 health professionals agreed to participate to the study. Almost two-thirds of the participants were in the age range of 18 to 35 while the other one-third was aged 35 to 55 with one participant being 55 and above. Furthermore, among the participants, 62% or 22 of them were confident with technology while 28% or 10 of them were somewhat confident. The remaining 10% consisted of one participant not confident and technology and other participants who preferred not to say. It was observed that there was no correlation between age and technology literacy since there were participants within the ages of 18 to 35 that were somewhat or not confident while there were participants within the ages of 35 and above who were confident. Lastly, 83% of the participants use the EMR on a daily basis while the remaining 17% use it either on a weekly or a monthly basis. How frequent participants use the EMR was observed to be not correlated to roles and most likely be dependent on the strategy their respective clinics implement with regards to EMR implementation.

4.2 SUS Score

Even though with an overall mode SUS score of 67.5, participants rated the EMR with an overall mean SUS score of 70.76 with a standard deviation of 10.54, just slightly lying above the accepted passable score of 70 (Bangor et al., 2008). However, it must be noted that the range of SUS scores ranged from as low as 40 to as high as 90.

Findings showed that age was a factor in rating the usability of the EMR as participants within the age range of 18 to 35 provided an overall mean SUS score of 71.75 while participants within the age range of 35 to 55 had provided an overall mean SUS score of 66.25 giving a huge 5-point difference. From here, it can be said that the EMR appeared more usable to younger participants compared to older participants.

It was also observed that confidence in technology was also a factor affecting the SUS score. Participants who indicated that they were confident in using technology and computers provided an overall mean SUS score of 73.75 while participants who indicated that they were either somewhat confident or not confident at all using technology and computers provided

Table 1: Mapping of SUS items and interview questions to key usability factors.

Usability Factor	SUS item	Interview question
Efficiency	”I find the EMR unnecessarily complex”, ”I find the various functions in this EMR are well integrated”, ”I think there is too much inconsistency in this EMR”	”Which tasks take the longest to accomplish using the EMR? What are the steps you take to accomplish these tasks?”, ”Does the EMR become unresponsive at times? What are the steps you take when it does?”
Effectiveness	”I think that I need the support of a technical person in using this EMR”, ”I imagine that most people can learn how to use this EMR very quickly”, ”I find the EMR very unmanageable to use”, ”I need to learn a lot of things before I can start using this EMR well”	”How often do you encounter errors when using the EMR? Which tasks are error-prone?”, ”Have you had to change any part of your workflow in order to fit using the EMR? Which part of your workflow did you change and how?”
Satisfaction	”I want to use this EMR regularly”, ”The EMR is easy to use”, ”I feel very confident in how I use the EMR”	”Would you prefer to have alternative (e.g. paper and pen, record book) methods in storing your medical records? Why, or why not?”

an overall mean SUS score of 62.5. Computer literacy and confidence in technology proved to be a key factor in assessing the EMR's usability.

The roles played by participants within their work did not however affect the SUS score. Encoders, nurses, and municipal health officers as groups provided overall mean SUS scores within the range of 70 to 73, all rating the EMR system as passable.

4.3 Interview Results

A total of 300 minutes worth of interviews were recorded during the one-on-one sessions. Table 2 illustrates a summary of findings from the interviews.

With regards to efficiency, most of the participants agreed that there were no tasks intrinsic to the EMR that took glaringly long to accomplish. Words such as "easy" and "responsive", after translation to English, were used by the participants to describe the system. The tasks that did take long to accomplish were reliant on required third-party service providers and a stable internet connection. It is important to note that these issues causing delays to the users' workflow is the technology required in order for physicians to receive incentives specified in the Universal Health Care Act.

On the topic of effectiveness, participants state that errors happen only on the tasks that concern submission for eClaims. Aside from these, participants find no other tasks error-prone. Furthermore, participants also express that apart from the initial change brought by learning how to use the system, the EMR has caused no major change to their respective workflows. The participants explain that they have been able to adjust well to the requirements of the technology and find that their original workflow is not as different as their current process with the EMR. However, it was noted that the participants had to extend work hours sometimes well beyond closing time as their internet connection would only stabilize by afternoon onwards. Albeit this change being the biggest adjustment to the users' workflows, it is an issue that must be solved immediately as it deprives users of regular work hours.

Finally, compared to traditional paper-based records, participants were very satisfied with their EMR but were more keen to the idea of implementing an EMR while still keeping paper-based records for the purpose of backup. As a response to intermittent internet connection causing multiple downtimes during the day, users adapt by using paper records first then encoding the records once connection is stable.

