Association for Information Systems
AIS Electronic Library (AISeL)

Impact of Software Ecosystems on the Implementation of Open Source-Based Electronic Health Record Software

Donald Wynn
Operations Mgmt, Decision Sciences, University of Dayton, Dayton, OH, United States., wynn@udayton.edu

Renee Pratt
Business Administration, Washington and Lee University, Lexington, United States., prattr@wlu.edu

Randy Bradley
Accounting and Information Management, The University of Tennessee, Knoxville, TN, United States., rbradley@utk.edu

Impact of Software Ecosystems on the Implementation of Open Source-Based Electronic Health Record Software

Donald E. Wynn, Jr.
University of Dayton
dwynn1@udayton.edu

Renée M. E. Pratt
Washington and Lee University
rpratt@wlu.edu

Randy V. Bradley
University of Tennessee, Knoxville
rbradley@utk.edu

ABSTRACT

In this manuscript, we examine the ways in which the members of the ecosystem surrounding an open source software (OSS) based EHR system impact the quality and success of the resultant implementation. Following a brief theoretical review, we provide narratives of successful OSS-based EHRs at three US hospitals, followed by a brief discussion of the contributions and effects of the open source ecosystem that differ from those expected in proprietary EHR installations.

Keywords

Electronic Health Records, Open Source Software, Software Ecosystems.

INTRODUCTION

Proponents of electronic health records (EHRs) have predicted that their implementation leads to higher operational efficiencies, higher quality of care, reduced medication and prescription errors, and several other benefits that are eventually manifest on the hospital's bottom line as well. However, the adoption and implementation of EHR systems in hospitals and private practice settings has been considered slow and nonexistent until recently. Before 2009, only 17% of US hospitals were considered to have basic EHR systems in place (Jha et al. 2009). In many cases, providers were hesitant to adopt EHRs because of the potential loss of productivity, lack of capital resources, substantial cost, and perceived lack of financial return (Blumenthal 2009; DesRoches et al. 2008).

However, this has begun to change since EHR systems were positioned as a key component in the health care reform measures implemented by the US government. Under the American Recovery and Reinvestment Act of 2009 (ARRA), $20 billion are available as an incentive for hospitals and private practices to use EHRs. Organizations that do not deploy these systems in a meaningful way by 2015 will suffer significant penalties in their value of their Medicare payments (Landro 2009). Despite these incentives, many providers are struggling to afford these systems, which may run upwards of $20 million dollars for a medium sized hospital.

Open source software (OSS) is an attractive option that potentially can help healthcare providers overcome the cost barriers to the adoption and implementation of EHR. OSS is a version of software that enables users to collaboratively modify the code as needed and to distribute the software to all users without incurring significant licensing costs. This differs from proprietary software, which typically has higher licensing costs and more restrictions than open source. OSS-based EHRs provide access to the same information available to proprietary software applications, such as computerized patient data including labs, pharmaceutical and nutritional services, and much more for all healthcare providers to share. Despite the perceived barriers, several healthcare organizations have been able to resolve these issues in order to successfully install open source EHR applications such as Medsphere, OpenEMR, and ClearHealth. In addition to the concerns over EHRs in general, common barriers to the adoption of OSS cited by hospitals and other organizations include the availability of operational support and other services, the actual quality of the software, and security concerns.

The purpose of this study is to investigate how these software ecosystems influence the quality and benefits of an OSS-based EHR system. We will also identify the attributes and success factors which may lead to successful cost

saving implementation of these applications by healthcare providers seeking to meet the requirements of the current federal legislation. We begin with a look at the background literature on EHRs, software ecosystems, and success of information systems. Next, we discuss the methodology used in the study and details regarding the case settings. We then describe and analyze the cases in an effort to highlight a set of findings regarding the applicability of OSS to successful EHR implementations as well as future practical and theoretical research opportunities.

