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Restructuring Human Infrastructure: The Impact of EHR Deployment in a Volunteer-Dependent Clinic

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ABSTRACT

Non-profit organizations (NPOs) are often resource-restricted and rely on volunteers to function. As such, their human infrastructure—the social system supporting work—is different from conventional organizations, and technologies that function in a traditional organization with a stable workforce may not work in NPOs. Through an investigation of the deployment of an Electronic Health Record (EHR) system in a safety-net free clinic serving underprivileged populations, we report how the EHR system disrupted the human infrastructure—namely, the work typically enacted by volunteers. Specifically, there was a mismatch between the technological and human infrastructures leading to diminished volunteer roles, an increased workload for paid employees, and a negative impact on the quality of patient care. In turn, employees acted to reconcile the disrupted human infrastructure by creating new work roles for volunteers, re-establishing the quality of patient care, and developing workarounds for volunteers to resume their volunteer work. Finally we discuss how the commercial EHR system failed to support the fluid volunteer-based human infrastructure of the free clinic.

Author Keywords

Free Clinic; Volunteer-Dependent Work Practices; Electronic Health Record; Human Infrastructure; Volunteer Coordination; Technology Deployment

ACM Classification Keywords

H.0 [information systems], K.4.3 [organizational impacts] J3.Life and Medical Sciences: Health, Medical Information Systems

INTRODUCTION

Uncovering the technological and organizational impacts of information systems has long been an interest of the CSCW community. Past studies have identified many critical issues regarding how technologies are implemented, adopted, and adapted, as well as how such systems influence the communication, collaboration, and coordination behaviors within organizational settings [14, 15, 16, 25, 26, 30, 31]. Through a socio-technical lens, these studies point out the important role of the human infrastructure—"the arrangement of organizations and actors that must be brought into alignment in order for work to be accomplished" [21]—in sustaining technological infrastructure in organizations. In particular, Giddens [12] argued that human agency and social structures have a recursive relationship, and Orlikowski [24] showed how a similar relationship exists between technology and human action. On one hand, technology mediates human action; on the other hand, it is also adapted by human action.

Whereas prior work has led to deep empirical and theoretical understandings of how to design, develop, and deploy technologies in organizations, these insights are mostly drawn from conventional organizational environments where the human infrastructure consisted largely of employees[1], and where work performance was typically evaluated through standard business metrics such as productivity and revenue [14, 15, 16, 25, 26, 30, 31]. However, technology adoption and use is not limited to organizations with a stable workforce, but can also be examined within the context of resource-restricted organizations, such as many non-profit organizations (NPOs), where the operations rely on not only paid employees, but also those who volunteer to provide assistance. The challenges of designing and deploying technologies in these settings are considerably different since the human infrastructure underlying work practices are distinctly different [7].

Given the pervasiveness and rapid development of technology, even resource-restricted NPOs have been pressured to adopt new technologies for managing work-related information and enhancing efficiency [20]. Yet, little

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[1] In this paper we use the term employees when referring to the paid staff to distinguish them from volunteers.

is known about the work practices of NPOs and their technology use, including the impacts and challenges of deploying technologies designed for conventional organizations, as resource-restricted NPOs often have to perform work in non-conventional ways due to a lack of financial and human resources [10, 34]. For example, a recent study has found that NPOs had to repurpose database systems designed for conventional organizations in different ways to manage their large pool of volunteers [33].

In healthcare settings, implementing large-scale information systems, particularly Electronic Health Record (EHR) systems, have been found to cause significant disruptions to the routine work practices of healthcare providers [19, 32]. Many unintended consequences have been found after introducing new information systems in clinical settings, such as decreased work efficiency, increased threats to patient safety [1, 8, 13] and end-user resistance and even failure in adoption [3, 5]. These studies highlighted important challenges in designing and deploying new information systems in healthcare organizations, and proposed potential solutions that could alleviate and avoid these problems.

Given government mandates requiring all healthcare organizations to implement an EHR system in the near future, and the goal to achieve improved efficiency and quality of patient care, healthcare organizations are increasingly adopting large-scale EHR systems. As a result, even resource-restricted healthcare organizations, which are typically underfunded, have to purchase and implement EHR systems. Nevertheless, few studies have examined the impacts of EHR system implementation on the work practices and infrastructures, especially the human infrastructure, of these resource-limited healthcare organizations. In particular, non-profit *safety-net* clinics are often limited in resources and volunteers are instrumental to their sustainability. These clinics provide a broad range of healthcare services to medically underserved and uninsured populations, regardless of a patient's ability to pay. Therefore they play an indispensible role in the US healthcare systems. The unique attributes of non-profit safety-net clinic settings make their technology adoption and use an interesting and important research topic to explore.

In this paper, we explore technology deployment and use in a safety-net clinic serving a homeless and poverty-stricken population, paying close attention to the impacts of a new technology on the organization's human infrastructure. Specifically, we observed the rollout of a comprehensive EHR system at the clinic and interviewed key personnel, including those leading and those affected by the transition from paper-based records to the EHR system.

Building on previous work investigating EHR deployment in healthcare settings, we make several important contributions to CSCW scholarship. First, we contribute a better understanding of how the human infrastructure was disrupted when the EHR system, which was not intended for resourced-restricted volunteer-based organizations, was deployed in the non-profit safety-net clinic. The disruption prohibited volunteers from carrying out tasks that they had been trained and were responsible for prior to EHR adoption. Thus, the disruption caused to the human infrastructure greatly mitigated the potential benefits of the EHR system as it disrupted the practices surrounding volunteerism that the operation of the free clinic had heavily relied upon, even though the rollout was generally regarded as being successful. Second, we contribute new insights into how the EHR system caused a change in the social system—in this case, the human infrastructure—where the human infrastructure and work practices were re-structured around the new technological infrastructure. In particular, the way in which work was organized by volunteers and around volunteer services shifted dramatically, as volunteer roles both diminished and changed around the adoption of the new technology. Third, we identified a tension between the goal of achieving interoperability across organizations and the constraint of limited technology options imposed upon resource-restricted organizations. Lastly, we contribute a novel solution, time-sharing licenses, as a financially-viable and HIPAA-compliant remedy for providing EHR access for the volunteer workforce in resource-restricted organizations.

