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A Micro-analysis Approach in Understanding Electronic Medical Record Usage in Rural Communities: Comparison of Frequency of Use on Performance Before and During the COVID-19 Pandemic

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Abstract

In strengthening eHealth in the Philippines to support the universal health care (UHC) law, the scaling up and full adoption of electronic medical record (EMR) systems was strategically scheduled and supposedly completed in 2020. The Covid-19 pandemic, however, delayed these strengthening efforts. We wanted to assess the status of EMR adoption in primary clinics of rural health units (RHUs) and understand the frequency of use, particularly during the pandemic. Through analyses of EMR usage logs from selected RHUs in 2020, we estimated frequency of EMR usage based on duration of use and tested if this was influenced by the performing RHU and pandemic event. We also determined the most frequent EMR activities through process maps and tested if there were differences in the conduct of these activities before and during the pandemic. Results showed that EMR use during work hours was significantly dependent on the performing RHU (p<0.001). High-performing RHUs used EMRs more than 3 hours/day while low-performing RHUs used the systems for less. The pandemic either significantly decreased or increased EMR use during work hours by around 5 hours/day in some RHUs (p<0.01). Process maps revealed that there were additional activities performed by RHUs during the pandemic. Except for Update Patient Profile and Add Patient EMR features, significant differences (p<0.01) were observed in accessing frequently used features before and during the pandemic. The results suggest some uneven level of utilization of EMRs at the primary care level which can impact readiness to support full

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implementation of the UHC law. The study shows the potential of using a more granular approach in studying adoption to help improve the quality of EMR use and contribute to improving health service delivery and financing.

1. Introduction and Background

In 2005, the World Health Organization (WHO), recognizing the potential of using information and communication technologies (ICT) to positively transform the delivery of health services and systems, urged its member states to draw up long-term strategic plans for eHealth or the use of ICT for health [1]. The Philippines adopted a national health information system strategy in 2007, formed a Technical Working Group to assist the Department of Health (DOH) in developing eHealth in 2010 and formally launched a national eHealth strategy in 2013 as the Philippine eHealth Strategic Framework and Plan (PeHSFP) [2].

One of the indicators used to measure the level of adoption of eHealth among member states is the presence of a national electronic health record (EHR) system. The country continues to work on this as part of the strategic plans for eHealth and in support of the implementation of the Universal Health Care (UHC) Act (Republic Act No. 11223, 2019) [3]. Known as the Philippine Health Information Exchange (PHIE), it is aimed to be a "platform for secure electronic access and efficient exchange of health data and/or information" among various health stakeholders and will "integrate and harmonize health data coming from different electronic medical record and hospital information systems" [4, 5].

With the UHC Act stipulating that health service providers maintain a health information system consisting of EHRs, it is imperative to scale up full use and successful implementation of this system in the country. However, scheduled strategies for attaining this were disrupted as the entire Philippine health system, especially its human resources, was heavily challenged and burdened by the Covid-19 pandemic in 2020.

The pandemic has heightened the role of information technology in health systems. It has accelerated investments in tele-medicine, digital technologies, and information systems. On the other hand, it exposed the lack of interoperability and other critical functions of electronic medical records (EMRs) as well as user issues which hindered their capacity to provide timely access to patient information and ensure a well-coordinated referral system [6].

This study examines the adoption and use of EMR technology in rural primary care settings to glean lessons as the country embarks on universal health coverage. Our findings will provide baseline data on patterns of EMR use before and during the pandemic, during work and outside work hours. This data will help present a picture of workflow using time events and EMR features as indicators of efficiency and performance. Understanding such data has implications for improving processes in the system and optimizing EMR use during normal conditions but more importantly, during critical periods such as in a pandemic. In the long run, efficient use of the EMR informs decision-making that supports UHC, improves patient care outcomes and ultimately, strengthens the health system.

