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Improving Eye Care Delivery Through Data Sharing Technology

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aecp
the armenian eyecare project
bringing sight to armenian eyes

Abstract

Preventable blindness has massive social, economic, and societal impacts around the world. The Armenian EyeCare Project (AECP) is addressing this through a network of regional and subspecialty ophthalmological clinics, but current data collection, storage and sharing methods are inadequate. With the organization's input we conducted focused research to determine current state and best practices, and synthesized this information to develop recommendations and implementation plans for Electronic Medical Record and teleconsultation systems which would improve data sharing for better patient care.

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Acronyms

AECP	Armenian EyeCare Project
ARMD	Age-Related Macular Degeneration
COE	Center of Excellence
ECM	Evaluation Criteria Matrix
EMR	Electronic Medical Record
IO	Input/Output
ISP	Internet Service Provider
LAMP	Linux, Apache, MySQL and PHP/Perl/Python
MEH	Mobile Eye Hospital
MOJ	Ministry of Justice
ONC	Office of the National Coordinator for Health Information Technology
PDP	Private Data Processing
REC	Regional Eye Center
ROP	Retinopathy of Prematurity
USPHP	Ukraine Swiss Perinatal Health Project

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The team, left to right, Alex Lemmon, Katie Dunphy, Julia Dunn, Alex Alvarez

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Executive Summary

At the beginning of the 21st century roughly 45 million people around the world had some form of blindness (WHO, 2007). Of these cases, the vast majority could have been prevented if the patients had had access to adequate and timely care. Ninety percent of those suffering from blindness live in less developed regions of the world with little or no access to such care, leaving them with little chance of treatment. While high, the direct medical cost of blindness pales in comparison to the indirect socio-economic and humanistic costs. The blind may be unable to contribute to their communities, suffer from crippling depression, and often pull family members away from their other obligations. The immediate impact of widespread blindness is cause enough for attention, but the long-term effects that cripple a society's ability to grow and adapt demand large-scale action.

The country of Armenia suffers from a disproportionately high rate of preventable blindness, and the national government's resources are strained by war, natural disaster, and an economy struggling to modernize in the post-Soviet era. The Armenian Ministry of Health has therefore reached out to outside organizations to help address the need for quality eye care. In this context, the Armenian EyeCare Project (AECP) was founded in 1992 and began treating patients and training local doctors to help relieve the burden (AECP, 2017). In November 2002, the AECP began operating a Mobile Eye Hospital (MEH) that delivers eye care to rural populations that cannot access the hospitals and clinics of Yerevan, the capital of Armenia. More recently, the AECP has developed a new operating model involving five Regional Eye Centers (REC) in rural regions of Armenia to extend the availability of care. However with this new network of clinics, the AECP must develop new ways of data storage and data sharing.

The goal of this project was to develop a set of recommendations for the implementation of an Electronic Medical Record (EMR) and a teleconsultation system, to be used throughout all of the AECP's facilities. This was intended to improve existing methods of recording, storing, and sharing data to support physicians as they provide high-quality patient care. We interviewed doctors and conducted observations at the RECs to determine how records are kept and shared among the different facilities. We also identified the gaps in communication between doctors and evaluated the feasibility of a more structured method of teleconsultation. Working with the AECP, we were able to identify the requirements of the new systems to recommend an EMR and a structured teleconsultation network.

Research Methods:

To determine the specific needs of the AECP, we conducted initial and follow-up observations at the regional clinics. We also interviewed one of the regional doctors to understand the current state of data storage and sharing. After we determined the current practices in these two areas, we

worked with the AECP administration to develop requirements for potential systems. Subsequently, we researched EMR systems and teleconsultation best practices through case studies. We analyzed EMR findings by defining critical features, functional features, and non-functional features. An evaluation criteria matrix was used to assign weight to various features and thus provide quantitative data for each system based on its associated features. An EMR was selected as the recommendation based on the qualitative and quantitative data produced. With regard to teleconsultation analysis, we decided to use a technical and operational framework and which deliverables should accompany it. In addition, we developed implementation plans for both EMR and teleconsultation systems accounting for aspects such as technical infrastructure and staff training. Finally, we refined our recommendations and presented them to the AECP along with our deliverables.

Electronic Medical Record Recommendation:

In researching EMR systems, we found that open source systems would be best for the AECP as they are free to download and use and can be modified easily to fit the needs of the organization. We worked with the AECP to define the critical features of the EMR, including the need for security and a multi-lingual interface, and prioritized the goals of the organization for the integration of the system. From these goals, we developed an evaluation criteria matrix based on system features that accomplish these goals to objectively determine how well the EMR would fit the AECP's needs. Once a system was determined to meet the AECP's requirements, we analyzed non-functional features to determine the relative ease of implementation. From our observations, we also determined a need to update the technical infrastructure of the clinics to ensure operation of the system.

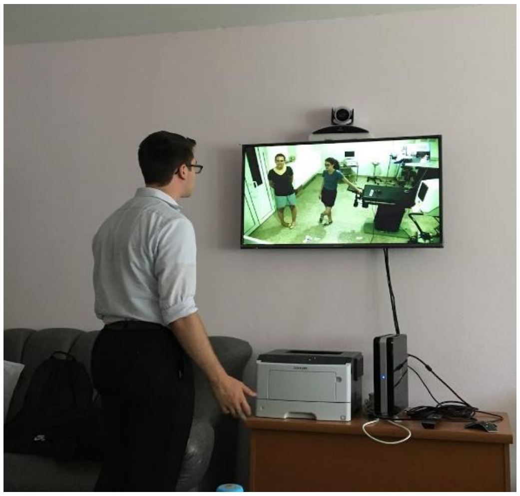
Based on the EMR system analysis, we recommended the AECP adopt OpenEMR as its medical records system. OpenEMR is the most popular browser-based open source system, so there is a large community of highly active system users who can offer free support to the AECP during its implementation process. Because it has been used in over 30 countries, OpenEMR has been translated to English, Armenian, and Russian, among other languages. The system also has met security regulations in most of these countries. From the evaluation criteria matrix, OpenEMR received the second highest feature raw score, and the missing features can be easily coded into the open source system. OpenEMR software can be installed and functional in a single day, meaning clinical use is relatively simple, and the patient portal is very easy to access and navigate. Finally, the ophthalmology exam module of the system was developed by an ophthalmologist making it conducive to the clinical environment and receptive to flexible data input methods. In addition to the EMR system, we recommended the AECP adopt a network of local servers with low-cost servers in each clinic. The redundancies produced by the local servers will enable staff access to the system even if Internet access is lost, a server goes offline, or the local router fails. The initial investment of the servers will quickly pay for itself, as the AECP will not have the recurring cost of renting server space overseas.

For the implementation of the EMR we recommended a cross-functional team, composed of an AECP administrative staff member as a core team leader, a lead software developer, an IT leader, and a primary clinician. The purpose of this team is to provide a holistic view of the AECP during planning and implementation and ensure common goals among all staff groups within the AECP regarding the EMR. We recommend a rolling training of the clinics where the cross-functional team will train the first clinic once the EMR had been modified and the hardware been set up. The first clinic will learn to use the EMR by digitizing relevant paper records; once the clinic has reopened, the cross-functional team will leave the clinic. This first trained clinic will give feedback on the system and once this feedback is incorporated, the second clinic can be trained. The staff of the second clinic will travel to the first to observe and use the EMR in a live clinical setting under the guidance of previously trained clinicians. All future training clinics will be determined based on proximity and EMR proficiency.

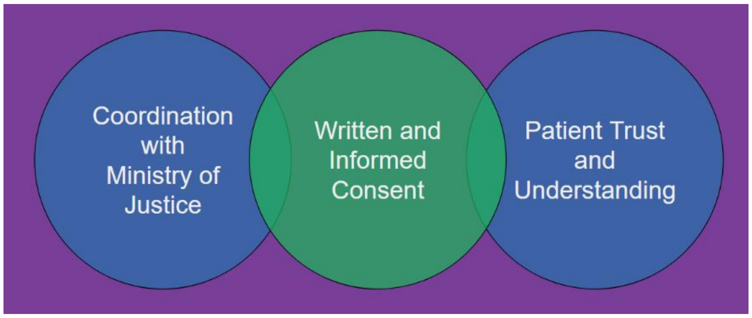
Teleconsultation Recommendation:

One of the first things we discovered during our observations in the regional clinics was that the AECP has access to three Polycom systems at their facilities, but use of these systems was almost nonexistent. We also discovered that the current process of unstructured teleconsultation was utilized nearly every single day by the REC doctor with whom we spoke. This process involved an REC physician phoning a colleague from his or her professional network and discussing the case. It seemed inefficient to informally phone personal contacts in the hopes that they would be able to help, and having access to the Polycom technology but not using it seemed wasteful. We decided to combine the technical aspect of teleconsultation with the operational aspect, and synthesized deliverables to structure telemedicine and provide the information to not only the AECP but also the physicians who would be using this system.

The teleconsultation deliverables will help doctors utilize the system better. Our main deliverable was a teleconsultation guide, which consists of an installation guide (to help IT personnel install systems at future clinics) as well as a technical user manual, escalation protocol (decision tree for doctors to determine which specialists to contact when), and database of all AECP-affiliated doctors, their specialties, locations, and contact information. In addition, we set up the hardware of three of the available Polycom systems to be used by the AECP. We established a connection between two of the systems (pictured left), and provided a recommendation to improve internet reliability in the third center so that system could be connected as well. We wrote an email template for AECP doctors to distribute to their own professional contacts to request permission for their contact information to be included in the list as well. Finally we created a cost breakdown of Polycom systems to help the AECP determine which models to provide for future facilities. Our main recommendation was that the AECP utilize the Polycom systems and installation guide we created for scheduled calls in nonemergency situations, and we also suggested that, if financially feasible, the AECP invest in the Polycom RealPresence Group 700 system for any future clinics because it has far more capabilities than other Polycom systems. Lastly, we recommend training occur in a peer-to-peer format as often as possible with IT personnel available to physicians for a month or two after the system is first adopted.



Two additional considerations when making such large-scale changes to a healthcare organization's infrastructure are patient privacy and change management. To understand Armenian patient privacy regulations we spoke with a lawyer to determine necessary safeguards to include in our recommendations. Based on this conversation we recommend that the AECP work closely with the Ministry of Justice to ensure compliance with private data processing regulations, and that written patient consent is obtained upon every visit to ensure patient trust. These recommendations are illustrated in the graphic to the right. We researched change management, which we foresaw as a significant concern when asking medical professionals to change their practices. We determined that the best way to facilitate this was to involve peer-to-peer training as much as possible, so we integrated this into both our teleconsultation and our EMR implementation plans.



Our recommendations are aimed at helping the AECP improve patient data storage and sharing to provide better patient care. The EMR allows patients to be seen on a holistic level by doctors to provide better care, while the cloud based nature of the system enables all doctors in the AECP's network to use and analyze patient data and the patient portal gives patients access to their health information and treatment plans. Restructuring teleconsultation reduces the strain on patients by increasing the quality of care available at the regional clinics. The video sharing technology allows specialists to have a better understanding of the case, while the escalation protocol increases the network of specialists available, and streamlines the process of selecting a specialist, making it more effective. By implementing our recommendations and utilizing our deliverables, the AECP should be able to store and share data more effectively, and thus provide better patient care.

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Chapter 1: Introduction

In 1996, it was estimated that there were 45 million cases of blindness worldwide; of these cases, an estimated 75 percent could have been avoided by early intervention and access to primary eye care (World Health Organization, 2007). Over 90 percent of the world's visually impaired people live in less developed countries without access to adequate eye care. Visual impairment in the country of Armenia, especially that which is preventable, closely follows the world trend (Jrbashyan, 2013). In the decades since the fall of the Soviet Union, the Armenian Ministry of Health has worked to improve the crumbling healthcare system and stabilize healthcare for all citizens, including the poorest third of the country (Tonoyan, 2004). Despite this effort, Armenia still suffers from an unacceptably high rate of preventable blindness.

In response to this tragedy, the Armenian Eye Care Project or AECP was formed (AECP, 2017). By partnering with the Malayan Ophthalmological Center, and aiding with the training of physicians in the capital city of Yerevan, the AECP successfully improved the quality and availability of eye care. To address the needs in the rural regions, the AECP purchased a Mobile Eye Hospital, or MEH, which is a tractor trailer outfitted with a surgical suite, exam room and an administrative room. The MEH circles the country, providing care to patients and making a full loop every two years. To better serve the population year-round, the AECP is in the process of upgrading its care delivery model to include regional clinics, in addition to the base hospital and subspecialty clinics in Yerevan. There are currently two Regional Eye Centers (REC) in operation, in addition to the circulating MEH. As new locations come on line, there is an increasing need for enhancing communication between clinics and providers. To address this, the AECP is looking to increase the efficiency and effectiveness of its operations by improving interconnectivity between facilities and ease of access to patient records.

In a similar fashion, organizations around the world have developed different models depending on the culture, local conditions, and situations that each initiative faces. These models, multi-tiered or not, all require management systems to organize and deliver information to where it will have maximum impact. Common practices include the use of Electronic Medical Records (EMRs) and teleconsultation systems, which constitute a subset of telemedicine that specifically refers to doctors advising each other on cases remotely. (Zhang, Zhang, 2017). These systems allow organizations to keep track of patient health records and communicate with other providers. The combination of systems like these allows organizations to better address patient care.

Despite the recognized need, the AECP has not yet put in place a system to manage records or facilitate communication among the clinics and MEH. While the organization has been addressing eye care effectively with the MEH and two RECs, in conjunction with the Malayan

Ophthalmological Center in Yerevan, the AECP recognizes that its method of records storage and communication could be improved with the implementation of EMR and teleconsultation systems. Currently, the two RECs operate on a paper-based medical record system that does not allow for easy sharing of information between facilities. Similarly, there is no system connecting the RECs, the MEH, the central hospital in Yerevan, and doctors abroad through teleconsultation.

The goal of this project was to develop recommendations for the selection and implementation of an Electronic Medical Record (EMR) system and a teleconsultation system to be used throughout all of the AECP's facilities. To accomplish this goal we completed the following objectives:

- Identified the required features and functions of an EMR system and structure of a teleconsultation system specific to the AECP's needs.
- Identified optimal EMR systems and teleconsultation structures given the required features.
- Developed a cohesive set of recommendations of the optimal systems.
- Developed a plan for implementation of these systems within AECP facilities.
- Implemented teleconsultation technology as a model in an AECP clinic.

To this end, we used observations and interviews to identify the requirements for the EMR and teleconsultation systems. We then researched EMR options that fit the given requirements and weighed and analyzed these systems with an Evaluation Criteria Matrix (ECM) in order to identify those that best addressed the AECP's needs. We also investigated the existing teleconsultation equipment present at several facilities and worked to set up and test an integrated communications network to allow doctors to collaborate and consult with each other remotely. This research culminated in the development of a set of recommendations for the AECP that are intended to improve data sharing among the AECP doctors and between clinics, which will provide better patient treatment and outcomes. In turn, these improvements will help the AECP operate more efficiently and effectively, allowing them to maximize the impact of their work on the Armenian population.

Chapter 2: Background

In this chapter we review the best practices and implementation strategies for an EMR and telemedicine system within a multi-tier health care delivery model. First is a review of EMR systems, and how to bring them in as a standardized system of tracking patients' information and treatments across connected eye care centers, both at the primary and specialized level. Subsequently, we examine the development of telemedicine in the view of implementation and effectiveness. In this research we also examine the impact that these systems have on patient care and outcomes, as the overarching goal of our project must follow the AECP's mission to provide the best care to patients in rural areas.

2.1 Eye Disease and its Prevalence in Society

The rate of eye disease has been increasing worldwide, from 161 million visually impaired people in 2002, to 314 million in 2006 (World Health Organization, 2007). Of those 314 million people, 45 million are considered blind (defined as less than 3/60 vision or loss of visual field at 10 degrees, even with best correction possible). Furthermore, out of the eight primary causes of blindness, five are medically preventable and constitute 75 percent of cases, and nearly 50 percent of all cases are due to cataracts, shown in Figure 1 (World Health Organization, 2007). On a personal level, patients experience pain, suffering, and often early death due to these psychological factors, and this impairment forever changes the life of the individuals it affects. This can be seen in the effects of cataracts, which is one of the most common preventable causes of blindness (Hodge, Horsley, Albiani, Baryla, Belliveau, Buhrmann, et al., 2007). During the wait for cataract surgery, patients often experience a decreased quality of life, which is accompanied by an increased rate of falls and depression. This is important because the wait time for treatments can last weeks or months in many less developed countries. In cases where there is no access to care, the wait is forever. Vision loss can also lead to increased anxiety, which further exacerbates the issue of individuals caring for themselves and for others (Augustin, Sahel, Bandello, Dardennes,

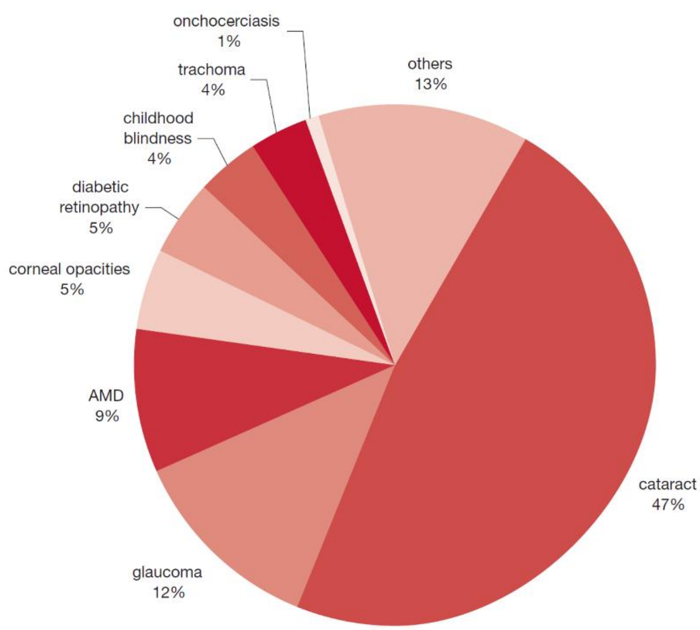


Figure 1: Global causes of blindness due to eye disease (World Health Organization, 2007)

Maurel, et al., 2007). This anxiety can snowball into an increased likelihood of social withdrawal and isolation. For these reasons, and many others, the loss of vision is “one of the most feared results of aging” (Rosenberg, Sperazza, 2008, para 3).

As devastating as blindness is to the individual, the impact of their condition is also felt by those around them. The three main factors that contribute to the likelihood of visual impairment are age, gender, and socio-economic status, and with the rate of eye disease and blindness increasing, all societies are facing massive humanistic and socio-economic costs. These costs, particularly economic ones, are both direct and indirect. Direct costs are those included in eye care and the treatment of these preventable diseases (which include pharmaceuticals, research, and personnel), while indirect costs have a far more extensive and long-term effect on society and the economy. These include the lost earning potential of the visually impaired and their caregivers, as well as visual aid expenses such as equipment, rehabilitation, and welfare, and overall they can be up to five times higher than the direct costs. Addressing visual impairment early benefits not only the patients, but also their communities as a whole. In the effort of addressing socio-economic cost and individual patient welfare, the prevention of blindness is not only a possibility, but also a duty to those who can bring about the change.

A report issued by the Program for the Prevention of Blindness and Deafness evaluated the causes of blindness and found that cataracts were the primary factor, followed closely by glaucoma and diabetic retinopathy (Resnikoff, Pascolini, Etya'ale, Kocur, Pokharel & Mariotti, 2004). Cataract cases are most common in the Americas (58%) and Europe (28-36%), while Europe on its own experiences the highest rates of diabetic retinopathy (15%) and glaucoma (16%). When there is high volume, high quality cataract treatment can be provided for as low as 10 US dollars, which makes it one of the most inexpensive methods of intervention. This low cost emphasizes how easily a vast number of cases can be treated.

The prevention of ailments that cause blindness can be handled at the community level by educating the population, in conjunction with increasing accessibility to preventative and treatment services (Cheng, Henderson, Sinclair & Sanders, 2015). Often, people may be aware of the signs and symptoms of preventable eye diseases such as glaucoma, but they do not know what preventative methods are available and how they can receive treatment. The *British Journal of Vision Impairment* stated that, in Scotland, 82 percent of elderly patients were aware of the free annual Scottish eye tests offered to citizens and even 77 percent were aware of what glaucoma was, but only 24 percent understood that proper glaucoma treatment was available and how it worked. Similarly, only 43 percent of elderly patients knew what age-related macular degeneration (ARMD) was, and only 17 percent knew of the available treatment. General treatment for ARMD is simply taking various vitamin supplements daily, but many elderly patients do not know that there is such a simple solution (American Academy of Ophthalmology, 2017).

As important as awareness is, the barriers to treatment cannot all be solved by educating patients. A study done in India shows that while many people do not know how to reach treatment clinics, or accept blindness as part of the aging process, many others are simply unable to reach care due to geographic or socioeconomic barriers (Bettadapura, Datti, Donthi & Ramaswamy, 2013). Often, the challenge is as simple as not having anyone available, be it a friend or family member, to act as a caregiver and accompany them to a clinic.

2.2 Patient Information Systems

The implementation of a patient information system such as Electronic Medical Records allows for efficient and accurate tracking of patients so that treatments are followed and the frequency of medical mistakes is reduced. A typical ophthalmological EMR data entry screen is shown in Figure 2.

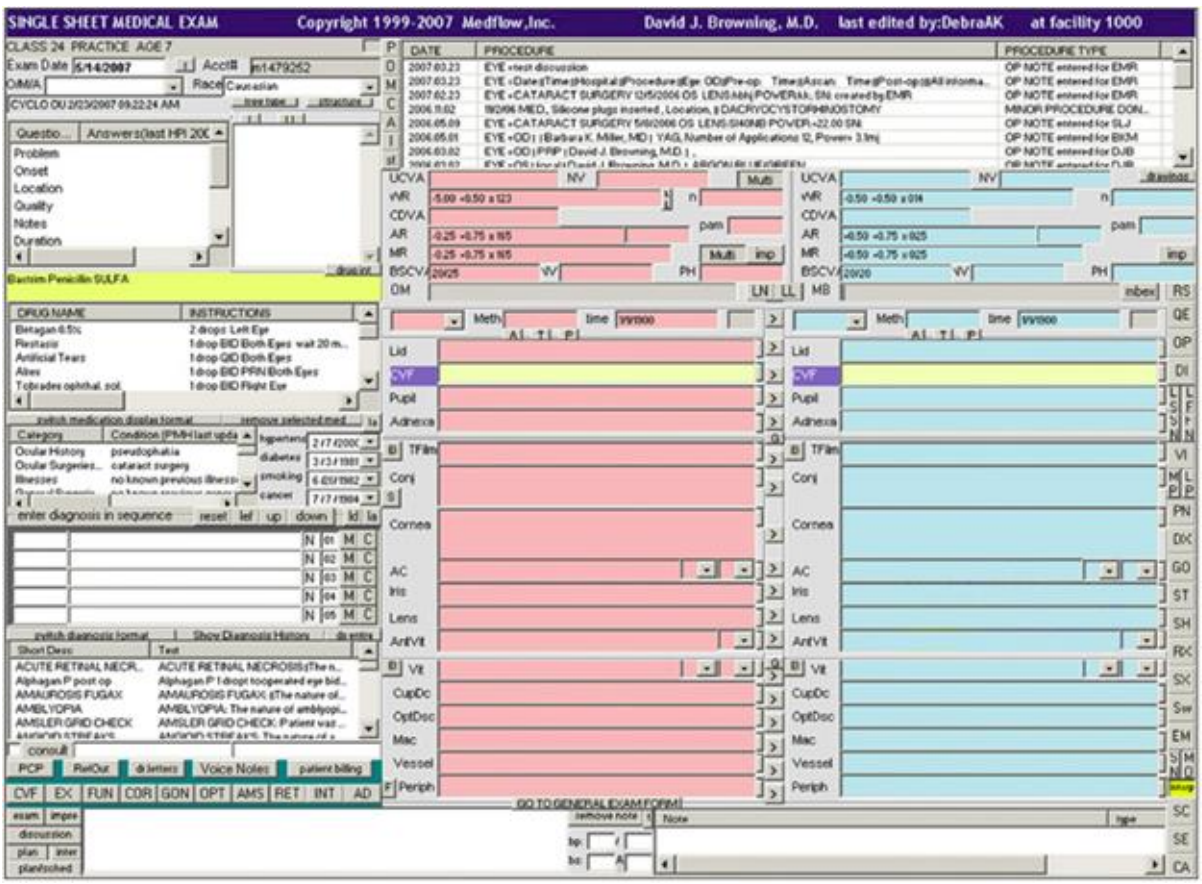


Figure 2: A typical ophthalmological patient encounter screen for a John Doe patient

EMR’s typically contain patients’ contact information, medical information, treatment history, and sometimes images such as those of a patient’s retina. The use of a standardized EMR makes it possible for patient records to be accessed by multiple providers and from multiple locations. This is especially important in the case of patients with complicated cases who require follow up and further treatment, but it is also useful for providers to be able to keep track of their patients’ health trends over time. Standardized EMRs are particularly necessary in multi-tier systems to ensure the consistency and accessibility of records both within and outside of the clinic.

2.2.1 Recent Perspectives on EMR Systems

Due to the growing need for healthcare services and the growing need for a way to store patient information, EMR systems have seen a steady increase in implementation among healthcare providers worldwide (Zhang, Zhang, 2016). Providers use these systems to “improve the accuracy of patient care information recorded in health records, support clinical decision-making, and improve accessibility of patients' healthcare information for continuity of care over space and time” (p. 1). Through EMR systems, patient data are easily entered, tracked and fully accessible at all times, allowing for more informed care decisions as well as more efficient scheduling of care appointments.

The key benefits of using an EMR are that it greatly improves access to and quality of data, and that the data is standardized throughout the organization (Zhang, Zhang, 2016). Furthermore, its format as an electronic document allows for greater completeness and accuracy, as computers perform validation checks to make sure required data is entered correctly. It also allows for better time efficiency and quality of care as there is greater adherence to patient protocol and reduced medical error. Secondary benefits of using an EMR include improved health services in administration and disease surveillance, as well as reduced billings and transcription costs, reduced patient cycle time, and increased utilization of resources.

The most significant drawback of an EMR is the amount of administrative work it places on health providers, especially in the absence of a staff member acting as a scribe, which requires doctors to input information themselves while in the middle of a patient visit. Unfortunately, while data quality and consistency are particular strengths of an EMR, it is not immune to human errors in the entry and retrieval of this data, or of lapses in communication. These errors are often the result of “sociotechnical” factors, which refer to the inherent challenges that result from people interacting with technology, particularly when exacerbated by a lack of training or experience (Zhang, Zhang, 2016). Such errors can include typos, improper data entry, and problems related to language translation. Other secondary issues may include privacy and confidentiality, problems with hardware, system failures, system operating learn time, and decreased patient-physician interaction.

By synthesizing the benefits and effects of an EMR system, Zhang and Zhang examined the four key dependencies for such a system. Based on previous research, the factors on which a beneficial EMR system depend are “comprehensiveness of information, duration of use and retention of data, degree of structure of data, and ubiquity of access” (Zhang, Zhang, 2016, p. 5). Analysis of these factors reveals that they all depend on the functionality and design of the EMR, and a general layout is shown in Figure 3. The functionality of an EMR system springs from the need for a historical overview of patient health records, which is necessary in making informed care decisions and generates this integrated view of patient data. This in turn creates a need for sharing the data among facilities and providers, but implementation of such a large integrated system is difficult. In addition, the system must be standardized across patients, staff, health plans, and providers as differing jargon and means of data entry can cause discrepancies within the system. Because of these complications, the design of such a system is paramount, but often difficult to create in a way that addresses all aspects of healthcare. In general, an EMR system requires structured data entry and a simple and intuitive user interface. Structured data entry most often takes the form of an encounter form completed by a medical professional but other forms include transcription of notes or direct entry at the point of care. The user interface must be simple in layout, navigation, and color scheme as overcomplicating any of these makes the system less efficient and more difficult to use and understand. This includes, grouping or symbolizing information to allow for easier data field recognition as well as less information density on screen. An additional concern in the design of an EMR system is privacy and confidentiality, so authentication and access control are also invaluable features during development.

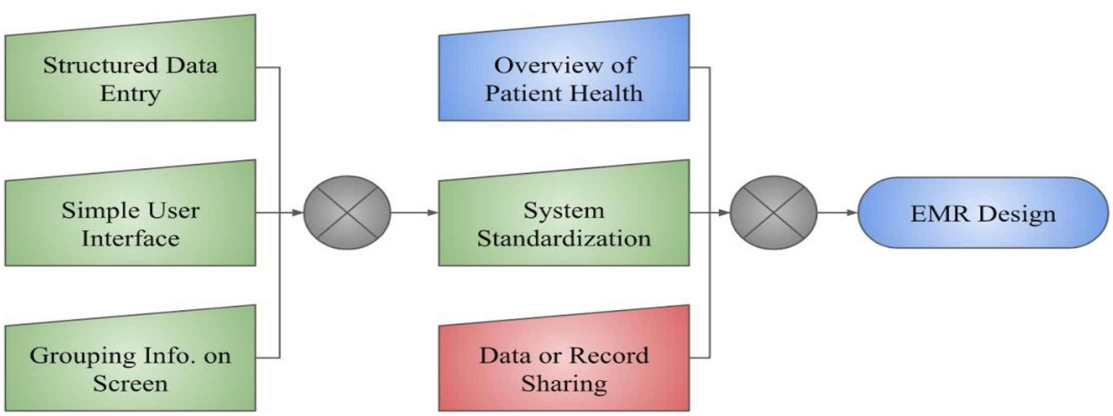


Figure 3: Components of an EMR system

2.2.2 Selection of EMR

Searching for the right EMR system for a given implementation consists of five primary steps (Outlook Associates 2011). These break down the research process to ensure that the EMR is the best meets the needs of a specific organization, and must take the context of implementation into account. The first step is to set initial guidelines for the system, including the critical features needed, allowing the organization to quickly eliminate a number of extraneous options without the need for in-depth analysis. Examples of these critical features include language needs, security, and practice specialty. The more specific features will vary based on the organization itself. Once these critical features are clearly and explicitly defined, the second step it to assess what the goals of implementing the system are. This means understanding not only if the implementing organization wants the EMR, but why they want it and how should it change the performance of the practice. By prioritizing the goals of the implemented system, the organization will be able to more objectively analyze what the system needs to do, instead of making a decision based on possible function appeal. Once the goals are identified and ranked by the organization, the third step associates EMR functionalities with the goals they help achieve, and these are then ranked accordingly by level of impact within that goal. For example, a common goal for medical organizations is "improved patient care," and a function that is a part of this goal is to have clinical rules and alerts.