RELATED WORK

Re-thinking infrastructure

Whereas infrastructure is generally regarded as being physical or technical, recent work has investigated infrastructure from a more human-centered perspective [21, 28]. In this view, infrastructure is composed of various social, organizational, and technical components [28], including shared social practices, information and material flows, and the associated processes involved in building and maintaining these practices and flows [27]. Here we are concerned with the social component, or, the human infrastructure.

The human infrastructure is the underlying foundation of a system, in this case social, constituted by the pattern of relationships of people, through various networks and social arrangements [21]. It plays a crucial role in the success of work coordination and collaboration [21], and thus serves as an underlying foundation of social systems like workplaces, and even societies [22]. Importantly, human infrastructure does not exist in a vacuum—it is intertwined with other infrastructures, particularly physical and technological infrastructures [28].

When changes to a social system occur, e.g. from some external force, in what Barley [2] terms "slippages", such events can then trigger new ways to act. Thus, the integration of a new EHR system into a clinical environment can cause the human infrastructure to restructure around the new technological infrastructure. For example, Mark et al. [22], in examining the effects of war on the human infrastructure, described how the physical and/or technological infrastructures would need to be switched so that people could maintain their routines for work and social

life when the human infrastructure was disrupted by external environmental factors such as natural disaster or war. In other words, when physical or technological infrastructures are disrupted or changed, the human infrastructure will likely adapt to changes in other infrastructures. This is especially true in clinical settings: when a new technological infrastructure, such as an EHR system, is introduced, this can trigger changes to the human infrastructure, as people often have to reconfigure or adapt their work practices around the new technology. For example, in a hospital environment where people are accustomed to working face-to-face, the introduction of computing technology has since enabled certain types of doctors, such as radiologists, to work remotely, thus at times never interacting with patients on a personal level. Conversely, the human infrastructure may also actively reconfigure the technical infrastructure in order to support former work practices. For example, groups who once relied on certain routine work practices may have to change their practices and develop workarounds that enable them to maintain former practices as a result of the introduction of a new technology.

The infrastructures supporting clinical work in non-volunteer-based healthcare organizations

As information systems become pervasive across organizational domains and contexts, scholars have investigated the social and organizational impacts of information systems, especially EHR systems, in conventional healthcare organizations [14, 16, 25, 26, 31]. Research examining EHR systems in clinical settings has largely focused on identifying the benefits of deploying EHR systems, resulting in new technical infrastructures or uncovering challenges and barriers.

EHR systems have been widely implemented to replace paper medical records in clinical settings. The benefits of EHR systems include improvements in accessibility, patient safety, accountability, and cost-savings [3, 4]. However, the design of these systems has largely focused on EHR systems as information storage and retrieval tools for administrative, research, and legal usage [25], with little attention to how EHR systems can support the human infrastructure via communication, coordination, and collaboration [1, 5]. In fact, properly designed and implemented health IT solutions have the potential to support collaboration among a variety of stakeholders, from patients to clinicians, individuals to institutions, and policymakers at all levels.

Other studies have suggested that EHRs fall short in supporting the work practices of its primary users [e.g. 9, 26]. In particular, Heath and Luff [16] argue that despite the great benefits that the system intends to offer, "the practices through which the document is written, read and used within consultation have been largely ignored." In this regard, many studies have reported cases in which poorly designed IT infrastructures led to unintended consequences after deployment, including dissatisfaction, adoption failures, inefficiencies, and even increased medical errors [6, 8].

Although the impacts of EHR systems are well documented in the non-volunteer-based organizational space, what remains unclear is the extent to which EHR deployment would affect the operations of volunteer-based clinics. The increased adoption of EHR systems in non-profit settings in recent years makes it critically important and timely to address the complex interplay among human, organizational, and technological infrastructures in healthcare settings.

Technology deployment in NPOs

Whereas previous work has mostly been conducted in conventional healthcare organizations—especially in large hospitals [14, 16, 25, 26, 31]—few studies have illuminated the challenges of technology deployment in NPOs [10, 20, 23, 33]. Merkel et al. [23] found that ICTs have been beneficial for volunteer recruitment, public relations, fund raising events, and information management. Moreover, Voida et al. [34] reported how the tensions between standard database systems and the diverse ways of managing data in NPOs forced users to develop and reconfigure their own databases at NPOs. Similarly, Dombrowski et al. [10] described how e-government intermediaries, who assisted low-income households in using welfare systems, often experienced issues of access and trust when working with the technologies available to them. These studies imply that not all members of the human infrastructure are accounted for when technologies are integrated into NPO work practices.

Our study builds on recent work that examines technology use and adoption by NPOs, only our investigation is within the context of a non-profit healthcare organization with limited resources. We identified how the lack of EHR access by volunteers resulted in an unexpected debilitating effect on the clinic's day-to-day operation. We contend that the deployment of an EHR system, without taking into account the way the human and technological infrastructures are intertwined during implementation, can adversely affect the ways work is accomplished. We describe this in the context of an EHR rollout in a nonprofit volunteer-based healthcare clinic.

RESEARCH SITE AND METHODS

To investigate the impacts of EHR deployment on resource-restricted health organizations, we conducted an ethnographic study consisting of field observations and interviews at a free outpatient safety-net medical clinic located in Southern California. We chose to study this free clinic due to a longstanding partnership with the university one of the authors was affiliated with.

Research Setting

The study reported in this paper was conducted in the outpatient medical unit of a safety-net NPO. Founded in 1970, the NPO has been providing high quality service to low-income and homeless individuals and families in the county. It consists of three health units: medical, dental, and mental health counseling services, and two social services

units that provide "necessity resources", such as food, clothing, and financial support for housing and transportation. The organization houses about 55 full-time employees offering services supported by over 400 volunteers with various backgrounds. Most paid employees are at supervisory level and they oversee volunteers who carry out their work. The annual budget of the NPO was $7.5 million for the year of 2012-2013, including in-kind donations.