1.1. EMR Adoption in the Philippines

In 2016, the Philippine Health Insurance Corporation (PHIC/PhilHealth) released Advisory 2016-40 requiring all Primary Care Benefit (PCB) providers to select an EMR that has passed the software validation process of the joint DOH-PHIC validation team [7]. At present, these EMRs continue to be used among public hospitals and primary health care facilities in the country. These include the Integrated Clinic Information System (iClinicSys), the Community Health Information and Tracking System (CHITS), Wireless Access for Health (WAH), Segworks and

SHINE (Secured Health Information and Network Exchange) OS+. All were required to contain a set of national data standards [8].

It has been reported that registered users of selected EMRs in health care facilities increased since the initial implementation [4]. However, increase in registered users does not provide a full reflection of adoption of the system. There is a need to probe deeper into the usage to understand how the system is being utilized by the health facilities.

Research on EMR usage logs define EMR adoption based on a set of multiple measures ranging from frequency and duration of actions, frequency of higher-level activities defined by researchers, activity sequences or clusters, and networks of EMR users [9]. Researchers proposed core time-based measures of EHR use which reflect multiple dimensions of practice efficiency. They indicated that the following: total EHR time, work outside of work, time on documentation, time on prescriptions, inbox time, teamwork for orders, and the amount of undivided attention patients receive from their physicians during an encounter are feasible measures relevant to clinical and operational decision-making [10].

A local study on the adoption of EMR among health workers using process mining of usage logs found that users varied in levels, with majority only accessing its basic features and not maximizing the use of the EMRs [11]. Another local study among certain hospitals in Luzon identified several barriers for EMR use including several technological and organizational issues as well as compliance to data privacy [12]. On the other hand, among primary health care facilities in selected regions in Visayas and Mindanao in 2018, redundant data encoding existed as traditional paper-based encoding was still used despite the presence of EMR in the facilities [13].

2. Methodology

2.1. Study Design

A longitudinal study design was constructed using system generated EMR usage logs from January to December 2020 in selected rural primary health care clinics in Western Visayas. Selection criteria include facilities in the selected region which have been using EMRs since its required engagement in 2016. Rural health units (RHUs) were categorized into high-performing and low-performing based on mean duration of EMR use per day. Data obtained from January 1 to March 10 were classified as pre-pandemic phase while data starting from March 11 to December 31, 2020, covered the pandemic period based on official declaration of the WHO Director-General [14]. There is one user account per clinic, usually assigned to the clinic's physician. A total of 272,785 records from six users representing six RHUs were included in the study.

2.2. Variables

Frequency of EMR use was based on two core measures proposed namely: a.) total EMR time and b.) Work Outside of Work [10]. Total EMR time was estimated as the total duration of all EMR actions performed by each user per day during scheduled work hours (8 am to 5 pm, Monday to Friday). Work Outside of Work (WOW) was measured as total EMR time of each user outside scheduled work hours per day (beyond 5 pm to 7:59 am, Monday to Friday and anytime during weekends). Since the system logged the different actions per session, the mean duration of all sessions was determined per month then multiplied by the average number of sessions performed daily, either during or outside work hours by each facility. The relative frequency of each EMR feature used was also determined. Relative frequency was defined as the number of activities performed over the total number of activities within one usage cycle per facility. Cycle was defined as usage for entire period selected. In our study, there were two usage cycles: before pandemic and during pandemic.

The type of action or EMR activity most frequently performed within total EMR time and Work outside of Work is presented in Table 1. This was based on the following actions previously mapped and classified [11]. Basic usage refers to features (activities) that allow the user to digitally record information; advanced usage means that other features such as views and referrals are used; complete usage means full adoption of the system including editing records, managing extensions and plug-ins and syncing data for submission and back up.

Table 1. List of activities based on EMR features and usage category

Basic	Advanced	Complete
Add Patient	View Patient Profile	View Dashboard
Edit Health Record	View List Records	View Profile
Create Health Record	Search Records	View Eclaims Page
	Check Patient PhilHealth ID	View Eclaims Forms
	Update Patient Profile	

2.3. Data Processing and Analysis for EMR Use

Usage logs containing the information needed for this study were extracted from the EMR systems used by the six facilities. The platform's built-in logger was used to record anonymized user interaction with the system. Specifically, the logger creates a new record in the database every time the user performs actions such as submitting online forms, saving records, navigating pages and other possible actions in the EMR. Records were checked for consistency and completeness. The data was also cleaned such that user input (e.g., typing in a text field, clicking a dropdown button) was removed as we are concerned only with feature access.