Table 2: Summary of responses to interview questions pertaining to key usability factors.

Usability Factor	*Question*	*Findings*
Efficiency	Which tasks take the longest to accomplish using the EMR? What are the steps you take to accomplish these tasks?	There are no tasks that take long to accomplish within the system, Weak internet connection is the main culprit when tasks take a while
	Does the EMR become unresponsive at times? What are the steps you take when it does?	Long loading times caused by weak and unstable internet connection
Effectiveness	How often do you encounter errors when using the EMR? Which tasks are error-prone?	Errors happen not often and are immediately solved by service provider when brought to attention, Tasks that are error-prone are data entry to eClaims and patient admission
	Have you had to change any part of your workflow in order to fit using the EMR? Which part of your workflow did you change and how?	Workflow did not change as same processes are followed, Work hours increased however due to availability of internet
Satisfaction	Would you prefer to have alternative (e.g. paper and pen, record book) methods in storing your medical records? Why, or why not?	A mix of electronic and paper records is preferred

5 DISCUSSION AND RECOMMENDATIONS

Initial scoring on usability of SHINEOS+ EMR falls short compared to global counterparts. EMR systems such as the DataPall system in Africa which scored 77.5 Shah et al. (2013) and the NexTech system in Florida which scored 82 Schumacher et al. (2010) are ahead in terms of usability.

Based on results of the survey, SHINEOS+ EMR achieved good reviews with regards to its efficiency, effectiveness, and user satisfaction, all pillars of usability. However, there are still more improvements that can be made to improve the service. It is apparent that the main issue users encounter are with availability due to internet and interoperability with third-party services. A solution to this can be the use of the offline version of SHINEOS+ EMR where data entered is first stored on local storage and is only saved to the cloud once a connection to the internet is available. This innovation will allow users to be able to work during the day without downtime which in turn allows them to finish work within work hours.

Furthermore, it is also recommended that members of the SHINEOS+ EMR team conduct more visits to their users whether for the purpose of updating them on what is new, or acquiring their feedback on the current system, or checking on what makes the work of their users harder and how the team can address those issues. It is understandable how distance can be an issue so a substantial visit every 6 months can be a reasonable timeframe for this. A cornerstone of user-centered design is the users themselves and conducting a visit every once in a while not only allows system makers to quickly and iteratively improve their product but also gives users the opportunity to participate in the development of the tools that they use and more confidence in their chosen EMR.

6 FUTURE RESEARCH

It was a common trend among all rural health units to have a staggering number of patients as early as 8 A.M. At these times, it was normal for the receiving area of each building to be filled by individuals that need care or by mothers with children suffering from an illness. Given the large number of people at such an early time, as well as having a limited number of staff, and only having one doctor assigned to each rural health unit, these establishments had adopted unique strategies for attending to their patients. Figure 1 illustrates three observed strategies.

Strategy A utilizes a completely paper-based approach of recording until the information is handed to an encoder for encoding to the EMR as well for processing of the patient record for the extra provisions specified in the Universal Health Care Act. Strategy B involves a paper-based approach of profiling until diagnosis where a doctor writes the diagnosis on paper while a nurse by the doctor's side encodes the diagnosis to the EMR as the doctor states it. Strategy C uses an all-EMR approach.

It is interesting to note that during the diagnosis stage of the strategies, some doctors encode directly onto the EMR while some doctors still write their diagnoses on paper. When the doctors who preferred writing on paper were asked why so, the general consensus was that it would take them longer to encode than to write particularly due to slow typing speed and intermittent internet connection. However, it was stated by some nurses and encoders that they have a hard time reading doctors' notes and result to consulting with the doctor about what they wrote before encoding to the EMR. Considering the high demand for fast patient turnover especially in the most rural areas, every minute is precious and doctors can not afford to waste time dealing with their EMR.

Studies by Poissant et al. (2005) and Hill Jr et al. (2013) have shown that electronic charting can take significantly longer compared to traditional handwriting. Furthermore, as of late, most EMRs only support typing input but Smelcer et al. (2009) explains that many physicians still prefer to write on paper. A challenge, then, is to figure out how to give doctors another method of EMR data entry that is less cumbersome than manually typing through a computer. Developing a solution for this will remove the extra time taken to encode data from paper to an EMR and will allow encoders to reallocate their time saved from deciphering doctors' notes to other tasks that may improve overall rural health unit performance.