The field site under investigation, which was the medical unit of the NPO, is a free outpatient clinic that serves patients who are uninsured, unemployed and/or do not have a primary care provider. The clinic conducts over 18,000 clinical service encounters annually and about 75 percent of the patients at the clinic require chronic care. Seventy-five to 80 percent of the patients are Spanish speakers, and all of the providers are conversant in medical Spanish to varying degrees. As such, a translator is needed about 10 percent of the time. The medical assistants and front desk staff are fluent in both English and Spanish. Since this is also the only free clinic in the county that serves walk-in patients, on average, the clinic receives 40 new walk-in patients each day. New patients are required to arrive at the clinic between 7:30 AM to 8:00 AM in order to be guaranteed assessment by a provider, and as a result, there is always a long line of patients waiting outside the clinic before 7:30 each morning.

Beyond basic medical services, the clinic also operates under the umbrella of a large non-profit regional healthcare delivery network with hospitals providing comprehensive healthcare services to patients who need further medical assistance, e.g. hospitalization or surgeries. There are four paid providers at the free clinic: two physicians, a physician assistant, and a nurse practitioner. Each of them sees patients 8 out of 10 half days every week. Volunteers at the clinic are mostly college students majoring in the health sciences through the university's community engagement programs. There are also approximately 10 volunteer clinicians who are clinical retirees and they see patients at the free clinic from one half-day a month to a day a week.

Data Collection

The ethnographic study consisted of two phases. First we conducted 40 hours of observations before and after the EHR system implementation to understand the organizational structure, work practices, as well as the changes that occurred during and following the rollout of the system. Two members of the research team conducted field observations, and they were stationed around the main work locations of the clinic to uncover the work practices occurring at these locations. For instance, the observations conducted at the front desk enabled us to understand how patients were registered and how medical records were used at the beginning of medical visits, whereas the observations of the physician assistants while stationed at their workspaces allowed us to observe how work practices differed before, and after the EHR rollout. Other critical locations we studied included hallways, the medical records storage room, and physicians' offices. Each observational session ranged from 2-4 hours in length, during which field notes were taken with pen and paper, and were transcribed soon after observations were completed. We also asked participants brief questions to clarify issues we did not fully understand during observations. Field observations provided us with a comprehensive view of the free clinic's day-to-day operations, enabling us to identify major roles in the clinic and access the people who held those roles. It also allowed us to sample key interviewees for the second phase of the study, and develop an interview protocol. Given the clinic's size, the EHR implementation was undertaken via a big-bang approach, where all functions of the system went live at the same time. As such, observations were split before and after the system rollout and each phase consisted approximately 20 hours.

Second, we conducted 15 semi-structured interviews with 14 participants to obtain a deeper understanding of their experiences with, and perceptions of, the EHR deployment and its subsequent use. The participants [2] had diverse backgrounds, held various roles, and had been with the clinic for different lengths of time from less than one year to over twenty years. Their roles in the clinic included: a medical assistant, a patient advocate, a physician assistant, a nurse practitioner, a medical biller, a health educator, a volunteer coordination manager, a patient service representative, a medical record coordinator, a operations director (previously a volunteer at the free clinic), a pharmacy director, a medical director, and two volunteers. We interviewed the medical director a week prior to and a week after the EHR rollout. The remaining interviews were all conducted over four months after the system rollout. The timing of the study ensured that all participants had sufficient time to interact with the system.

Participants were recruited and sampled during and through our field observations, and we were able to interview the majority of the paid employees. Although more than 400 volunteers worked at the clinic at any given time, it was important to understand the perspectives of paid personnel, considering volunteers mostly carried out routine clerical tasks that were only supportive to the clinical activities at the clinic, e.g. pulling medical charts from storage and calling patients for follow-up information. As such, we sampled volunteers who represented the different volunteer categories at the clinic, e.g. student volunteers who served the clinic only for a few months and senior volunteers who have been with the clinic for years. Since most volunteers took on the same clerical tasks and their involvement in the clinic's operation and system rollout were similar, we felt the two interviews we conducted with volunteers were sufficient to understand their behaviors and perceptions.

[2] Throughout our analysis, we do not include participant roles for several quotes so as to maintain the anonymity of our participants.

The main findings of this paper are based on semi-structured interviews. During interviews, we inquired into how participants carried out their work, volunteer roles, and people's interpersonal interactions before and after deploying the EHR. The interviews were organized into four question blocks covering different issues and were tailored for each interviewee based on insights obtained during observations:

- General questions: What is your position? How long have you been working here? What were your expectations of the EHR system before rollout?
- Questions on pre-EHR work practices: How did you work before the EHR system? What was a typical day like? How did you work with other staff members and volunteers? What kind of support did you receive?
- Questions on the transition experience: What was the transition like? How and for how long was training conducted? Do you feel like you are still in transition or do you feel like you have settled into a routine?
- Questions on post-EHR work practices: How do you work with the EHR system? What is a typical day like? How do you work with other staff and volunteers? What kind of support do you receive?

Interviews lasted between 30-45 minutes and were audio-recorded. Each interviewee was compensated $15.00 for participating in the study. The recorded interviews were transcribed to provide accurate records for data analysis.

Data Analysis

Data analysis was performed using an approach from grounded theory's inductive analytic method through open coding for identifying, naming, categorizing and describing phenomena found in the transcripts in order to establish categories and properties [29]. The transcripts were iteratively read and re-read, and incidents identified were grouped into concepts based on similarity of patterns. For example, incidents related to system procurement, training, and changes in volunteers' work practices were identified and grouped into respective categories. The goal was to understand and make sense of the subjective experience (phenomenology) of the research participants and allow themes to emerge naturally.

We next describe the operations of the clinic, and emphasize the characteristic patient population and the work conducted by volunteers prior to the integration of the EHR system into its daily clinical practices. This sets the context through which we describe how the human infrastructure was affected after the EHR system was deployed.

CLINIC OPERATION PRIOR TO THE EHR DEPLOYMENT

Before the EHR deployment, the clinic primarily relied on paper charts. There was a computerized practice management application for patient scheduling and storing patient demographic information. All other patient care documentation, such as consultation notes, lab and diagnostic test results, and referral requests, were all paper-based and had to be filed in patient charts upon receipt and after use. However, participants described how paper charts were often mishandled—where they were misfiled either in the wrong sections of a chart, or in a wrong chart altogether. These errors often resulted in a lack of access to patient information during medical visits, forcing clinicians to treat patients without knowledge of their medical history. As such, most employees at the clinic were eager to embrace the new EHR system, as it was believed to not only solve the issues associated with the misfiling of patient charts, but also improve work efficiency and reduce workload at the clinic.