In addition to the features of the EMR system, it is necessary to define the technical needs that support the system (Outlook Associates, 2011). These include the required operating system, device integration, and possible reporting tools, among others. By defining these needs, the organization can understand the feasibility of implementation, along with the associated costs, and ensure that the system not only meets the requirements of the end users, but is able to integrate with existing infrastructure and practices such that the end users can actually make full use of it. Finally the organization must define the expectations for implementation support, system enhancements, and long-term support post-implementation. These expectations will vary based on the source of the EMR system, but whether the support is coming directly from the vendor, a third party contractor, or an in-house specialist, it is necessary to define the expectations in advance to ensure the needs of the organization will be met throughout the use of the system.

All throughout this process it is imperative that the organization is considering their priorities regarding the introduction of an EMR system to their practice. It is very easy to window shop through potential systems, and become engaged with options which do not meet the needs of the organization. Implementers must continuously evaluate the critical features, as well as the goal-oriented features, to meaningfully direct the research process.

2.2.3 Types of EMR

By far the most common type of EMR use by large hospitals or healthcare networks are those developed by large, well-established vendors. These companies have a wealth of experience working with the healthcare industry and often build long-lasting relationships with their clients, but their most significant advantage by far, relative to other sources of EMRs, is the sheer number of resources at their disposal. Large vendors tend to have large development and support teams, and the financial weight to back them, and this is the primary driver of their disproportionate market share. Their very size, however, is also their main drawback. Because they have a large client-base, and these clients tend to also be large and well-established, these vendors have a reputation for being slow to respond to user requests. An end-user may identify a problem with a given feature, or request an entirely new one, but their request will not be implemented quickly, or even at all, for two main reasons. First, they are one of many tens or hundreds of thousands of system users, and even a large development team cannot hope to properly consider and implement all of the modification requests they receive. Second, because these EMRs are centralized products, whatever changes are made are implemented as part of a software update that affects every single implementation of the given system. Therefore the only changes that are made are those that are deemed beneficial to a critical mass of users, not those sought by individual providers. Occasionally, if demand is high enough, companies will release multiple versions of their core software that are optimized for specific specialties, but these tend to be just as rigid as the default software, and share many of the same drawbacks. These systems are also very expensive, typically costing several hundred dollars per month for every provider using them.

A second category of EMR consists of mid-tier systems that fall below the former in cost yet ahead in flexibility. These systems tend to be either low-cost, or entirely free, albeit with sponsored advertisements to offset the lost revenue, but do not feature the extensive support networks of their larger counterparts. This is not to suggest that clients are left on their own, however; several systems in this category have well-regarded customer support, but the relative lack of resources translates into smaller development and support teams. As a result, these systems tend to cater to small and mid-sized practices that either don’t have a need for their more expansive cousins, or simply cannot afford them. Some, though not all, of the EMRs in this category also allow for a certain degree of flexibility for the end-user. The interface may be customizable to suit the needs and preferences of individual providers, and form templates can be created, downloaded from public databases, or uploaded to share with others. Several systems even allow for integration with third-party tools or more in-depth feature modification, but these are few and far between and while significantly more flexible than large-vendor-provided options, they tend to be limiting in what they allow end users to get away with.

The third category of systems is open-source. This refers to software whose source code is made freely available for distribution and modification, and open-source software is often developed and supported collaboratively by a community of contributors. Open-source EMRs tend to be more bare-bones than those developed by companies, but what they lack in elegance, they more than make up for in flexibility. The primary advantage of open-source systems, apart from being free, is the fact that because the source code is available to all users, there is no limit to how much they can be modified. Functionality can be added or removed to suit the needs of the end users, and the whole system can be made to represent the priorities of the implementing organization, rather than forcing users to accommodate and adjust to the particularities of the EMR. The main drawback is the added time and effort required to actually implement the desired changes, and one of the prerequisites of such a system is the in-house expertise to install and manage it, or a third party to which these responsibilities can be outsourced.

2.2.4 Key Success Factors Behind EMR Adoption in Thailand

Although the concept of an EMR has been around since the 1970s and the systems have been implemented in health organizations worldwide to great benefit, they are still only used by a minority of healthcare providers globally (Narattharaksa, Speece, Newton & Bulyalert, 2016). This is due in part to the difficulty of and resistance to implementation and management of such a system. Key issues like the technology itself or the willingness of doctors to accept the technology are important, but often not as complicated as understanding how to properly manage the EMR system implementation process. Due to this, many countries, including the United States, have not yet fully adopted and standardized the use of EMR systems.

Thailand offers an excellent case study in this regard. Despite its prosperity, Thailand lacks sufficient healthcare infrastructure (Narattharaksa, et al, 2016). Government policies show that it is committed to bolstering healthcare initiatives but is still early in the execution stages. Around 80 percent of hospitals surveyed had some form of basic EMR system to deal with outpatients, but only about half used EMR systems for inpatients, and only five to ten percent used an EMR comprehensively. In light of this, there is no standardized implementation process or conduct for using an EMR system in Thailand. A 2004 survey of 728 healthcare professionals across Thailand found that “integration and utilization of information” ranked second in major obstacles to implementing such systems in hospitals. Twenty seven percent of those professionals agreed it was a major obstacle, and 95.5 percent said it was definitely a problem. The same survey was then given to consulting groups for those hospitals who validated the data as they cited the “integration and utilization of information” and the “medical recording process” as the first and third largest obstacles to healthcare providers in Thailand. There are also a number of factors that impede the implementation of EMR systems, including high provider workload, inadequate budgeting, and poor project coordination.

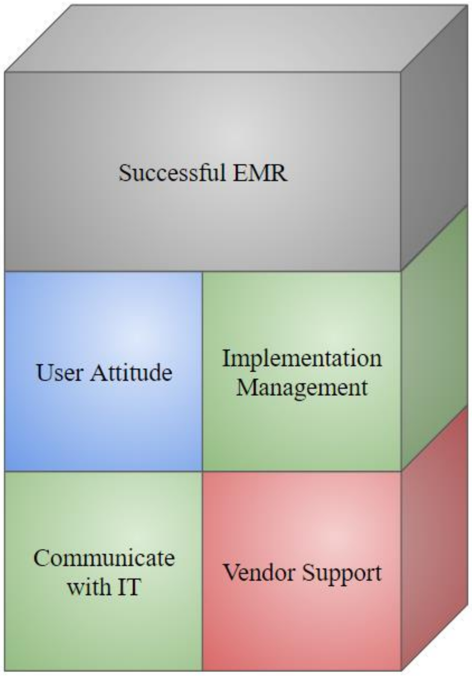


Figure 4: Criteria for successful EMR implementation

In this study, the four factors that influenced the successful implementation of an EMR system were identified through surveys and interviews and are shown in Figure 4 (Narattharaksa, et al, 2016). First, implementation depends on the attitudes of users; if the users do not like the system and subsequently refuse to use it, it will fail. Second, the management of implementation must be adapted to the given context by having clear goals and scope and be supported by an adequate budgeting process. Also, users must have input on the goals and scope of the project to ensure their cooperation. Third, electronic communication within the IT department is key. The prioritization of this communication network, along with experience of IT staff, determines how effective the EMR system is with healthcare professionals. If professionals are under-trained or uncommunicative about problems they are having, then IT staff will find it difficult to adapt the EMR system to the needs of the users. Lastly, support from the vendor is critical, as they must work with the customers to implement the EMR system. If there is limited or no vendor support, then the provider will have more difficulty with the system, causing them to consider abandoning it. Because of this, communication between vendor and provider must be continuous.

2.2.5 Best Practices in the Implementation of New EMR Systems

The Cleveland Clinic was one of the first users of electronic health record technology, and has been making changes to the system to make it more widespread across all care centers through the implementation of computerized physician data entry (Levoy, 2011). To achieve success in these initiatives, the Cleveland clinic prepared well in advance for the new system with the aid of Alego Health, a consulting firm focused on IT solutions in health delivery. The clinic examined how the EMR would fit into the facility as well as the required infrastructure to implement the system. Once the technology required was determined, the clinic developed a training plan in advance of implementation to ensure personnel were involved and educated.

In addition to this, the allocation of support and local talent must be determined (Levoy, 2011). At the Cleveland Clinic, the most experienced IT members are only used when needed, to make the best use of their time and reduce cost, so entry-level and mid-level support staff are used whenever possible. Relying on internal sources of expertise when employing new systems rather than relying on the vendor's support staff also tends to be far more cost-effective in the long run. Once the system is in place, it becomes necessary to train existing medical staff with basic IT skills and literacy, so that they can either handle trivial matters on their own or better communicate with dedicated IT staff when a problem arises that they are unable to resolve. Furthermore, a degree of interface flexibility can help accommodate individual providers and ensure that they are able to use the system for maximum effectiveness. This often-overlooked aspect is critical, given that the EMR is first and foremost intended to improve patient care. Regular training of clinicians on the use and capabilities of the system is important for complete integration into the care model. Finally, the practice must communicate fully through all assets to ensure that all goals, timelines, and issues are addressed in the same manner. Effective communication allows all those involved in the new system to be successful and also encourages input from all parties in what the goals and issues are. There must be established procedures and systems in place, and communication across all parts of the operation chain need to be fine-tuned and continually monitored, in order to ensure organizational discipline, efficiency, and enhanced patient care.

2.3 Telemedicine

In rural and hard-to-reach populations, it is often difficult for patients to gain direct access to specialists. For difficult cases other methods of diagnosis and treatment must be employed. The use of telemedicine has become an increasingly popular solution in these situations.

Telemedicine is an electronic communications method used to deliver specialized patient care in geographically hard to reach locations. It "provides healthcare professionals with the ability to remotely interact with patients, monitor physiologic measurements, and receive long-distance mentoring or education from other medical professionals" (Kierkegaard, 2016, p. 1).

2.3.1 Mapping Telemedicine Efforts: Surveying Regional Initiatives in Denmark

The European Union has made it a goal to "achieve widespread deployment of telemedicine services by 2020" (Kierkegaard, 2016, p. 1). In order to create protocols for such deployment, the EU is looking at model countries such as Denmark to highlight the benefits of telemedicine adoption. In order to understand Denmark's success with telemedicine, it is important to understand the deployment of their telemedicine system.

To track “the progress, purpose and current activities of telemedicine in Denmark” (p. 2), a publicly available database, Telemedicine Landskort, has been put in place. The group that is responsible for hosting and coordinating this database, MedCom, is a joint venture by Danish authorities, organizations, and private firms that are part of the Danish healthcare sector. A total of 125 projects were analyzed and any that were missing more than four data fields were excluded, resulting in 118 projects. The database covers the telemedicine efforts within the five regions of Denmark, which vary in size and population, and regional health services accordingly. The study looks at a six categories (the benefits of the system, medical specialization, telemedicine activities, user groups, types of technologies, and method of funding) (Kierkegaard, 2016).

All projects expected financial benefits from the telemedicine system and most expected clinical/professional benefits

- The projects covered 30 different disciplines from cardiology to diagnostic radiology.
- Provider activities included a large amount of conferencing, diagnostics, patient consultation and monitoring, education and mentoring of professionals, and providing remote healthcare services.
- The user groups included 15 different groups of people, the top three being physicians, specialists, and nurses.
- Thirteen different types of technology were supported, with the most common being videoconferencing and home monitoring and patient reporting systems not far behind.
- All projects pointed to a healthcare organization as a primary source of funding, with some also referencing a partner such as the government.

Based on analysis of the results, many clear patterns emerge. First, regions differ in motivation to implement a telemedicine system. This makes sense in Denmark as the regions vary in population and have different strata of citizens (Kierkegaard, 2016). Regions with low populations and low population densities have different health service needs and financial concerns from regions with high densities. An example of this is a region with low population density being affected by geography and thus expecting patients to have difficulty with transportation, while regions with high populations have a large patient intake across the region and so do not have to worry about transportation. In this instance, telemedicine is used to reach patients in remote regions who cannot travel to a central facility. The second pattern was the role of expertise in the telemedicine system. Videoconferencing and other forms of communication allow knowledge sharing between healthcare professionals, which is especially useful in regions with low population density. This is useful because it allows for the centralization of specialists while primary care workers can be dispersed throughout regional facilities. The third pattern was the financial burden an operational telemedicine system has on the overall budget of an organization. Telemedicine is an expensive mode of care for organizations but it has been shown experimentally that organizations that employ roles like clinician drivers (transportation workers responsible for picking up and dropping off patients for clinics) have reduced telemedicine expenses. Lastly, there is a pattern of regions with better technological infrastructure being heavier users of telemedicine. This is important as regions with poorer infrastructure, like internet with bandwidth limitations, tend to have less effective or lower quality telemedicine systems. Ultimately, the implementation of a telemedicine system depends on factors like regional motivation, degree of professional expertise, access to care, funding, and regional technological infrastructure. Organizations considering implementation of a telemedicine system should take all of these factors into consideration when evaluating and designing their system.

2.3.2 The Emergence of Telemedicine and E-Health in Hungary

Before breaking free of its socialist regime in 1989, Hungary's healthcare infrastructure was centralized, managed and financed by the state government (Sass, Feko, 2011). After 1989, Hungary introduced various reform measures and allowed private service providers to operate in the market. Despite this attempt at diversification, assets in the healthcare field such as hospitals, were still owned by the state government. In addition, services were provided to citizens free of charge, with few exceptions, but there were exorbitant copay fees for "extra" services. Because of the disorganization of the country's healthcare system, many hospitals, and even departments within them, had unequal access to funds. These factors, among others, contributed to the present state and future development of telemedicine systems within the Hungarian healthcare system.

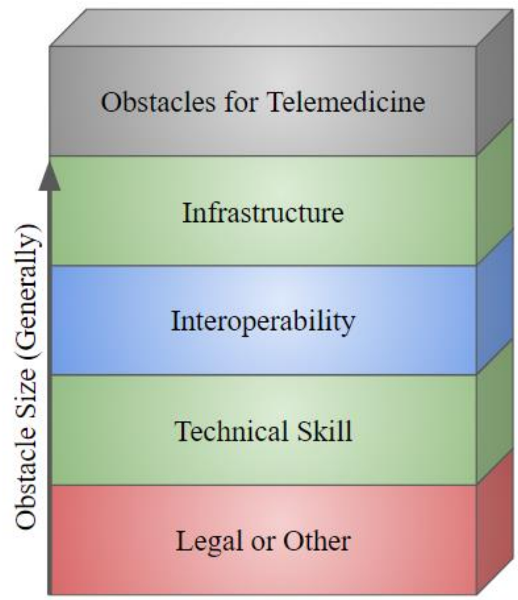


Figure 5: Obstacles to the use of telemedicine

Based on Sass and Feko's extensive interviews of Hungarian nurses, doctors and IT specialists, the four factors that obstruct the use of telemedicine are the level of technological infrastructure, lack of interoperability, lack of technological skill, and unresolved legal, technical, or other problems (Figure 5) (Sass & Feko, 2011).

From statistical data, the use of telemedicine is low in regions with low technological infrastructure (Sass & Feko, 2011). The hospital infrastructure is good but the level of telemedicine infrastructure is very low. For example, many Hungarian hospitals have access to personal computers and printers, but their average age is 4.5 years and they are of low or even dysfunctional quality. Because of this, it is difficult to implement a cohesive, well-functioning, system. Additionally, point-of-care testing and mobile instruments are available in only 28 percent and 18 percent of hospitals, respectively. Lack of internet bandwidth, especially in remote locations, can also be a large hindrance to telemedicine. Lastly, financial inadequacy can hinder the implementation or upgrading of telemedicine equipment, internet bandwidth, and software.

Another factor that obstructs the use of telemedicine is the lack of interoperability, the ability for hardware and software systems to communicate (Sass & Feko, 2011). Interoperability allows a medical facility to share data among internal providers as well as with outside facilities. At the end of 2008, Hungary only had 38 health institutions, or 18% of the total, with electronic interoperability or a database of sharing information, usually pertaining to patients. When 30 hospitals from this group were interviewed, there were 13 different, incompatible database systems in use. Due to the incompatibility and lack of standards for the format of electronic data, there are often problems with the flow of information among providers within a facility as well as among hospital groups. Because of this, information may be duplicated or misinterpreted and can cause further problems for both patients and providers.

Linking the two previous problems, lack of technological skills among providers can directly hinder the use of telemedicine (Sass & Feko, 2011). According to the interview results, medical workers often have “relatively narrow professional IT skills and knowledge.” Fortunately, this is only a secondary problem as proper training and explanation of telemedicine procedures can help to reduce provider error within the system. The real problem comes with lack of access to proper training. While doctors tend to be satisfied with their level of knowledge, nurses admit that they often run into technical difficulties while performing tasks. Unfortunately, they do not often have access to proper training courses or are unaware of services that the hospital provides.

Unresolved problems dealing with legality, technology, or some other aspect can hinder the implementation and use of telemedicine (Sass & Feko, 2011). One important topic that many nurses and doctors brought up was security of access and information. Both of these require additional software on top of basic databases and telecommunication systems. Another general problem is the increased administrative workload that providers must take on to complete database information. Solutions for problems such as these tend to be specific to the organization looking to implement a telemedicine system, but a cohesive plan to implement the system is generally a good way to start addressing these problems.

Based on the variance and extensiveness of these four factors, it was determined that developing a cohesive plan to implement a telemedicine system is an important step for an organization. The plan must address as many issues as possible but must at least aim to achieve a high level of interoperability and address as many technical issues as possible. The plan must also take into account qualitative and quantitative data on staffing and technological infrastructure. By focusing on both of these aspects within the plan, an organization should be able to create a telemedicine system that works cohesively both inside and outside the facility.

2.3.3 Difference Between Telemedicine and Teleconsultation

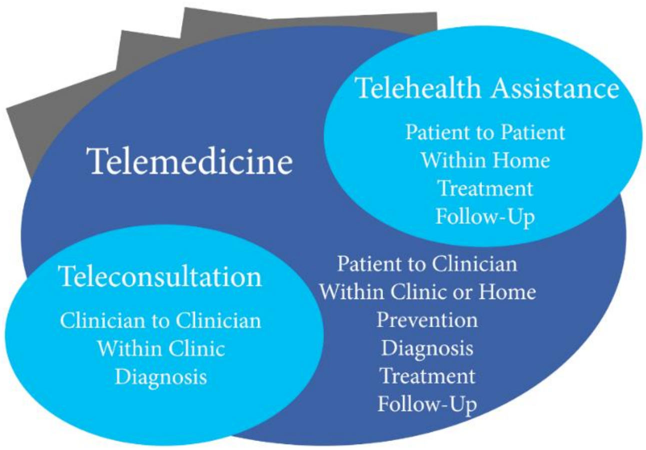


Figure 6: Differences between telemedicine and teleconsultation

As shown in Figure 6, Telemedicine is a broad term that encompasses all medical services provided remotely (Yan, Guo, Vogel, 2016). More formally, "[telemedicine] is 'the use of electronic information and communication technologies to provide and support healthcare when distance separates the participants'," (p. 1) and it can take many different forms. One of these forms, teleconsultation, "is 'a particular type of telemedicine typically involving one healthcare provider – usually a primary care provider seeking advice from another – usually a specialist or sub-specialist – who has specialized expertise regarding the health problem at hand'" (p. 1-2). The providers involved consult on cases, allowing for better diagnoses and treatment plans. In this way, teleconsultation is a tool that can be used for training and education that enables new or inexperienced doctors to learn by observing their peers at work and by asking questions. Therefore, the key differences between telemedicine and teleconsultation are that telemedicine is used for general purposes to deliver medical aid to remote patients, while teleconsultation is used to educate providers by allowing them to collaborate with peers, in order to provide better medical aid.

2.3.4 Establishment and Use of a Teleconsultation Network in Ophthalmology

In late 1997, as part of its 19th International Conference, the Institute of Electrical and Electronics Engineers conducted a study to explore the establishment of a teleconsultation network for ophthalmology in Germany (Zahlmann, Kluthe, Obermaier, Mertz, Mann, 1997). The network would aim to connect "seven private ophthalmologists, one University ophthalmology department, one diabetes department and a research institute" (p. 1). In order to establish a teleconsultation network, the medical issues that teleconsultation aims to address and the modes of teleconsultation use must be defined.

In terms of addressing medical issues, the ophthalmic field unanimously points to communication of pre- and postoperative care between providers as well as cooperation on "special, complex and rare cases" within private and clinical practices (Zahlmann, et al., 1997, p. 2). The operative care cases tend to deal with cataracts, strabism, and lasercoagulation, while the complex cases are more focused on decision timelines for treatments, like laser treatment, for cases like vessel closures and retinal detachments. In order to address these communication needs, synchronous and asynchronous teleconsultation as used. Synchronous teleconsultation refers to consultations that occur in real time, such as phone calls and videoconferencing. Asynchronous teleconsultation refers to communication that is not in real time, like email or web messengers. The more general cases, like normal operations, can be handled via asynchronous teleconsultation, but complex or emergency cases should be handled via synchronous teleconsultation as it allows for immediate provider response.

The experiment itself looked at the number of uses and purposes of use for both modes of teleconsultation within the connected German network (Zahlmann, et al.). Over a period of three months, 10 synchronous and 25 asynchronous teleconsultations took place. Of the 25 asynchronous conversations, 15 were related to glaucoma and 10 dealt with pre- or postoperative care. The 10 synchronous teleconsultations were used to consult for surgery, obtain a second opinion, or enable shared care. These teleconsultations lasted between 10 and 20 minutes and resulted in confirmed need for surgery, hospitalization, confirmed diagnosis, or confirmed therapy. The asynchronous teleconsultations only lasted for about two minutes, assuming necessary images were made available ahead of time.

Based on the results of the experiment, it is shown that synchronous teleconsultation results in longer, more detailed, and more thorough examinations and patient diagnoses (Zahlmann, et al.). Unfortunately, setup of a synchronous teleconsultation system is time consuming and often strenuous on an organization. Additionally, access to the patient database in conjunction with the teleconsultation system is often difficult.

2.3.5 Holistic Approach to Design and Implementation of a Medical Teleconsultation Network

In 2015, the Department of Computer Science at AGH University of Science and Technology in Kraków, Poland decided to revamp their TeleDICOM I system, a teleconsultation system built to handle imaging capabilities for a large number of medical specialties (Czekierda, Malawski, Wyszkowski, 2015). To do so, the department had to conduct an in-depth study of the system's first iteration and combine it with state-of-the-art technology and management practices. Through this study the department was able to identify the system requirements and develop the architecture needed to fulfill each requirement. The result of these efforts was the development of TeleDICOM II, which addressed the problems with the first system and built upon it further to create a highly functioning platform for medical professionals.

The first major requirement the system had to address was the various user requirements (Czekierda et al., 2015):

- Data storage and formatting - medical systems had to be able to store images of various formats (DICOM and JPEG) and quality as well as the general patient information
- Data analysis - tools for data analysis included measurement, transformation, 3D reconstruction, anonymity, annotation
- Consultation processes - established goals and shared data via voice chat, image sharing, screen sharing, or videoconferencing
- Results or Diagnoses - documentation of consultation procedures, diagnosis, and treatment plan, where actions and comments had be noted for educational and legal purposes

The second requirement for the system was to have a set organizational network or a layout of all the involved medical providers (Czekierda et al., 2015). The goal of creating this framework was to establish "formal contacts between medical centers, [by] specifying service operation rules, users and external data repositories which can be accessed" (p. 5). This definition generated what was called a "cooperation workspace" (p. 5). Within the workspace, areas were isolated and users had defined services within the workspace so that there was an operational hierarchy and users were only permitted to access their respective area and service. The point of this was to allow for a higher level of productivity through compartmentalized collaboration of users according to specialty within separate workspace areas, as well as accommodate data access policies. Because security was such a crucial requirement for the medical systems, "authentication, authorization and accounting [components were] provided" (p. 6). In doing so, there was a defined and traceable path for the system user. With regard to the data itself, encryption was used whenever necessary, especially for data storage and data transfer.

The third and final requirement for the teleconsultation system was the actual system infrastructure. The system infrastructure was comprised of three substructures (Czekierda, et al, 2015):

- Data distribution - transferred data between teleconsultation systems, data archive systems, and session participants and excluded participants from data transfer process
- Session organization - created and executed the consultation session, managed the selection of session participants and scheduling of sessions, checked user permissions, and provided event notifications
- Consultation - allowed for synchronous communication and interactive images, viewmodels, etc.

To meet these large requirements, the TeleDICOM team had to start the new system from scratch so as to address the problems from TeleDICOM I and meet all of the requirements explained above. They were able to successfully build a system that did all of this but explained further that the system requirements and challenges are applicable to most, if not all, teleconsultation systems. Additionally, the focus on the communication and cooperation network model has shown to have a higher impact on the quality of medical specialties like teleradiology. Lastly, it is important to note that the teleconsultation system must also consider the medical providers organization itself as tailoring the teleconsultation system to the provider through more flexible system structures allows the system to deal with a larger variety of cases.

2.3.6 Cross-Cultural Telemedicine via Email in Cambodia

Cambodia is a small country in Southeast Asia, with a population of approximately 14 million (Heinzelmann, Chau, Liu, Kvedar, 2009). Approximately 85% of the population lives in remote rural regions, which are served by only 13% of government-employed healthcare providers. These regions have some of the highest rates in the world of child mortality, HIV, tuberculosis, malaria, chronic disease, and trauma from landmines and traffic accidents. The shortage of medical professionals in areas of so much need begs for a solution.

This gap can be sustainably bridged through teleconsultation. Despite the many indicators of poor health, certain areas of Cambodia have adequate internet access, often through a satellite connection (Heinzelmann et al., 2009). A teleconsultation system was implemented to provide local practitioners with access to specialists at the Partners HealthCare network in Boston and the Sihanouk Hospital in Phnom Penh, the capital city of Cambodia.

This system relies heavily on local healthcare professionals, as they must complete a patient history as well as various tests on each patient (Heinzelmann et al., 2009). This information is recorded in English and is then emailed along with any relevant images to the Partners HealthCare and Sihanouk Hospital healthcare networks. Upon arrival, each case file is sent to the specialist who could provide the best consultation on the case. After the consulting doctors view and diagnose the case, they provide a set of recommendations related to the patient's treatment. These recommendations are then sent back to the healthcare providers in the rural areas. This process has occurred approximately 1000 times over the past seven years at two clinics in Cambodia.

This program was launched in the small district of Rovieng, approximately six hours by car from the capital city (Heinzelmann et al., 2009). A single nurse from Phnom Penh typically assesses between 25 and 40 patients during a five-day visit each month, and approximately half of these cases require further consultation, in which case they are sent electronically to either Boston or Phnom Penh for consultation. The nurse also occasionally collects blood and urine samples which are taken to the lab in Phnom Penh. From this case study, we discovered an important use case for telemedicine. The five steps are:

- A doctor and nurse assesses the patient
- Patient records are transcribed in English, and images are taken
- The patient's record and images are emailed to Boston and Phnom Penh hospitals
- Coordinators at these hospitals divert incoming cases to appropriate specialists
- Specialists develop diagnoses and treatment plans, which are then sent back to the original physicians

This service has been utilized extensively by the residents of these rural areas because of the expensive and logistically challenging journey to Sihanouk Hospital.

Because of the success of the Rovieng program, a new program was initiated at the Rattanakiri Referral Hospital (Heinzelmann et al., 2009). This program is similar to the Rovieng program, with the exception that patients are triaged by local physicians instead of by nurses. The rest of the process is similar, with patients' conditions being evaluated by these physicians with outside consultations as needed. Another significant difference is that this site has access to much more advanced technologies such as ECG and X-ray capabilities.

As a result of this program, the proportion of referrals to other clinics decreased 51% (Heinzelmann et al., 2009). This resulted in less money being spent by poorer rural citizens on unnecessary travel to the capital city for treatment. In addition, it increases the efficiency of the country's treatment as a whole; more specialized doctors in Phnom Penh were able to work to the top of their certificate. Several hundred patients were treated through this teleconsultation system, and many were diagnosed with diseases such as hypertension, anemia, diabetes, and thyroid disease. These diagnoses were important, because the conditions require relatively simple treatments but can be extremely detrimental to someone's health without these treatments. This teleconsultation caused a “reduction in the duration of the patients’ chief complaints and fewer offsite referrals” (Wootton, 2008, pg. 2).

From the analysis of these respective systems, several factors were determined to play instrumental roles in the success of such a teleconsultation system. The first, and most important, is the personal aspect: patients must feel satisfied with the care they receive from such a system (Heinzelmann et al., 2009). This can be accomplished by local healthcare workers providing a complete, extensive exam so that referral doctors have as much information as possible in making a diagnosis and treatment plan. These referral doctors should also consider cultural practices when considering treatments, in order to ensure that this modern form of medicine is accepted by the villagers.

It is also important to ensure that economic and technological factors are met to ensure that the teleconsultation structure is sustainable (Heinzelmann et al., 2009). The satellite technology used was donated by a Thai telecommunications company and the rest of the program was funded by a combination of donations, grants, and foundations. Most local practitioners donate their time to triage patients, but while this has been a good solution so far, changes might need to be made if demand increases or funding for the technology runs out. The internet has been reasonably reliable so far, and the infrastructure is powered in large part by solar panels. Email is the primary method of communication and requires low enough bandwidth to allow it to be functional, but expanding the project as a whole would require far more regions to have access to the internet, which was not a feasible solution at the time of publication due to poverty, language barriers, and government regulations.