THEORETICAL BACKGROUND

Electronic health records are touted as an essential component in the modern healthcare information technology toolkit. Proponents have suggested that the widespread implementation of EHR systems would lead to higher operational efficiencies, higher quality of care, reduced medication and prescription errors, increase patient safety, intelligent decision support, and more (Pentecost 2006a; Simon et al. 2007). However, the benefits of EHRs can only be realized once the software is implemented by providers and healthcare organizations. This has proven to be difficult as many providers are unsure how to address the many challenges associated with EHRs, including costs, technical barriers, and privacy concerns (Ross 2009). Unfortunately, most small providers are not technologically savvy enough to evaluate and resolve these challenges independently, not to mention the challenges of interoperability with other providers and specialists(Pentecost 2006b).

Today's software industry typically depends on a system of consultants, service providers, and other partners to develop, integrate, deploy, and maintain a given enterprise software application. Each of these partners contributes services and/or products, which are combined with the contributions by other partners to ultimately provide a portion of the net benefits available to the end-users of the software. Open source software (OSS) provides an enhanced example of this system of contribution and compensation.

The low initial costs of OSS, along with the unrestricted usage, distribution, and modification, are often cited as reasons firms select OSS components and applications for deployment within their enterprise software platforms. However, many firms require ongoing technical support and other services in order to ensure that the applications can be used effectively and without operational interruptions. These services form the basis for many commercial business models revolving around OSS (Fitzgerald 2006; Watson et al. 2005).

There have been several papers recently to discuss and define ecosystems within the software industry (Messerschmitt and Szyperski 2003; Popp and Meyer 2010). One such definition is "a set of actors functioning as a unit and interacting with a shared market for software and services, together with the relationships among them. These relationships are frequently underpinned by a common technological platform or market and operate through the exchange of information, resources, and artifact." (Jansen et al. 2009). In this paper, we use the ecosystem concept as a means of developing an understanding of the impact that a software ecosystem has upon the implementation of open source software-based electronic health records applications. As such, we define an ecosystem as the set of individuals and organizations operating within a given market space in order to provide a complete value proposition to the end customers who are also part of the ecosystem.