Transient patient population

Since the free clinic provides healthcare services to underserved populations, there is typically a high patient turnover rate, requiring a large amount of manpower to address the needs of a constant flux of patients in and out of the clinic. In particular, since this is the only free clinic in the county that serves walk-in patients, the clinic sees an average of 40 new patients each day, in addition to those who return to the clinic (patients who had previously visited the clinic). The new patients often presented varying and complex sets of medical problems; some had also been treated in other medical facilities or hospitalized. The constant turnover of patients created a chaotic atmosphere where patient health history and other information were often lacking. Much effort and time were required to manage patient information and the clinic desperately needed a system that would allow providers to obtain information from other institutions quickly, and to be able to locate its own patient records accurately.

To remedy these issues, the clinic chose to implement an EHR system that was interoperable with the systems used by the hospitals within their affiliated healthcare network so that patient information could be shared across organizations. Other criteria that took into account the non-profit nature of the clinic's operation were also used when choosing the EHR system, such as a limited budget, user-friendly interfaces, and good technical support. Moreover, since patients at the free clinic were often uninsured, it was crucial for providers at the clinic to make requests and send reports to external organizations for free products and services, such as complimentary drugs and *pro-bono* specialty referrals to meet the needs of their underserved patient population. These case-by-case referrals and requests, and the subsequent follow-ups, were labor and time intensive.

Volunteer work before EHR deployment

In order for the clinic to operate efficiently, a large number of volunteers were needed to support and carry out a variety of mundane, yet important tasks. To do so, the free clinic utilized the services of more than 400 volunteers, mostly students, at the same time. Since every volunteer worked at the clinic for only a few hours per week, eight volunteers were needed every morning and every afternoon to handle the clerical work described above. Student volunteers at the

clinic were cross-trained so that they could perform a variety of tasks, as needed. More specifically, they were indispensible members of the human infrastructure as they assisted staff in filing charts, obtaining information from charts, and transporting charts intra-organizationally or inter-organizationally, either physically or by using technology, e.g. fax machines, scanners and e-mail. In essence, volunteer work was primarily performed behind the scenes to support the front-end patient care activities conducted by paid employees. As described by a clinical employee, P6:

"Most of our documentation was through just traditional paper charts, so we would see a patient, and have a piece of paper, and read up on the chart, and document our visit on the sheet… All the documentation, and copies of consultant notes, radiology, labs, are all faxes, and so we had papers that we filed in the chart…we were able to obtain help from volunteers to help us look up that information, or to be able to refer patients to alternative providers."

Importantly, the most frequently performed and most challenging task for student volunteers was to locate charts. When a medical chart was not available for a consultation, doctors would have to perform medical evaluations without having any prior medical history to guide them. Nevertheless, this seemingly easy yet critical task was quite challenging for volunteers, as described by our participants:

"45 minute training module on medical records individually as each person comes in here because it was so important that they'd filed appropriately and that, you know, I mean a lost chart is a nightmare and this is a patient's life." (P8)

"Tracking down charts… was one of the big things that we always had was lost medical records." (P9)

"Our biggest issue was finding charts." (P11)

In addition to student volunteers, the free clinic also relied on volunteer clinicians to offer medical care to patients. About 10 retired clinicians volunteered at the clinic and provided medical services sporadically, from one half-day per month to one day a week. These volunteer clinicians were instrumental in providing needed medical care at the clinic. Yet, they all had used only paper charts before their retirement and were generally not tech-savvy. They were comfortable with paper charts and able to perform their medical work without difficulty prior to the EHR rollout.

Volunteers served a central role prior to the deployment of the EHR system at the clinic. Volunteer clinicians provided pro-bono medical care needed at the free clinic and student volunteers ensured timely and accurate performance of clinical work. Together, the volunteers ensured that the clinic operated smoothly, and that patients received proper medical care and treatment.

The deployment of the EHR system ultimately replaced most paper charts circulated at the clinic, and dramatically altered the practices involved with handling patient charts. In the next section, we introduce the EHR system and the implementation process.

IMPLEMENTING EHR AT THE FREE CLINIC

When choosing the EHR system for the free clinic, a leadership team consisting of the IT director, medical director, associate medical director, and the operations director, consulted all the employees for their opinions and ultimately decided to purchase a system that was interoperable with other systems used within the clinic's healthcare network. Considering other members of the healthcare network providing many comprehensive services, such as surgeries and inpatient treatment, for the free clinic, interoperability would allow patient information to be accessible and shared across the entire network.

The EHR system procured for the free clinic offered comprehensive features commonly found in most EHR systems equipped with both practice management and clinical modules. The practice management module was used for storing patient demographic information, scheduling, and billing information, and the clinical module was primarily used to support clinical work and documentation. The latter was also used for ordering lab and diagnostic tests, and receiving reports. It is also capable of administering eReferrals to organizations in the same healthcare network. However, due to the free clinic's reliance on pro-bono services offered by external specialists and health organizations, some capabilities of the EHR system such as eReferrals could not be utilized, which will be described in detail later. Below, we describe how the EHR was implemented, from setting up different levels of access, the pre-rollout training, and the actual rollout process.

Different levels of information access

Before the EHR rollout, all paid employees were consulted to inquire about the information they would need to perform their job. In accordance with the Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule, which was developed with the intention of protecting the privacy of personal health information in the United States [18], the EHR system was set up to provide different levels of user access. The technical implementation was developed so that employees could only access information they needed to carry out their work activities, since it is illegal to access a patient's information if one is not involved in a patient's care. Therefore, the EHR system was customized based on employee roles prior to the rollout. Specifically, the medical director and the associate director had full access to the EHR system. Other employees had access to only specific data that they needed for their job, although every employee was given access to basic patient information, e.g. name and demographic information. All EHR access was password protected and each employee had a unique user name and password, corresponding to the number of licenses billed to the clinic by the service provider.