2.3.7 Perinatal Teleconsultation in Ukraine

Continuing education is vitally important for many different professions (Blunier, Zahorulko, Dobryanskyy, Brauchli, 2006). Medical professions in particular need access to information on a continuous basis in order to be able to treat patients most effectively, especially since “the right knowledge available at the right time in the right place directly influences the right outcomes” (Blunier et al., 2006, p. 2). However, this knowledge can be challenging to obtain from in-person exchanges, paper resources, libraries, and journals due to issues like transportation, finances, scope, and accessibility, respectively. For this reason, medical professionals in several regions in Ukraine including obstetricians, gynecologists, and neonatologists, participate in the Ukraine Swiss Perinatal Health Project (USPHP), which is a teleconsultation program linking Ukrainian perinatal doctors with Swiss medical professionals.

The program began in 2003, when two Ukrainian hospitals each designated a doctor to be in charge of coordinating this teleconsultation network (Blunier et al., 2006). This program takes advantage of Ukraine's available technology, including computers, access to internet, and a server application called iPath. The obstetrics and gynecology department of the University Hospital of Zurich serves as the consulting hospital, and the doctors at both hospitals communicate via the iPath application. A shared database provides medical information, images and a communication platform accessible to both parties.

Typically, a patient needing teleconsultation is examined by a Ukrainian physician who then enters the patient's information into the database (Blunier et al., 2006). The iPath application then converts this information into plain text, and the doctor adds any specific questions he or she may have for the Swiss hospital. Photos and other images can be added as well, and comments are used to annotate any particular items that need further explanation. The file is then sent to doctors at the Zurich hospital through this software or through email for slower connections. A response is typically received within 48 hours, with treatment recommendations for a particular patient.

Some important considerations for such a system include effectiveness, technology, and sustainability. Overall, the Ukrainian physicians expressed "partial or complete satisfaction" with this system (Blunier et al., 2006, p. 6). One concern, however, was the language used--not all doctors were able to use the system as it was, so a group of doctors formed a similar forum for teleconsultation, only this one was in Ukrainian so all the doctors could understand it. The doctors also translated the iPath interface into Ukrainian. The technology used in this system did not present a barrier to implementation as telephone lines were used to provide internet access to the hospitals. Because the iPath software was developed by a Swiss university, there was no resulting cost incurred by the program. The network appears to be sustainable, with interest in expanding teleconsultation access to other specialties. Other aspects of this to expand include standardization of the forms within the application, and implementation of a separate server in Ukraine. An organization is also being established so that telemedicine can continue after the partnership with the Ukraine Swiss Perinatal Health Project is over.

2.3.8 Other Teleconsultation Cases

Other teleconsultation cases provided more pieces of information. More information about escalation protocols was found in an article about rural clinics in Canada utilizing teleconsultation to determine whether or not a patient should be referred to a retina specialist. Another important resource was a book called Telehealth in the Developing World, which contained a lot of case studies related to global telemedicine and teleconsultation (Wootton, 2008).

2.4 The Armenian EyeCare Project and Our Project Scope

The Armenian EyeCare Project (AECP) is an organization founded by Dr. Roger Ohanesian in 1992 to combat and eventually eliminate preventable blindness in Armenia and make modern eye care services available to the public (AECP, 2017). In doing so, the AECP has raised millions of dollars to develop an eye care model that will address all levels of preventable blindness. Within this model is the Mobile Eye Hospital (MEH), a converted tractor-trailer outfitted with a medical examination room and a surgical suite. This mobile unit circles Armenia in a two year period, visiting the more rural regions to ensure people in those areas also receive eye care. In addition, there are many subspecialty clinics in the capital city of Yerevan, such as the Center of Excellence (COE), a clinic established in 2012, designed to treat Retinopathy of Prematurity (ROP), a condition that causes blindness in premature infants. While the MEH and COE have been effective at reducing preventable blindness, a barrier remains in terms of rural citizens' geographic accessibility to these centers. To provide ophthalmological care to people in all parts of the country, the AECP is also creating fixed Regional Eye Centers (RECs), with two already in place. These centers can conduct examinations and provide treatment and surgery when necessary. The AECP's goal is to have five regional centers by the end of this transition period so that they can create an eye care network and eventually retire the MEH to a permanent location. There are several facets of operation within each REC to integrate it into the overall multi-tiered model.

Figure 7: Map of Armenia showing regional clinics (AECP, 2017)

The AECP's structure for eye care has become a multi-tier system with the addition of the five RECs (AECP 2017). The current operating model includes the RECs and the MEH. The Malayan Ophthalmological Center provides tertiary level care, and because of its centralized location, has more specialized ophthalmologists as well as the capacity to house a majority of the specialized equipment. Outside of the Malayan Ophthalmological Center is the MEH, which takes two years to complete its circuit around the country. The MEH has been operating as a primary eye care facility, offering screenings and vision assessments, while also providing surgical procedures. Recently, two RECs in Spitak and Ijevan (Figure 7) have begun operations, with the third center in Kapan on schedule to open in mid-July 2017, and the AECP plans to establish their fourth and fifth centers by the year 2020. These centers provide services similar to those of the MEH, offering eye assessments and early eye disease detection services, as well as periodic surgical services. The RECs are capable of intercommunication and will contact doctors outside of the AECP, such as those at the Malayan Ophthalmological Center in Yerevan and providers abroad, when the case is too complex to be handled by the REC staff. This configuration is shown in Figure 8.

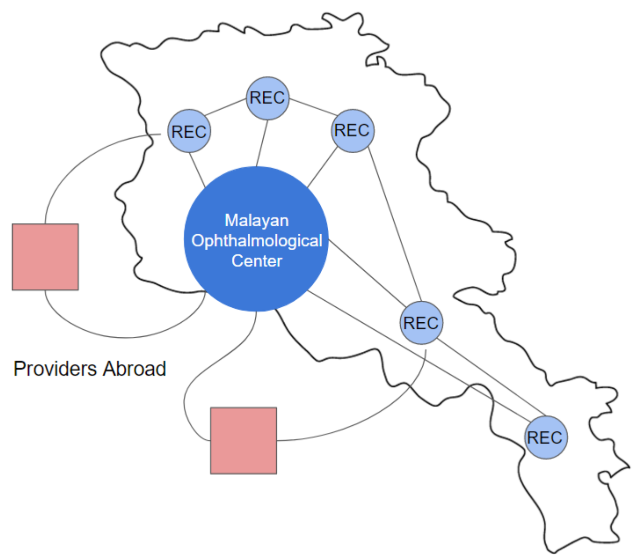


Figure 8: Multi-tier healthcare model map for the AECP

This project addressed the data sharing, communication and interoperability required to run such an operating model. The goal of the project was to develop recommendations for the integration and implementation of an EMR and a teleconsultation system to be used throughout all of the AECP's facilities. To develop these recommendations we have investigated best practices and experimental procedures.

Chapter 3: Methods

The goal of this project was to develop recommendations for the selection and implementation of an Electronic Medical Record (EMR) and a teleconsultation system to be used throughout all of the AECP's facilities. To accomplish this goal we completed the following objectives:

- Identified the required features of an EMR systems and structure of a teleconsultation system specific to the AECP's needs.
- Identified optimal EMR systems and teleconsultation structures given the required features.
- Developed a cohesive set of recommendations of the optimal systems.
- Developed a plan for implementation of these systems within AECP facilities.
- Implemented teleconsultation technology as a model in an AECP clinic

The methods detailed in this section enabled us to collect pertinent data to achieve each of these five objectives. Figure 9 below depicts a logical sequence of the tasks that were completed over the course of the project in order to accomplish each objective.

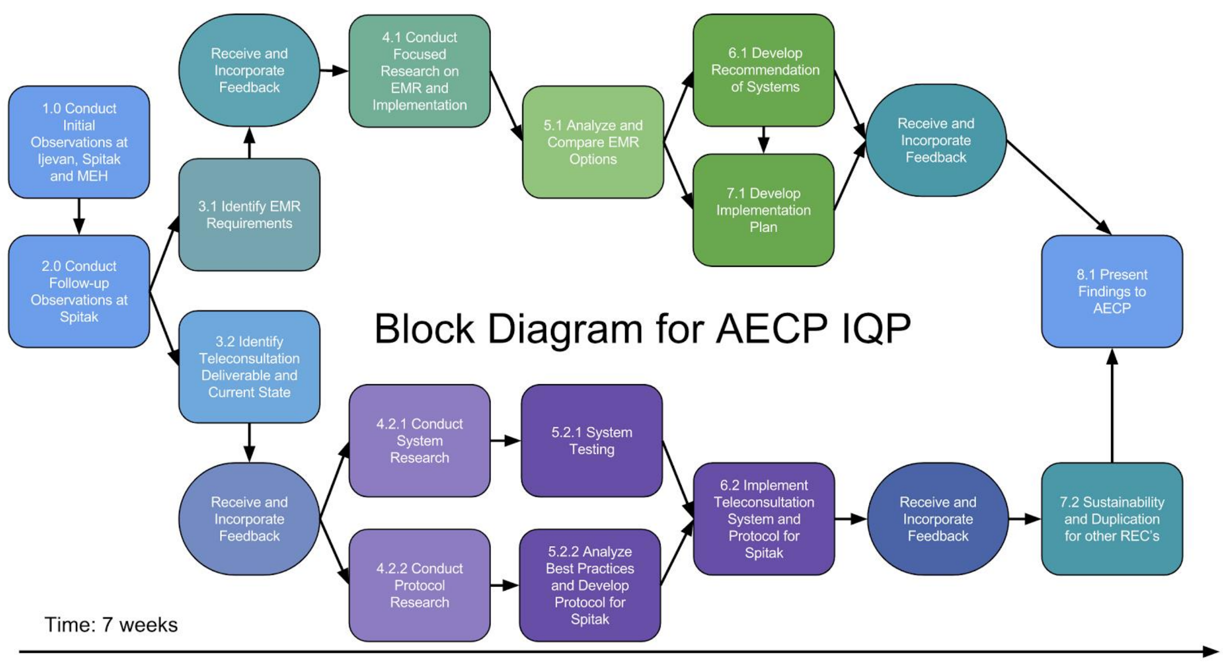


Figure 9: Project process for recommending an EMR system and a teleconsultation system for the AECP

3.1 Conduct Initial Observations

To establish a baseline for the needs of the organization, and the feasibility of potential solutions, we began our project by visiting the regional centers in person. There is a lot of information that cannot be transmitted by photos and phone calls, so we decided to visit the two existing regional clinics which are located in the towns of Ijevan and Spitak. Prior to our visits, we prepared lists of questions to ask staff in order to determine the current state of the AECP's operations. In each clinic, we asked English-speaking doctors brief, preliminary interview questions related to the current record-keeping system. We also inquired about communication protocols among doctors both within the clinic and across the AECP network, and the technological resources they have at their disposal such as Wi-Fi or computers (Appendix D). We made sure to bring bilingual printouts of our questions that were translated from English into Armenian by the AECP office staff in Yerevan to ensure that the meaning behind our questions was conveyed properly. We also observed various features of the clinic and made notes on what to follow up on.

We recorded general observations about basic infrastructure and technology at the clinics such as the presence of devices compatible with a wireless network. We also observed the storage location of paper records to approximate the volume of records that would need to be transferred into an EMR. This observation also helped us to evaluate part of the impact of our project; digitizing records will free up a lot of space for the AECP clinics that they can use in other ways.

These original observations at the clinics were completed by the middle of our first week in Armenia. The information we collected helped us refine the interview protocol we had developed during our preparation term, and provided guidelines on what questions would be best to ask during our follow-up observations.

3.2 Conduct Follow-Up Observations

Following the initial observations, the information collected was used to refine the interview protocol for a second visit. We returned to the clinic at Spitak, which was the only one with an English-speaking doctor, to conduct a more in-depth interview about teleconsultation and EMR systems. Notes from this interview can be found in Appendix E. As with the preliminary observations, we asked a member of the AECP staff to translate the interview questions beforehand, and we brought a printed copy of both the English and Armenian versions. This translation helped prevent misunderstanding and helped us obtain more thoughtful and thorough responses. We also conducted more detailed observations of the clinic's resources such as the equipment present as well as Internet and teleconsultation infrastructure, and examined the hospital's current teleconferencing system to establish whether or not it could be used as part of our network recommendation. We took photos of all of the equipment and recorded the make and model of each system to determine what capabilities were present at the center. All of the information from the observations and interview was recorded and organized for later analysis. This initial data collection was completed by the second week of the project.

3.3 Identify EMR and Teleconsultation Requirements

In order to determine the best EMR system and teleconsultation structure to implement, we developed a set of requirements for appropriate technical infrastructure and teleconsultation operations. These requirements were used to evaluate potential options to ensure they met the needs of the AECP.

3.3.1 Identify EMR Requirements

To recommend the most effective system, we began by researching the different categories of EMRs, the goals that healthcare organizations hoped to achieve by implementing an EMR, and common features of these systems. By the end of the second week we were working with AECP staff to understand their reasons for implementing an EMR and setting goals accordingly. Each of these goals was broken down into the functional features which helped achieve it as well as the critical features necessary for any system the AECP would adopt. From here we developed a prioritized list of goals, functional features, and critical features which guided our research of EMR systems.

3.3.2 Identify Teleconsultation Deliverables and Current State

To determine the requirements for a teleconsultation system, we relied mostly on conversations with Dr. Nune Yeghiazaryan, Dr. Varvara Kalashyan, and Dr. Nairuhi Jrbashyan. Based on these conversations, we identified two specific areas of focus for our teleconsultation recommendations and developed a list of deliverables that could help accomplish these goals.

3.4 Conduct Focused Research on Systems and Implementation

Using the lists of features for the EMR system, we began investigating potential systems options and their capabilities. With the information provided by the AECP staff, we were able to conduct focused research on implementation and operational best practices for teleconsultation systems. Research on potential systems was completed by the middle of the fourth week. EMR and teleconsultation case studies were mostly studied separately, but we also devoted some time to researching the applicability of best-practices to AECP operations.

3.4.1 Focused Research on EMR Systems and Implementation

We used Gartner and Forrester database systems and clinical associations to conduct initial research on EMR systems and their capabilities. From these sources, we developed a list of possible systems for the AECP to use. As we identified potential systems, we recorded pertinent information such as the name, price, license information, and other attributes identified during the process in Section 3.3.1.

We also spoke with ophthalmologist Dr. John Hovanesian, the founder of health portal MDbackline and an AECP visiting doctor (Appendix F), as well as Sean West, the current CEO of MDbackline (Appendix G). Our conversations with these experts not only confirmed our research findings, but also provided new ideas and considerations for the systems we would eventually recommend to the AECP. Additionally, we spoke with Dr. Dwayne Baharozian, an ophthalmologist of Armenian descent with a particular interest in EMR systems, to gain his insights into the direction of our research (Appendix I). During our preliminary observations we also learned about an EMR system the AECP is using in a subsection of their operations, so we also interviewed the web developer responsible for this system (Appendix H).

3.4.2 Focused Research on Teleconsultation Structure and Implementation

To determine what type of teleconsultation structure would be best for the AECP to use, we decided to break it into two categories: the feasibility of a structured network of teleconsultation between the clinics, and the incorporation of the system and an associated decision tree into the doctors' practices. We first looked at the technical requirements of successful teleconsultation, obtaining information from the vendor websites to determine how the existing technologies of the AECP's system could interface with each other, and what they require to function. This was done by obtaining information about the hardware and software specifications as well as how the system interfaces with other devices. Besides researching the technical infrastructure of the system itself, we also analyzed the way doctors communicate with one another during inter-clinic consultations.

To research teleconsultation infrastructure and operations, we used WPI library databases to find case studies depicting successful uses of teleconsultation, particularly in developing countries. We also spoke with Dr. Benjamin Suratt, who works in the Pulmonary Disease and Critical Care division of the University Of Vermont Medical Center. He is consulted often by doctors based at smaller hospitals, so he provided valuable insight into the teleconsultation network he is a part of (Appendix J).

3.5 Analyze System Options

To ensure that our recommendations were aligned with the AECP's needs, we held meetings with Drs. Yeghiazaryan, Kalashyan, and Jrbashyan, our contacts at the AECP, to assess the identified EMR systems and teleconsultation systems. Based on the results of our analysis, we gave each EMR system a weighted score to refine the list of possible options, and designed a teleconsultation network and technology system by the end of the fourth week.

3.5.1 Analyze EMR Options

To analyze the potential EMR options, we created an Evaluation Criteria Matrix (ECM) as a tool to quantitatively compare the functional features of the previously identified EMR programs. In a spreadsheet the goals were ordered left to right in increasing order of importance, with all features listed in column form under each respective goal. Features with multiple instances were highlighted and moved to the top of the column to which they belonged. To avoid over-weighting a single feature, all instances of repetition were deleted after the first instance. Next, each column was inspected in order to rank the impact of each feature on the goal. The goals were then weighted based on their importance, with the least important goal given a weight of 1. There was also an extra column with features that were given no weight because they were deemed unnecessary or bonus. Because each goal had a different number of features associated with it, the weight of the goal was multiplied by the number of associated features, and then again by 10. This number is the weighted total number of points allotted to the goal. From here, the weighted total number of points was distributed to the associated ranked features, where the top feature received the largest percentage of points, and the lowest listed feature received the smallest percentage of points. Once this had been completed for all goals we totaled the number of points in the matrix. An example calculation is shown below in Figure 10.

Improved Clinical Operations (1st Goal)	X	Improved Patient Care (2nd Goal)	X	Reduction in Medical Errors (3rd Goal)	X	Improve Info Access (4th Goal)	X	Increased Revenue/Reduce Cost (5th Goal)	X
Online, direct access to web-based reference data	1	← Function with More Than 1 Instance							
Efficient on-line charting features and tools	2								
Strong integration with practice management data and processes	3								
Flexible electronic interfacing for outside entities	4								
Organized clinician "inboxes" with priorities and reminders/Intra-office messaging	5								
Direct integration with diagnostic & the clinical equipment	6								

Weight of Goal: Improved Clinical Operations =	5
Number of Associated Functions =	6
Multiply by a Factor =	10
Total Weight of the Goal	5 X 6 X 10 = **300**

Figure 10: Example calculation for weighting goals in ECM

Using the list of weighted features, we calculated a weighted decimal score for each EMR system according to the system's attributes and the importance of each attribute using the ECM model. This number was then divided by the total EMR weighted score to obtain a percentage score. From each score, we were able to see which system had the most functional features that would meet the AECP's goals, with a higher EMR score corresponding with a better fit. We then compared the EMR weighted scores to determine the best fit system for the AECP.

3.5.2 Analyze Teleconsultation Options

Our team traveled to two of the AECP's centers to determine the feasibility of using the current technological infrastructure. We set up some of the systems and tested them, using this as a proof of concept to make our recommendation in terms of teleconsultation technology. In order to provide the best possible recommendations for the AECP, we also analyzed the best practices from our research, as well as our interviews with experts and conversations with the AECP. The synthesis of this research with the proof of concept setup helped us to develop a preliminary recommendation for teleconsultation technology and structure based on the AECP's existing resources and system.

3.6 Develop EMR Recommendation and Teleconsultation Implementation Plan

We chose an EMR system based on the ECM, then we developed a plan to implement our teleconsultation recommendation.

3.6.1 Develop EMR Recommendation

Although the ECM provided a quantitative, data-driven recommendation of the EMR with the highest score, it didn't take nonfunctional features into account. These features were analyzed by examining studies and reports related to EMRs' features. Nonfunctional features were quantified, and a separate ranking of systems was developed based on these features. To develop a final recommendation, the AECP was presented with the results of the ECM and the nonfunctional feature analysis. We provided explanations for both ranking systems, and asked the AECP for their decision on a system. In this way, the AECP was able to select a system which had the proper balance of appropriate functional and nonfunctional features, as well as all of the critical features necessary.

3.6.2 Develop Teleconsultation System Implementation and Escalation Protocol Implementation

After developing a preliminary recommendation, we created deliverables that will allow the AECP to implement teleconsultation technology into all existing clinics. To ensure the sustainability of the system, we created an installation guide, user manual, and recommendation of future systems to purchase. In order to standardize interactions and make each teleconsultation as efficient as possible we created a contact list of doctors, including names, specialties within ophthalmology, and contact information. Because this list was incomplete, we also drafted a letter for AECP physicians to send to other physicians in their personal networks worldwide to request permission for their inclusion in the list. Finally, we developed an escalation protocol decision tree to provide a framework for physicians on how to use the system.

3.7 Develop EMR Implementation Plan and Teleconsultation Sustainability and Duplication Plan

We developed a plan by the end of week six to guide the implementation of the recommended EMR system, as well as a protocol for teleconsultation implementation in future REC's. We considered facets such as the AECP's current resources and budget, degree of implementation difficulty, as well as the urgency of the implementation. Those factors were all important, but emphasizing one resulted in a trade-off as the others were downsized. We conducted more research and interviewed more AECP staff members as necessary to develop this plan.

3.7.1 Develop Implementation Plan for EMR

To enhance the ease of implementation of this EMR system, we researched and developed a complete implementation plan after confirming several aspects of implementation with Dr. Yeghiazaryan. To streamline the technological side of implementation, we offered a recommendation on how to effectively use technical support and provided a list of technology that would be necessary for full implementation of the recommended system in all of the current clinics. To combat the issues related to change management, we also developed recommendations related to training staff on how to use the system. In addition, a cost breakdown and implementation timeline were included in this recommendation.

3.7.2 Develop Sustainability and Duplication Plan for Telemedicine System

We developed a sustainability plan for our teleconsultation system recommendation, in order to ensure similar systems could be implemented in future RECs. This plan included a teleconsultation guide that would not only help doctors to use the recommended system effectively but also aid the AECP in setting up new systems in clinics that would open in the future. This guide consisted of several of our implementation documents created in Section 3.6.2 as well as some additional information about how the teleconsultation technology could interact with other devices.

3.8 Present Findings to AECP

To ensure that our recommendations and implementation plans were helpful and useful to the AECP, we presented them to the staff throughout the development process during weekly sponsor meetings as a form of continuous feedback. This was done particularly extensively after requirements were identified, and after implementation plans were developed. Based on the AECP's feedback, we returned to the recommendation and implementation plans as necessary, to ensure our recommendations were sound. We formally presented our finalized sets of recommendations and corresponding implementation plans to the AECP by the middle of week seven.

Chapter 4: Findings and Analysis

Upon arriving in Armenia, we conducted research and analyses of the AECP's existing procedures, examined equipment, and determined the precise need of the organization. Conversations and interviews were conducted with AECP administrative staff to learn more about specific operations and to ensure that our project goals aligned with those of the organization. We also consulted with doctors at various medical centers who would ultimately be tasked with implementing the end result of our work. We continued research into industry best practices and available EMR and teleconsultation systems, and developed analysis methods to identify those best for the AECP.

4.1 Observations of Current State

To begin our research, we arranged brief visits to the two existing RECs in Spitak and Ijevan. These initial visits lasted about an hour each, and were intended as preliminary research to inform more in-depth visits in the future. Following these visits we used our observations to identify what specific gaps would be filled by EMR and teleconsultation systems and how these systems might integrate with existing procedures.

4.1.1 Spitak and Ijevan Medical Records Observations

Figure 121: Patient walking into the Spitak regional

The AECP wing of the Spitak Medical Center (Figure 11) includes two exam rooms and two offices for the doctor and nurses. Staff have access to the hospital's surgical suite, which is in another part of the building. The AECP's Spitak clinic receives about ten patients on a typical day, some of whom travel long distances to receive care. Upon arrival, the patient's information is recorded by one of the nurses who also performs preliminary measurements and tests. Patient records are kept in a 25-page booklet that contains everything from identifying data to specific measurements and notes taken by the doctor. A new booklet is used for every case and accompanies the patient for the duration of his or her visit. While the patient is being

Figure 112: Imaging equipment located in the second exam room

examined by the doctor, the accompanying nurse sits at a nearby desk and transcribes data that the doctor reads off. After the patient's visit is complete, the records are kept on a shelf, with closed cases organized in binders that correspond with specific years, while open cases are placed in a pile next to them until they are resolved.

The medical equipment present at the site was sourced from the United States and Japan, and seems able to output digitally, which could allow them to communicate directly with an EMR system or teleconsultation technology (Figure 12). The center is well-equipped with slow but relatively reliable internet and stable electricity, as well as computers, printers, and access to fax machines elsewhere in the hospital. Prior to our arrival, a Polycom system had been set up but had not been used.

Figure 13: Storage of paper records and medical supplies

Our subsequent visit to the Ijevan Medical Center not only confirmed many of our observations from Spitak, but also provided a chance to see the AECP's operating model at work in a different environment. The AECP's allocated space at Ijevan is comprised of only one dedicated room that functions as both an exam room and office, and a single surgery suite in a different wing of the hospital with similar equipment to the one at Spitak. Patient processing is handled identically to Spitak, and supplies are kept directly in the exam room in a set of cabinets alongside the stacks of record booklets as shown in Figure 13.

Some of the equipment in the surgery suite is equipped with cameras which are connected to a network relay that can forward the feed to the Malayan Eye Hospital in Yerevan. This feature is not currently in use, especially since the travelling surgeon, Dr. Asatur Hovsepyan, is the resident expert and is unlikely to require outside aid. Despite this, AECP staff have expressed interest in using this capability to allow less experienced doctors to observe surgeries from afar. The facility also features WiFi and a backup generator to ensure an uninterrupted supply of electricity.

While the patient record booklets are stored in cabinets, as in Spitak, Dr. Hovsepyan maintains his own personal record system in Microsoft Excel for surgeries he performs. This allows him a greater level of flexibility, particularly since the AECP does not have a comprehensive system for tracking bulk appointment data (each REC has a paper logbook with this information), and highlights the organization's desire for a computer-based system.

By generalizing our observations from both clinics, the process by which a patient's paper medical booklet is created, filled out, and stored can be summarized in Figure 14. More detail for this specific use case is given in Appendix L.

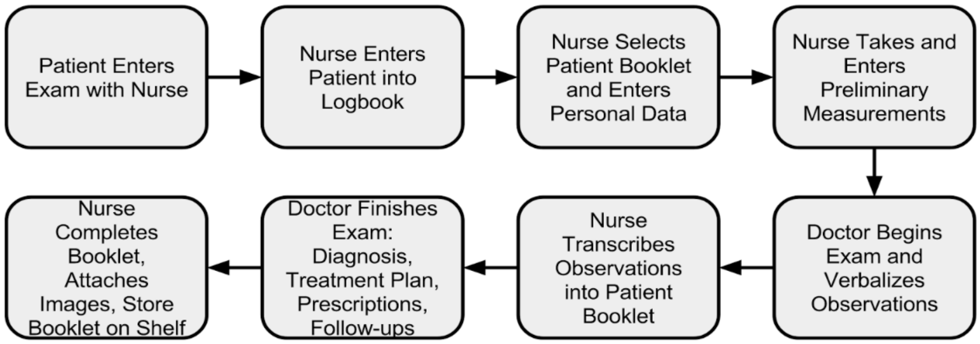


Figure 14: Use case of exam using current paper records booklet

4.1.2 Spitak Teleconsultation Observations

After our initial observational visit to Spitak, we conducted a follow-up interview there with the English-speaking doctor, Dr. Haira Sardaryan, on teleconsultation and EMR use (Appendix E). We decided to consider the results of the interview as representative of the opinions of the entire AECP medical staff, in part because of the language barrier that exists between us and many of the other doctors, and also due to the similarities between the operations at Spitak and those at Ijevan.

Doctors in the AECP's regional clinics utilize teleconsultation on a regular basis to provide the best possible treatment for their patients. We discovered that Dr. Sardaryan consults other ophthalmologists about one or more of her patients nearly every day. These consultations usually occur with doctors in Yerevan, but three or four times per month she is unable to reach a diagnosis with the doctors in the capital city, in which case she consults other doctors abroad. She provided the names of three AECP doctors as well as one non-AECP doctor that are able to help her with the majority of the complex cases. When asked how she decided which doctor to contact in a given case, she said that all the doctors she talked to were friends from her professional network. There did not appear to be a formalized procedure for which ophthalmologist she contacted for a specific case.

Our interview questions also covered the technology behind the teleconsultation. We asked Dr. Sardaryan how she contacted other doctors when she needed a second opinion or advice on a diagnosis or treatment. She said that if it was an Armenian doctor she would call them on the phone, while she would typically contact a doctor outside Armenia through email. We also asked if any documents such as a copy of the patient's card or ocular images were sent during each instance of teleconsultation and she responded that each teleconsultation encounter usually only consisted of a conversation and did not include any images.

By generalizing the observations and findings regarding current teleconsultation practices, the current informal consultation process can be summarized in Figure 15. The fully detailed use case can be found in Appendix M.

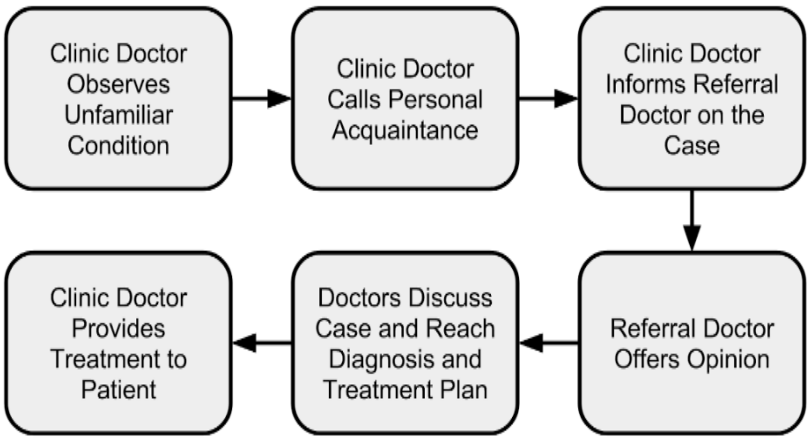


Figure 15: Current teleconsultation process

4.1.3 Center of Excellence (COE) Medical Records and Teleconsultation Observations

The AECP currently employs a patient database for its work on Retinopathy of Prematurity (ROP), which was developed in 2016. Within the ROP project, the AECP has been conducting screenings, referrals, and population health analysis across the entire country with thousands of patients. The browser-based database allows them to track all screenings conducted on patients, track their progress and outcomes of treatments, and conduct more in-depth population health analysis. The ROP database was developed by a contracted software developer with input from the AECP

Figure 16: Entrance to the Center of Excellence

staff as well as the COE (Figure 16) doctors to ensure that the features it possessed were the ones required and desired by the professionals using it. We were able to speak with the primary developer of the system, Arpy Vanyan, and she informed us that the initial construction of the database took about three months to complete, and that the ROP database is updated as new needs arise, which encourages medical professionals to continue using it (Appendix H). Nurses are the primary scribes on the ROP database during exams and procedures. The AECP staff informed us that medical staff training on the system consisted of one day-long primary training session, with brief check-ins during the following week. We also discovered that nurses and doctors use laptops to access the ROP database during the screenings.