The core VistA EHR software is maintained by developers associated with the United States Department of Veterans Affairs (VA) (Herbsleb et al. 2010; Longman 2010). In turn, this software is adapted and re-released as a separate open source distribution by independent vendors such as Medsphere, Vx-Vista, and WorldVistA. These vendors contract with hospitals to install, maintain, and support these EHR distributions, often supported by other independent developers and service providers. Consistent with most OSS products, hospitals typically do not pay software licensing fees, leading to significant savings compared to proprietary vendors. However, support and maintenance fees are often comparable. Figure 1 details the various entities which form the software ecosystem surrounding the typical installation of a commercial VistA based EHR.
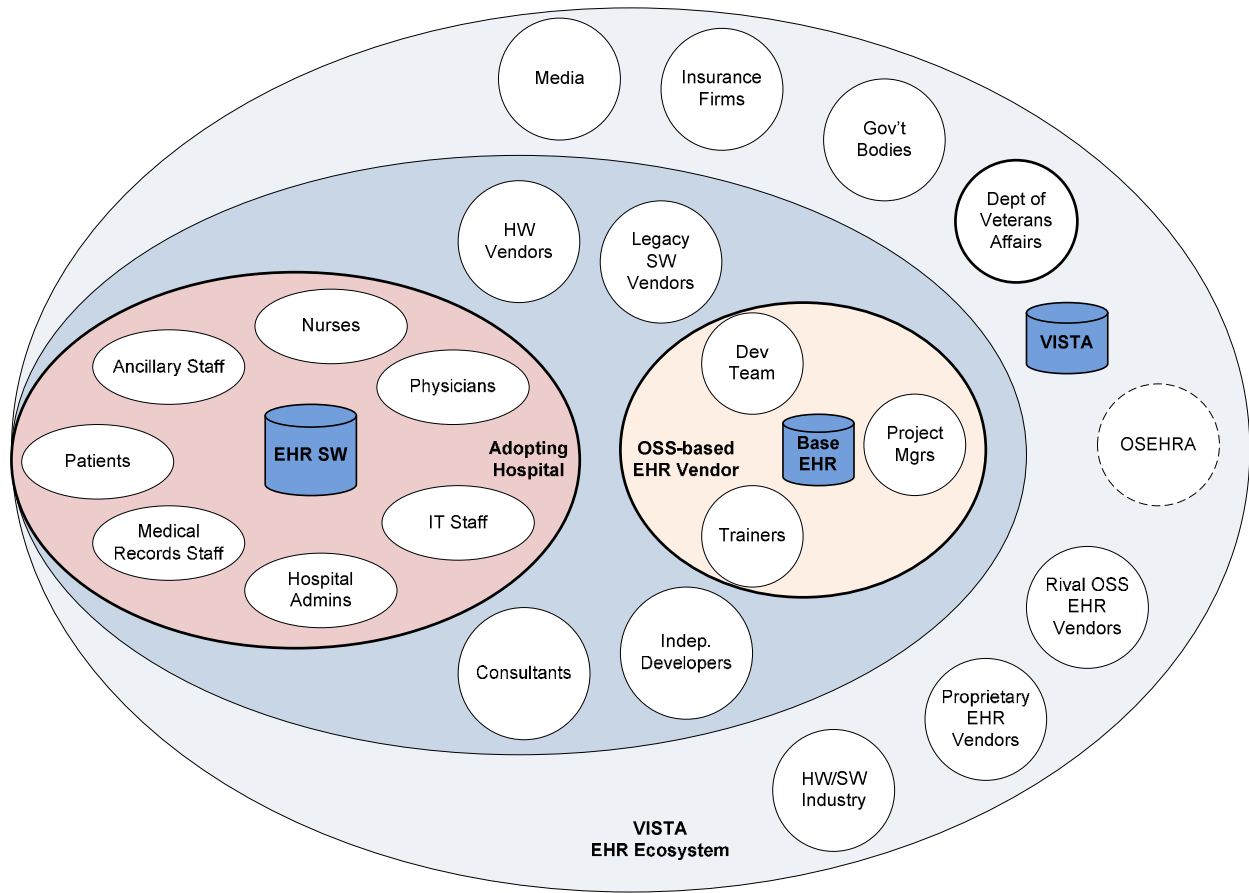
Figure 1: VistA Ecosystem (Expanded View)

The contributions by members of this ecosystem are provided through the many interactions that exist between the hospital staff and administrators on one hand, and the vendor and other external entities on the other. The quality of these interactions affect the quality and usage of the EHR information system, which ultimately leads to increased net benefits including improved patient outcomes, higher financial performance, and increasing levels of workplace retention and morale. Consistent with the Information Systems Success Model (DeLone and McLean 1992; DeLone and McLean 2003; Petter et al. 2008), the quality of an EHR implementation can be viewed in terms of its system quality, service quality, and information quality (Häyrinen et al. 2008; Van Der Meijden et al. 2003). Within these attributes, we can identify several indicators of the quality of a system, including its ease of use, accuracy, and the technical competence of the IT staff (see Table 1). Similar arguments can be made for the impact of the ecosystem on usage and the net benefits generated by the system. For OSS-based software, the increased involvement of entities beyond employees of the hospital and the EHR vendor (beyond that of proprietary installations) results in the increased importance of the ecosystem.

Attribute	Definition (Petter et al 2008)	Example Indicators for EHRs (Hayrinen et al 2008, van der Meijden et al 2003)
Quality Measures		
System Quality	The desirable characteristics of an information system	Ease of Use; ease of learning; usability; timesaving
Info Quality	The desirable characteristics of the system outputs	Completeness; accuracy; reliability; availability
Service Quality	The quality of the support that system users receive from the IS dept and IT support staff	Responsiveness; technical competence; empathy of the IT staff

Usage Measures		
Use	The degree and manner in which staff and customers utilize the capabilities of an IS	Frequency of use; retrievability
User Satisfaction	Users' level of satisfaction with the system	User attitude; satisfaction; acceptance
Benefits Measures		
Individual Benefits	The extent to which IS are contributing to the success of individuals	Changed clinical work patterns; faster clinical decision-making; changed habits
Organizational Benefits	The extent to which IS are contributing to the success of the organization	Patient satisfaction; length of patient stay; physician-patient interaction

Table 1: Evaluating the Success of an EHR application

METHODOLOGY, SITE SELECTION, AND DATA COLLECTION

To study the impact of open source ecosystems on the implementation of EHRs, we conducted an exploratory case study of existing OSS-based EHR installations. We selected three non-VA hospitals that have implemented VistA-based EHR projects (shown in Table 2). As of February 2012, each of the hospitals have achieved full meaningful use certification (stage 1) and received the first of several Medicare EHR incentive payments under the ARRA.