Sufficient pre-deployment user training

The same leadership team worked together to ensure all users of the EHR system received adequate training prior to the system rollout. Specifically, the operations director worked closely with an implementation specialist from the vendor on the practice management module to make sure the scheduling functions and the billing codes were set up correctly. Afterwards, both the operations director and the implementation specialist started training the staff on practice management for 4 hours in a training room at the clinic.

Next, the implementation specialist trained the operations director intensively for a total of two weeks to show her how to customize the system. All the full-time providers were trained for 12 hours. Other employees received 4 to 8 hours of training depending on their job responsibilities and the extent to which they would be utilizing the EHR.

A well-prepared system rollout

The system rollout occurred in a big-bang approach where the entire EHR went live all at once. In anticipation of possible chaos during the rollout, patient load was intentionally reduced—no walk-in patients were accepted during this period and patient load was cut to 30% of the regular load in the first week, 50% in the second week, 80% in the third week and, finally, 100% from the fourth onwards. Yet, even with the reduced workload, there were challenges embracing the new system and new work practices. As one participant mentioned:

"*The day that we switched to [the EHR system], everyone was like running around with their head cut off*" (P3).

In the first two months after the rollout, the employees had to work an additional 20 hours per week to cope with the additional tasks during the transition from paper to electronic-based work, since they had to review the paper charts for patients with appointments the next day, and to mark the pages before scanning them into the system. During the fourth month after the rollout, the clinic was operating at 80-90% of its regular patient load. It was expected that patient load would reach 90-100% by the sixth month.

Despite the chaotic atmosphere and emerging issues, we found that, overall, our participants were positive towards the transition from paper to the EHR system, including the training and the support they received, and considered the rollout to be successful. Employees exhibited high morale and considerable understanding of the potential issues that could emerge during the rollout period.

"We helped and asked each other. It was like a working team, unbelievable! Everybody was shoulder to shoulder. Everybody was together when we start to learn everything. It was incredible. This period was like, for me, a very, very, very nice experience. And I am very proud of me, and [giggle] everybody" (P8).

Although we did not observe any major unintended impacts like inefficiencies and system adoption failures that have been reported in prior EHR implementation literature [3, 5], one main issue uncovered in the study was the impact of the new system on volunteer work. In the following sections, we describe how the EHR system led to a breakdown in the human infrastructure, and ways in which members of the clinic attempted to reconcile the newly emerging disruptions to the day-to-day operations of the clinic.

RESTRUCTURING THE HUMAN INFRASTRUCTURE

Although the rollout was considered a success, various problems emerged when the EHR system was deployed into the clinic, as volunteers were not given access to the EHR system. The lack of access to patient information led to a major disruption to the human infrastructure and a restructuring of work around the new technological infrastructure. Volunteers, and employees who relied on volunteers, were no longer able to perform routine tasks as they used to before the system was deployed. As a result of volunteers being excluded from the implementation of the EHR system, a variety of sociotechnical issues emerged within the clinic.

Disruptions to the Human Infrastructure

Prior to the EHR deployment, volunteers were indispensible in a variety of behind-the-scene tasks supporting front-end patient care activities. However, only paid employees of the clinic could access the newly deployed EHR system, substantially affecting the clinic's workflow, mainly because the clinic could no longer utilize its large number of volunteers effectively, as before. This caused a disruption to the human infrastructure, as not only were volunteers affected on an individual level, but there also existed greater consequences across the clinic as other employees who relied on volunteer work were also impacted, as described by a participant:

"We had paper charts so we were able to obtain help from volunteers… now with the new system, we have to do it all ourselves" (P2).

In the following, we describe how volunteer roles diminished, how the diminished role of volunteers impacted employees who relied on volunteers to assist with their work, and finally, how patients and the quality of patient care were impacted.

Diminished role of volunteers

As we have already described, the operation of the free clinic relied heavily on volunteer services. At the same time, volunteer satisfaction, which has been found to contribute to the success of volunteer programs [7], hinges upon whether a clinic can provide their volunteers with a rewarding experience. Thus, a clinic's operation and volunteer program are interdependent. That is, disruption to one can adversely impact the other.

In our field site, the clinic's operation was disrupted as volunteers lacked access to the EHR system. This prohibited

them from performing the tasks that they once routinely conducted before the EHR system deployment. Volunteers, many of whom found their roles within the clinic had diminished, also began to feel unsatisfied at the clinic and, understandably, a considerable number of them began to consider alternative places to volunteer. For example, a volunteer (P3) was unhappy as she felt that she could no longer contribute to the clinic. She described how she considered looking for another place where she could contribute her time in a volunteer capacity:

"Now each week my tasks keep getting smaller and smaller… But I've got to find something that I can do every single time so I feel like I'm making a contribution… If I feel like I'm no longer contributing, then, like, I need to find someplace else to be. Some place else that really really wants me to be there. I feel like a lot of volunteers are going to leave or they're just going to cut back on their hours, just because they feel like [the clinic] doesn't need them anymore."

This had a significant impact on the operation of the clinic and the quality of patient care, as the sustainability of volunteer programs is integral to most NPOs, and our study site is no exception.

Increased workload for employees

While volunteers became dissatisfied with their experience volunteering, the employees of the clinic also faced challenges, as they had to assume additional tasks and responsibilities that were previously performed by volunteers. The majority of our participants described how the diminished role of volunteers impacted their day-to-day work practices after the EHR system was deployed. For example, a medical record coordinator described how they could no longer rely on volunteers to help with their work:

"Before, [volunteers] used to help me out, you know, and I was doing different things. Right now I'm doing everything by myself with my friend, [the EHR system]… because it's [an EHR] and we cannot give permission to nobody to, you know, work in our system, I have to do all by myself" (P8).

Also, as discussed by a medical assistant (P15):

"Before, if a volunteer was trained on how to do vitals, then we had the chart, the volunteer used to help us ask the questions for the superbill, have the patient sign, do all the inside questions like allergies, LNP, recent surgeries, any medications, the vitals, everything… Now there is a big impact because… I mean, they're not able to do that."