During our site visit at the COE, we were informed by IT personnel that the COE had access to two Polycom systems and was using one of them in the surgical suite to share video from the surgical microscope with providers around the world. The two Polycom systems they have are RealPresence 700 (Figure 17) and RealPresence 500, with the 500 being connected to the surgical microscope. Currently, the 700 model is not in use, but the AECP plans to move the 500 to the Malayan Ophthalmological Center, and begin using the 700 at the COE. The RealPresence systems conduct synchronous videoconferencing that interfaces with medical equipment, like the surgical microscope, to allow providers to interact, consult, and educate in real time. Each system is composed of a system box, remote, camera, and microphone, with the appropriate cables connected to a screen. Due to the decreased rate of ROP and the lack of complex cases, the videoconferencing capabilities of the system have only been used three or four times since the system's installation in June 2015, with the last clinical use having been in April 2017. The Polycom System has been used for both complex case consultation and educational observation.

Figure 17: Polycom RealPresence Group 700 system box and camera

4.1.4 Patient Privacy Observations

Patient privacy appears to be far less of an active consideration than we had expected, with multiple patients and accompanying persons allowed in the exam room in order to reduce the processing time for each patient. The nurse's room has bookshelves as storage space for paper records but not all records are securely stored in this archive. We did not observe patients signing any sort of consent form before they began their exam, whereas our assumption had been that most doctors would typically require patients to sign a form consenting that their exam information and data could be recorded, stored, or shared with other providers.

In addition to this, we learned that patients are responsible for their booklet in the case of referral to an outside clinic. The release of the booklet from the regional clinic has two repercussions. With the booklet leaving the clinic, the AECP no longer has these records to use in their operations and clinical analyses. More significant, however, is the risk of the patient's information being compromised. The booklets include a patient's name, passport number, personal demographics, and medical information, all of which could be wrongfully used if the patient booklet was lost or stolen.

4.2 AECP Gap Analysis of the Current State

To make meaningful recommendations, the gaps in the AECP's current medical record system and teleconsultation system needed to be analyzed. Doing so allowed us to build upon aspects of the systems that function well and improve the aspects that could function better.

While the AECP's paper medical record is practical at present, much time is wasted re-entering basic patient information and history from previous visits because previous records are difficult to reference. The existing system does not include a method of cataloguing these records, and the staff must sift through a small pile of completed booklets to retrieve specific ones. This situation will grow from a mere inconvenience to a significant logistical challenge as time progresses and records pile up, particularly as records are currently intended to be stored indefinitely. We consider an EMR to be an effective way to address these gaps in paper data storage, while associating data with patients instead of with cases. The advantage of this approach is that full medical history is always accessible at any AECP location. Fortunately, the patient record booklets were designed by the AECP and therefore include all the information needed for diagnosis and treatment plans, providing a convenient checklist for EMR system research. Both RECs also appear to have the necessary infrastructure needed for the implementation of an EMR, though equipment integration may still prove difficult. This is because not all diagnostic imaging devices are designed to output the data they collect digitally, much less in a format that is readable by every system. As a result, we took the time to inspect and document the various pieces of diagnostic equipment to determine what data could be output to a computer. In some cases, the only data that is output is numerical, and can be easily copied manually instead of linking the machine with the EMR, but this ought to be avoided whenever possible in an attempt to reduce the number of manual tasks necessary, thus reducing the burden on staff and avoiding potential transcription errors. Finally, the selected EMR needs to be capable of importing images captured by the equipment, as well as supporting hand-drawn annotations or a digital equivalent. This is because it is common practice for ophthalmologists to incorporate pictures, drawn or generated, into patient notes, and this flexibility is seen as a requirement by most providers. A unified system would also present the opportunity to combine scheduling with patient records and demographic data, which is particularly valuable to the AECP as it assesses the impact of its work.

Based on the teleconsultation observations, we identified two areas to focus on to produce the most effective and efficient teleconsultation recommendations. The first aspect of teleconsultation that we examined was the decision protocol that determines which doctor is contacted for consultation in a given case. Although Dr. Sardaryan appeared to have a well-developed network of colleagues to consult, we realized that not all clinic doctors would necessarily have that same network. We also wanted to ensure that doctors' time was not wasted with fruitless phone calls, so we decided to create an escalation protocol formatted like a decision tree, which could be used to determine which doctor to contact in a particular situation. The second point of analysis was the technology that was used for these teleconsultations. While a phone call or email is acceptable, the AECP would like to use a network of Polycom systems, of which they have three at their disposal. This would allow for doctors to communicate more effectively, and assist with the sharing of images and other data that would make reaching an accurate diagnosis much easier on all parties involved.

4.3 EMR Findings and Analysis

By working with the AECP we were able to identify the system requirements and associated importance for the EMR we would recommend. From this we conducted research to identify potential systems to recommend to the AECP. We then analyzed these potential systems using an Evaluation Criteria Matrix (ECM) and an investigation of non-functional features.

4.3.1 Transition to EMR

To build on the current method of tracking medical records and the success of the ROP database, the AECP is looking to move to a comprehensive EMR system in all of their facilities to improve clinical operations and patient care. Based on our observations we agree with the AECP's initiative to transition to an EMR. As the final RECs are opened, patient numbers will increase and become more dispersed, making it imperative to have information accessible to doctors across the organization. The AECP's current record-keeping system is entirely paper-based, which will not be practical as patient volume increases. Implementation of an EMR will allow providers to look at patient history holistically as opposed to on a case-by-case basis. Through this, diagnosis and treatment plans can be made to best fit the patient. Additionally, the use of an EMR for entering patient and exam information reduces medical mistakes, encourages more comprehensive data collection, and makes interpretation of other doctors' notes easier. An EMR will also increase security and patient privacy, while decreasing the potential to lose patient information, especially in the case of referrals where data can be transferred automatically and securely instead of by the patient bringing his or her booklet. Finally we see the EMR as an investment which will economically benefit the AECP. EMR systems improve and increase ease of population health analysis and clinical performance analysis, both of which are very important for the AECP to receive donations, funding and research grants.

To ensure that our vision of how the EMR would impact the operations of the RECs is in line with what the AECP wants, we developed a preliminary use case to show how the implementation of the EMR would alter the operations of the clinic (Figure 18). The orange boxes represent changes to the procedural flow that differ from the paper-record use case above. The detailed use case can be found in Appendix N.

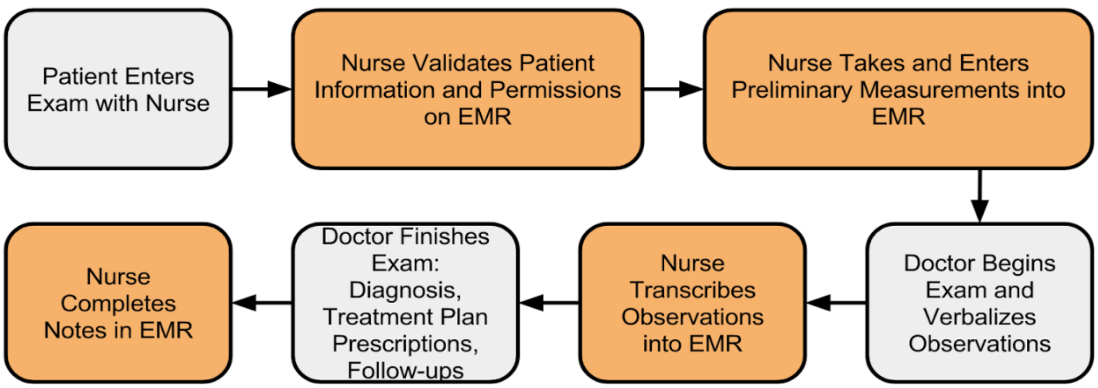


Figure 18: Use case of exam using EMR

4.3.2 Identification and Preliminary Research of EMR Systems

We began our research of EMR systems by understanding commonly used features of leading systems used in developed countries such as eClincialWorks and EPIC. EMR systems from major vendors proved to be far beyond the price range of the AECP. No budget was specified by the organization, but senior staff immediately rejected the proposed commercial systems when we presented the estimated costs, which prompted us to turn to free and open source options. We continued our initial investigations and research of available systems for the first week of this project to fully understand potential options. From our research we concluded that an open source EMR system would be the best course of action for the AECP. Three factors lead to this decision:

- The AECP is funded by grants and donations, so a low cost option is best
- The AECP is a very unique international medical organization and will require a similarly unique EMR solution
- The AECP continues to have a good relationship with the developer of the ROP database, and could continue to work with her during the implementation and customization of a new system

As we focused on open source systems, when an EMR was found to have a tool or feature that was nonstandard and of possible benefit to the AECP, we made a note of the feature, and how it might be useful to the AECP. In this way we were able to assemble a list of EMR features the AECP may want to consider including patient portals, flexible charting, and clinical equipment integration.

4.3.3 Definition of Evaluation Criteria

After we created a solid foundation of understanding regarding possible options for the AECP, we worked with the administrative staff to develop selection criteria. We categorized this criteria in three feature groups:

- Critical Features - features without which the EMR cannot be considered a potential option
- Functional System Features - features within the software which allow the EMR to meet the needs of the organization
- Non-Functional Features - features which relate to hardware and user interaction

The critical features of the EMR system are security and language. For legal and ethical reasons, the AECP must ensure the safety and security of their EMR system. While these two terms appear interchangeable at first glance, they refer to very different issues. System safety refers to the protection against the loss or corruption of data, and is typically addressed by regularly backing up data and ensuring that the hosting server has safety features that prevent the sudden loss of power, such as a battery. System security refers to the protection against improper access to or theft of the data, and this is addressed through password protection, data encryption, and restricting physical access to the server. To this end, the system we recommend must meet the Armenian Ministry of Justice regulatory standards in both regards. The second critical feature of the system is language. The AECP is based in the United States, with all clinics in Armenia and a network of specialists around the world. The system must be able to function in Armenian as well as English, at a minimum. Currently the AECP operates in Armenian, Russian, and English, so a trilingual system is ideal.

The next step was the identification of the functional features. These features populated the ECM and allowed us to perform an objective assessment of the EMR options. To define the evaluation criteria, we first needed to set and prioritize the goals of the AECP regarding the integration of an EMR into their practice (Outlook Associates 2011). Seven primary goals were identified and presented to the staff of the AECP, who then ranked their top five goals as follows:

- Improved Clinical Operations and Efficiency
- Improved Patient Care
- Reduction in Medical Errors
- Improved Access to Information
- Increased Revenue/Reduced Cost

Each of these goals has between three and six associated EMR features, which impact how the EMR meets this goal. To define these features we break the discussion down by goal.

The first goal is to **improve the clinical operations and efficiency** of the RECs. To do this we have identified six key features of the EMR, keeping in mind that there is some overlap in the features under each goal (Outlook Associates 2011).

- Online or direct access to web-based reference data - the EMR is able to link to outside reference databases to inform rules or outcomes of treatments, and is meant to help doctors, as well as provide extra information to patients
- Efficient online charting features and tools - custom templates or flows, clinician preference lists that evolve with system use, and flexible input methods such as charts and drawing to make charting easier for clinicians
- Integration with practice management data and processes - to facilitate the administrative aspects of the clinic such as scheduling, which helps consolidate processes
- Flexible electronic interfacing for outside entities - to improve workflow and communication within the clinic
- Direct integration with diagnostic/clinical equipment - to simplify workflow and reduce intermediate steps
- Organized clinician inboxes with priorities and reminders - to increase communication within the office and keep the information all in one place

The second goal, to **improve patient care**, also has six associated features, which focus primarily on how the EMR system works with clinical and patient interaction (Outlook Associates 2011).

- Preventative and chronic care reminders/alerts - to identify patient-specific recommendations for the provider in support of patient care standards (American Academy of Family Physicians 2017) and aid treatment plan development.
- Clinical rules and alerts in general - to ensure that information and results are flagged accordingly, which streamlines diagnostic processes.
- Missing results reminders - to alert providers when results and information have not been entered for the patient, ensuring complete records.
- Population health analysis - to compile patient data and develop an actionable patient record and understand potential outcomes.
- Disease registry and or integration - to evaluate specific outcomes for a population based on a disease.
- Patient reminders and education materials - to inform patients on their particular situation, which can be distributed directly via printing, or by email which will include the patient in his or her treatment plan.

In conjunction with improved patient care, the AECP's third goal is to **reduce medical errors**. While there are many EMR features which impact this, there are three unique features to consider, primarily concerning prescriptions and medications (Outlook Associates 2011).

- E-prescribing with full interaction checks and alerts - to reference any existing medications in the patient file with a new one entered during the visit, to ensure there will not be any threatening interactions.
- Testing integration with clinical rules, treatments, history and directives - to recommend treatments based on the history of the patient.
- Dosing algorithm support - to identify appropriate dose recommendations based on the patient conditions and characteristics, such as age and weight.

The final two goals are less focused on patient care, and more on the administrative side of the EMR within the practice. The first of these two goals, and the fourth overall, is to **improve access to information**. Within this goal are four features (Outlook Associates 2011).

- Remote access to full medical records - to allow the AECP's network of doctors to keep track of patients during the referral process as well as share case details in the case of inter-clinic consultations.
- Wireless tools for greater mobility - so that the system can be used on multiple devices and is supported on laptops, desktops and on mobile, which helps with accessibility during field screenings.
- Scanning integration - to allow documents to be directly uploaded to the records.

- Full email integration - to allow for information to be sent directly out of the system.

The last goal of the AECP is to **reduce cost and increase revenue**. Reduced cost is associated with increased efficiency. Many of the features already discussed impact efficiency. Rather than repeat them here and potentially misrepresent their importance, only the features that have not been mentioned in prior goals are listed (Outlook Associates 2011).

- Efficiency features to reduce paperwork - to reduce the need to generate paperwork; the reduction of generating paperwork saves time and allows more patients to be seen.
- Direct billing interface - to reduce overhead and time required in the process.
- Insurer rule integration - the more comprehensively the system can deal with such processes the more streamline the process can become.

With the priorities of the AECP set, we developed the ECM based on the goals and associated features. We did not factor the critical features into the ECM, as they carry too much importance; instead, they are the initial feature check which we performed before testing an EMR in the ECM. Any EMR that did not have the critical features was eliminated from consideration and only systems that met these critical features were evaluated.

Finally we defined non-functional features, which are assessed more subjectively based on user experiences and comparative studies. The first feature is the technical requirements of an EMR, which tell us what infrastructure is needed for the AECP to physically install the system, such as the server requirements, the operating system required, and the ease of installation. The second feature is the usability of the EMR, which considers the amount of training required for day-to-day use of the system, the clinical efficiency of the system, and technical literacy required for more in-depth troubleshooting and maintenance. The final category of non-functional features is a generalized fit to the organization, and this concerns how customizable the system is to the AECP's needs. We considered all of these non-functional features together with cost to understand what investments this would require from the AECP.

4.3.4 Analysis of EMR systems

From the goals and associated features we were able to build the ECM tailored to the AECP. The first step was to order the relative importance of each feature with respect to the other features associated with that same goal. The order of the features lists was then checked with the administration of the AECP and is included in Table 1 below, with the goals in the top row, and the prioritized associated features in the corresponding columns:

Table 1: EMR goals and prioritized associated functions

Improved Clinical Operations/Efficiency (1)	**Improved Patient Care (2)**	**Reduction in Medical Errors (3)**	**Improve Info Access (4)**	**Increased Revenue/Reduce Cost (5)**
Online, direct access to web-based reference data	Clinical rules and alerts	E-prescribing with full interaction checks and alerts	Remote access to full medical records	Efficiency features to reduce paperwork
Efficient on-line charting features and tools	Population health analysis	Testing integration with clinical rules, treatments history and directives	Scanning integration	Direct billing interface
Integration with practice management data and processes	Patient reminders and Education Materials	Dosing algorithm support	Full email integration	Insurer rule integration
Flexible electronic interfacing for outside entities	Preventative and chronic care alerts/reminders		Wireless tools for greater mobility	
Organized clinician "inboxes" with priorities and reminders	Disease registry capabilities and/or integration			
Direct integration with diagnostic & clinical equipment	Missing results reminders			

From this chart we employed the ECM methodology as described in section 3.5.1. The first goal of improving clinical operations carries a weight of 5 points, with a total of 6 associated features, resulting in a product of 30 points. This number is then multiplied by 10 to produce a total of 300 points allotted to the goal. The second goal of improving patient care was weighted as 4 points with 6 associated features, resulting in 240 points being allotted to the goal. Using this same methodology the process of allotting points to goals was carried out for each goal, and then the points from each goal were distributed to the associated features to reflect the relative importance of each. The point distribution resulted in Table 2 below, where the rows in bold show the goal and total number of points within the goal and below each bolded row are the associated features with their respective points, totaling in the goal points.

Table 2: Point distribution among EMR features

Goals and Features	Points
Improved Clinical Operations/Efficiency (1)	**300**
Online, direct access to web-based reference data	80
Efficient on-line charting features and tools	70
Strong integration with practice management data and processes	60
Flexible electronic interfacing for outside entities	40
Organized clinician "inboxes" with priorities and reminders/Intra-office messaging	30
Direct integration with diagnostic & the clinical equipment	20
Improved Patient Care (2)	**240**
Preventative and chronic care alerts/reminders	70
Population health analysis	60
Disease registry capabilities and/or integration	50
Patient correspondence reminders and Education Materials (email, paper)	30
Clinical rules and alerts	20
Missing results reminders	10
Reduction in Medical Errors (3)	**90**
E-prescribing with full interaction checks and alerts	40
Order/testing integration with clinical rules, treatments history and directives	30
Dosing algorithm support	20
Improve Info Access (4)	**80**
Remote access to full medical records	30
Scanning integration	20
Full email integration	20
Wireless tools for greater mobility	10
Increased Revenue/Reduce Cost (5)	**30**
Efficiency features that will reduce paperwork and allow more patients to be seen	10
Insurer rule integration	10
Direct billing interface	10
Total Points	**740**

As each new EMR was assessed in the matrix, it was awarded feature points in full for having the feature. The total number of points awarded to each system was tallied and compared to the greatest possible points an EMR could earn, 740, to create a raw score of functional features. Only open source EMR systems were entered into the ECM for analysis, and this occurred only after a critical feature check was performed.

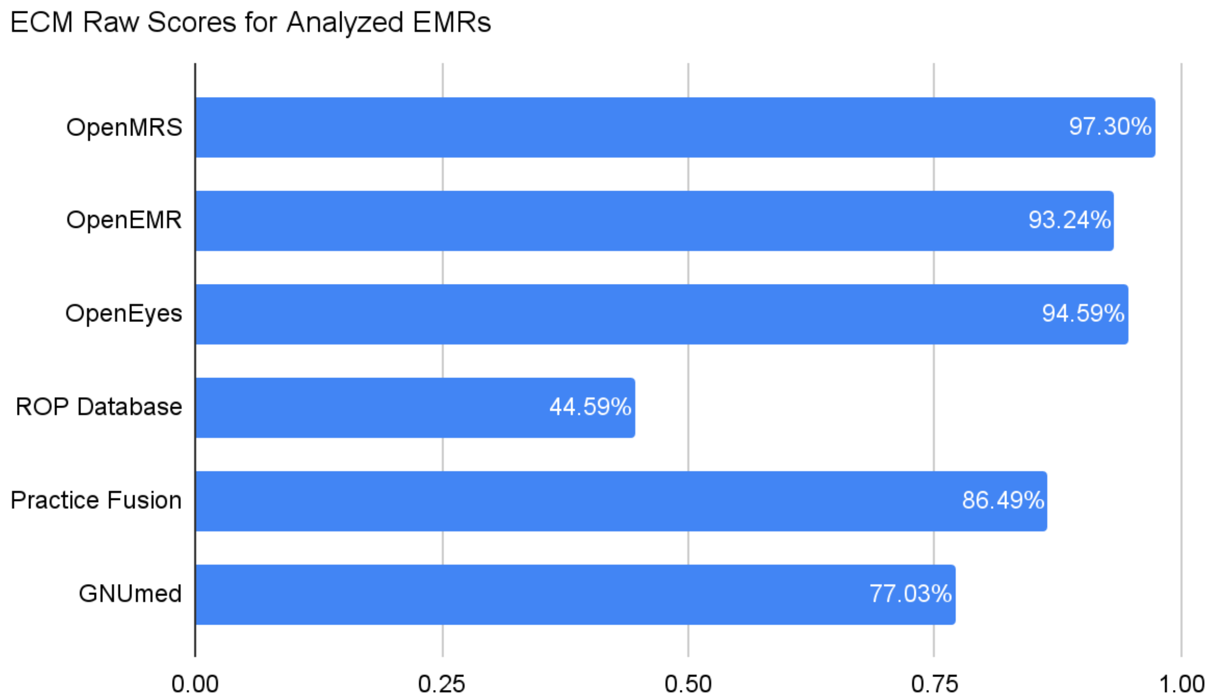


Figure 19: ECM raw scores of analyzed systems

A total of six EMR's were analyzed with this matrix, and a raw score of functional features was produced for each one as shown above in Figure 19. These raw scores provided a context as to how well the examined systems would fit the needs of the AECP. Based on the grouping of the scores we decided to further research three systems as potential candidates for the AECP:

- OpenMRS (openmrs.org/): An application for the design of a customized EMR requiring little programming knowledge. This is a common framework, and is popular around the world and particularly with medical informatics efforts in developing countries (OpenMRS, 2016).
- OpenEMR (www.open-emr.org/): The most popular free and open source EMR and practice management system that can run on most operating systems and is browser based. This is certified by the Office of the National Coordinator for Health Information Technology (ONC), meaning that the system meets security and meaningful use policies within the US (OpenEMR, 2017).
- OpenEyes (www.openeyes.org.uk): An ophthalmology-specific EMR with flexible charting. The system is browser based and easily allows for information to be accessed anywhere (OpenEyes Foundation, 2017).

Once we identified potential EMR options based on how well they fulfilled the needs of the AECP, we turned to non-functional features. These features focus less on what the system does, and more on how the system interacts with the rest of the AECP. Because these systems are open source, there is no vendor to provide support. In light of this, we researched how active the user community is. The more active the user community, the more support an organization can expect to experience regarding the use of the system. Both OpenEMR and OpenMRS have highly active communities which offer support to users and have developed extensive module libraries that can be downloaded. We also looked at implementation time, ease of implementation, and ease of modification. While all three have variable ease of implementation depending on the situation, we found that OpenEMR and OpenEyes require the least amount of setup time prior to implementation, as both are downloaded as functioning EMR systems, while OpenMRS is primarily a framework which still requires a relatively large amount of setup before installation. The last non-functional feature to analyze was the system's ease of modification. Because OpenMRS and OpenEMR are used in such a high number of diverse clinical applications, these systems are highly versatile and can be modified to a larger extent than OpenEyes. The implications of these basic non-functional features provided guidance to recommend the systems that would best fit the AECP. We will review these systems and provide a recommendation in the following chapter.

4.4 Teleconsultation Findings and Analysis

Using our observations of current systems and protocols, we implemented the available Polycom system network to serve as a teleconsultation platform and created an escalation protocol for AECP providers to follow when conducting teleconsultation.

4.4.1 Improved Teleconsultation

From interviews and observations at the clinics, as well as multiple conversations with other AECP staff members, we determined that we should develop an effective escalation protocol for the consultations themselves, as well as install and test the equipment currently available. To ensure that the communication network we set up is used effectively, we also included documentation of our work and instructions on how to install and operate the equipment. Much of this need was identified in response to clinicians' reliance on personal contacts for consultations, as well as the untapped potential of the Polycom systems accessible to the AECP.

To ensure that our vision of how an improved teleconsultation system would impact the operations of the RECs was in line with what the AECP wanted, we developed a preliminary use case (Figure 20) to show how the implementation of the teleconsultation system and escalation protocol would alter the operations of the clinic. The orange boxes represent changes to the procedural flow that differ from the informal teleconsultation use case above. The detailed use case can be found in Appendix O.

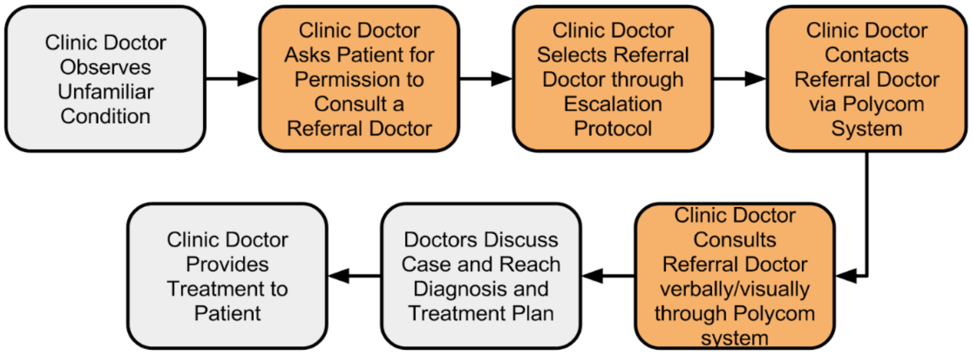


Figure 20: Improved teleconsultation process

4.4.2 Implemented Polycom System

We were able to set up the hardware for all three Polycom systems that the AECP has access to and run and test the software on two of the Polycom systems. Setup details can be found in Appendix U. The three systems are located at the COE, Malayan Ophthalmological Center, and the Spitak Regional Clinic. We were able to test the software at the COE and the Spitak Regional Clinic. Based on these tests, we have developed a list of findings from this phase of the setup:
Medical providers at the regional clinics (e.g., Spitak) can make calls to specialized clinics in Yerevan (e.g. COE) to discuss complex medical cases.

- These calls allow for real time communication and imaging via connected devices (e.g., surgical microscope, slit lamp, etc.).
- Medical professionals are able to call in to a Polycom system or an already established call via the Polycom People+ Content IP software (available on smartphones and computers) no matter their location, which is useful to international professionals that want to be consulted or educated on a case.
- Polycom hardware setup is relatively simple for those familiar with basic computer hardware and setup.

Additionally, the tests also allowed us to develop a list of potential issues that should be addressed before implementing this teleconsultation network:

- Initial setup of the teleconsultation network can require coordination of a large number of personnel due to the large distances that can separate the Polycom Systems.
- Polycom systems require constant high speed internet and a large amount of bandwidth due to the transmitting of high resolution video and images.
- Using wired inputs and outputs with the Polycom System Box is more desirable than wireless but can pose a problem when trying to connect devices that are in different rooms, buildings, etc.
- The Polycom System software is often not able to connect to another system due to issues with the ISP, LAN, port forwarding, etc.

The analysis of our tests and observations agrees with our background research. We found that while the synchronous teleconsultation system makes communication and data sharing more efficient, it is a difficult system to set up due to the issues above. Additionally, we were only able to set up two points in the network over a period of two days which will become very time consuming for the AECP as they expand their clinical operations. Going forward, the research suggests tailoring the use of the teleconsultation system to the AECP so that installation and use of the system is more efficient. To do so, we have developed a basic Teleconsultation Guide for the AECP staff to use and included it in Chapter 5.

4.4.3 Escalation Protocol

To formalize the current escalation process at the AECP, we documented some of the information we learned from observations, interviews, and the AECP website. The website has biographies of all the AECP doctors' in-country and a significant number of internationally practicing doctors that had been on medical missions to Armenia in the past. Most of the Armenian doctors work in the regional clinics, subspecialty clinics, or mobile eye hospital, while the American doctors work in private practice or research hospital settings in the United States. We realized that there is a significant amount of untapped medical expertise within the AECP's network. To address this, we assembled a list of all AECP doctors, in Armenia, the USA and Great Britain (Appendix S). This list includes the doctor's name, his or her subspecialty (for example, glaucoma, retina, pediatrics, etc.), location (for the sake of time zones), and contact information.

While this network is significant, it could be expanded to provide even better treatment. There is currently an AECP fellowship program in place that sponsors doctors to travel to the United States and around the world in order to gain even more expertise in their area of specialization. We determined that contacts from this program would be incredible assets to add to the teleconsultation recommendation. To take advantage of this expertise, we drafted a letter to be sent to other physicians who have connections to the AECP, asking them to be part of the teleconsultation network (Appendix T).

In addition to increasing doctors' resources, we also wanted to increase the efficiency of the entire teleconsultation process. We analyzed each of the eight wastes of lean to determine how to best save time, money, and resources (iSixSigma, 2017). The three main wastes of lean we wanted to avoid were Skills, Waiting, and Transport. All three of these wastes were analyzed in the context of the AECP and our project, and their definitions and examples are provided in Table 3] below.

Table 3: Examples of waste in the current operating model

Waste	Definition	Example
Skills	Everyone should work to the top of his or her certificate, or people should do the most skilled jobs they are qualified to do and let someone less qualified do the jobs that require less qualification.	A patient wouldn't go to a neurosurgeon for an annual physical exam, because his or her skills would be wasted. Instead the patient would go to a primary care doctor so the neurosurgeon can focus on patients whose conditions are too complex to be seen by the primary care doctor.
Waiting	Waiting time should be minimized, because wait time does not add value to the process or stakeholders.	Scheduling a call, sending images, or establishing a connection could be considered waiting time for a doctor, because it's non-value-added time that doesn't directly contribute to treating patients.
Transport	This waste involves any unnecessary transport, and the time and money costs that go into it.	A patient who has to travel to Yerevan for treatment has to pay directly, such as for a bus fare or gas for a car, as well as indirectly, such as through the wages that are lost during the time traveling instead of working.