Hospital/Location	Size	Launch Year	Cost	Vendor	Reason Specified for Choosing OSS
Midland Memorial Hospital, Midland TX	371 Bed	2006	$7.1M	Medsphere	Cost, System Obsolescence
Kern Medical Center, Bakersville CA	222 Bed	2011	$3M	Medsphere	Cost, ARRA
Oroville Hospital, Oroville CA	153 Bed	2011	$10M	WorldVistA; Self-Managed	Cost, ARRA

Table 2: Hospitals adopting OSS-based EHRs

The data was obtained by collecting published interviews, case studies, and other materials available from news articles, marketing materials, podcasts, and the hospital websites. Typically, this included information quoted from the hospital CEO or CIO. To date, this includes over 80 pages of source material. In addition, we conducted and transcribed interviews with several employees of the vendor firms and third party providers. The transcripts and published materials were qualitatively analyzed to identify the roles and contributions of various participants as well as any quality and performance aspects that were discussed. In the next section, we discuss the implementation and results at each of the three sites, followed by a discussion of the impact of the ecosystem participants on the success of the project.

IMPLEMENTATION NARRATIVES FOR THREE HOSPITALS

Midland Memorial Hospital

In November 2002, Midland Memorial Hospital was faced with significant financial concerns. In addition, they had been notified that several key modules of their existing health information system were soon to be obsolete. An assessment of the long-term viability of their platform and applications led to the decision to implement a comprehensive EHR system. However, a proprietary EHR application would have cost over $20M for upfront licensing and hardware upgrades, with millions more required annually for ongoing maintenance costs, licensing fees, and support.

> *"We were somewhat shell-shocked from the sticker price. We were not in a financial situation to take advantage of the commercial systems that were being offered." (CIO David Whiles interview, Forbes Magazine, July 6, 2009)*

Midland executives became aware of the VistA software through several sources, including their interactions with the nearby VA hospital and several residents that rotated through both hospitals. They became aware of Medsphere and its OpenVista software, which was a version of VistA adapted for non-VA providers. In 2003, Midland put together an executive team consisting of lab, pharmacy, radiology, and nursing staff along with several physicians and administrators. The executive

team began an extensive 12-month evaluation of VistA products, including OpenVista and Medsphere. In late 2004, Midland selected Medsphere to implement OpenVista. In January 2005, the IT steering committee approved the implementation project.

The initial development began in early 2005, along with clinical configuration and training of local staff. Midland and Medsphere shared project governance via regular meetings and communications. The Medsphere staff worked closely with the Midland staff throughout the project, providing additional training and support. The ultimate goal was to reduce Midland's reliance on the vendor for the majority of its operational and maintenance tasks. As an example, six registered nurses were hired by Midland and trained by Medsphere to create templates, clinical rules, and configurations for the new system. In addition, several committees were formed to assist in the transition of key issues related to specific processes, including medical records, computerized provider order entry (CPOE) functionality, pharmacy, and bar code medication administration. Each committee reported to the IT steering committee, which met monthly.

The entire hospital was kept involved in the installation process even before the contracts were signed. This included a number of internal marketing actions and constant updates such as weekly status newsletters. This was necessary to ensure that the entire hospital team was fully on board with the implementation. The hospital also offered financial incentives to physicians to encourage them to use the system.