The increased workload of employees reduced the clinic's capacity to meet the needs of its patients as the employees had to perform additional tasks themselves without the support of volunteers. This had a negative impact on the quality of patient care, due to the sheer number of patients that were visiting the clinic on a daily basis:

"If you come here before 7:45 there's a line from the front door here to the warehouse and those are just mainly new patients coming in… if you saw what was happening in the morning, and then you can see the waiting room how it looks at eight o'clock. And most of those are new people and that's the turnover everyday."

Unintended consequences on patient care quality

The fact that volunteers were unable to access the EHR system also impacted the quality of patient care as some tasks were delayed due to the limited personnel who could access the system. For example, substantial volunteer efforts were required to help with medication dispensing before the EHR system was deployed, and this process was much delayed as it was now conducted entirely by pharmacists with EHR access. As described by the director of pharmacy (P11),

"We did not get medication for our patients for a week. So that was – it could have been really impactful."

Moreover, in order to enable the underserved patients to receive the proper medical care and treatment that they need, the clinic is involved in a number of essential tasks, e.g. requesting complementary drugs from drug companies and requesting pro-bono specialty care for patients with specialized medical needs, that require substantial human effort. For example, these tasks are generally very labor-intensive and time-consuming as they are heavy on paper work and phone calls. Before the EHR deployment, volunteers undertook these tasks, typically in the background. However, without EHR access, volunteers were no longer able to perform these tasks, which impacted the quality of patient care. As described by P11:

"We have a program… where… we use volunteers… they [volunteers] fill out applications for each patient to a specific drug company for a specific drug. And so it's hundreds of applications a day, and thousands a week – a month, thousands a month. And so they need access to the charts to find out phone numbers of these patients, their addresses, what medication they're actually on, if it's changed, the dose has changed, that sort of thing.... Well now they don't have access into that [EHR] and it's very frustrating."

This directly impacted the quality of patient care offered at the clinic as when certain tasks were delayed, patients' health and well-being was also impacted.

Reconciling Disrupted Human Infrastructure

Thus far we have illustrated how the clinic's human infrastructure was disrupted as a result of the EHR system deployment. Volunteers found that they had little left to do as they could not access the system. This led to a shift in the workload from volunteers to paid employees, which negatively impacted the quality of patient care.

In order to ameliorate the negative impact of the EHR system on the human infrastructure, especially with respect to volunteer services, employees of the clinic looked to reconcile the human infrastructure by: *creating new work roles for volunteers*, *re-establishing quality patient care,* and *developing workarounds*. This was important, as volunteers are important resources to NPOs including this free clinic,

and, developing and maintaining a volunteer program requires substantial effort and time.

Creating new work roles for volunteers

Employees were concerned with the possible negative ramifications associated with the lack of volunteer work. As such, to reconcile the disrupted human infrastructure, employees were actively seeking new roles for their volunteers. As described by the volunteer coordination manager (P9):

"A lot of volunteers with a whole lot of nothing to do…It's been kind of interesting because I've had to do a lot of nosing around to a lot of different people in a lot of different departments saying, 'I've got some man hours available. Do you have any projects for my kids?'"

The free clinic was being served by a considerable number of volunteer clinicians (who are typically retired clinicians). These older clinicians were not comfortable using a computer. Therefore, a new role emerged where chosen employees began serving as scribes to assist novice technology users in accessing and using the EHR system. As described by the director of pharmacy (P11):

"Those older pharmacists [volunteers], we always told them, 'Don't even worry. You will have a scribe with you at all times. You won't even have to go on the computer, really.'"

In other cases, departments that typically did not rely on volunteers were now assigning volunteers new roles and integrating them into their daily work practices. For example, a patient service representative whose primary responsibility was to link patients with various county health programs, was able to use more volunteers with her work as many volunteers were unable to access the system and accomplish work as they were accustomed to pre-EHR deployment:

"We use the volunteers to mail letters, to call the patients to schedule appointments, or they help us putting the MSI applications together… In the past the volunteers, they were more busier, you know, filing charts, looking for charts. But now there is – they have been helping us a lot" (P10).

Re-establishing Quality Patient Care

The new roles being assumed by volunteers served to empower them. Whereas prior to the EHR system deployment, volunteers only occasionally interacted with patients face-to-face, our participants described how following deployment, patient-volunteer interactions increased and volunteers were given more critical responsibilities within the clinic. Volunteer roles have since become more visible to patients as they now interact with them face-to-face, whereas pre-EHR deployment, volunteers were mostly engaged in clerical work, such as filing charts, behind the scenes. As described by P5:

"We're switching them [volunteers] to be assistants to the medical assistants, so they're helping ask questions, and, you know, they can help do finger sticks, they can help, you know, just prepare the rooms, they can talk to the patients, escort them back to the rooms, so they're doing… more patient care than just being in the file room..."

Volunteers also became more visible in the triage area. They were often asked to escort patients to exam rooms, and were also trained to perform basic medical assessments. As described by P14:

"I'm just starting to figure out, like, how the volunteers are helping out by doing vitals for you… we can have a volunteer at least get it started and have their vitals done so when the MA grabs them, all she has to do is input, she doesn't have to [actually do the vitals]… And it definitely always helps with triage because for most people they need a set of vitals."

Challenges in Reconciling Work Around the EHR

Apart from looking for existing work that volunteers could perform, some employees developed workarounds so that volunteers could assist them with their work. To illustrate, a participant was able to work around the EHR system so that she could continue to utilize the services of some volunteers. As previously described, most patients at the free clinic require referrals for specialty care and it was necessary to contact individual specialty physicians by phone to find out if they would be willing to provide pro-bono services to their patients. The free clinic maintains a list of physicians who could potentially tender the pro-bono referrals. In practice, referral requests are largely conducted through trial-and-error. Therefore, this task is very time-consuming and labor-intensive and had been previously fulfilled by volunteers.

After the deployment of the EHR system, however, our participant switched to first retrieve the EHRs of all the patients requiring a referral and then printed the needed information for volunteers to make the necessary phone calls. The volunteers also faxed patient medical information to specialty physicians for assessment. Finally, the participant documented the referral information in the EHR system with reference to the notes made by volunteers, which were included on printed copies. Through this workaround, the participant was able to perform her job near the level of efficiency before the EHR rollout.