Additional research yielded more factors to implement into a successful system (Table 4). Wootton (2008) provides five reasons a teleconsultation system might not be used. Each of these could be a roadblock to successful implementation of systems into the AECP's infrastructure, so it is vital to understand both these factors and how to mitigate their effects.

Table 4: Roadblocks to clinical use of teleconsultation

Factor	Definition	Application to Our Project
Thatcherism	The idea of a free source of information being less valuable than a paid source	Patients might consider the care they receive from teleconsultation to be of a lower quality than that they might receive in-person from a more expensive facility such as the Malayan Ophthalmological Center.
Stigma of Asking for Help	Doctors may feel uncomfortable asking for help on an issue that they believe they should be able to handle	REC doctors may feel uncomfortable having to consult specialists in Yerevan, as they may feel unqualified if they're seeking another opinion
Local Expertise	Sometimes local doctors can provide better treatment than more educated or experienced doctors, simply because they have better knowledge of their patients' daily lives	Specialists in United States aren't necessarily the most qualified to address some of these issues, as the REC doctors have more cultural and local context for an eye disease
Availability of Consultation Time	Doctors in rural clinics often have large patient loads, and doctors may feel that they are too busy with their patients to take the time to initiate teleconsultation.	REC doctors might have so many exams to conduct they don't feel they have the time to utilize teleconsultation when it's necessary
Loss of Control	Doctors might feel threatened by giving some jurisdiction over their case to another doctor.	REC doctors might feel a personal connection to their patients and thus might not want to have to talk to another doctor about them

Richard Wootton authored another book in 2008 in which he explored an additional four considerations for an effective teleconsultation program:

- Focus protocol on assisting REC doctors - most of the specialists are in Yerevan, and will not require as much assistance, the focus will ensure there is proper emphasis on direction of consultation.
- Use local staff as much as possible - this will ensure all resources are exhausted within the clinic before efforts are spent contacting outside providers to eliminate waste.
- Establish and maintain in-country networks - in country specialists are more likely to be available during hours of operation than those overseas due to time difference. This availability is crucial in making contact during emergency cases.

- Evaluate costs and effectiveness - through a cost/benefit analysis the organization should determine whether the program is worth continuing. The AECP is non-profit, so it is necessary to ensure that all funding is used as effectively as possible.

Based on these findings and this research, we developed a list of best practices we needed to consider in developing the escalation protocol.

- Utilize the REC doctor as much as possible prior to teleconsultation - this will minimize waste of provider skills and take advantage of local expertise. In addition, as many measurements, images, and tests as possible should be done before referral, as this will decrease time spent during consultation (Hanson, Tennant, Rudnisky, 2008).
- The escalation protocol should reflect what happens if a specialist is not available - this automates decisions, minimizing wait times and maximizing the time doctors are able to actively treat patients, (Wootton, 2008).
- Only refer patients to Yerevan if nothing else would work - to minimize transport and strain on patients (Wootton, 2009).
- Develop a set of use cases - to determine the interaction of the escalation protocol with the rest of the AECP's system (Heinzelmann, Chau, Liu, Kvedar, 2009).
- Include versions of the protocol translated into Russian and Armenian - to ensure doctors understand the teleconsultation protocol (Blunier, Zahorulko, Dobryanskyy, Brauchli, 2006).
- Educate doctors about teleconsultation - to remove any concerns that may be present, which will also mitigate the effects of Thatcherism, the stigma of asking for help, and the loss of control (Wootton, 2008).
- Design the protocol for use within the RECs - to have the most significant impacts (Wootton, 2009).
- Perform quarterly assessments throughout the first two years - to determine how to improve the system and allow for evaluation of the recommended protocol (Wootton, 2009).
- Include courses of action for both emergency and non-emergency cases in the protocol - in order to ensure patients get the best care possible (Hanson, Tennant, Rudnisky, 2008).

4.5 Data Collection and Medical Security

The AECP is very concerned with patient privacy, to ensure both patient trust and cooperation with Armenian Ministry of Justice (MOJ) regulations. To better understand the aspects of patient privacy that are relevant to the AECP, we interviewed an Armenian lawyer, Mr. Gevorg Hakobyan (Appendix K). Mr. Hakobyan is the founder of the E**law**phant Law Firm, which specializes in the legal fields of business, labor and IT. From Mr. Hakobyan, we learned about several aspects of private data. Private data is anything by which a person can be identified, and anything done with this information is considered private data processing (PDP). There are then four types of private data:

- Public - this information is accessible by anyone, and includes name, surname, and date of birth and date of death. This is the only type of data for which agreement for collection is not required, and anything an individual makes accessible to the public becomes public information. An example of this is posting one's date of birth onto social media
- Biometric - these are physiological characteristics of an individual, such as race and height, including photographs where a person can be individually identified. Consent of the individual must be obtained, and the MOJ must be notified of the intent to collect this information. Not following these guidelines can cost the organization large fines, and prevention from conducting future work. Biometric data must be stored securely with limited access.
- Special Category - this includes a person's religious, health, political, or philosophical information. For collection of this type of data, prior agreement from the individual is required in addition to MOJ notification. The risk for this is the same as biometric data.
- Personal and Family Life - this is any information which relates to the person and the family, and requires permission to collect. An example of this is marital status.

Violation of data collection, storage, or sharing policies can be detrimental to an organization such as the AECP, which collects public, biometric and special data. Failure to alert the MOJ about the collection of biometric and special data can result in a fine and prevention from collecting future data or using data already collected. In some cases the government may see unapproved collection of private data as criminal. The MOJ has published guides in Armenian to make it easier for the organizations to notify the ministry about collection of data. In conjunction with government approval, each organization must have the individual's permission to collect the data. The most reliable way to do this is with written notification so that there is a record of permission being given. The individual should be made aware of the purpose of collection, who is responsible for the information and how it will be kept. The individual should also know how to retract this permission. Consent in healthcare may be given by the patient if they are over the age of 18, but parents must give consent for children with the best interests of the child in mind.

The AECP works internationally, so once information is collected, it will often need to be shared. The MOJ in Armenia has a list of countries to which private data may be sent or stored in the case of offshore servers, which includes most of Europe, Russia and the USA. To send information to countries not on the list, written permission from the MOJ is necessary.

Once the MOJ grants permission for collection of these types of personal data, the organization must be very careful in the specific procedures surrounding collection. All employees must understand the purpose of data collection as well as the potential risks the organization faces with this collection. All stored data must have limited access and password protection, ideally with encryption. The development of a consent form is recommended to any organization collecting large amounts of information over long periods of time.

Consent in healthcare is a universal issue, and most organizations will use a form of informed consent (Shekelle, Wachter, Pronovost, Schoelles, McDonald, et al., 2013). This is a process whereby the patient signs a form to confirm that the provider explained to them the treatments, tests, information to be collected, what will be done with this information, and the risks and benefits of everything. It is the conversation which informs the patient, and the act of signing the form indicates that patient understands and agrees to the conditions as set by the provider. The benefit to the conversation is that the doctor allows the patient to clarify information in the event of low medical literacy, which is associated with old age and low overall education. In addition to not understanding the informed consent, many patients may not remember giving informed consent to the organization to collect, store, or share their data.

To combat the issue of patients not understanding the consent they give, or not remembering giving consent, there are multiple proposed methods (Shekelle, et al., 2013). Providing easy to understand materials and explanations to patients is best. Often these materials can take the form of written pamphlets and video education tools. Both of these are good options as they can be loaded into patient portals to give patients full and additional access. In addition to educational materials, many studies have shown significant increase in understanding and retention of consent information with the "repeat back method," which allows the doctor to ask the patient to repeat the information just explained. During this conversation the doctor has the opportunity to see how much the patient understood, and offer clarification at the time. The importance of consent and understanding lies in patient trust regarding the doctor and treatment.

Chapter 5: Recommendation and Implementation Plan

Based on our findings and analysis of EMR systems as well as teleconsultation networks and protocols, we have developed final recommendations for the AECP. These recommendations were made with the goals of the AECP in mind in the hope that the use of these technologies will improve data sharing and result in better patient care. We have also developed preliminary implementation plans for both the EMR and teleconsultation recommendations, with preliminary budgets for the installation and implementation of these systems.

5.1 EMR Plan

In this section we specify the recommended EMR system and the technical infrastructure to support it, as well as the necessary operational changes. These recommendations will enable the AECP to successfully install the system into its clinics, and we have also developed an implementation plan which highlights the timeline, staff training, feedback protocol, and post-implementation development. Finally, we have developed a preliminary budget for the installation and implementation of our recommended system.

5.1.1 EMR System Recommendation

After our identification, research, and analysis of open source EMR systems, we developed a recommendation of a system we believe will best fit the needs of the AECP. Based on the raw score produced by the ECM and the non-functional features of the system, we recommend that the AECP adopt OpenEMR as its primary data collection and storage platform. While the system did not receive the highest raw score of functional features (93.24%), we are confident that the simplicity of the system and the reduced effort to implement it will best fulfill the AECP's goals for integration of the EMR into their organization, and can be modified to include the features which it does not possess natively.

OpenEMR (Figure 21) is one of the most popular open source EMR systems in use today, employed in over 15,000 clinics in more than 30 countries. The browser-based system is ONC Certified, meaning that the system is considered secure within the United States, and the system has additional international usage (The ONC of Health Information Technology, 2016; OpenEMR, 2017). Constructed on a LAMP (Linux, Apache, MySQL and PHP/Perl/Python) platform, the open source code is entirely free to download, use, modify, and upgrade. With fully integrated electronic health records, practice scheduling, a patient portal, and ample free community support, OpenEMR runs with Windows, Linux, and Mac OSX. In addition to its medical functionality, OpenEMR supports the use of multiple languages within a single clinic/practice, including Armenian, Russian, and English. Around 2010, the first Armenian organization incorporated OpenEMR into its practice to test for the system's language ability and meaningful use (Rodrigues, Torre Díez, & Sainz de Abajo, 2012).

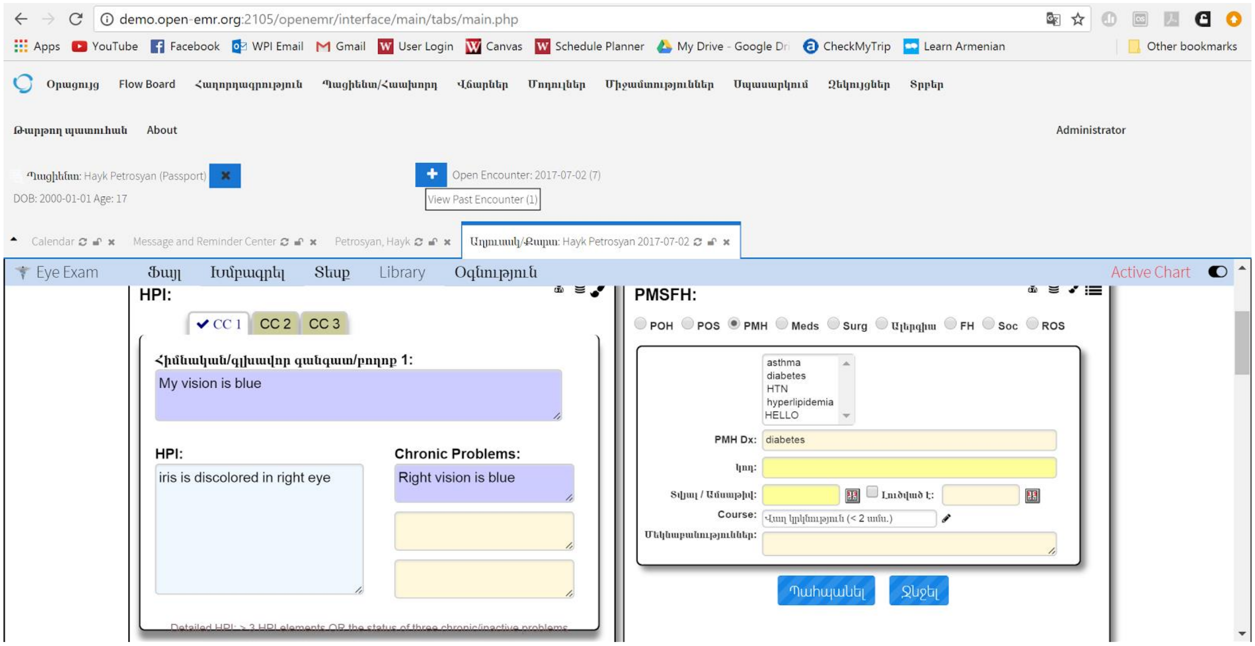


Figure 21: Screenshot of a test patient eye exam in OpenEMR

With regard to the patient demographics and exam documentation, OpenEMR covers primary information (name, DOB, sex, identification number, and language) and contact information, and is fully customizable (OpenEMR, 2017). The system is also capable of supporting scheduling in multiple facilities. While OpenEMR was designed for general practice, it also has an eye exam module integrated into the system. The module is for ophthalmology and optometry, and maintains a user-friendly interface with support for many features. Designed by an ophthalmologist, the module is meant to fit the workflow of the provider, and is adaptable for each doctor. Lastly, the eye exam module allows for the input of information via text, drawn images, and shorthand notes, making it easy and efficient to use. The unique aspect of the drawing feature is its ability to interpret and record the input as numerical values, and store the values in an exam record for future analysis.

While there is currently no specific way to integrate imaging machines into OpenEMR, the files can be uploaded to the system through the DICOM medical standard as long as the images can be saved to the computer (OpenEMR, 2017). The system is also capable of producing population measure calculations and clinical quality measures calculations to ensure that the practice is delivering safe and effective patient centered care. Data analysis is very important to the AECP, and we are confident that the system will make this task simpler, thereby allowing for more in-depth analysis. Additionally, between the multi-lingual, cloud based nature of the system and inter-clinic messaging, OpenEMR makes it easier to securely share patient records across the organization and to send information for referrals to outside specialists. Likewise, the patient portal is simple to navigate, making it possible for patients to keep track of their diagnoses, treatments, and prescriptions, as well as maintain access to their own records without going through a doctor.

In addition, by having an incredibly active community, OpenEMR also has published installation instructions which reduce the expected amount of technical literacy required by an implementer (Zaidan, et al., 2015). Even with access to a very low amount of technical literacy, an organization can expect to have the program installed and ready for use in less than a day, excluding the time for initial modification. The rapid installation combined with the highly developed system means OpenEMR has the potential to be installed in clinics earlier in the EMR timeline of the organization. Finally, compared to similar EMRs, OpenEMR is the easiest to learn for the providers, which is important in the case of the AECP, where none of the clinicians have used a system like this before.

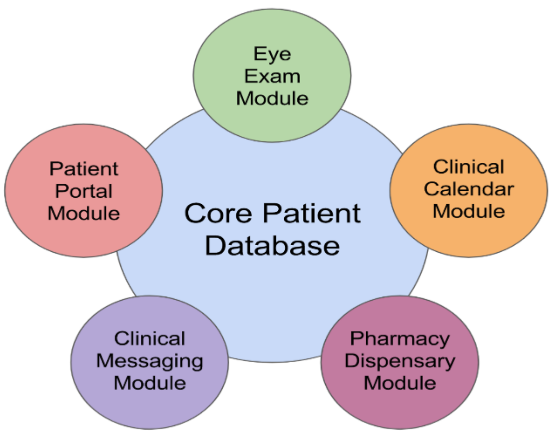


Figure 22: How modules are added to the base EMR

As was stated above, OpenEMR is built in a modular framework (Figure 22) and although it was built in Python, the system can support any language with which it can communicate. As long as the modules are written with the intent of integration, they can be developed in languages other than Python. The system, combined with years of community development and continuous updates, should require little pre-implementation development, but post implementation modifications should still occur, as with the ROP database.

We acknowledge that we do not have a complete view of the AECP's day-to-day operations, so we recommend a second system option should OpenEMR not fulfill the needs of the AECP. This second option is OpenMRS. While it is more customizable in its framework format, its features list is not much different than that of OpenEMR, and it is currently lacking an ophthalmology module. Additionally, OpenMRS will require a longer development period and implementation time than OpenEMR, with a greater amount of technical literacy required as well. We recommend OpenMRS as a good back up to OpenEMR because the technical infrastructure is the same for each system, meaning no additional investment outside of the software development contract will be required, and the AECP will be able to take qualities which they like from OpenEMR and develop these features within OpenMRS.

Only in the event that neither of these systems is able to meet the needs of the AECP, should the organization turn to expansion of the ROP database or developing an entirely new EMR. The option for the AECP to create its own EMR is costly, results in the loss of many existing features, and will take far longer to develop and implement.

5.1.2 Server Recommendation

To support the functioning of the AECP's EMR system, we are also recommending a localized server network. Our recommendation is to have the AECP install low-cost servers at each REC with a primary server at the AECP main office in Yerevan (Figure 23). This system will require an initial cost of purchasing and installing the equipment, which will quickly pay for itself as the AECP will no longer need to rent outside server space. The AECP will have to maintain the system by expanding its existing contract with a third-party IT firm to include server maintenance. The benefits to this setup far outweigh the relatively low costs involved. Aside from having direct control over its own infrastructure, the AECP will be able to avoid many location-specific problems such as outages or system failures while simultaneously having a very robust network of backups for the data it collects and generates. The regional servers are the key to these advantages because each one will be capable of operating independently, storing all of the information from the entire AECP locally and allowing the staff at each REC to access it over the local area network. The regional servers will be in constant communication with each other, synchronizing data over the Internet as it is entered, modified, or deleted, and ensuring that if one part of the network goes down for any reason, the other sites remain unaffected and still have access to all of the information. Lastly, because the REC staff will be accessing the EMR directly from the local server instead of over the Internet, they will avoid problems associated with slow speeds or local ISP outages.

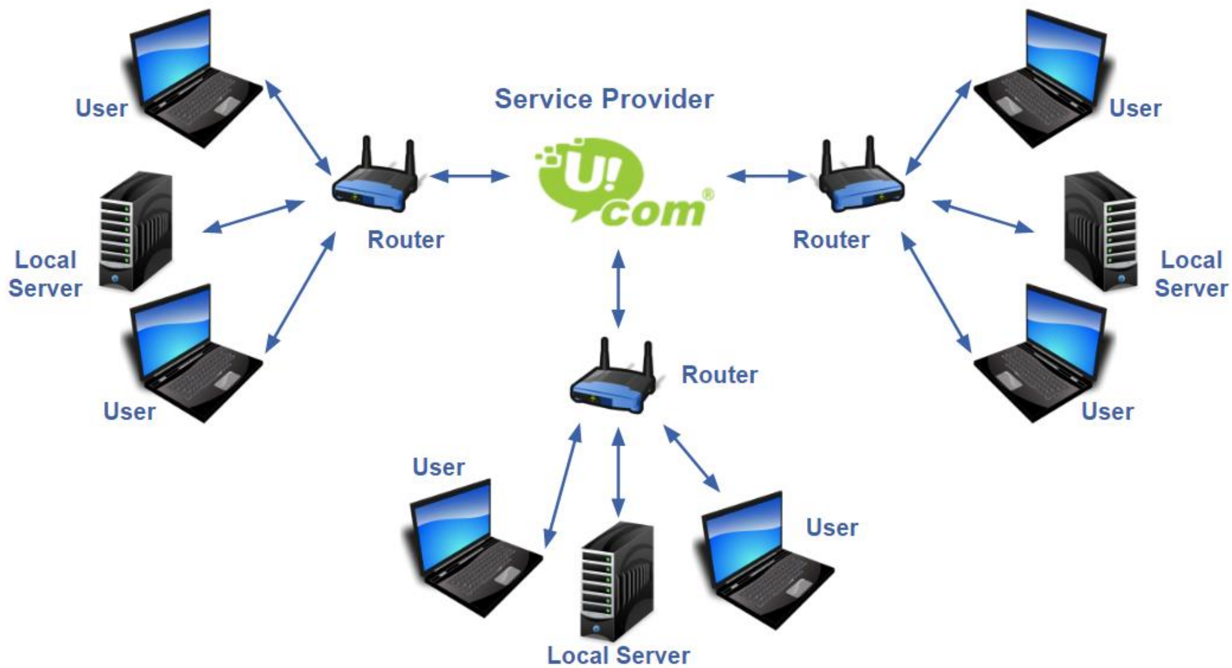


Figure 23: Local server infrastructure map

Such a system will also offer the most flexibility when something goes wrong. While the system is accessed through a browser window, the best way to connect to it will be through the local server directly using its local network address instead of navigating to a website. This means that in the case of an internet outage lasting several minutes or hours, the staff will not even notice the lack of Internet because they will not be using it to access the EMR. Doctors will continue to access the local copies of files previously downloaded from other locations as well as continue to enter their own data. Any additions or changes made during this time will automatically be synchronized with the rest of the AECP's network when internet access is restored. In contrast, if the AECP were to rely on an outside server, the staff will have no means of accessing any existing data and will have to revert to using paper cards to record patient information, which will then have to be copied into the EMR when internet access is restored. If the local router were to fail, a computer could be plugged into the local server and access the data via direct connection. While inconvenient, it will allow local staff to access existing records saved to the local server instead of being stranded without any access at all. Lastly, in the highly unlikely event of the server itself failing, the doctors and nurses could continue to use the EMR by connecting to another facility's server over the Internet.

Server requirements of open-source systems are significantly lower than most big-name EMR solutions. Minimum requirements for most implementations are (OpenMRS Inc., 2016):

- 1-2 processors, 1.5-2+ Ghz each
- 2+ GB RAM
- 150+ GB of storage space in RAID configuration

The storage requirements above do not factor in backup storage drives. If operating with a parent/child server model, local servers will likely not need as much performance as the primary centralized server, but given the low cost of meeting these requirements it is advised that all servers be able to handle the full data load to avoid gradual loss of performance as data accumulates over time, or in case data needs to be rerouted in the event of a loss of one of the servers.

In summary, the benefits and drawbacks of this local server system are:

Benefits:

- EMR can be accessed without Internet
- Medical staff can access system from other servers if necessary
- Multiple available contingency plans if things go wrong
- Very robust system of backups to ensure data integrity
- Redundancies built into the system result in improved user-side reliability.
- Updates and modifications are easier to implement
- Low cost, one-time equipment expense
- AECP no longer has to pay $350/month to rent server space

Drawbacks:

- System is not “out of sight, out of mind” as with a third-party hosting service
- Increased chance of individual components going offline due to lack of constant professional supervision
- Increased reliance on IT contractors
- Possible $50/month increase to IT fees

Contracting a third-party hosting service, as is the case with the ROP database, is the most common way to fulfill server needs. The greatest advantage to such an approach is that all the needs of the server are handled away from the AECP and the contract includes immediate professional troubleshooting. Having the server hosted in a single outside location requires users to have a constant and reliable connection to the Internet to access the EMR, and our observations both in Yerevan and at the regional centers indicate that this cannot be taken for granted. While the current ROP database functions well on such a system, its use is concentrated primarily in Yerevan and is infrequent enough compared to the rest of the AECP’s operations that internet access issues have not been a significant problem. An organization-wide EMR will inherently see many more instances of use, resulting in a significant number of users who will need to access patient data simultaneously and around the clock. In this case, unreliable internet access will very quickly evolve from an inconvenience into a system-crippling problem. Furthermore, the AECP is not in a position to address the root cause of the issue; slow internet speeds and frequent outages are common in Armenia inherent to Armenia's infrastructure, and the only entities that who can improve the situation are the Armenian government, internet service providers (ISPs), and the hospitals in which the AECP clinics are embedded. This situation therefore demands a solution that makes the best of available resources while finding workarounds wherever possible. Given that the EMR ultimately adopted is intended to be modified and updated on a regular basis, the presence of a parent administrative server in Yerevan will allow the local developer to access the system directly as needed instead of having to upload successive versions and patches to a third-party host.

5.1.3 Steps for Implementation

For the AECP to successfully implement the EMR, the organization must prepare their technical and staffing infrastructure to support the system. These preparations must occur before the EMR itself is brought into the clinics for training. Here we cover the infrastructure, staffing and preliminary cost analysis, followed by the timeline for implementation and training.

Infrastructure

Certain technology infrastructure requirements must be met to prepare for the implementation of an EMR. Such requirements include reliable electricity, internet connection, and a local area network (OpenMRS Inc., 2016). Clinic-specific workstations, including laptops, should be equipped with basic virus protection to help prevent malicious software from infecting connected devices and the system at large. While some larger health facilities often hire dedicated staff for data input, the AECP will be best served by ensuring that the nurses and doctors at the RECs have the basic computer skills necessary to input the data themselves.

With regard to electricity, all clinics are vulnerable to unexpected power loss so a backup power source is necessary. This usually involves a kind of battery called an uninterruptible power supply, or UPS (OpenMRS Inc., 2016). Relying solely on a backup generator or alternative power source is not sufficient because the brief delay between losing grid power and backup systems coming online can damage the server and result in data loss or corruption. Most conventional UPSs can keep a small- or medium-sized server operating for several hours, and if electricity is not restored by the time it reaches critically low power levels, a UPS can issue a command to the server to initiate a safe shutdown sequence before power is lost. Additionally, many UPSs also regulate the voltage output to the devices connected to them, which prevents damage from disturbances in the voltage. Because this functionality is not standard to all UPS units, it is worth making sure that the unit ultimately sourced is one that includes it, saving the expense of purchasing a separate power conditioner.

To add an extra layer of redundancy, we advise use of external backup drives to safeguard copies of recorded data in the event of sudden and catastrophic failure of either the system or supporting architecture (OpenMRS Inc., 2016). Regularly scheduled daily backups on such external devices are recommended to ensure simple and easy system recovery if it proves necessary.

Furthermore, we recommend that the AECP provide medical staff at the RECs with small, inexpensive laptop computers to facilitate data entry and retrieval. While each center currently has a single desktop computer that is sufficient for a nurse acting as a scribe, each additional nurse will need a workstation of his or her own to enter preliminary patient data to save time in the examination room. The doctor may also want to be able to view patient data and history without going to the desktop computer, and with multiple users trying to use the EMR simultaneously, the single desktop can easily become a bottleneck in the patient flow process. As an added security measure, the AECP should restrict the use of these laptops to work-related needs to guard against the spread of malware.

Lastly, for situations in which personnel need to submit forms from the field such as with the MEH screening teams, the EMR can be accessed from mobile devices that cost as little as $20 (OpenMRS Inc., 2016). Patient forms and other data can be sent via SMS, GPRS (2G and 3G cellular data), or WiFi.

Breakdown of Technology Needs:

Infrastructure

- Reliable electricity and Internet access, including a local area network
- Backup UPS systems
- Backup storage drives (1TB)

Data Entry

- Low-cost laptops or tablets to allow for multiple users per site and mobility
- Smartphones and/or tablets for mobile screening teams
- Firewall and anti-malware software

Staff

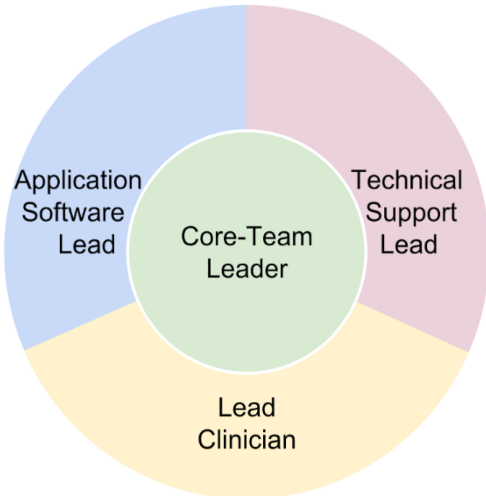


Figure 24: Cross-functional team members

During the implementation of the EMR system the AECP will need to form a cross-functional team (Figure 24). This is a group of people with different functional knowledge who will work towards the same project goal. The benefit of this strategy is increased communication between the groups of the AECP, and it ensures that each functional group within the AECP understands the universal goals of the EMR, and how the new system will impact all aspects of the operation. The members of the team will have basic level of competency in the other members' responsibilities for the EMR so that they can make informed decisions during the implementation phase. In the case of the AECP this will be a core team-leader from the AECP administration, the application software lead of the system, technical support lead, and a lead clinician who can represent, and also inspire change in the other clinicians.

The core-team leader needs to have a clear picture of what the end goals and priorities of the implementation are, including what requirements the EMR needs to meet, what concerns need to be addressed, and the medical staff's interactions with the system. Problems encountered during the implementation process that cannot be addressed with a simple technical fix should be referred to the team leader, and while the technical details are the domain of the application software lead and IT staff, the team leader should shape the overall implementation strategy. Most importantly, the team leader should serve as an enabler for the personnel beneath him or her, ensuring that the application software lead, IT technicians, and clinicians have access to all of the information and equipment they need to successfully complete their work.

The AECP will need to designate the application software lead, or the person responsible for developing and maintaining the system. This individual does not necessarily need to be an AECP staff member, but must have extensive experience coding in Java and Python and using the supporting software that the system relies upon (e.g. the database and data transfer tools). Additional skills needed by the application software lead include data dictionary design, specifically the ability to infer dictionary concepts from a form and related modeling skills, as well as expertise with installing, configuring, and managing the database environment with associated queries and scripts (OpenMRS Inc., 2016). Lastly, and perhaps most importantly, this person must understand clinical form design and how to create meaningful, useful, and non-ambiguous questions and answers. This includes some basic medical knowledge to understand what questions and answers make sense and what is clinically relevant, the technical expertise to understand how these questions and answers are interpreted by a computer, and the data management expertise to understand how this information will be used for reporting and research. The application software lead should be expected to work full-time for approximately three months during the implementation phase, and then be available on a part-time, as-needed basis to implement any modifications and updates the AECP requests.