> *"It was never pitched as an IT project. It was an organizational project and we had to have buy-in." (CIO David Whiles, presentation OSCON 2010)*

Several other parties collaborated with the hospital for various services, including VistA developers, outside clinicians, vendors, and consultants. For instance, Hewlett Packard provided hardware support and installation services associated with the new servers installed to run the software. Vendors associated with the legacy systems that were to be integrated with the new EHR also provided support.

Portions of the new system were rolled out for several units in October 2005 and continued into early 2006. The system, named EDITH (Electronic Data Information for Team Healthcare) was implemented in 35 departments across Midland's two sites and integrated with the 15 remaining legacy systems, and was fully operational by January 2007. By February 2007, the hospital had removed their existing paper records. The ultimate cost of this implementation was under $6.4M (including $0 for licensing costs), far less than the original estimates for installing a proprietary package.

Midland has been able to customize several aspects of the software to fit their own needs without contacting the vendor for additional support.

> *"It has been a real life saver to be able to pull out the source code for an existing interface…make minor modifications, and put a new module in place without having to call [medsphere]," (CIO David Whiles, OSCON 2010 presentation)*

They have also been able to request several system enhancements to the OpenVista software beyond the original software implementation. Several of these enhancements (such as physician dashboards and an improved template tool) have been implemented into Medsphere's product development roadmap to be available for future Medsphere installations.

By early 2008, Midland Memorial Hospital had become one of the first nine hospitals to achieve HIMSS Stage 6 certification, signifying the hospital's successful efforts to include physician data as well as electronic order entry and documentation. They had also achieved a number of operational and clinical benefits, including a 59% reduction in medication errors, 88% reduction in infection rates, shorter average length of stay for patients, and reduced nursing overtime. Departments such as the emergency room now had immediate access to a patient's medical records, whereas the previous paper records may require 20 minutes or more. Midland also achieved several financial benefits, including the elimination of paper storage costs, saving nearly $1M per year. The hospital was also able to eliminate a $16.7M coding and billing backlog for 4500 patients in four weeks. As of January 2012, Midland has met the requirements for stage 1 federal meaningful use and received the first of several reimbursement payments, totaling $3.3M of an expected $7M.

Oroville Hospital

Oroville Hospital arrived at the decision to implement an open source based EHR system after extensive interviews with proprietary vendors and the realization that they likely could not afford the expense. A physician attended a conference where VistA was being discussed and mentioned to the CEO that he believed the core VistA software was free. After downloading and installing the software, the IT staff determined that although it worked, it would not be sufficient to be used as is. Thus, Oroville sought out a vendor that could provide implementation, training, and maintenance services. They originally selected Medsphere in 2007, but eventually decided to implement the software on their own, without vendor support. The initial CIO

was not comfortable with the idea of installing an open source software package for such an important system. But the hospital was convinced that it was the right way to proceed, so a new CIO was hired to manage the implementation efforts.

To assist with the implementation project, Oroville eventually partnered with WorldVistA and the VistA Expertise Network. WorldVistA is an organization whose mission is to help adopters and programmers develop, install, and maintain variations of VistA outside the VA. The members work for various other organizations or as independent contractors. Through their connections with WorldVistA, Oroville was able to contract with a number of contributors to develop new system enhancements and to implement and configure key pieces of the infrastructure. The VistA Expertise Network brokered the hiring of additional contractors and provided training for Oroville's own staff, who has now become VistA experts.

While some physicians were initially somewhat apprehensive about giving up their paper records, several physicians championed the idea. One physician was familiar with EHR systems, having installed one in his private practice before the Oroville VistA project began. During the transition, he was active in demonstrating the system's possibilities and addressing other physicians' concerns regarding the new system. He has also contributed to the development of new components and modules for the system.

The first office went online in March of 2009. By 2011, all of the hospital wards and 17 of the 20 clinics they operate were up and running, including nearly 1200 users and 400 physicians. The total cost of the implementation was approximately $10M, including the necessary upgrades to hardware and infrastructure, along with a number of iPads, mobile computer carts, and physician laptops that are scheduled to be integrated into the system. In 2011, the hospital completed implementation and certified for meaningful use, receiving nearly $3M in incentive payments.