Yet workarounds were not common; in fact, they were severely limited and in many cases not always practical. As described by our participants:

"We have a workaround, but that's pathetically slow and pathetically limited."

"If we didn't have a workaround we wouldn't even use them [volunteers]. And frankly, if we hadn't developed the workaround, we couldn't use them and it would shut down our department. We really rely heavily on volunteers."

Although these two participants revealed the use of workarounds, no further details of how the workarounds were accomplished were provided during our interviews. This is likely because workarounds were generally

perceived to be negative, like cutting corners, employees at the clinic were thus cautious of accidental disclosure even though they did express their concern for legal compliance when developing workarounds. As described by our participants:

"Now that we have stricter HIPAA regulations and we have a different system with the electronic health records, some of their [volunteers'] work's been taken away. So we're sort of in transition now figuring out how to use that extra mass of volunteers that we don't have a job for at the moment."

"I'm trying to find the best solution, you know, to implement our volunteers to work with the system, but it's taking time. You have to find the legal solution, because you cannot let everybody to access [the EHR system], and we still, you know, trying to find the best solution for them because we cannot let nobody to get in the system."

It is important to repair a disrupted human infrastructure in a timely manner for an operation to run efficiently. In our study, participants developed several mechanisms to reconcile the disruption caused by the lack of volunteer access to the EHR system. First, new work roles were created to counter disrupted work practices, such as the use of scribes to meet the needs of the older volunteer clinicians so that they could continue to offer services at the clinic. Second, volunteers were brought to the front of the operation increasing their interaction with patients as a means to enhance the quality of patient care. Last, although it was challenging, workarounds were developed to fill in the gaps in work practices, where volunteers could then continue to contribute to the clinic's operations.

DISCUSSION

Based on the findings presented in our study, in this section we first discuss the implications for resource-restricted free clinics adopting new technologies, and then unpack why a commercially designed technological infrastructure was unable to support a volunteer-based human infrastructure at the free clinic under investigation. These discussion points provide an in-depth exploration of the findings we uncovered in the study, and lead to possible implications and approaches for redesigning the human-technological infrastructure to better accommodate volunteer work—especially considering that technology adoption is becoming more and more inevitable even in resource-restricted organizations.

Mismatch between license-based access and volunteer-dependent human infrastructure

Despite a relatively smooth rollout of the EHR system, our study revealed a major disruption to volunteer work stemming from a mismatch between the license-per-user service model and the fluidity of volunteer work practices that were integral to the clinic's operation. As a result, volunteers were unable to access the EHR system and contribute positively to the overall operation of the clinic, since most of their tasks required access to patient information stored in the system. The work previously conducted by volunteers had to be reassigned to, or assisted by, other employees who had access to and could use the system. The loss of valuable manpower that was key to the clinic's operation—in this case, volunteers—created additional work for other employees who were already burdened by the new system.

On the surface, this mismatch appeared to be a system implementation oversight where the designers and management team simply neglected to include volunteers as end-users during system customization. But in reality, the problem was rooted in the EHR system's lack of support for the fluidity and composition of the human infrastructure at the free clinic. Current EHR systems are mostly designed for a steady workforce that is prevalent in conventional healthcare organizations, where a relatively fixed number of access licenses are needed under the license-per-user service model typically adopted for EHR systems. Our study provides a counterpoint; one where the variability in the volunteer workforce at the free clinic revealed the need for a large number of access licenses, e.g., hundreds of licenses, in order to provide each volunteer access to the EHR system despite the fact that volunteers may only work for a few hours each week and in short bursts of time. Given the shortage of financial resources the clinic was facing, it was simply impractical to purchase sufficient licenses for the entirety of the human infrastructure, especially for volunteers, as they were large in number.

Implementing an EHR system is already a substantial financial investment. For example, it was estimated that the cost per physician for a 5-physician practice during the first 60 days following EHR implementation is $32,000 [11]. This is because investments in EHR system implementation include not only the technology—software and hardware—but also a variety of additional costs associated with implementation, such as training, lost productivity during training (and throughout and following the system implementation), as well as various consulting and technical costs. Some of these costs, such as training fees, would increase profoundly if volunteers required training as well.

Moreover, the license-per-user service model is tightly coupled with the HIPAA Privacy Rule, which dictates that only authorized personnel can access and use patient personal health information. The license-per-user model embedded within the current EHR design largely reinforces the HIPAA Privacy Rule since only those who have access to validated user accounts can access protected patient information in the system. Importantly, all information access is logged and can be audited later to decide who have accessed which patient information at what time. In fact, protecting patient privacy is one of the intended benefits of EHR and a motivation behind such large-scale system implementations.

Due to severe financial constraints and the strict HIPAA Privacy Rule, under the current license-per-user model, the free clinic could not purchase enough licenses for every volunteer, nor were they able to create a unified shared-

access volunteer account (i.e. an account with the same user name/password for multiple users to use) since they would be unable to identify who actually accessed and documented information in the EHR. Thus, it is critical to think about a more sustainable way to support temporary workers without violating the HIPAA Privacy Rule.

We propose a special license for health organizations housed with a large number of transient workers with variable schedules—a time-sharing license, as opposed to user-based license. Each time-sharing license would allow multiple users to access the EHR system at different times, somewhat similar to the time-sharing of resources in computing or well-known timesharing vacation club programs. In this vein, organizations with large numbers of transient workers would be able to obtain time-sharing accounts, where any one account could allow access by several users who are charged for the amount of time they use the system as opposed to per-user basis. Each time-sharing user would log on the system with his or her own user name and password so that their individual activities are logged as well. Since essentially only one user could log into a time-sharing account at a given time, this account can be billed in a much more affordable way, and the associated individual login information can still identify the user's identity and thus protect patient's privacy and safety in this manner. In this way, the volunteers who work only a few hours at a time will have access to the system, allowing the special license to be best utilized.