IT support staff should be available to troubleshoot errors with the servers and local area networks. As with the application software lead, IT personnel do not necessarily need to be members of the AECP, and can similarly expect a relatively brief period of activity as supporting infrastructure is installed and tested. After this process, their only expected responsibilities should consist of periodic maintenance and occasional repairs. Aside from an understanding of how the specific server network operates, no special skills outside of a normal IT portfolio should be needed, and existing contractors should prove more than sufficient. IT staff should coordinate with the application software lead during the development and implementation phases on a regular basis, since they will be tasked with maintaining the system that the application software lead creates and each party should take the other's perspectives and priorities into account. The AECP may also want to consider designating a local staff member at each site to liaise with both the application software lead and IT personnel. It would also be beneficial if medical staff members could perform basic maintenance and troubleshooting on the servers, however it is imperative that they are trained to do so to prevent any damage from being done to the system. The decision to include medical personnel in this secondary capacity should ultimately be at the discretion of the software lead for software and IT staff for hardware.

Clinical staff will be trained on the new system and will be tasked with entering and editing patient data into the EMR. As they become proficient in using the system, they should help train staff at other facilities and act as resources for their colleagues. In this way, any doctor or nurse who has a problem with the EMR can ask their peers for help before reaching out to higher level staff in Yerevan. When not caring for patients or otherwise occupied by their normal duties, clinical staff should work on digitizing old paper records for historical data analysis purposes.

Breakdown of Staff and Responsibilities:

AECP Core-team Leader

- Tasked with oversight and management of the implementation process

- Ensures that the work done meets the organization’s goals
- Makes strategic decisions when problems arise
- Ensures that other personnel have the resources they need to accomplish their tasks

Application Software Lead

- Lead developer on the project, tasked with building and installing the system
- Reports to AECP oversight staff
- Liases with IT personnel to coordinate installation and server synchronization
- Begins initial training before medical staff are able to take the lead

IT Staff

- Install and maintain server hardware, Internet infrastructure, and computational resources
- Demonstrate proper hardware operation to medical staff and identify which, if any, are qualified to perform basic maintenance tasks

Clinical Staff

- End users of the EMR tasked with uploading and maintaining patient records
- Nurses responsible for data entry while doctors ensure the system is supporting patient needs
- Assist others as their own experience and expertise grows
- Digitize old records for archiving and analysis

Cost Breakdown and Analysis

The largest expense for the system we are recommending will be the development costs. The development costs will focus on customizing the open source system to meet the AECP’s needs. We used the ROP database as a benchmark because it was developed by the same individual who will most likely be called upon to implement the AECP’s EMR. We are therefore estimating that a three month contract for the modification of OpenEMR will cost approximately $5000.

Our main concern regarding IT costs was the requirement that technicians occasionally travel to the rural sites to install and maintain hardware. The AECP currently spends $100 per month on IT services, so we included an increase to $150 per month in our analysis due to the increased travel and labor required.

The AECP’s hardware costs fall into several categories. First is the initial cost of the servers themselves. The most capable are commercial servers, but these are typically used for businesses with intensive needs and tend to be quite expensive. Many manufacturers also sell comparable versions of their equipment known as white box servers that are significantly cheaper. Both of these options provide far more capability than the AECP will realistically need. Professionally refurbished servers offer the most cost-effective solution for the organization. Refurbished equipment from well-reputed vendors is used extensively in industry and is just as reliable as their name-brand counterparts, and because the AECP's needs can be met by a simple desktop tower we recommend that the organization follow this approach (Table 5).

Table 5: Server price comparison

System Type	White Box Enterprise Server	Professionally Refurbished Desktop Server
Starting price	~$1,200	~$120
Summary	Commercial-level server with the same internal hardware as name-brand equipment and used for businesses with high server needs.	Small-scale server used by individuals and small businesses with low server needs.

Second, each server setup will require a UPS as a backup power source, as well as peripherals such as a monitor and keyboard for a technician to access the server directly. Basic UPSs start between $70 and $150 and a keyboard, mouse, and screen can be purchased for less than $50 total.

Third, IT staff will need to ensure that they have the proper cables and adapters to connect medical equipment to a computer with access to the EMR, though much of this is already on hand. Some of the equipment may only output an analog signal while the computer it is connected to may only receive digital ones, in which case a signal adapter will be necessary (while analog-to-analog or digital-to-digital adapters for different cables can simply be plugged in, adapters which convert a signal from analog to digital or vice versa require external power). Such converters can be found for under $10.

For supplemental computers, basic Chromebook laptops are available from a variety of manufacturers, are well-regarded for simple internet needs, and can cost as little as $150. Each REC will ideally have two or three of these small, highly portable laptops to supplement the existing workstations, and we recommend that all laptops purchased be of the same model so that staff can swap out batteries and share power supply cables when necessary.

A summary of the cost breakdown is shown in the Table 6 below. The table includes the cost of the item(s) in USD as well as the frequency of payment for each.

Table 6: Cost breakdown of technology needs for the EMR

Item	**Cost**	**Cost**	**Frequency**
Development	$5,000	**$5,000**	Single Payment
Current IT services	$100	$100	Monthly
Proposed IT services	$150	**$150**	Monthly
Current server hosting services	$350	$350	Monthly
Proposed server hosting services	$0	**$0**	Monthly
White box server	$1,200 ea.	---	Single Payment
Total (3 RECs and office)	$4,800	---	Single Payment
Refurbished server **(Recommended)**	---	$120 ea.	Single Payment
Total (3 RECs and office)	---	**$480**	Single Payment
UPS	$100 ea.	$100 ea.	Single Payment
Total (3 RECs and office)	$400	**$400**	Single Payment
Server peripherals	$50 ea.	$50 ea.	Single Payment
Total (3 RECs and office)	$200	**$200**	Single Payment
1TB external backup drive	$50 ea.	$50 ea.	Single Payment
Total (3 RECs and office)	$200	**$200**	Single Payment
Chromebook laptops	$150 ea.	$150 ea.	Single Payment
Total (3 RECs)	$1,350	**$1,350**	Single Payment

Proposed Total	$11,950	**$7,630**	**Single Payment**
	$150	**$150**	**Monthly**
Monthly Savings	$300	**$300**	**Monthly**

Note: Cables and adapters are omitted because the AECP already has several, and if more are needed their cost is negligible. The numbers in bold reflect our recommendation.

Timeline

When developing a timeline (Figure 25) for implementation of the recommended EMR system, we referenced previous implementations elsewhere in the world as well as the AECP's experience with the ROP database. As a result, we expect the AECP to be able to fully roll out its new EMR in as little as three months. OpenEMR can be installed in a single day, but we allow a month for further development and modification which the AECP sees necessary for initial implementation, particularly for thorough integration of the modules and edits to the interface. During this modification time the cross-functional team will be developing training materials for the clinicians, to ensure training covers all aspects of the EMR. Given that most of the desired features are already incorporated, this one-month estimate may be generous, but it seemed prudent to budget for this time and possibly be ahead of schedule instead of having to delay other phases of the implementation. The end goal of this period should be a minimum viable product. This will produce a fully functional system meeting the needs of the AECP, but will not have extraneous features. This will minimize development time and give the AECP a chance to ensure the system is a good fit before spending too much time and money. If ahead of schedule, the application software lead may choose to further expand on some features, but this and other tasks such as optimizing the user interface should be a secondary priority.

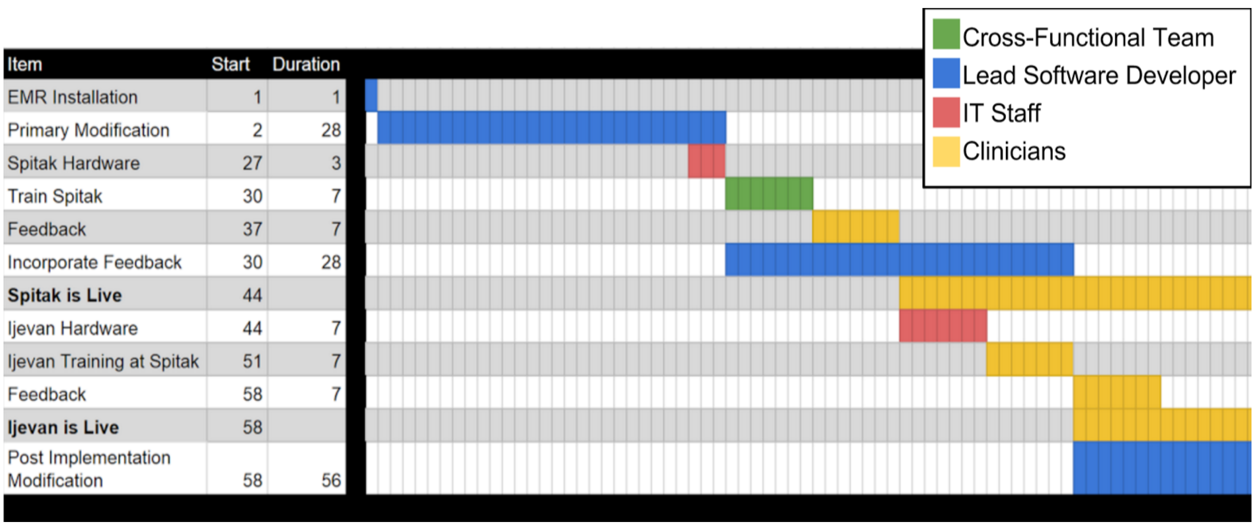


Figure 25: Timeline of EMR implementation and training

Staff training and adoption of the EMR are expected to take the most time in the implementation. The implementation process will include staff training, digitization of relevant paper records, and a formalized feedback process to the application software lead. To minimize the disruption to the AECP's overall operations and ensure smooth integration of the EMR, we recommend the EMR to be implemented at one site at a time. We recommend that the first site is Spitak based on the existing infrastructure and enthusiasm of the doctor regarding this new technology. The primary implementation team, composed of the application software lead and a project head from within the AECP will train the clinicians on system use. This training is not a set of entirely new procedures. For example: we recommend that the nurses continue to act as scribes during patient examinations. Based on previous implementations of OpenEMR and similar systems, we expect this training will take somewhere between a few days and a full week (OpenEMR, 2017;

OpenMRS Inc., 2016). During this training time the Spitak nurses and doctors should become familiar with the operation of the system and its benefit to their clinic. As a part of this first site's training we recommend that no scheduled patient visits occur during the first one to two days of training, and that staff familiarize themselves with the use of the system through digitizing some of the current paper records, starting with open cases. This is practical in two ways, as there are no patients needing treatment during this task, and partial digitization is something which will need to happen during implementation. Once all open cases have been digitized, over time the clinicians should continue with the remaining paper records, from most recent to oldest records. After these first one to two days, the clinic should reopen with fewer scheduled patients than normal, as the clinicians may need extra time to use the system in practice. As the clinicians become more familiar with the system they will have the opportunity to give direct feedback to the application software lead regarding the usability of the system and any changes they would like to see incorporated. At the end of the training period, when the application software lead has left the clinic, we recommend providing at least a week during which the Spitak clinicians can formally submit feedback to the application software lead, which can then assimilate the feedback into the system. Once all feedback has been incorporated, the EMR should be implemented in the next clinic.

We believe the best method for training subsequent clinics is for previously trained staff already familiar with the EMR system to train the next group. In most situations professionals are more receptive to change when it is presented by their peers, so a nurse training another nurse will result in a higher chance of satisfaction with EMR use and better adoption of the system overall than a member of the administration conducting the training. We recommend Ijevan to be the next clinic trained in EMR use. All nurses and doctors at the Ijevan REC should travel to Spitak and spend between 3 to 5 days receiving live training on the EMR. This training will start as observations, as early as the second day, the Ijevan clinicians will have the chance to complete patient records with the EMR with the guidance of the Spitak clinicians. Once they are confident with the system, the Ijevan staff will return to their clinic and begin using the EMR with a reduced patient load for the first few days while they become fully comfortable with the system, and transfer their paper records into the system. The Ijevan REC will also have the opportunity to submit feedback to the application software lead as they begin using the EMR in the clinic.

This process will continue with the Kapan REC and other future clinics, as well as the subspecialty clinics around Yerevan and possibly the Malayan Ophthalmological Center. The clinic that oversees the training will be selected based on proficiency with the EMR as well as proximity to the new clinic. Prior to beginning training at a new site, the AECP should designate a champion staff member to help his or her peers adjust to the system (OpenEMR, 2014). This does not necessarily need to be the most senior staff member present, or even the most technologically savvy, but this individual must be enthusiastic about the adoption of the EMR and helping his or her colleagues transition to the new system. Ultimately, this person and others like them should be relied upon to instill fundamental change in the mindset of employees and encourage the new practices we are recommending as a way to provide better patient care and fulfill the AECP's operational goals.

When training is complete, we anticipate a period of one to two months during which all implementation locations report a substantial number of problems, concerns, suggestions, and other feedback. The application software lead should therefore be available on at least a part-time basis to address these issues and makes modifications as necessary. If there are any features that were not fully incorporated in either the initial development phase or the gap weeks between training, they should be completed during this time.

Post-Implementation Support and Maintenance

Following the feedback and modification period, the EMR should be fully functional with all features and capabilities complete and all staff fully trained. At this point, the application software lead's main responsibilities will be concluded, and he or she will only need to keep the system updated and handle bug fixes. As the AECP's experience with the EMR progresses or new needs arise, the application software lead may be asked to return and implement new changes which may vary in their complexity and impact. This is already the role of the developer of the ROP database, and we recommend that the AECP continue to use this model after the EMR is implemented.

While the application software lead maintains the EMR software, the server network itself will need to be managed by IT staff. This responsibility can be divided between AECP-contracted technicians and local IT personnel employed directly by the hospitals at the discretion of the AECP's contractors, since they will be more familiar with the system and architecture. This work can include keeping the servers' operating systems up to date, ensuring that the hardware continues to function properly, and replacing aging Internet infrastructure such as routers. Additionally, IT staff can expect to assist medical personnel with the new workstations, resolve issues with data feeds from medical equipment, and help doctors use the Polycom systems. These last areas may eventually be covered by medical staff as they become more familiar with the equipment they are using and learn from the technicians' troubleshooting, but it is worth reiterating that only qualified personnel should be allowed to interact with the servers.

5.2 Teleconsultation Plan

Based on our findings, we developed a recommendation and corresponding implementation plan for the AECP to use to move forward with a structured teleconsultation system. This recommendation includes the use of a teleconsultation procedure with a network of contacts available to all the AECP doctors, as well as a multi-location Polycom network. The implementation plan includes a cost breakdown to highlight different Polycom system implementation options, and a staff training protocol to help facilitate the use of these systems.

Our teleconsultation deliverables include the following:

- Installing and testing the Polycom Systems that the AECP currently has access to
- A comprehensive Teleconsultation Guide (Appendix V) that includes:
- An Installation Guide for use in future clinics
- A User Manual for the Polycom System
- An Escalation Protocol in the form of a decision tree
- A list of all AECP doctors, their locations, and their specialties
- A form email (Appendix T) which the AECP can use to reach out to ophthalmologists with connections to the AECP in order to add them to the teleconsultation network
- A set of use cases (Appendix M and O) detailing the current operations of the AECP's teleconsultation system, and the future operations of the system after our recommendations are implemented
- A sample cost breakdown of other system models to purchase to connect future clinics to the network
- A suggestion for areas of future research to enhance the system and associated framework

5.2.1 Teleconsultation Recommendation

Our recommendations for teleconsultation fall into two categories. We suggest that the AECP:

- Purchase and install Polycom systems for each clinic to support teleconsultation
- Utilize a structured protocol and network for specialized consultation

A Polycom system is far more effective than a phone call at helping doctors consult effectively because of its many features. The high-definition camera has an impressive zoom feature and can pan around the room to focus on patients, doctors, machines, or anything else that users deem relevant for the particular case. In addition, the Polycom System can utilize a screen sharing method and various device inputs to provide more information. For example, the Polycom System can connect directly to the slit lamp in the examination room and the surgical microscope in the operating room. This real-time connection will help provide specialists with better information about the case, and will help them make better recommendations when consulting with a doctor on diagnoses.

We developed a Teleconsultation Guide (Appendix V), which we recommend the AECP adopt in tandem with providing access to Polycom systems in all of their clinics. The Teleconsultation Guide will have extensive information on implementing and using the technology as well as on contacting the appropriate providers for a particular case. Using this resource as a guide to utilizing the Polycom technology will result in more productive calls with less waste.

The first topic covered in the Teleconsultation Guide is a basic Installation Guide for a Polycom System (Appendix W). The goal of the Installation Guide is to assist the AECP's IT personnel or technical staff with installing a new system in other facilities as necessary. The guide needs to be concise enough that the System can be set up quickly and efficiently, but detailed enough that the IT personnel are not left guessing at what steps to take during installation. In short, the guide covers:

- The required items for proper installation
- The Polycom System Box Input/Output (IO) Panel layout
- Basic hardware installation instructions
- Basic software walkthrough
- Basic system testing
- Troubleshooting

The second topic in the Teleconsultation Guide is a basic User Manual for a Polycom System (Appendix X). The goal of the User Manual is to assist the AECP's medical staff with placing and receiving calls using a Polycom System. The manual must be easy to read and understand so that the medical staff are aided by this system and not distracted by focusing on getting it to work. To this end, the manual covers:

- The Polycom System Remote layout
- How to turn the Polycom System on for use
- How to place a call from the Polycom System
- How to receive a call on the Polycom System
- Basic Troubleshooting

Another important aspect of teleconsultation is the network of providers, and the logic behind which provider to contact in a given situation. Optimizing this workflow will lead to better patient outcomes and less time being wasted by doctors on unproductive consultations. A diagram known as the Escalation Protocol (Figure 26) was created to help the doctors determine what sequence of teleconsultation to follow and is the third topic in the Teleconsultation Guide. It is, in essence, a decision tree that starts at the red decision diamond and ends at one of the blue outcome boxes. A more detailed explanation of the protocol is in Appendix R.

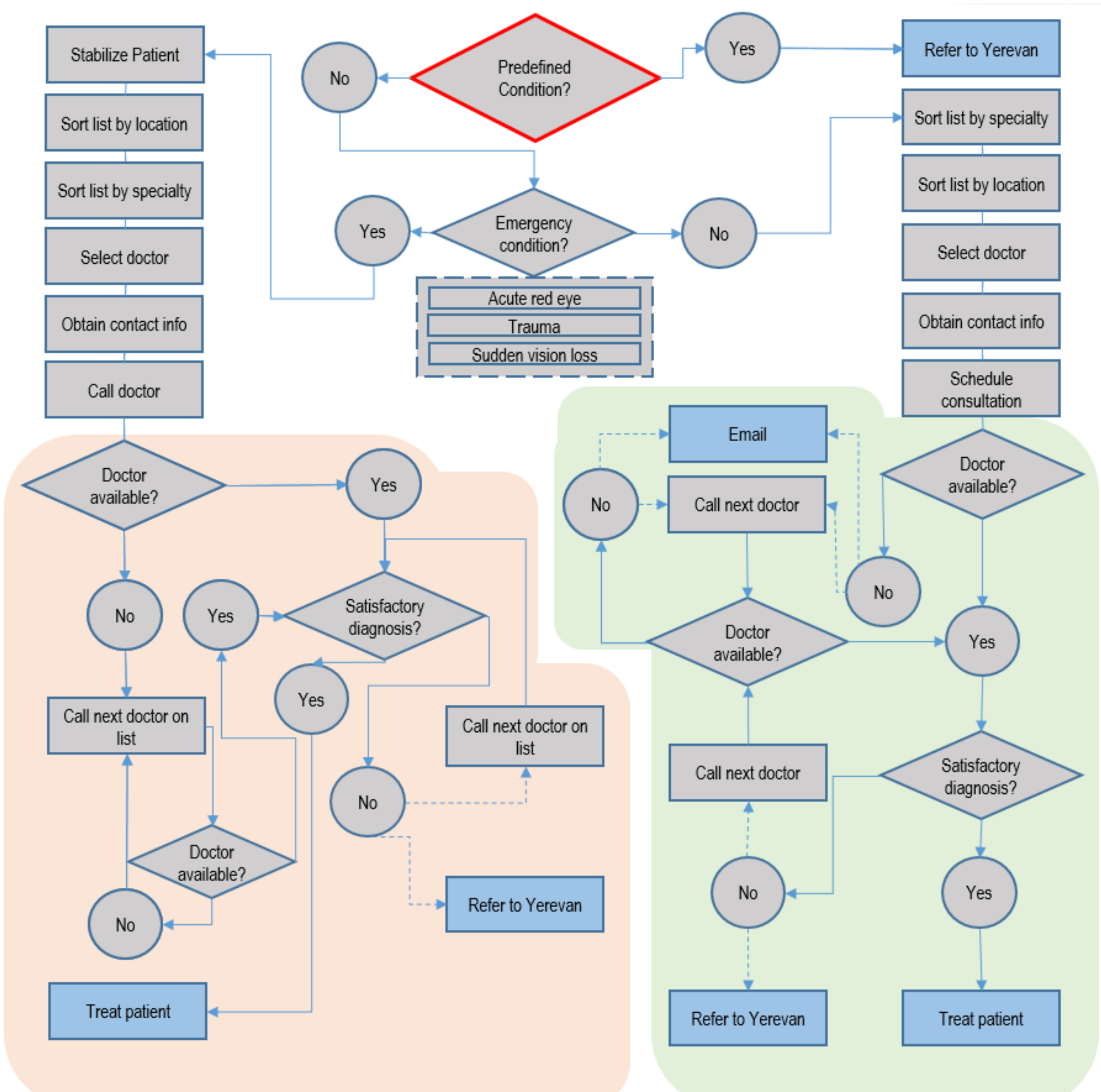


Figure 26: Escalation Protocol

Besides the Escalation Protocol, we also created an ophthalmologist database (Appendix S). We obtained the names, locations and specialties of each of the AECP's doctors both in Armenia and around the world through the AECP website. Dr. Yeghiazaryan reviewed this document as well, to confirm the information and provide new insight. This document is kept in a Google Drive, and will be made accessible to the AECP's doctors as part of the implementation. Because it is cloud-based, anyone can update it with new entries and information. To go along with this database, we drafted a letter of consent for other doctors' information to be stored in that database as well (Appendix T). Because many of the AECP doctors have completed fellowships or other education around the world, they each have broad professional networks. Ideally the doctors will reach out to their personal networks and introduce the concept of teleconsultation, then send the letter to their contact. This should grow the network while ensuring its members are invested in the AECP and able to provide high-quality consultation.

5.2.2 Teleconsultation Implementation

The first step of implementation is to ensure that all necessary systems are installed and working. This is already the case in the Spitak REC and the Center of Excellence, but new centers will not necessarily have the Polycom systems installed and operational. To aid in the implementation of these systems at new sites, we have developed a list of general specifications for a Polycom system that provides details on both a basic and advanced system that fit these specifications. The specifications are:

- Architecture for audio and video communication input - this is generally filled by the ability to connect a microphone and camera via standard audio/video ports (VGA, DVI, HDMI, etc.)
- Architecture for audio and video communication output - this is generally filled by the ability to connect to a TV Screen/Monitor and a speaker via standard audio/video ports (VGA, DVI, HDMI, etc.)
- Architecture for internet connectivity - this is generally filled by wired or wireless connectivity with a router via standard LAN/Ethernet ports
- Architecture for various device connectivity - this is generally filled by wired or wireless connectivity with the device via standard video ports (VGA, DVI, HDMI)

To meet these specifications, we have detailed a basic and an advanced Polycom system in Table 7 below. The price ranges for these systems are also given in the table and a full data sheet for each is given in Appendices Y and Z.

Table 7: Polycom system comparison

System Name	Polycom HDX 6000-720	Polycom RealPresence Group 700
Audio/Video Input	1x Polycom EagleEye HD Camera Port 1x DVI-I 1x Polycom Microphone Port	2x HDCI 3x HDMI 1.4 1x YPbPr Component 1x Dual RCA Composite 1x VGA 2x Polycom Microphone Ports
Audio/Video Output	1x HDMI	3x HDMI 1.3 3x VGA
Internet Connectivity	IPv4 Support 1x 10/100/1000 Auto NIC (RJ45)	IPv4 and IPv6 Support 2x 10/100/1G Ethernet Switch
Price	~$5000 USD	~$15000-18000 USD
Summary	This is a basic system that can handle one extra device input and only output to one device. It also has standard internet connectivity. This system is cost effective but may be difficult to connect to more than one input device.	This is an advanced system that can handle two cameras and four extra device inputs. It can also output to six different devices. Lastly, it has high speed internet connectivity. This system has a very high price but can connect to multiple input and output devices.

Using either of these Polycom systems, or any system that meets the specifications, will benefit the AECP as detailed previously. We recommend investing in the Polycom RealPresence Group 700 as it is much more capable than the HDX 6000-720. However, because of the large upfront cost, it may necessary for the AECP to use a grant or partner with a hospital to invest in future Polycom systems as new RECs are opened. Due to the many unknown factors related to these future clinics, no official timeline can be set; rather we rely on the AECP's judgement to determine how best to incorporate this technology into future clinics.

Despite the clear benefit to utilizing these systems, the doctors will not take advantage of them unless they fully understand how to properly use them and they are convenient. To bridge this gap, we recommend each doctor and IT professional is provided with a copy of our Teleconsultation Guide. The system will be unfamiliar to the doctors at first, but with the explanations provided in the Teleconsultation Guide they should understand the systems a little better. Based on our conversations with the AECP, we recommend that all calls except emergency ones are scheduled, and we recommend that the Polycom system is utilized for every call possible. To ensure doctors are able to focus only on the conversation with the consulting ophthalmologist, we recommend that an IT professional is in the room with the doctor and the Polycom to operate the system and troubleshoot any situations that may arise for at least the first month of system use. If doctors feel comfortable using the system after this time period, the IT professional can start transitioning out of his or her role and be available only on an as-needed basis for updates to the Polycom system or provider questions.

5.3 Change Management

One of the most significant obstacles of implementing an EMR system and teleconsultation system is convincing the stakeholders that it is a worthwhile investment. Medical professionals are often methodical in their routines, so adding new methods for collecting, storing, and sharing data could bring them out of their comfort zones (Hiatt, Creasy, 2003). As people are taken out of their comfort zones, change management practices must be employed to ease the process.

To improve the transition, we researched methods of change management that could be utilized during implementation. We analyzed the six stages of change management, determined what each stage might look like in terms of staff attitudes and behaviors toward the systems, and provided methods to mitigate the effects of each stage and ease the transition. The stages and descriptions are provided in Table 8 below (Swayne, Duncan, Ginter, 2012).

Table 8: Stages of change management

Stage	Definition	EMR	Teleconsultation
Resistance	Employees actively resist, or occasionally sabotage, the change, hoping that it will not stick	Nurses refuse to use the EMR system, and deliberately use paper records	Doctors continue to contact friends via telephone or email, ignoring the Escalation Protocol and Polycom
		Solution: Staff training provides adequate understanding of how the EMR works and all it does	Solution: Staff training provides adequate understanding of how the teleconsultation system works and technical staff are available to assist doctors

Passiveness	Employees no longer resist but still dislike the change, hoping that it will not stick if they ignore it	Nurses don't use EMR system unless specifically told, choosing paper records instead	Doctors consider using aspects of the Polycom or Escalation Protocol but end up reverting back to unstructured consultation
		Solution: Staff training provides adequate understanding of AECP policy and how the EMR works	Solution: Staff training provides adequate understanding of how the teleconsultation system works and technical staff are available to assist doctors
Convince Me	Some employees are ready to give the change a try, but are skeptical about change actually occurring	A few nurses are ready to try using there system instead of paper records, but are not convinced it will be beneficial	Some doctors consider using the Polycom or escalation protocol, but aren't ready to change their teleconsultation system
		Solution: The benefits are explained explicitly to the nurses to help them understand that the EMR will provide better patient care	Solution: The benefits are explained explicitly to the doctors to help them understand that structured teleconsultation will provide better patient care
Hope	More employees start to see the potential value in the change but still are not convinced it can be implemented	More nurses see the improved efficiency the EMR could provide, but feel overwhelmed by the changeover	More doctors recognize the benefits of structured teleconsultation but feel overwhelmed by the changeover
		Solution: Barriers to implementation are discussed, and a complete implementation plan is provided	Solution: Barriers to implementation are discussed, and a complete implementation plan is provided
Involvement	Most employees realize a change is necessary, and are ready to work through the obstacles	Most nurses and doctors see the EMR as a benefit, and feel prepared to start working through the changeover	Most doctors feel ready to switch to this structured system, and feel ready to begin overcoming some of the obstacles
		Solution: As staff members begin to use the system, they start to understand its benefits	Solution: As staff members begin to use the system, they start to understand its benefits

Advocacy	Employees realize the value of the change and its impact on operations, and get on board	All staff members are excited about switching to the EMR and see its benefits as they implement it	All staff members are excited about switching to a structured teleconsultation system and see its benefits
		Solution: Staff members are so excited about the system that they recruit others	Solution: Staff members are so excited about the system that they recruit others

5.4 Recommendations for Patient Privacy

From our knowledge of Armenian policy regarding the collection, storage, use and sharing of public, biometric and private data, all of which the AECP takes part in, we have the following recommendations. We encourage the AECP to work with the Armenian MOJ or a lawyer with expertise in Armenian medical law and data collection to fully understand the regulations it must meet and the permissions necessary. Because the consequences of failure to follow the government's policies are so severe, this is necessary to ensure uninterrupted clinical operations for the AECP. For general clinical practice we recommend an expanded patient consent process, to ensure patient understanding and trust. Issues which the AECP must be concerned with regarding the technology recommendations are security and limited access of storage, and permissions to send patient information to doctors both domestically and abroad.