With the new EHR system, Oroville was able to upgrade their infrastructure and software applications, and achieve several clinical improvements. The ability to instantly share information between the hospital units and the clinics has yielded several improvements in patient care. In one documented situation, a patient belonging to one of the early physician adopters came into the ER. The ER physicians were able to use the system to access the patient's chart and read the doctor's handwritten notes relatively quickly, positively influencing the prescribed treatment.

In addition, the new software enabled the hospital to generate quality measures that they were unable to generate beforehand. These new measures enabled Oroville to discover that these measures placed them among the top 5% of US hospitals. Benefits such as this were an important factor toward encouraging additional adoption by physicians and nurses.

The collaborations with WorldVistA and the VistA Expertise Network were key in allowing the hospital to achieve Stage 1 meaningful use in December of 2011.

> *"All in all, we were able to achieve both Hospital and Ambulatory Certification through the efforts of dedicated volunteers in the open-source community with major parts of the project funded by both WorldVistA and Oroville Hospital. Without this 'Village Effort' it would not have been possible," (Matthew King, Chief Clinical Content Developer, January 2012)*

The CIO estimates that Oroville has spent about $500K developing approximately five dozen customizations and add-ons. In turn, Oroville is contributing the software developed during the implementation project back to the open source community, after testing them thoroughly. In addition, they donated $150K to WorldVistA in recognition of the efforts that its members spent in assisting the Oroville staff.

Kern Medical Center

In 2008, Kern Medical Center was in need of a new EHR system, based on the upcoming federal regulations and an overall operational need for such functionality. They were unable to find an acceptable solution due to the high cost and after a few months of research, they settled on a VistA-based solution from Medsphere, signing the services contract in November of 2009. The hospital was attracted by several factors, including the low upfront costs of implementing the system compared to proprietary systems and the short time required to implement OpenVista.

Several of the physicians were already familiar with VistA based on previous residency rotations through VA hospitals. Kern executives were also attracted by the ongoing support available from the existing Medsphere and VistA ecosystems, which they hoped would mitigate some of the issues they had experienced with their previous health information systems.

> *"The systems we currently have, every time we need even a minor customization, it's a very expensive, lengthy process. Sometimes it can't even be done. And often after it's done, it doesn't meet our needs. So the idea that we would have open source and our own people could be trained to go in and make the minor modifications or*

add the applications that we needed, it was really very exciting and very exciting to our IT people as well."
(CEO Paul Hensler, vendor interview, 5/19/2010)

After signing the contract, Kern moved pretty quickly in order to meet the deadlines for attaining the meaningful use incentive payments, with implementation beginning in early 2010. Had Kern not been able to qualify for meaningful use, the contract stipulated that Medsphere would have to reimburse the first year's subscription service fees.

In order to facilitate a smooth rollout of the system to the hospital staff, the transition team established a number of subcommittees along with the steering committee. There was some excitement in the ability to interface with other members of the VistA ecosystem.

> *"To be able to be part of a system and a group spread throughout the country… and to be able to talk with these people nationally and pick some of the best brains across the country and the best ideas, and then to be able to customize our applications, or borrow applications, or create our own and share them with others, really adds a whole dimension. It makes you feel you're part of the electronic medical records system you're using, rather than something that was taken out of a box and plugged in for you." (CEO Hensler, vendor interview, 5/19/2010)*

Although the majority of the staff was looking forward to it with "cautious optimism", several other physicians were somewhat resistant. Fortunately for the implementation team, one physician was particularly excited about the prospects of implementing the new system. She was designated as a champion to address the other physicians' needs, try to find ways to resolve any persistent issues, and sell the new system to the resistant physicians.

> *"She meets with physician representatives for each of the functional departments on a biweekly basis. We discovered that we're better off having a physician talk to the physicians rather than having staff try to get the information." (CIO Bill Fawns, Medsphere podcast, 9/16/2010)*

Nearly 100 other users were identified as super users, tasked with supporting other users support issues as the system was rolled out. These super users were trained in an intensive session in late 2010, with the rest of the hospital staff slated for training over a five week period prior to launch. The system was scheduled to go live in early February, 2011.