Mutual reconfiguration of human infrastructure with technological infrastructure

As we found in our study, without the capacity to access the EHR system, volunteer roles have greatly diminished, to the point where they had little, and in some cases, nothing to do. The tasks that they used to perform had to be shifted to the employees after the system rollout. The diminished volunteer roles, however, had been gradually restructured around the performance of new types of tasks that were not assigned to volunteers previously. For example, student volunteers rarely had the opportunity to interact with patients before the EHR rollout but they became more visible to patients after the EHR system was deployed, such as when they engaged in the new practice around escorting patients to exam rooms.

This finding suggests a co-evolving nature of technology deployment where not only did technologies impact the work practices of the clinic, but the work practices, in particular, the human infrastructure, shifted to better support the system being deployed. The process of reconfiguring human infrastructure was ongoing, particularly when new problems emerged. For instance, although a workaround was developed so that volunteers could help with arranging referrals (as eReferrals were not possible due to the need for pro-bono services), the leadership team continued to work with the vendor to find a long term solution so that the features of the EHR system could be more fully utilized.

Meanwhile, we found that the nature of volunteer work had gradually shifted from being a behind-the-scenes support role, to more visible, collaborative work with employees. The employees, in turn, had to find a way to make volunteer-work work. As such, they served as a mediator between the new technological infrastructure and the volunteer workforce, taking on additional responsibilities as facilitators for volunteer work. Thus, resource-restricted organizations that rely on volunteer work should plan for additional mediation work when adopting new technologies.

Our findings echo what has been reported in prior literature [12, 24], we found a duality existed between the technological and human infrastructures supporting work in the free clinic. The disruption caused by the new technology triggered a process of human infrastructure reconfiguration. The human infrastructure also began to reconfigure practices around the new technological infrastructure, such as by adopting and changing roles. The new roles people assumed even empowered volunteers in some cases, as they assumed roles with greater responsibilities and patient interaction that was not previously part of their workplace identity.

Thus, our results imply that it is a co-evolving process for technologies and human infrastructure to fit together in organizations. Actually defining and reconfiguring the work of volunteers are necessary when more similar organizations are moving into digital-based practices. It is possible that through carefully redesigning the sociotechnical system, volunteers may not always engage in labor and time intensive tasks, but may take on more intelligent and complicated tasks that are complementary to the existing skill sets of the employees. This is important considering that there were more technology related tasks after the system rollout, and the current employees and volunteer clinicians may not always have sufficient skills to perform some of these tasks, whereas the college students who had sufficient computer skills could thus enrich the task force of the free clinic.

The tension in achieving interoperable practices and restricted options for technologies

Our study clinic offers only basic medical care to underprivileged patients who, however, often require further medical attention such as inpatient care, and surgeries. Therefore, the clinic has to rely on a variety of services provided by other healthcare organizations within their affiliated delivery network, such as a nearby comprehensive hospital. In addition to the pervasive pressure from other healthcare organizations in going digital, the free clinic was urged to implement an EHR system so that it could interoperate with the EHR systems used within the healthcare network. The benefits of having an interoperable EHR system have been well recognized as it enhances workflow and data sharing among EHR systems and health care stakeholders [17]. It can also help reduce the number of duplicate lab and diagnostic tests, which is particularly important to the resource-restricted clinic under investigation, so that their limited resources would be best

utilized by other patients who were also in need of those services.

However, moving towards digitization so that the free clinic could enjoy the benefits afforded by interoperability was not without its share of challenges. Importantly, the clinic did not have an opportunity to choose a system based on its own needs, or design a system from the ground up. Rather, the choices of EHR systems for the clinic were limited by the requirement of compatibility with other systems in the network. Only three commercially designed systems, all of which were designed for conventional healthcare organizations, were available. The limitation in choices also mitigated the clinic's potential to obtain a more customizable system to meet the specific needs of the free clinic, such as the capability to more flexibly accommodate user licenses for its large number of volunteers.

As demonstrated in our study, the benefits of interoperability clearly limited the possible opportunities for the free clinic to choose the most appropriate technological solution. This observation indicates that there may exist a tension between the technical requirements for interoperable practices and the type of work practices supported by the underlying human infrastructure of resource-restricted organizations. With the rapid digitalization across work domains societally, it is likely the same challenges also exist in other networked systems where intra-organizational collaboration is essential.

Given that the network of organizations may consist of both large companies that are financially stable, and small resource-restricted NPOs that have limited funding, it is critical to ensure that resource-limited organizations are also able to appropriate technologies that suit their own needs. The use of proprietary systems designed for conventional organizations, as we found in our study, cannot always be adapted and effectively used by resource-limited organizations—to use an old adage, technologies are not "one-size fits all".

To that end, we suggest that careful coordination of technology solutions within any given organizational network is crucial. Rather than being forced to use what others have adopted in their network, under-resourced organizations that are most likely to adopt technologies at a later stage should be given the opportunity to voice their needs and concerns earlier in the process. Moreover, we argue that interoperability should be maintained while allowing for any given organization to support its own set of practices so that disruptions to local practices would be minimized. This means that while achieving interoperability, the organization must also take its human infrastructure into consideration, in addition to its technological infrastructure.

CONCLUSION

The study reported in this paper uncovered a major disruption to the human infrastructure in a volunteer-based safety-net free clinic after the implementation of an EHR system, which led to a restructuring of work around the new technological infrastructure. Given the lack of access to patient information by volunteers, members of the clinic were unable to perform routine tasks as they used to before the system was deployed. Thus, employee workloads increased substantially, which brought about unintended consequences that impacted the quality of patient care as some tasks were delayed due to the limited personnel who could access the system.

In order to repair the disrupted human infrastructure, especially with respect to volunteer services, employees of the clinic attempted to reconcile the human infrastructure by creating new work roles for volunteers, re-establishing quality patient care, and developing workarounds. We then discussed implications for resource-restricted free clinics adopting new technologies and why a commercially designed technological infrastructure failed to support a volunteer-based human infrastructure. We also proposed a new type of EHR user license, time-sharing licence, to meet the specific, fluid needs of the volunteer-based clinic. Finally we illuminated the challenges of small resource-restricted healthcare settings in achieving interoperable practices within major healthcare networks. Above all, our work suggests that volunteers should not be overlooked as critical members of the human infrastructure, and offers new knowledge and useful insights for advancing the healthcare system implementation—especially considering that technology adoption is becoming more and more inevitable even in resource-restricted organizations.

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