The introduction of an EMR system will be beneficial for informing patients and receiving consent for testing procedures and treatment, as well as to gain permission to use their results in clinical outcome or disease analysis. We recommend that the AECP employ a method of getting written consent from the patient regarding the collection, storage, use, and sharing of public, biometric and private data at the start of any visit. The redundancy of getting patient consent each visit will decrease the likelihood of wrongful use of information by the AECP and an increase in patient awareness for how their information is being used. To standardize the process of obtaining patient consent, we recommend the first clinician to interact with the patient during a visit engage in a conversation with the patient about how the data will be collected and stored, what the data will be used for, and how the information will be shared. During this conversation, the clinician should confirm understanding of all information before continuing to the next point. At the end of the conversation the patient will sign the form to indicate both understanding of and agreement to the conditions. During an initial visit this conversation will take longer, but the more times a patient takes part in this conversation, the less time it will take. As an aspect of the patient portal there should be an easy-to-understand version of the patient consent document for the patient's reference. The AECP must also seek the permission of the MOJ before the collection of any private data by submitting the method of collection and storage as well as the purpose for collection and use of the data.

The OpenEMR system meets many international regulations for security, and we recommend that the system undergoes additional encryption by the software developer in accordance with the MOJ as well. The default security protocol includes a password required login for the clinicians to access any patient information. We suggest the AECP requires regular changes to passwords to ensure security of login information. Additionally the laptops which we recommend the clinicians use during the exams must be used only to access the EMR and related clinical systems, and these computers should not be removed from the clinic. In the event a clinic laptop is lost or stolen, all the patient information in the EMR system becomes vulnerable. The AECP staff and clinicians must all be aware of the threat of ransomware, and how to protect against it. Limiting use to anything other than the EMR on the designated laptop is critical, as is conducting regular system backups to protect and save existing records from corruption.

With regard to teleconsultation patient privacy, it is important to determine whether all network doctors live in locations that are approved by the MOJ for sending this private data. To our knowledge, the AECP is in compliance with these restrictions for sending private data, as the majority of the international network of doctors is located in the UK and the US, both of which are approved countries. Despite this, and because we hope to see the AECP network grow, we recommend that the AECP work with the MOJ to ensure permission to send private data out of the country to these locations, and confirm the security of the method for sending this information. The Polycom systems which we are recommending for the AECP network are highly secure because they are a closed system which uses IP addresses for calling. Finally there are additional security precautions the AECP can take by encrypting the servers to which the systems are connected and putting up multiple firewalls.

5.5 Suggestions for Future Work

In order to ensure that our project is sustainable and will stay dynamic to match the changing nature of the AECP, we have a few suggestions for future studies. Some of these could possibly become IQP projects for future students, while others could become projects taken on by either the AECP or other non-governmental organizations.

- Evaluate the feasibility of implementing an online forum or messaging platform to supplement the Polycom teleconsultation system. This could be helpful to the AECP because it will allow for troubleshooting without having to go through an IT specialist. It will also help other organizations install their own Polycom systems (Blunier et al., 2006).

- Integrate a system of email alerts with images into the teleconsultation protocol. This will be incredibly helpful for nonemergency cases because REC doctors will be able to pass all the necessary information off to the best possible doctor to consult without having to worry about availability (Blunier et al., 2006).
- Evaluate the feasibility of spreading teleconsultation to another specialty in each regional hospital. This could be helpful for the residents of the rural area as well as the AECP, because more people will receive more diversified treatment, and the hospital's other departments will help cover some of the costs of purchasing the Polycom systems (Vassallo et al., 2001).

5.6 Conclusion

The recommendations we developed are aimed at helping the AECP improve patient data storage and sharing to provide better patient care. The EMR system allows patients to be seen in a holistic view for doctors to provide better care. The cloud-based nature of the system enables all doctors in the AECP's network to use patient data for smoother referrals and consultations, and the automatic compilation of data allows for a greater depth of analysis of patient outcomes and clinical performance. Finally, the patient portal gives patients access to their data and treatment plan, allowing the patient to be more informed of and involved in their care.

Restructuring teleconsultation reduces the strain on patients by increasing quality of care available at the regional clinics, making referrals less common and necessary. The video sharing capabilities of the Polycom systems allows specialists to have a better understanding of the case, as they can interact with the doctor directly, and see the patient. The escalation protocol increases the network of specialists available, and meaningfully streamlines the process of selecting a specialist, making it more efficient and effective. We hope the implementation plans we developed regarding these recommendations are effective, and that the AECP is able to provide better patient care as a result.

Appendix A: Sponsor Description

Founded in 1992, the mission of the Armenian Eye Care Project, or AECP, is to eliminate preventable blindness in Armenia and to make 21st century eye care accessible to every Armenian child and adult (AECP, 2017). The AECP, based in Orange County, California, is classified as a California Nonprofit Public Benefit Corporation. Their funding is largely donated by individuals within the Armenian Diaspora as well as private organizations and philanthropies.

The founder of the AECP, Dr. Roger Ohanesian, is Armenian by ancestry and, when contacted by Armenia's Deputy Minister of Health (seeking doctors to provide medical aid in response to the war, economic hardship and natural disasters facing the country), felt the need to help (AECP, 2017). Dr. Ohanesian spent two weeks on his own treating 300 patients using donated resources, focusing on war casualties and children. Since his first visit, Dr. Ohanesian has returned to Armenia more than 50 times, recruiting doctors internationally as well as training Armenian doctors. All of his efforts culminated in the founding of the AECP.

The AECP's staff consists of the project team in Armenia and the administrative staff based in California, and is governed by a board of directors. The board of directors operates via a traditional nonprofit structure, whereby a group of individuals is tasked with overseeing the organization's activities to ensure the AECP is executing its mission. The staff based in the US is minimal (5 employees) in order to reduce costs; their primary focus is on the marketing and macro-level program design for the AECP. Meanwhile, the staff based in Armenia (16 employees) oversees the medical program activities and operations in Armenia, including the Mobile Eye Hospital (MEH). Under In-Country Director Dr. Nune Yeghiazaryan, the responsibilities of the Armenian staff include fiscal management, medical training and education, research and data collection, program promotion and outreach, and recruitment of medical professionals. Our project team worked primarily with the team in Armenia as they work to implement their permanent Regional Eye Centers (RECs).

While the AECP began their mission with the MEH, they are transitioning to a more permanent delivery model with RECs. The AECP also partners with sub specialty clinics in Yerevan. Each REC is staffed by one to two ophthalmologists, and two to three vision technicians. In addition to these clinic staff members, the AECP has a network of specialists in Armenia and internationally. The AECP has plans to implement three more RECs to serve the more remote parts of the population in order to increase access to care. The existing regional clinics are located in Spitak and Ijevan while the three new centers will be located in Gyumri, Yeghegnadzor, and Kapan, and will be fully functioning facilities with professional personnel, services, and education on eye health care.

Other organizations also do similar work to the AECP. The International Agency for the Prevention of Blindness (IAPB) is "an alliance of civil society organizations, corporations and professional bodies promoting eye health through advocacy, knowledge and partnerships" (IAPB, 2017, p. 1). The IAPB works with the World Health Organization (WHO) and other governmental and non-governmental organizations (NGOs) to reduce preventable sources of blindness and visual impairment. The IAPB is involved in programs in nearly every country in the world, including Armenia. Unfortunately, the AECP and the IAPB do not work together, despite the similar goals of the two organizations; the AECP focuses more on medical treatment, while the IAPB's main goal is to promote education about the causes and treatments of blindness.

The AECP has also worked with a US government agency, the United States Agency for International Development (USAID) to develop a Center of Excellence to treat Retinopathy of Prematurity (ROP) (AECP, 2017). The Center of Excellence, partially funded by USAID, teaches Armenian ophthalmologists how to reverse ROP, a simple procedure which is effective approximately 90% of the time. USAID works with the AECP, providing funding for certain endeavors such as the Center of Excellence, while the AECP provides the ophthalmological expertise.

Appendix B: Definition of an IQP

The motto of Worcester Polytechnic Institute, WPI, is “Lehr und Kunst” which translates to Learning and Skilled Art and is more recently referred to simply as Theory and Practice (WPI, 2017). This motto is evident in all aspects of WPI life but is most notably portrayed by the Interactive and Major Qualifying Projects. While the Major Qualifying Project, or MQP, focuses on in depth topics relating to a student’s major, the Interactive Qualifying Project, or IQP, is much more a culmination of technical skills and social science research. The IQP is unique in engineering education in that it is geared towards project-based learning and provides students an experience regarding the human dimension of technical solutions.

At its core, an IQP is a project undertaken by students of various majors to address scientific, engineering or technological problems in conjunction with social issues in order to develop a cohesive and often sustainable project (WPI, 2017). Many projects deal with challenges to energy, the environment, resource conservation, cultural preservation, and technological policy but there are many projects outside this scope. Projects take place both on and off campus, with project centers ranging from Melbourne, Australia, to Worcester, England. The projects are also either student inspired or sponsored by a company or organization to address challenges in their community or with their clientele. The students themselves spend seven weeks in a preparatory class learning the ins and outs of social science research as well as developing proposals for their projects. They then spend seven to eight weeks on site, executing their project, collecting data and developing solutions for the problem they are addressing.

With all this in mind, our project, sponsored by the Armenian EyeCare Project, or AECP, meets all the qualifications of an IQP, but more importantly, the project is an authentic one, with the potential of great impact. The goal of our project is to improve the data sharing and communication across the whole of the AECP’s network, including the RECs, central subspecialty clinics and specialist abroad. In order to meet our goal, the IQP team will recommend an EMR system, as well as a telemedicine system, and provide implementation plans for both. The recommendation and implementation plan will involve looking at various facets of both systems and exploring technological improvements in order to fully realize solutions to operational gaps in the AECP. This project combines the social science issues of medical data sharing with technological solutions and structures to provide better care to patients and make the AECP’s operations more effective and efficient.

Appendix C: Reliant Medical Group Interview Notes

From April 4, 2017

An interview of Stephen Knox and Sue Booshada, of Reliant Medical Group in Massachusetts, was conducted in order to gather information on best practices in medical clinic structure, communication and telemedicine. After consent was obtained, the discussion topics were summarized in order to provide a base for research. The interview topic summaries are as follows:

The first major topic was the optimized use of staff skill sets. If a medical provider is not working to the top of their certificate then the organization is wasting multiple resources, including time and money. To this end, Reliant has its medical professionals working in groups were specialization determines what provider sees what patient at the given time. To exemplify this, the Worcester MA clinic has three Ophthalmologists supported by three Vision technicians each, and eight Optometrists supported by two Vision technicians each. The Vision technicians handle the less skilled work, like transcribing medical records, while the Ophthalmologists handle operations and the Optometrists handle exams. In this way, the more specialized medical professionals are performing tasks that only they can perform, leaving the more logistical tasks to those who are less specialized.

The second topic, telemedicine and communication, is one that is not very developed by Reliant, however, they provided ideas for ways to improve such systems. In terms of telemedicine itself, Reliant does not use it as it is not billable by insurance and would therefore have zero return for the organization. Despite this, they believe they will need it at some point and are hoping to have it be used in real time, in tandem with their EMR. With regard to communication, they hope to push provider to provider contact via telemedicine systems to help bolster their mostly bottom up approach.

The third and final topic covered in the interview was medical clinic structure. There were several parts to this discussion but the key idea was that centralization of the specialized doctors and the transportation of patients to that central location is a much more efficient and effective way of handling ophthalmological care. To this end, Reliant have satellite clinics in locations throughout northeast region but have only a few centers equipped to handle the more advanced cases. Reliant staff also impressed on us the importance of having patients travel to the advanced centers instead of having the doctors travel. There are lots of wastes associated with transporting the doctors to the patient, and it is not recommended as it is inefficient.

Appendix D: Team Introduction to Regional Eye Clinics

From May 31, 2017

This is a bilingual document which the team used during the initial observations at the Regional Eye Clinics (REC). The purpose of this document was to introduce ourselves and the purpose of our time at the RECs and the AECP in general. We decided to use a written bilingual document at the RECs to help with communication with the doctors. At both the Spitak and Ijevan RECs there was one English speaking doctor with whom we could communicate, but their English was limited. By providing our questions in Armenian the doctor was able to interpret and understand the question before responding to us. This document was translated by Ms. Marina Aghavelyan, a member of the AECP staff at the office located in Yerevan.

We are a team of students from a university in the United States working with the Armenian EyeCare Project to recommend an Electronic Medical Record system and related telemedicine system.
Մենք ունենք մի թիմ բուհերի ուսանողների է Միացյալ Նահանգների հետ աշխատում է Հայկական ակնաբուժության նախագծի խորհուրդ է տալիս էլեկտրոնային բժշկական ռեկորդային համակարգը եւ համապատասխան հեռաբժշկության համակարգ.

Today, we are observing the operations of the clinic to understand the basic procedures and setup of the clinic. While we are here, we would like to know the following:
Այսօր, մենք ականատես ենք հասկանալ, հիմնական կլինիկա գործողությունները եւ ընթացակարգերը կլինիկայում ընդլայնված: Եւ մենք այստեղ, մենք ուզում ենք իմանալ, թե հետեւյալը.

1. Where are medical records stored?

Որտեղ բժշկական գրառումները պահվում:

2. Who writes the medical records?

Ով գրում բժշկական գրառումները.

3. Can we watch an eye exam in progress?

Մենք կարող ենք հետեւել առաջընթացը աչքի քննության:

4. Does the clinic have reliable electricity?

Արդյոք կլինիկան պետք է հուսալի էլեկտրաէներգիա:

5. Does the clinic have computers?

Անում կլինիկայում համակարգիչները:

6. Does the clinic have a fax machine?

Արդյոք կլինիկան ունեն փաքս մեքենա:

7. Does the clinic have a printer?

Արդյոք կլինիկան ունեն տպիչ.

8. Does the clinic have reliable access to internet?

Արդյոք կլինիկան պետք է հուսալի ինտերնետ:

9. Where are medical supplies stored?

Որտեղ բժշկական պարագաներ պահվում:

10. How are medical supplies organized?

Թե ինչպես կարելի է կազմակերպել բժշկական պարագաներ:

Thank you for helping us today!
Շնորհակալություն օգնելու համար մեզ այսօր:

Findings:

At the Spitak clinic we found that the AECP has a full wing of the hospital, with 2 exam rooms and 2 offices, and there is a dedicated room for the AECP in the surgical wing. The clinic services approximately 10 patients per day. The patients are received by a nurse who records their visit in the clinic logbook, and then opens a new case booklet. These case booklets are 25 pages and hold all of the patient's personal and medical information. The nurse keeps the booklet and follows the patient throughout the whole visit, conducting initial measurements, and then acting as a scribe for the doctor during the remainder of the patient's visit. At the end of the visit the case booklet is filed on a shelf in the locked nurse's office. Open cases are left in stacks on one shelf, and closed cases are filed into binders chronologically. The equipment, split between the two exam rooms, was primarily sourced from the US and Japan, and most could output images electronically. The hospital has slow internet and stable electricity. Within the clinic, the AECP has computers and a printer. A fax machine is located elsewhere in the hospital.

At Ijevan we were able to confirm that many findings from Spitak. The designated AECP area in this hospital consists only of one room, a waiting room, and a designated surgical suite. The protocol for processing a patient with respect to the booklets seemed the same, but here booklets are kept on unlocked shelves in the exam room. In the surgical suite we learned the microscope can output video to a network for outside doctors to watch the surgery, although this capability is not often used, as the resident surgeon is typically the one performing the surgery. Similar to Spitak we found internet and reliable electricity, but we received the additional information that the hospital has a back-up generator as well.

Appendix E: Regional Eye Clinic Doctor Interview Protocol of Telemedicine and EMR

From June 9, 2017

An interview of Dr. Haira Sardaryan, an English-speaking AECP doctor at the Spitak REC was conducted in order to gather information on the current teleconsultation and records system. After consent was obtained, the responses were recorded in order to determine the current state of the system. We decided to use a written bilingual document to guide the interview. By being able to read our questions in Armenian, Dr. Sardaryan was able to interpret and understand the questions better before providing a response. This document was translated by Ms. Marina Aghavelyan, a member of the AECP staff at the office located in Yerevan. The interview questions, in English and Armenian, and justification for each are as follows:

1. Have you contacted other doctors for help on a patient case?

Դիմե՞լ եք այլ բժիշկների օգնությանը որեւէ հիվանդի/կլինիկական դեպքի քննարկման համար:

2. If you have not contacted other doctors for help, why have you not?

Եթե չեք դիմել այլ բժիշկների օգնությանը, ապա ի՞նչ պատճառով:

3. How do you communicate with doctors at the other regional center or the MEH?

Ինչպե՞ս եք հաղորդակցվում (կապվում) այլ տարածաշրջանային կենտրոնի կամ Աչքի շարժական հիվանդանոցի բժիշկների հետ:

4. How often do you communicate with doctors at the other regional center or the MEH?

Ինչքա՞ն հաճախ եք հաղորդակցվում (կապվում) այլ տարածաշրջանային կենտրոնի կամ Աչքի շարժական հիվանդանոցի բժիշկների հետ:

5. How do you communicate with doctors at the Malayan Ophthalmological Center in Yerevan?

Ինչպե՞ս եք հաղորդակցվում (կապվում) Երեւանի Մալայանի ականբուժական կենտրոնի բժիշկների հետ:

6. How often do you communicate with doctors at the Malayan Ophthalmological Center in Yerevan?

Ինչքա՞ն հաճախ եք հաղորդակցվում (կապվում) Երեւանի Մալայանի ականբուժական կենտրոնի բժիշկների հետ:

7. How do you communicate with doctors around the world?
Ինչպե՞ս եք հաղորդակցվում (կապվում) այլ երկրներում աշխատող բժիշկների հետ:

8. How often do you communicate with doctors around the world?
Ինչքա՞ն հաճախ եք հաղորդակցվում (կապվում) այլ երկրներում աշխատող բժիշկների հետ:

9. Does the method of communication with other doctors always work?
Այլ բժիշկների հետ հաղորդակցման (կապի) ներկա մեթոդը միշտ հուսալի՞ է եւ աշխատու՞մ:

10. What type of information is normally exchanged between doctors?
Առօրյայում ի՞նչ տեսակի տեղեկատվություն է փոխանակվում բժիշկների միջեւ:

11. Is there a specific communication schedule?
Կա՞ արդյոք հաղորդակցման հատուկ ժամանակացույց:

12. How quickly do you receive a response from other doctors after you contact them?
Ինչքա՞ն շուտ եք ստանում այլ բժիշկներից պատասխան (արձագանք) նրանց հետ կապվելուց հետո:

13. Would you suggest any changes to make communication between doctors more effective?
Ունե՞ք առաջարկներ, որպեսզի բժիշկների միջեւ հաղորդակցումը դարցնել առավել արդյունավետ:

EMR Follow-Up

1. We have looked through your patient cards. Is there anything that should be added or taken off?
   Մենք ուսումնասիրել ենք Ձեր հիվանդների բժշկական քարտերը: Կա՞ արդյոք որեւէ բան, որ պետք ավելացնել կամ հեռացնել այնտեղից:

2. Would you prefer to have a personal computer that can move with you as needed, or would you prefer to have a separate computer at each station or machine?
   Դուք կնախընտրեիք ունենալ անձնակա՞ն համակարգիչ, որը կարելի է տեղափոխել անհրաժեշտության դեպքում, թե առանձի՞ն համակարգիչ, որը կկցվի յուրաքանչյուր կայանին կամ բժշկական սարքին:

3. How many of your staff speaks Russian?
Ձեր անձնակազմից քանիսն են խոսում ռուսերեն:

Findings:

We found out a lot more information about current teleconsultation and EMR practices from our second Spitak visit. Teleconsultation occurs nearly every day at the Spitak clinic and occurs via phone call. Teleconsultation with international doctors is done a few times per month through email. Communication occurs mostly with Dr. Sardaryan's friends from her professional ophthalmological network, especially with her mentor in Yerevan. Currently communication is reliable but unscheduled, and the only information that is passed to the consulting doctor is typically surgical information. Response rates are typically high; she often hears back from Yerevan physicians immediately, and most international queries are addressed within 24 hours. Images and charts are not shared during the current practice of teleconsultation.

Referrals to the Malayan Ophthalmological Center occur for between zero and three patients each day. This includes anyone with absolute glaucoma, diabetic retinopathy, or vitreous hemorrhage; three conditions Dr. Sardaryan is unable to treat at her clinic. Dr. Sardaryan talks to the doctors at Malayan then gives each patient his or her paper chart to carry with them for the consultation.

Finally, we were also able to see the Spitak clinic's Polycom system which we had been told was "broken". It consisted of a system box, a camera, a microphone, and a remote. We took photos of the system and also documented the model number so we could find out more information about it from the vendor website.

Appendix F: Dr. John Hovanesian Interview Protocol and Findings

From June 5, 2017

An interview of Dr. John Hovanesian, an AECP doctor in California, was conducted in order to gather information on best practices in Electronic Medical Records systems. After consent was obtained, the responses were recorded in order to determine the current state of the system. We decided to use a list of priorities of the AECP as well as some of our own questions to guide the interview. The interview questions are as follows:

Dr. John Hovanesian is a board certified ophthalmologist and a leader in the fields of corneal, cataract, refractive and laser surgery. He works with Harvard Eye Associates in California, and is within the AECP's network of overseas specialists. We lead this as an informal interview over Skype. Prior to the interview we sent Dr. Hovanesian a list of priorities given to us by the AECP regarding EMR to provide context:

- It would be helpful to have a system in Armenian, or compatible with translation, as the doctors and nurses work in Armenian.
- The EMR system needs to be cloud-based to allow doctors to interact with patient records on a global level.
- The EMR system needs to be either specialized for ophthalmology or address ophthalmology-specific needs within the larger system.
- The AECP needs a low cost system, as it is a non-profit organization.
- The system should be user-friendly and easy-to-learn, since many of the nurses and doctors won't have worked with an online patient record system before.
- The AECP is planning to work with local IT professionals, so it is important to understand how this will impact EMR options.
- Compatibility with the imaging machines would be beneficial so that images can be uploaded directly from machines to electronic patient records.
- The AECP is considering compatibility with broader EMR systems as the Armenian government is working on implementation of a universal EMR, but this will not be in place for quite a few more years.
- The AECP would like to explore the use of a patient portal, so that patients can view diagnosis, treatment, and prescription information on their own. Perhaps something like MDbackline?

The IQP project team also provided a small list of guiding questions, to prepare him for the subject of the call:

1. Based on the AECP's priorities, are there any EMR systems that you recommend we look into?
2. If systems have similar or identical capabilities, how do you differentiate between the systems?
3. Are there any systems that are tailored specifically for non-profit organizations?
4. What tends to be some of the biggest hurdles for implementation of EMR systems?
5. To what degree can different EMRs interact with each other? Can they output data in a format than can be read by another?
6. How modifiable do EMR systems tend to be? Could the AECP contract an IT firm to translate it or add/change functionality?

Findings:

The major features and requirements in our situation are to be able to quickly record and retrieve exam information, to create patient specific templates based on need, diabetes and diabetic retinopathy information records, SOAP notes, and translation. Typical features which Dr. Hovanesian predicts will have less importance are billing and insurance, as well as less stringent patient privacy than in the US. We also learned that intercommunication with the EMR as well as patient follow-up systems are good for doctor-to-doctor cooperation.

Dr. Hovanesian, as he got involved with the AECP, understood the nature of their funding, and recommended that we prioritize a system which can allow the AECP to track and analyze patient demographics, as well as analyze outcomes within their clinics. To do this would enable the AECP to offer greater research to apply for more funding and grants. With this, being able to update the EMR is a must-have feature, to incorporate new research modules. We were recommended to research what other large non-profit hospitals have used as a records keeping system. We should investigate their solutions in terms of cloud based versus local servers, and determine what makes the most sense given current structure of the AECP.

Finally Dr. Hovanesian gave the IQP team some valuable insight, recommending that we explore general EMR options which have an ophthalmology module, instead of simply focusing on eye care. We must investigate the adaptability of these systems to eye care in Armenia, which includes language requirements. We were left with the instructions that doctors must be convinced of the system, most doctors resist EMRs because they find it frustrating, but if we can alleviate the causes of frustration and make it user-friendly, an EMR is a good option for the AECP.

Appendix G: Mr. Sean West Interview Protocol and Findings

From June 5, 2017

An interview of Mr. Sean West, the current CEO of MDbackline, a patient portal service, was conducted via Skype in order learn more about EMR system. After consent was obtained, the responses were recorded in order to determine the current state of the system. We sent the following lists of questions in advance of the call to prepare Mr. West for the call and make best use of his time. During the interview we took notes, and have summarized the findings below.

In order to recommend a system to meet their needs, the AECP has given us a list of priorities for the EMR system in order from highest to lowest priority:

- It would be helpful to have a system in Armenian, or compatible with translation, as the doctors and nurses work in Armenian.
- The EMR system needs to be cloud-based to allow doctors to interact with patient records on a global level.
- The EMR system needs to be either specialized for ophthalmology or address ophthalmology-specific needs within the larger system.
- The AECP needs a low cost system, as it is a non-profit organization.
- The system should be user-friendly and easy-to-learn, since many of the nurses and doctors won't have worked with an online patient record system before.
- The AECP is planning to work with local IT professionals, so it is important to understand how this will impact EMR options.
- Compatibility with the imaging machines would be beneficial so that images can be uploaded directly from machines to electronic patient records.
- The AECP is considering compatibility with broader EMR systems as the Armenian government is working on implementation of a universal EMR, but this will not be in place for quite a few more years.
- The AECP would like to explore the use of a patient portal, so that patients can view diagnosis, treatment, and prescription information on their own. Perhaps something like MDbackline?

In addition to discussing these points, we have the following specific questions for you:

1. How familiar are you with open source EMR options? What are your thoughts on these? OpenEMR, OpenMRS, OpenEyes, IQ Care (primarily in developing countries)

2. How can you differentiate the quality of a function between EMRs?
3. For example, if two EMRs do the same thing, how can we tell which does it better?
4. What would you consider the necessary functions of an EMR?
5. What functions would you consider unnecessary for an organization such as the AECP?
6. We are looking into the potential use of localized servers as a redundancy against loss of internet.
    a. In your experience, does this approach place too much of a logistical burden on implementers compared to third-party hosting?
7. How would you compare the building-block-style (module) implementation of the previously mentioned open-source options with developing a tailor-made system from scratch?
8. We are worried about offline accessibility, for instance a user accessing a local database server over the local network without internet access. Do you have any insights into potential solutions?

Findings:

While Mr. West has an overall positive view of open source EMRs, one of the points highlighted was the importance of partnering with the IT staff during the entire process. Because of the critical role they play in implementing and sustaining the final system, their perspective and concerns ought to be taken very seriously. Ultimately, much depends on the relationship between the various parties involved, and it is critical to ensure that everyone shares the same goal and is part of the solution.

We were also encouraged to consider the total cost of ownership in the real world, as opposed to a theoretical calculation taken from advertised values. This includes analyzing all of the secondary costs and their implications, because any system will require supporting architecture, training, and support. To accurately gauge how these costs tend to play out, we were advised to research previous implementations of open source EMRs in various contexts. When looking at OpenEMR, for instance, it was important to identify factors such as the specific site was it, what the experience of that implementation was, whether or not it is still in use, and to talk to current or former users if possible.

This method of analysis also applies to individual features. Mr. West used built-in pharmaceutical requests as example: to begin with, was the feature actually helpful or was it merely a distraction? Particularly with features that are designed to transfer data outside of the system, it is important to consider what other platforms will be interacted with and how this can affect performance.

Mr. West also stressed the importance of recommending an EMR that is pliable enough to enhance the provider's workflow and works for the doctor, as opposed to being so rigid that the doctor must accommodate the system. A common feature for accomplishing this is the ability to create and modify form templates, especially to maximize user friendliness and streamline workflow.

Lastly, we asked for his input on our idea of using a network of localized servers to host the EMR, and he explained that this was indeed a common practice to improve performance and redundancy. Oftentimes a practice will use a hybrid model that includes local servers acting as primaries while keeping a more powerful central server in support or as a backup.

Appendix H: Ms. Arpy Vanyan Interview Protocol and Findings

From June 13, 2017

Ms. Arpy Vanyan is a software engineer and single-handedly developed the AECP's database for retinopathy of prematurity. Aside from this work, she is the daughter of an AECP staff member and has significant experience with the organization. Not only was she our primary technical source for what is feasible for the AECP, but she will most likely be tasked with implementing our recommended EMR, so her input was enormously valuable to us. All responses were recorded and used with consent. Questions used during the interview are below, followed by our formalized findings.

Non-technical questions

- How long did it take you to develop this system from scratch?
- How many people do you need to develop such a system?
- How did you figure out what should go into the system?
- Do you have experience modifying open-source programs? What is the difficulty of this?
- How easily could the current EMR be expanded to include the rest of the AECP's system?
- What is the system's user capacity in terms of doctors? Patients?
- Is there any sort of EMR messaging, or email integration?
- Was this system designed with any national or international standards in mind?
- What security precautions have you made to ensure patient safety and security?
- Is there a backup plan in case of loss of internet?
- How does troubleshooting work? If there's a problem with the system, are you and your company able to take care of it?

Technical questions

- What languages were used to make this system? Would it be possible to interface with JavaScript API or other REST APIs?
- Where are the servers for this system located? How many servers are there?
- Would we be able to see the source code?
- Would it be possible to upload images into the EMR directly from any of the machines?

Ideas testing:

- To add an extra layer of redundancy and allow the patient database to be accessed in the event of an internet outage, how feasible do you think such a system of satellite servers would be, and what complications would you expect?
- While the EMR options we're looking at are web-based, we'd like to know if there's a potential way for an EMR user to access a local server over the local area network or by Ethernet cable without internet access.
- Can you access by LAN?
- Do you know anything the national medical records system the government has been working on? Do you think it would be feasible to be able to communicate with it and upload data to it?
- Do you think it would be feasible to interface closely with messaging and videoconferencing software such as Polycom or others?

Findings:

We learned that the ROP database took about three months to develop, with Ms. Vanyan working by herself. The content of the system was discussed with AECP staff, and she used the existing paper record booklet as a template for the digital forms. While she and her company have not worked with open source software yet, they are familiar with the concept and some open source systems. She is also familiar with GitHub, where many modules for various open source EMRs are kept.