Summary statistics on the frequency of EMR use was estimated and presented per facility using graphs. A multivariate analysis of variance (MANOVA) was done to determine if EMR usage was affected by the type of facility and pandemic period. P-values<0.05 based on Wilks' lambda (λ) statistics from analyses using STATA/SE version 15.1 indicated statistical significance.

2.4. Process Mining Analysis for Workflow and Relative Frequency

Process mining was performed on the EMR logs using the programming language R, and the open-source package bupaR. It is a requirement for process mining that the data is in the form of an event log with an associated a.) case identifier, b.) activity, c.) activity instance, d.) timestamp, e.) lifecycle identifier, and f.) resource for each entry. Since we are examining actions performed by a user on the system, which is a web-based application, each action in the event log corresponds to feature access.

The pre-processed logs only include completed feature access. Each event in the log was treated as the activity instance, and each event was given the Status of "complete." The Session ID was generated every time a new access token is created for the user that successfully logged in, thus one case in a process is made up of features accessed by a user from the time they are logged in to the time they log out i.e., a session. The values for the Action Type column were derived from patterns observed in the URL that the user is currently on, the URL the user is attempting to access, and the HTML element interacted with, all of which can be found in the EMR log. Finally, the Facility ID was used as the resource identifier. Each user of the system has an associated Facility ID that can be used to identify the actual facility where the EMR system is being used, therefore one Resource is representative of the whole facility.

Process Mining was performed on two subsets of data: a.) data for entries recorded in the pre-pandemic period, and b.) data for entries recorded during the pandemic period. Process maps were generated using a percentile cut-off of 95% for the most frequent activities i.e., for the most frequent activities until they were representative of 95% of the dataset. Differences in relative frequencies of activities before and during the pandemic were compared using one-sample z-test for binomial proportion in OpenEpi 3.01.

2.5. Ethical Considerations

The study, as part of the bigger project funded by the University Research Council (URC) of Ateneo de Manila University, has been given ethical clearance by the University Research Ethics Office (UREO). Data on EMR users were also anonymized and facilities were de-identified using unique identifier codes.

3. Results

3.1. EMR Usage

Figure 1 shows the average duration of daily EMR use per month by clinics in the rural health units (RHUs) during work hours. Based on mean duration of daily EMR use, RHUs 1, 2 and 3 were classified as low-performing RHUs while RHUs 4, 5 and 6 were considered high-performing RHUs. Before the pandemic occurred, RHUs used EMR during work hours for an average of 200 minutes (3.3 hours) per day. The lowest duration recorded was 27 minutes per day while the highest duration was seen in RHU 5 at 753 minutes (12.6 hours) per day, exceeding the 8-hour work period. RHU 5 had increased use of EMR before the pandemic, while the others had stable duration of use. During the pandemic, average use was similar at 192 minutes (3.2 hours) per day. The longest duration of average daily use was estimated at 964 minutes (16.1 hours) per day in RHU 6, also surpassing the number of work hours in a day. Non-use of EMR during work hours by RHU 2 for several months was noted. Except for fluctuating duration of EMR use by RHU 6 during the pandemic, others had relatively stable use.

RHUs used the EMRs outside work hours in 2020. Before the pandemic, mean duration of EMR use outside work hours was 81 minutes per day with the longest use at 261 minutes (4.4 hours) per day. During the pandemic, mean duration of EMR use outside work hours was 63 minutes per day with the longest use estimated at 340 minutes (5.7 hours) per day.
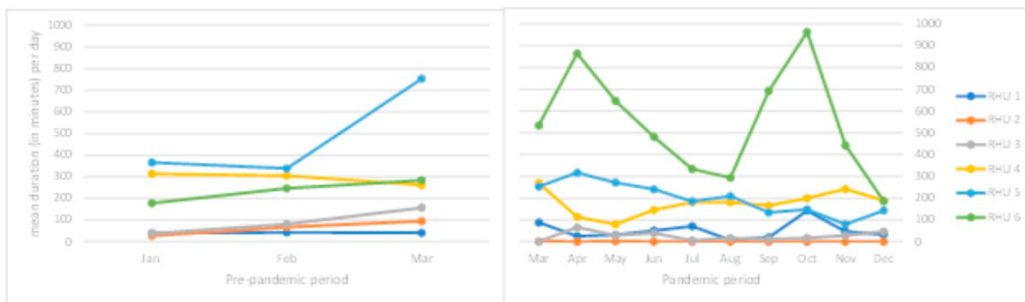