6.1 Handwriting Recognition

A possible solution and a continuation to this research is to explore supporting handwriting as a method for data entry to EMRs. This will be done by developing a handwriting recognition interface and integrating it to an EMR for testing, refining through user feedback, and iterative development. The SHINEOS+ EMR service will be used to pilot the technology as a testbed and for possible public use in the future.

Recognizing handwriting involves acquiring data such as plane coordinates, time between strokes, and pressure levels from a compatible digital surface that accepts handwriting input. Examples of digital sur-

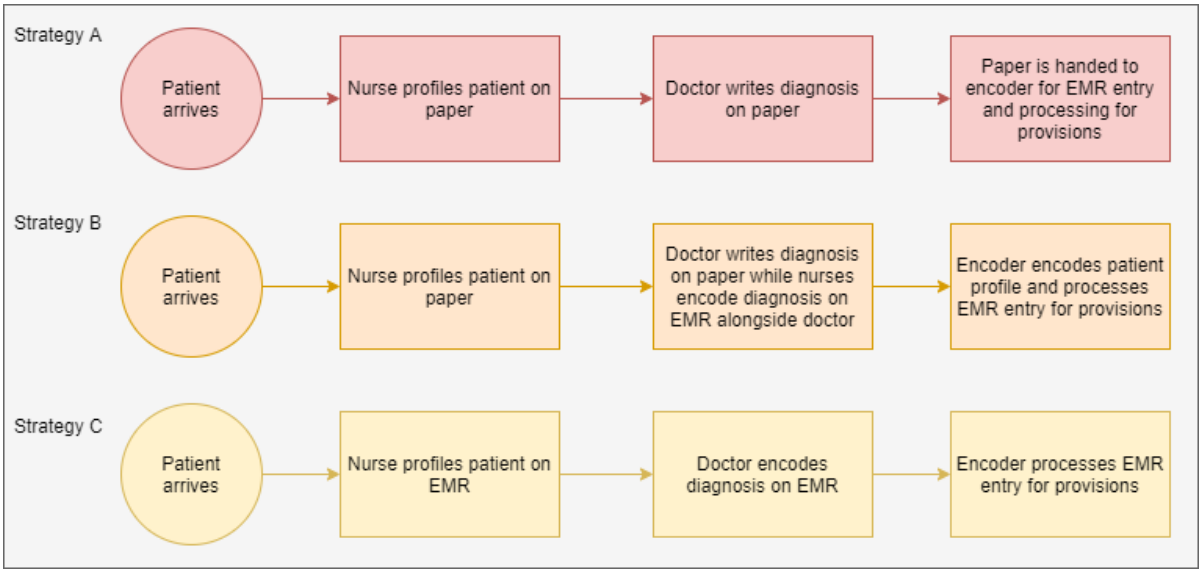

Figure 1: Observed strategies implemented in rural health units.

Figure 2: Sample handwriting recognition implementation.

faces are tablet computers and pen tablets used by graphic designers. The JavaScript library MyScriptJS will be used to abstract these functions and bring handwriting recognition to SHINEOS+. Figure 2 illustrates a sample implementation developed to test the capabilities of MyScriptJS.

Once initial capabilities have been measured, augmentations to the recognition algorithm will be explored in order to improve handwriting recognition accuracy if needed. Furthermore, user-centered design philosophies will be employed to ensure that the final outcome is a solution that is usable and has been developed with and for the users. After a desirable state is achieved, the handwriting recognition interface will be integrated to the SHINEOS+ EMR as an additional option for data entry during patient-physician consultation. Additional features such as key clinical text extraction and automatic mapping to EMR fields will also be developed to provide a seamless flow of data from doctor handwriting to free-text.

7 CONCLUSIONS

This paper explored the situation of healthcare in the Philippines, specifically in the context of the Universal Health Care Act and how health professionals are now to manage their practice with the aid of an EMR. Users of the SHINEOS+ EMR were surveyed to acquire their feedback and usability of their chosen EMR through carefully selected research methods and materials inspired by user-centered design philosophies. Results of the survey were reported and additional insights and solutions were discussed.

In the case of the Philippines, there is an apparent need for the provision of more policies and infrastructure that will support the technologies required by the UHC. At the end of the day, software can only go insofar as the resources it needs are available.

Even though the EMR discussed proved to be passable in terms of usability, this does not necessarily mean that it is also acceptable. Different contexts necessitate different strategies to overcome unique problems and technology should be made as flexible as can be to accommodate the widest range of use cases. In light of this, it is important that the users are also included in the formulation and design process of solutions. This assures that services and programs truly do cater to the users needs and not just to the assumptions of the provider.

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