Ultimately, they were able to install the system for $6.3M, including hardware and infrastructure costs of nearly $4M but not including the stimulus funding. In January of 2012, Kern announced that they had received $5M of an expected total $11M under the meaningful use guidelines. They also believe they have saved nearly $1.5M in annual paper and storage costs.

DISCUSSION

As evident in each case discussed above, the successful implementation of an EHR depends on the contributions of a wide range or participants. The role of many of the participants is the same for both proprietary and OSS based systems. For instance, both types of installation benefit from the involvement of physicians, nurses, and other staff early in the implementation process, shared project management governance structures, and the efforts of superusers and product advocates. In the cases above, many of these points are evident and warrant more detailed analysis later. However, for space purposes, we will restrict our discussion to several of the contributions and effects of the open source ecosystem that differ from those expected in proprietary EHR installations.

The involvement of external developers is a distinct advantage of open source software compared to proprietary EHR systems. As mentioned in each of the three cases above, hospitals adopting EHR systems have the ability to develop customized modules and interfaces for their specific sites, without having to contract the development with the vendor. However, there are networks of experienced VistA developers (e.g. the VistA Expertise Network) that can be contracted to develop add-on functionality that exceeds the capability of the in-house staff. As these new modules are developed, the system hopefully becomes a more useful tool in achieving the desired clinical, operational, and financial benefits.

As another benefit, open source licenses allow new modules to be shared so that other hospitals can implement the new functionalities to meet their own needs without having to go through the vendor first. For example, Oroville contracted with several external developers to develop modules for such features as electronic prescribing and pediatric growth charts. Midland sponsored development of physician dashboards and nurse flowcharts. In each case, the new functionality was made available to other VistA EHR adopters under an open source software license.

The ecosystem is also a key factor in the provisioning of ongoing support and maintenance. Through forums such as www.hardhats.org and vendor-specific outlets, a hospital's IT staff and users can contact other experienced VistA developers

and users for troubleshooting and support. In fact, the vendors depend on such support availability as a means of managing the scaling of support requests across its customers.

Based on this analysis, we conclude that the open source ecosystem surrounding an OSS EHR has the potential to directly impact the resultant system, information, and service quality of the implemented system. Consistent with DeLone and McLean (2003), these also impact the use and satisfaction with the system, especially in alignment with the efforts of the project management team and steering committees. Finally, these contributions are often crucial in enabling the administrative and clinical teams of the hospital to develop organizational workflows and safety measures that result in increased net clinical, operational, and financial benefits.

LIMITATIONS AND FUTURE RESEARCH

As mentioned above, space limitations preclude a deeper analysis of the current case data. The cases certainly offer the opportunity to derive several other findings regarding the relationships between the various members and their impact on the success of the EHR implementations. Future research will attempt to delve into the data to uncover these findings. In addition, we have begun an additional study into the ongoing implementation process of an additional county hospital to generate more contemporary data as the project is completed. We hope that the results of the current manuscript will allow us to develop additional insights in this next study.

As is true of many case studies, it has not proved possible to compare the process and outcomes of failed EHR implementation projects. We are also unable to compare the county hospitals here with larger hospitals, which have not adopted OSS-based EHRs essentially because larger hospitals can typically afford the hefty price tags associated with proprietary systems. However, we do hope to compare our findings with other cases involving the implementation of these proprietary EHRs in a subsequent study.

Finally, the entire VistA ecosystem is evolving rapidly in response to the VA director's decision to open source VistA at the VA. The initial stages are already underway with the establishment of the Open Source Electronic Health Record Agent (OSEHRA) to coordinate the consolidation and exchange of source code, modules, and suggestions across the various versions of the VistA software. The goal of this change is to allow the VA developers to contribute more freely to existing OSS versions of the software and to enable the VA to take advantage of the commercial ecosystems to modernize the base VistA software in an economical fashion. This change in the overall VistA ecosystem bears investigation as these changes take root across the various vendors and the VA itself.