Fig. 1. Average daily EMR use during work hours by facility per month, pre-pandemic (left), and during pandemic (right)

Figure 2 shows the average duration of daily EMR use per month by clinics in the RHUs. EMR use outside work hours was comparable among the RHUs before the pandemic except for RHU 2 and RHU 6. During the pandemic, RHU 2 did not use the EMR outside work hours, while RHU 1 and RHU 6 had notable fluctuations in EMR use. RHU 6 recorded the longest use of EMR outside work hours, before and during the pandemic.
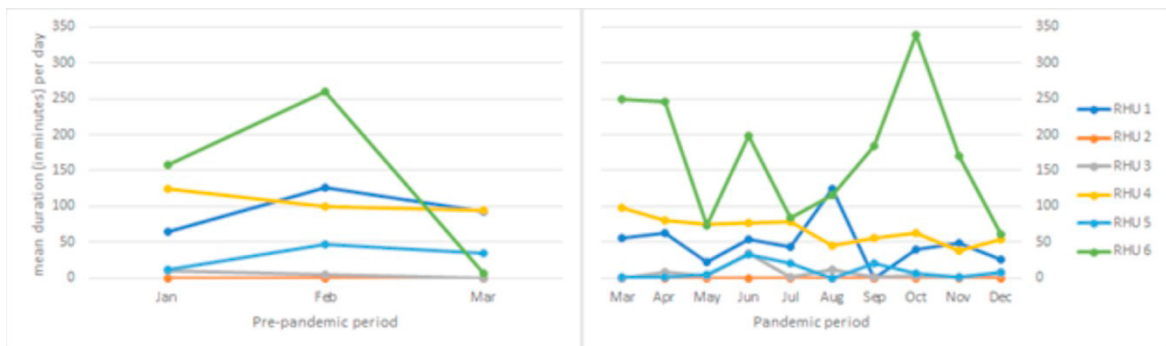

Fig. 2. Average daily EMR use outside of work hours by facility per month pre-pandemic (left), and during pandemic (right)

We tested an overall model where frequency of EMR usage is dependent on two factors, namely, RHU facility and occurrence of pandemic, as well as the interaction of both. Results from MANOVA showed that the type of RHU has a significant main effect (Wilks' λ=0.2369, F=13.44, df=8, 102; p<0.001) on frequency of EMR use,

particularly during work hours (F=15.44, p<0.001). Further examination of results revealed that regardless of the pandemic event, EMR use during work hours was significantly longer in RHU 4 (p<0.01) and RHU 5 (p<0.001). While the pandemic did not independently create differences in frequency of EMR use, it had a significant statistical interaction with RHU (Wilks' λ=0.5906, F=3.84, df=8, 102; p<0.001). During the pandemic, RHU 5 had significantly decreased (p<0.01) EMR use by around 299 minutes (~5 hours) while RHU 6 had significantly increased (p<0.01) EMR use by 298 minutes (~5 hours) during work hours.

3.2. Process Maps

Results of process mining display EMR activities as nodes with arrows directed towards the next activity performed by the user. The user can perform the same activity repeatedly resulting in a loop within a node. The darker lines in the process map indicate that an activity is more often an antecedent or precedent to another activity. Figure 3 shows the process map for high-performing RHU before the pandemic while Figure 4 shows the process map during pandemic for the same high-performing RHU.

Before the pandemic, typical workflow begins with four possible states: editing a health record, viewing the list of patient records, creating a health record, and adding a patient. Among these, the most frequent activity is editing health record with relative frequency of 34.26%, although viewing health record is more often the first choice of the user with relative frequency of 20.66%. Other significant flows would be from "Add Patient" to "Create Health Record" and from "Create Health Record" to "Edit Health Record". Most of the time, after viewing a patient profile, the next step that a user would take is to update the patient profile. The last activity is check health care visits which most of the time proceeds to editing a health record.
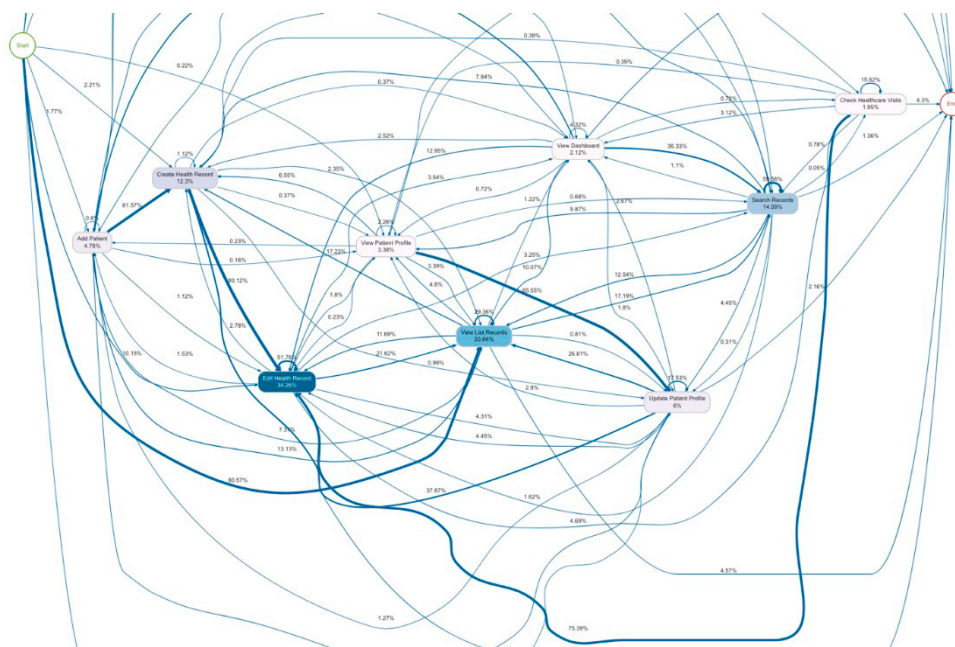

Fig. 3. Zoomed-in Process Map for high-performing RHU during the pre-pandemic period

In the pandemic phase, aside from the four possible states before the pandemic, check health care visits and search records appeared as features that were used, with search records having the highest relative frequency of 24.76%, followed by edit health record and view list with relative frequency of 19.51% and 17.06%, respectively. Three additional activities, though at small relative frequencies, were seen in the process maps during the pandemic phase, namely viewing Eclaims page, viewing Eclaims forms, and checking a patient's PhilHealth ID.