REFERENCES

1. Blumenthal, D. 2009. "Stimulating the Adoption of Health Information Technology," *New England Journal of Medicine* (360), pp 1477-1479.
2. DeLone, W.H., and McLean, E.R. 1992. "Information Systems Success: The Quest for the Dependent Variable," *Information Systems Research* (3:1), pp 60-95.
3. DeLone, W.H., and McLean, E.R. 2003. "The Delone and Mclean Model of Information Systems Success: A Ten-Year Update," *Journal of Management Information Systems* (19:4), pp 9-30.
4. DesRoches, C., Campbell, E., Rao, S., Donelan, K., TG, F., Jha, A., Kaushal, R., Levy, D., Rosenbaum, S., Shields, A., and Blumenthal, D. 2008. "Electronic Health Records in Ambulatory Care — a National Survey of Physicians," *New England Journal of Medicine* (359), pp 50-60.
5. Fitzgerald, B. 2006. "The Transformation of Open Source Software," *MIS Quarterly* (30:3), pp 587-598.
6. Häyrinen, K., Saranto, K., and Nykänen, P. 2008. "Definition, Structure, Content, Use and Impacts of Electronic Health Records: A Review of the Research Literature," *International Journal of Medical Informatics* (77:5), pp 291-304.
7. Herbsleb, J., Muller-Birn, C., and Towne, W.B. 2010. "The Vista Ecosystem: Current Status and Future Directions." Pittsburgh, PA: Institute for Software Research.
8. Jansen, S., Finkelstein, A., and Brinkkemper, S. 2009. "A Research Agenda - a Sense of Community: A Research Agenda for Software Ecosystems," *International Conference on Software Engineering*, pp. 187-190.
9. Jha, A.K., DesRoches, C.M., Campbell, E.G., Donelan, K., Rao, S.R., Ferris, T.G., Shields, A., Rosenbaum, S., and Blumenthal, D. 2009. "Use of Electronic Health Records in U.S. Hospitals," *New England Journal of Medicine* (360:1628-1638).
10. Landro, L. 2009. "An Affordable Fix for Modernizing Medical Records," in: *Wall Street Journal*.
11. Longman, P. 2010. *Best Care Anywhere: Why Va Health Care Is Better Than Yours*. San Francisco: Berrett-Koehler Publishers, Inc.

12. Messerschmitt, D.G., and Szyperski, C. 2003. *Software Ecosystem : Understanding an Indispensable Technology and Industry*. Cambridge, MA: The MIT Press.
13. Pentecost, M. 2006a. "Electronic Medical Records, Chapter One: The Promise," *Journal of the American College of Radiology* (3:2), pp 85-87.
14. Pentecost, M. 2006b. "Electronic Medical Records, Chapter Two: The Obstacles," *Journal of the American College of Radiology* (3:3), pp 167-168.
15. Petter, S., DeLone, W.H., and McLean, E.R. 2008. "Measuring Information Systems Success: Models, Dimensions, Measures, and Interrelationships," *European Journal of Information Systems* (17), pp 236-263.
16. Popp, K., and Meyer, R. 2010. *Profit from Software Ecosystems*. Norderstedt: Books on Demand.
17. Ross, J. 2009. "Electronic Medical Records: The Promises and Challenges. Journal of Perianesthesia Nursing. 24(5), 327-329.," *Journal of PeriAnesthesia Nursing* (24:5), pp 327-329.
18. Simon, S., Kaushal, R., Cleary, P., Jenter, C., Volk, L., Poon, E., Orav, E., Lo, H., Williams, D., and Bates, D. 2007. "Correlates of Electronic Health Record Adoption in Office Practices: A Statewide Survey," *Journal of the American Medical Informatics Association* (14:1), pp 110-117.
19. Van Der Meijden, M., Tange, H., Troost, J., and Hasman, A. 2003. "Determinants of Success of Inpatient Clinical Information Systems: A Literature Review.," *Journal of the American Medical Informatics Association* (10:3), pp 235-243.
20. Watson, R., Wynn, D.E., and Boudreau, M.-C. 2005. "JBoss: The Evolution of Professional Open Source," *MISQ Executive* (4:3), pp 329-341.