3.3. EMR Features

The EMR features are equivalent to the activities performed by the user. Examination of the most frequent activities done by a high-performing RHU showed that except for Update Patient Profile and Add Patient, there is a significant difference in relative frequencies per activity between pre-pandemic and during pandemic. View List Records and Edit Health Records had significantly higher relative frequencies ($p<0.001$) before the pandemic while Search Records, View Dashboard, Create Health Record, Update Profile, Add Patient, Check Healthcare Visits ($p<0.001$) and View Patient Profile ($p=0.011$) were significantly used more frequently during the pandemic. It is good to note that new activities are present during the pandemic including View Eclaims Page, View Eclaims Forms, and Check Patient PhilHealth ID.
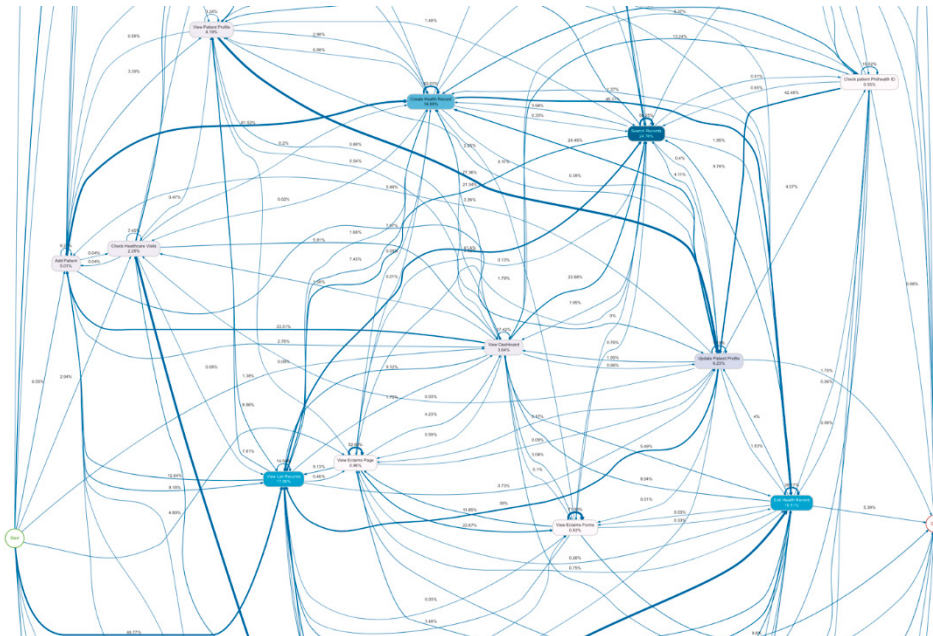

Fig. 4. Zoomed-in Process Map for high-performing RHU during the pandemic period

4. Discussion

4.1. Interpretation of Findings, Strengths and Limitations of the Study

Generally, RHUs had varying usage of EMR during and outside work hours, with notable low and high performers. High-performing RHUs typically used the EMR during work hours for more than 3 hours per day. In settings with widespread adoption of EMR, our results were consistent with previous research which found that healthcare providers used the system from 3.1 hours to 5.9 hours per clinic day [15] while primary care physicians used the EMR at 269 minutes/day during clinic hours [16]. Similarly, average EMR use outside work hours estimated in our study closely resembled that recorded by a previous study at 86 minutes after clinic hours [16].

Our study noted that some high performing RHUs exceeded the usual 8-hour workload at some months by using the EMR for 12-16 hours. Since the logged timestamps in these cases were within the work hours, we inferred that several systems in one RHU may have been kept running simultaneously, overestimating the duration of use. While most RHUs recorded consistent duration of EMR use (including non-use) regardless of the occurrence of pandemic, EMR use in selected high performing RHUs had contrasting results. Increased EMR use in one RHU during the

pandemic could be due to an increase in the number of documentation activities associated with greater patient volume while the opposite can be said for the RHU with decreased EMR use during the pandemic.

Initial inspection on the process maps for a high-performing RHU showed that the workflows have also changed with the occurrence of the pandemic. Relative frequencies of some activities as reflected in the features used by the physician also varied with the occurrence of the pandemic with changes in sequence of use and reflecting use of additional features. It is worth noting that the electronic claims feature was used during the pandemic as it indicated the need of the RHU to check on payments processed by PhilHealth.

To our knowledge, this is the first local study to provide an in-depth analysis of EMR usage logs comparing relevant public health periods. Strengths include using a large dataset spanning one year, with accurate information logged at the most granular level of use. Limitations include unavailability of other facility-level data as well as the general economic and governance conditions affecting an RHU's performance, which could further explain variations in duration of EMR use and frequency of EMR actions.

4.2. Conclusions

Further research is recommended to explain uneven adoption and use of EMRs which can impact readiness of primary care levels to support full implementation of the UHC law. Studies on behavior of users based on usage of basic, advanced, and complete processes should be done to generate knowledge on how to motivate its widespread use. Our findings show the potential of using a more granular approach in studying adoption, looking at frequency of use based on activities performed by the doctor as reflected in the features used most and used less. Improving the quality of use of EMRs can improve health service delivery and financing, particularly in the latter as EMRs can directly link to the reimbursement processes of PhilHealth, the main funding agency.

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