As one of the initial options we researched, the ROP database could be expanded to include the AECP's other work beyond retinopathy of prematurity. Such an expansion was originally planned for, but Ms. Vanyan indicated that this could prove costly in terms of time and money. From a software perspective, there is no limit to the number of possible end users, be they doctors or patients, but any significant increase would require additional storage space for more data and processing capacity to handle the increased traffic. There is currently no integrated messaging feature in the ROP database, though we were told that there were plans to add this functionality in the near future in the form of a chat room.

The ROP database was not designed with any national or international standards in mind, and while it is protected by passwords, firewalls, and other basic safety protocols, Ms. Vanyan acknowledged that there was room for improvement. There is no contingency in the case of loss of Internet, so staff using the system have no recourse in that event. When minor problems arise, she performs troubleshooting and maintenance at no charge, though if a problem were to require significant time and energy, she would ask for a small fee.

From a technical standpoint, the system is written in JavaScript and works with REST API. The host server is located in Canada, but the source code remains the AECP's property and is readily accessible. Images generated from the medical equipment are uploaded manually since Ms. Vanyan and the IT staff could not find a way to do accomplish this automatically, though it remains theoretically possible.

We took the opportunity to test some of our ideas with Ms. Vanyan. She indicated that while a network of local synchronized servers was possible, there needed to be someone to physically manage them and this is why a third-party hosting service was used. In the event of an Internet outage, local caching of the system could be implemented, and local servers could be accessed over the local area network even without Internet access. While Ms. Vanyan was aware of the medical record system being worked on by the government, she was not familiar with the project in depth. She did say, however, that as long as she had access to the other system's API there should be no problem with interoperability between the two systems. Lastly, we were interested in the possibility of having the final EMR interface with video conferencing software such as Polycom, and Ms. Vanyan seemed to think that this was in fact possible.

Ms. Vanyan finished by noting some of the feedback that ultimately made its way into the ROP database. First and foremost was the elimination of the requirement to fill in all available spaces. While there were concerns that this would lead to incomplete data, doctors pointed out that much of the information was only pertinent to certain cases, and that having staff members at the RECs fill in everything regardless of the relevance was a waste of time. An example of this would be cases in which symptoms arise in one eye but not the other, yet the information for both eyes needed to be filled in. Another requested feature was the consolidation of related or pertinent information in nested object structures to logically group information. The ROP database was also designed to include a data entry form that is identical to a printed one, and it would be a simple matter to make the digital version printable directly from the system.

Appendix I: Dr. Dwayne Baharozian Interview Protocol and Findings

From June 22, 2017
Dr. Dwayne Baharozian is a private practice ophthalmologist based in Westford, MA. He is one of the earliest adopters of electronic records systems in medicine and was able to give us some valuable advice on implementing such systems. This interview was conducted over Skype, and all responses were recorded and used with consent. Questions used during the interview are below, followed by our formalized findings.

- We've been looking at open-source systems so far, do you have any particular insight into these?
- What tend to be some of the biggest hurdles for implementation of EMR systems?
- What are factors to consider to make implementation smooth in terms of personnel and technology?
- To what degree can different EMRs interact with each other?

Findings:

While Dr. Baharozian does not use an open source system, he stressed the importance of a program's customizability, even to the point of recommending a generalized but flexible system over an ophthalmology-specific but rigid one. One of the biggest hurdles for implementation is the interfacing between various pieces of equipment, and this is particularly important in ophthalmology where doctors frequently share images of patients' eyes and use them for note-taking. Of even greater importance is the human factor, particularly because doctors have a tendency to think that they know best and resist major change. Convincing the doctors to adopt the system is therefore key, and there are a number of important points to help with this: digital notes aren't hampered by illegible handwriting, data can be accessed from anywhere as opposed to tracking down paper notes, taking notes digitally may be slower than writing them by hand but the time is more than made up for by the increase in organizational efficiency, and lastly, it's simply better medicine.

Other points covered included digital note-taking methods. While some systems feature flashy digital drawing systems, these tend to not be as easy and simple as using paper, and a better approach may be to use annotations overlaid on photographic images of patients' eyes. He also advised that a certain local staff members be tapped to help convert their colleagues to the new system, which often makes EMR adoption much smoother. In his experience, data transfer is done using HL7 as a standard protocol, as that is mandated in the United States. Dr. Baharozian finished by warning us that even free systems incur secondary costs associated with initial implementation of the system, modification, and upkeep.

Appendix J: Dr. Benjamin Suratt Interview Protocol and Findings

From June 22, 2017

An interview was conducted of Dr. Benjamin Suratt, who works in the Pulmonary Disease and Critical Care division of the University Of Vermont Medical Center. He is consulted often by doctors based at smaller hospitals, so we knew he could offer insight into the teleconsultation network he is a part of. An interview was conducted in order to gather information on best practices on teleconsultation systems. After consent was obtained, the responses were recorded in order to determine the current state of the system. We decided to use a list of priorities of the AECP as well as some of our own questions to guide the interview. The interview questions and summarized findings are as follows:

- Have you contacted other doctors for help on a patient case?
- If you have not contacted other doctors for help, why have you not?
- How do you communicate with other doctors?
- How often do you communicate with doctors?
- What type of information is normally exchanged between doctors?
- Is there a specific communication schedule?
- How quickly do you receive a response from other doctors after you contact them?
- How do consulting doctors decide which doctors in particular to contact?
- What is the difference between your emergency teleconsultation protocol and your non-emergency teleconsultation protocol?
- Would you suggest any changes to make communication between doctors more effective?

Findings:

From this interview we have determined three main points regarding teleconsultation. First, doctors communicate in real time via telephone or videoconferencing, as this is the fastest way of communicating data and meaning. These calls can be on an as needed basis, as is the case in emergencies, or scheduled in advance, for the purpose of consultation. Second, information that is exchanged includes patient information, case specifics, and necessary images. All this information is helpful in allowing the consulting doctor to make an informed recommendation. And third, there is a process to determine who receives a call. In the event of an emergency, whoever is on call at the time receives the call. If it is not an emergency case, then nurses triage the call to determine what specialist to forward the case to.

Appendix K: Mr. Gevorg Hakobyan Interview and Findings

From June 16, 2017

*An interview was conducted of Mr. Gevorg Hakobyan, founder of E**law**phant. He is works with businesses who collect and process private data. An interview was conducted in order to gather information on private data processing. After consent was obtained, the responses were recorded. The summarized findings are as follows:*

We met with Armenian lawyer Mr. Gevorg Hakobyan to better understand the matters of patient privacy that are relevant to the AECP. Mr. Hakobyan is the founder of the E**law**phant Law Firm, which specializes in the legal fields of business, labor and IT. From Mr. Hakobyan we learned that private data is anything by which a person can be identified, and anything done with this information is considered private data processing. Private data falls into 4 categories:

- Public - accessible by anyone, and includes name, surname, date of birth and date of death. This is the only type of data for which agreement for collection is not required, and anything an individual makes accessible to the public becomes public information.
- Biometric - physiological characteristics of an individual, such as race and height, including photographs where a person can be individually identified. Agreement from the individual must be obtained as well as notifying the Ministry of Justice (in the case of Armenia) of the intent to collect this information, or the organization can risk large fines and be prevented from future work. Biometric data must be stored securely with limited access
- Special Category - a person's religious, health, political, philosophical information. For this prior agreement from the individual is required in addition to notifying the ministry of intent to collect data. The risk for this is the same as biometric data.
- Personal and Family Life - any information which relates to the person and the family, and requires permission to collect.

If there is a failure to alert the Ministry of Justice about the collection of biometric and special data, the organization risks a fine, and can be prevented from collecting future data or using data already collected. Failure to follow these laws can also be seen as criminal. The Ministry of Justice has published guidelines in Armenian to make it easier for the organizations to notify the ministry about their collection of data.

The organization must also have the individual's permission to collect the data. The safest way to do this is with written consent so that there is a record that permission was given, whereas with verbal consent there is no way to prove consent was given. The individual should be made aware of the purpose of collection, who is responsible for the information and how it will be kept. The individual should also know how to retract this permission. Consent in healthcare may be given by the patient if they are over the age of 18, but in the case of children parents must give consent with the best interest of the child in mind.

The Ministry of Justice in Armenia has a list of countries where private data may be sent or stored in the case of offshore servers. This list includes Russia, most of Europe, and the USA. To send information to countries not on the list written permission from the Ministry of Justice must be given, or the organization risks fines and prevention of using collected data. Once Ministry of Justice grants permission for collection of these types of personal data, the organization must be very careful in the specific procedures surrounding collection. All employees must understand the purpose of data collection as well as the potential risks the organization faces with this collection. Electronic storage and collection of private data must have limited access and password protection, ideally with encryption.

Appendix L: Paper Records Use Case

The purpose of this use case is to detail the general procedure for documenting patient medical information in the paper record booklets currently used by AECP staff. The use case defines the current actors, stakeholders, and triggers, as well as the pre- and post-conditions to give background information for the case. The normal flow of the case is then given, along with any assumptions and exceptions.

Use Case Name:	Paper Records
Description:	Patient data is recorded in 25-page booklet.
Actors:	Doctor, Nurse(s), Patient
Stakeholders:	AECP, Doctor, Nurse(s), Patient, donors
Trigger:	Patient enters clinic.
Pre-condition(s):	Blank patient record booklets are available.
Post-condition(s):	Patient data is recorded and stored.
Normal Flow:	1. Patient enters clinic and waits 2. Nurse gets patient and brings them in 3. Nurse enters patient data into logbook (name, passport, DOB) 4. Nurse selects a blank patient booklet 5. Nurse enters patient information (name, passport, DOB, etc.) in booklet 6. Nurse begins exam with preliminary measurements 7. Nurse enters preliminary measurements in patient booklet 8. Doctor begins examination 9. Doctor verbalizes observations 10. Nurse transcribes doctor's observations and notes in patient booklet 11. Doctor uses imaging device to take images of patient's retina 12. Doctor finishes exam and provides diagnosis 13. Doctor gives prescriptions and follow-up instructions 14. Nurse records diagnosis and prescriptions and/or follow-ups in patient booklet 15. Image is printed and attached to patient booklet 16. Patient booklet is placed on shelf.
Assumptions:	REC has electricity The patient requires prescription(s) (13,14) Images are required for each visit (11,15) The visit does not require follow-up (See E2)
Exceptions:	**E1: Doctor encounters a problem and must consult with another physician remotely.** See teleconsultation use case **E2: Referral is necessary based on one of 3 pre-determined cases** 13. Nurse fills out patient booklet with diagnosis. 14. Doctor calls Malayan or sub-specialty clinic to inform them of referral 15. Doctor gives card to patient to bring to Yerevan

Appendix M: Unstructured Teleconsultation Use Case

The purpose of this use case is to detail the general procedure for provider to provider teleconsultation currently used by AECP staff. The use case defines the current actors, stakeholders, and triggers, as well as the pre- and post-conditions to give background information for the case. The normal flow of the case is then given, along with any assumptions and exceptions. Exception steps replace the normal flow steps of the same number.

Use Case Name:	Teleconsultation Unstructured
Description:	A doctor consults with another doctor about a patient
Actors:	Clinic doctor, referral doctor, patient
Stakeholders:	AECP, clinic doctor, referral doctor, patient, donors
Trigger:	Clinic doctor is unable to figure out how to diagnose or treat a particular patient
Pre-condition(s):	Patient's exam is conducted
Post-condition(s):	Patient receives diagnosis and appropriate treatment
Normal Flow:	1. Clinic Doctor observes unfamiliar condition 2. Clinic Doctor calls Referral Doctor known through personal acquaintance 3. Clinic Doctor informs Referral Doctor on the case 4. Referral Doctor offers opinion 5. Doctors reach decision on diagnosis
Assumptions:	Condition is not one of the three which result in automatic referral
Exceptions:	**E1: Specialist is not available at present time** 2. Clinic Doctor emails Referral Doctor 3. Patient is sent home and follow-up is scheduled 4. Clinic Doctor and Referral Doctor set a time to discuss case 5. Referral Doctor offers opinion 6. Doctors reach decision on diagnosis **E2: Doctor does not know a specialist in this field** 2. Clinic Doctor calls Malayan/subspecialty clinic to make a referral 3. Nurse fills out referral card 4. Patient is sent to Yerevan with their patient booklet and referral card **E3: Diagnosis cannot be made over the phone** 5. Clinic Doctor calls Malayan/subspecialty clinic to make a referral 6. Nurse fills out referral card 7. Patient is sent to Yerevan with their patient booklet and referral card

Appendix N: Generic EMR Use Case

The purpose of this use case is to detail the theoretical procedure for documenting patient medical information in an EMR. The use case defines the actors, stakeholders, and triggers, as well as the pre- and post-conditions to give background information for the case. The normal flow of the case is then given, along with any assumptions and exceptions. Exception steps replace the normal flow steps of the same number.

Use Case Name:	Undetermined EMR
Description:	Patient data is recorded in electronic medical record.
Actors:	Doctor, Nurse(s), Patient
Stakeholders:	AECP, Doctor, Nurse(s), Patient, donors
Trigger:	Patient enters clinic.
Pre-condition(s):	EMR and supporting infrastructure are working properly.
Post-condition(s):	Patient data is recorded and stored.
Normal Flow:	1. Patient enters clinic and waits 2. Nurse gets patient and brings them in 3. Nurse validates patient personal information in EMR 4. Nurse begins exam with preliminary measurements 5. Nurse enters preliminary measurements into EMR 6. Doctor begins examination 7. Doctor verbalizes observations 8. Nurse transcribes doctor's observations and notes in the EMR 9. Doctor uses imaging device to take images of patient's retina 10. Image is automatically uploaded to the EMR and saved 11. Doctor finishes exam and provides diagnosis 12. Doctor gives prescriptions and follow-up instructions 13. Nurse records diagnosis and prescriptions and/or follow-ups in EMR notes
Assumptions:	Patient has an appointment and previously provided background information The patient requires prescription(s) (13,14) Images are required for each visit (11,15) The visit does not require follow-up (See E2) There is power and WiFi within the clinic
Exceptions:	**E1: Power or WiFi outage** 1. See Outage use case **E2: Doctor encounters a problem and must consult with another physician remotely.** See teleconsultation use case **E3: Referral is necessary based on one of 3 pre-determined cases** 13. Nurse fills out EMR with diagnosis. 14. Doctor calls Malayan or sub-specialty clinic to inform them of referral

Appendix O: Structured Teleconsultation Use Case

The purpose of this use case is to detail the general procedure for improved provider to provider teleconsultation for AECP staff. The use case defines the current actors, stakeholders, and triggers, as well as the pre- and post-conditions to give background information for the case. The normal flow of the case is then given, along with any assumptions and exceptions. Exception steps replace the normal flow steps of the same number.

Use Case Name:	Teleconsultation Structured
Description:	A doctor consults with another doctor about a patient
Actors:	Clinic doctor, referral doctor, patient
Stakeholders:	AECP, clinic doctor, referral doctor, patient, donors
Trigger:	Clinic doctor is unable to figure out how to diagnose or treat a particular patient
Pre-condition(s):	Patient's exam is conducted
Post-condition(s):	Patient receives diagnosis and appropriate treatment
Normal Flow:	1. Clinic Doctor observes unfamiliar condition 2. Clinic Doctor asks patient for permission to share information with a Referral Doctor 3. Clinic Doctor selects Referral Doctor through Escalation Protocol 4. Clinic Doctor contacts Referral Doctor via Polycom system 5. Clinic Doctor shares information with Referral Doctor verbally and visually through Polycom system 6. Clinic Doctor and Referral Doctor discuss case and reach diagnosis and treatment plan 7. Clinic Doctor provides treatment to patient
Assumptions:	Condition is not one of the three which result in automatic referral
Exceptions:	**E1: The specialist cannot diagnose or develop a treatment plan for the patient** 6. Another specialist is contacted through the escalation protocol (restart the flow at 3.) **E2: The patient cannot be treated by the clinic doctor** 7. The patient is referred to either the Malayan Hospital, one of the subspecialty clinics, or an ophthalmological center abroad

Appendix P: Network Outage Use Case

The purpose of this use case is to detail the general procedure for AECP staff in the event of a network outage. The use case defines the current actors, stakeholders, and triggers, as well as the pre- and post-conditions to give background information for the case. The normal flow of the case is then given, along with any assumptions and exceptions. Exception steps replace the normal flow steps of the same number.

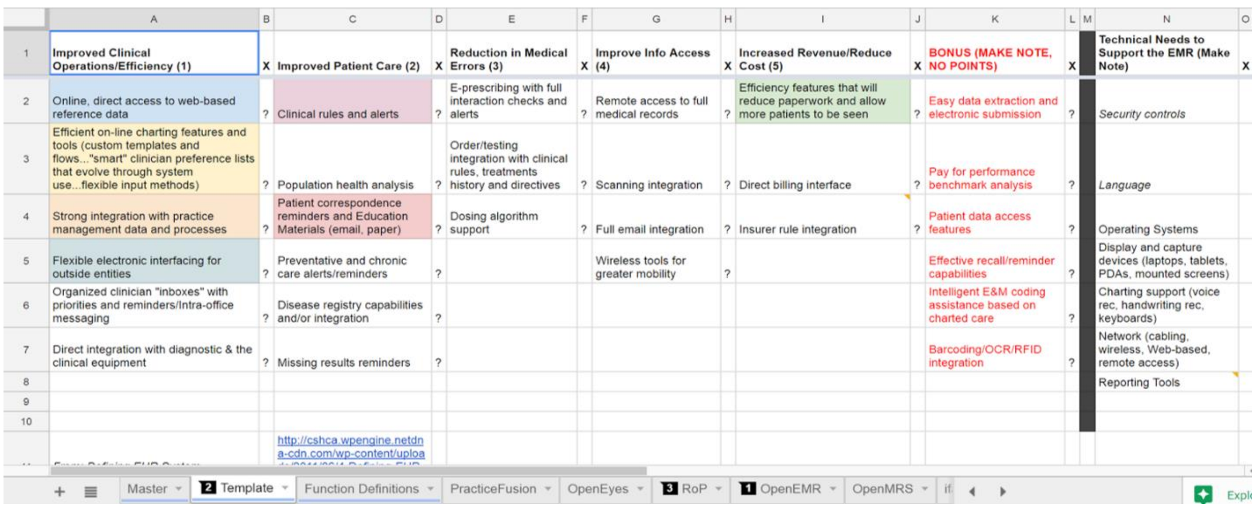
Use Case Name:	Network Outage
Description:	REC has no access to internet due to ISP outage.
Actors:	Doctor, Nurse(s)
Stakeholders:	AECP, Doctor, Nurse(s), Patient, donors
Trigger:	Internet goes down.
Pre-condition(s):	Normal operations with EMR.
Post-condition(s):	Normal operations continue uninterrupted.
Normal Flow:	1. Internet goes down 2. Staff continue to use EMR off of LAN server without interruption. 3. Server does not synchronize with network, and staff work with locally saved versions of records. 4. Internet connection is restored 5. Local server synchronizes data with other servers.
Assumptions:	REC has electricity AECP has a parent-child server network with a local server at each REC. System is configured such that users on local area network access the local server directly, and servers continuously synchronize with each other over Internet.
Exceptions:	**E1: Router fails and staff cannot access local server over LAN.** 1. Router fails 2. Staff revert to backup paper records for duration of fault. 3. Router is restarted, repaired, or replaced. 4. Server access is restored, and staff return to using EMR. 5. Paper records generated during outage are retroactively copied into EMR. **E2: Local server fails but Internet access remains.** 1. Server goes down 2. Staff connect to a different server remotely over Internet. 3. Staff continue to use EMR off of synchronized data. 4. Server is rebooted, or technician arrives to repair. 5. Functionality is restored, and staff revert back to accessing EMR via local server.

Appendix Q: Evaluation Criteria Matrix

This appendix is meant to show how the evaluation criteria matrix (ECM) was used in the analysis of EMR systems, the setup and creation of the ECM is outlined in Chapter 3.

This image shows the format of the ECM template with goals and associated features. The goals are listed in order of decreasing priority from left to right in row 1. In columns K and N, these are additional considerations to be made concerning the EMR, but do not carry any weight in the ECM. Below each goal is the list of associated features, which allow the EMR system to contribute to the achievement of the goal.

For each EMR system that we assessed, we created a new tab. In each tab, to demonstrate the EMR possessing the feature we changed each "?" to either an "X" for yes or "O" for no the EMR does not support the feature. All of the results are then populated into a master list.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	**Improved Clinical Operations/Efficiency (1)**	X	**Improved Patient Care (2)**	X	**Reduction in Medical Errors (3)**	X	**Improve Info Access (4)**	X	**Increased Revenue/Reduce Cost (5)**	X	**BONUS (MAKE NOTE, NO POINTS)**	X		**Technical Needs to Support the EMR (Make Note)**	X
2	Online, direct access to web-based reference data	?	Clinical rules and alerts	?	E-prescribing with full interaction checks and alerts	?	Remote access to full medical records	?	Efficiency features that will reduce paperwork and allow more patients to be seen	?	Easy data extraction and electronic submission	?		*Security controls*	
3	Efficient on-line charting features and tools (custom templates and flows..."smart" clinician preference lists that evolve through system use...flexible input methods)	?	Population health analysis	?	Order/testing integration with clinical rules, treatments history and directives	?	Scanning integration	?	Direct billing interface	?	Pay for performance benchmark analysis	?		*Language*	
4	Strong integration with practice management data and processes	?	Patient correspondence reminders and Education Materials (email, paper)	?	Dosing algorithm support	?	Full email integration	?	Insurer rule integration	?	Patient data access features	?		Operating Systems	
5	Flexible electronic interfacing for outside entities	?	Preventative and chronic care alerts/reminders	?			Wireless tools for greater mobility	?			Effective recall/reminder capabilities	?		Display and capture devices (laptops, tablets, PDAs, mounted screens)	
6	Organized clinician "inboxes" with priorities and reminders/Intra-office messaging	?	Disease registry capabilities and/or integration	?							Intelligent E&M coding assistance based on charted care	?		Charting support (voice rec, handwriting rec, keyboards)	
7	Direct integration with diagnostic & the clinical equipment	?	Missing results reminders	?							Barcoding/OCR/RFID integration	?		Network (cabling, wireless, Web-based, remote access)	
8														Reporting Tools	
9															
10															
			http://cshca.wpengine.netdna-cdn.com/wp-content/uploa												

The master list, pictured below, is a tab with the weighting of each feature (column A) and goal (column A, bold), and is populated by the information in each specific EMR tab. The weight of each goal is calculated by the priority, if there are five goals, then the highest priority goal is weight at 5, and the lowest priority is only 1. The weight of the goal with its associated features is based on the weight of the goal multiplied by the number of associated features and then again by a factor of 10. These points are then distributed to the associated features based on the amount of impact the feature has on the achievement of the goal. This point distribution is shown in column B, where the bold number (cell B2) is the total points allotted to the goal, and the non-bolded numbers below are the weights of the goal's associated features (cells B3-B8). The 1s and 0s to the left of each EMR column are a binary yes or no from the individual EMR tabs, which populates the score of that feature for the EMR.

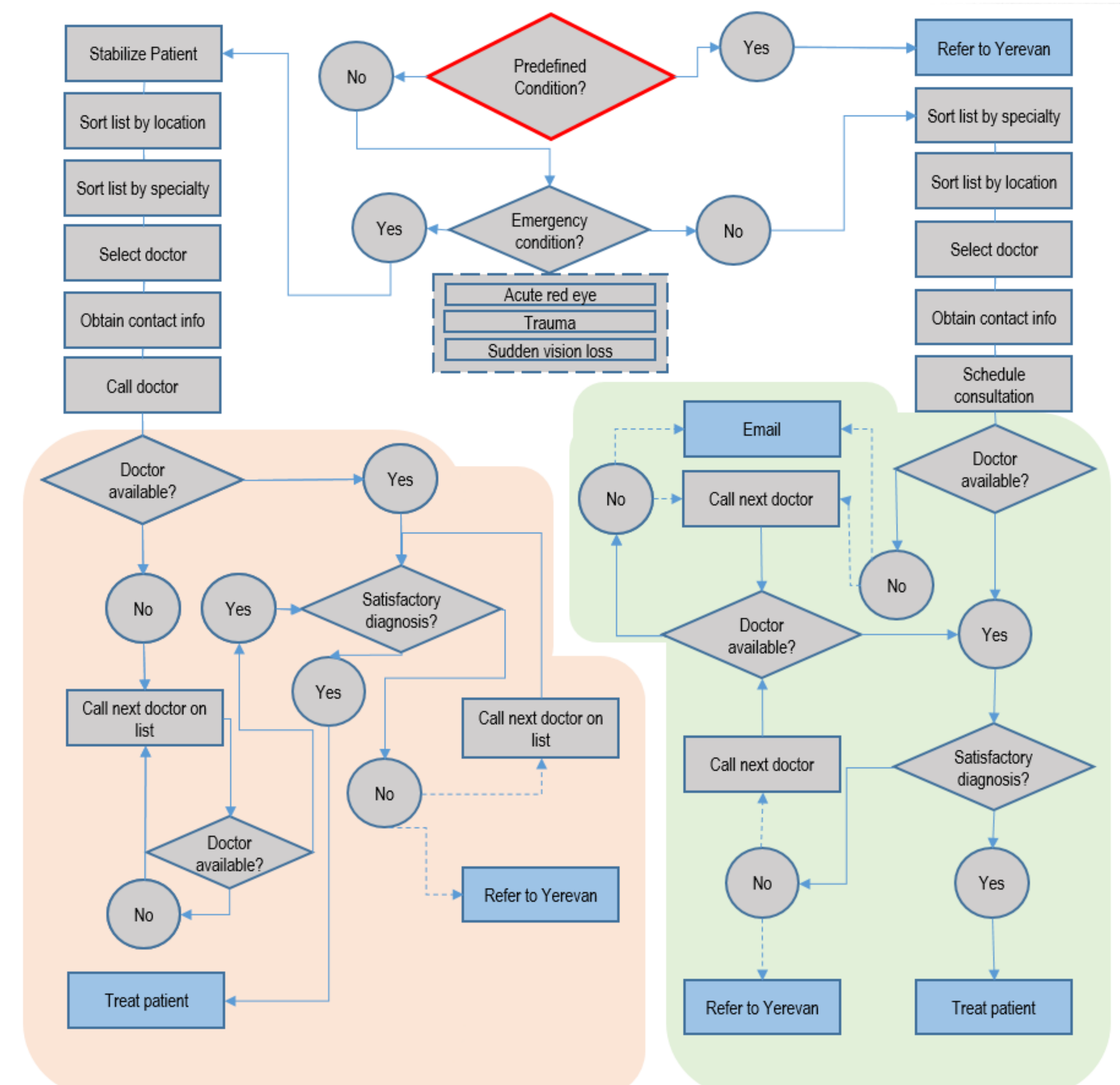
	A	B	C	D	E	F	G	H	I	J
1	Goals and Functions	Full Points (Maximum)		OpenMRS		OpenEMR		OpenEyes		RoP
2	**Improved Clinical Operations/Efficiency (1)**	**300**		**300**		**280**		**300**		**70**
3	Online, direct access to web-based reference data	80	1	80	1	80	1	80	0	0
4	Efficient on-line charting features and tools	70	1	70	1	70	1	70	0	0
5	Strong integration with practice management data and processes	60	1	60	1	60	1	60	0	0
6	Flexible electronic interfacing for outside entities	40	1	40	1	40	1	40	1	40
7	Organized clinician "inboxes" with priorities and reminders/Intra-office messaging	30	1	30	1	30	1	30	1	30
8	Direct integration with diagnostic & the clinical equipment	20	1	20	0	0	1	20	0	0
9	**Improved Patient Care (2)**	**240**		**230**		**240**		**230**		**130**
10	Preventative and chronic care alerts/reminders	70	1	70	1	70	1	70	0	0
11	Population health analysis	60	1	60	1	60	1	60	1	60
12	Disease registry capabilities and/or integration	50	1	50	1	50	1	50	1	50
13	Patient correspondence reminders and Education Materials (email, paper)	30	1	30	1	30	1	30	0	0
14	Clinical rules and alerts	20	1	20	1	20	1	20	1	20
15	Missing results reminders	10	0	0	1	10	0	0	0	0
16	**Reduction in Medical Errors (3)**	**90**		**90**		**90**		**90**		**40**
17	E-prescribing with full interaction checks and alerts	40	1	40	1	40	1	40	1	40
18	Order/testing integration with clinical rules, treatments history and directives	30	1	30	1	30	1	30	0	0
19	Dosing algorithm support	20	1	20	1	20	1	20	0	0
20	**Improve Info Access (4)**	**80**		**80**		**50**		**60**		**80**
21	Remote access to full medical records	30	1	30	1	30	1	30	1	30
22	Scanning integration	20	1	20	1	20	0	0	1	20
23	Full email integration	20	1	20	0	0	1	20	1	20
24	Wireless tools for greater mobility	10	1	10	0	0	1	10	1	10
25	**Increased Revenue/Reduce Cost (5)**	**30**		**20**		**30**		**20**		**10**
26	Efficiency features that will reduce paperwork and allow more patients to be seen	10	1	10	1	10	1	10	1	10
27	Insurer rule integration	10	1	10	1	10	1	10	0	0
28	Direct billing interface	10	0	0	1	10	0	0	0	0
29	**Total**	**740**		**720**		**690**		**700**		**330**
30	**Checks**		**0**		**0**		**0**		**0**	
31	**Percentage**			**97.30**		**93.24**		**94.59**		**44.59**
32										

Master | 2 Template | Function Definitions | PracticeFusion | OpenEyes | 3 RoP | 1 OpenEMR | OpenMRS

The score for each EMR is considered a raw score, and was only used to differentiate between how well the system could fulfill the goals of the AECP. From these scores an EMR could be identified as a good potential system for the AECP, which would then warrant further research on the system to assess feasibility of implementation to the AECP. These feasibility factors are timeline, cost, longevity, system manipulability, etc., and would give further differentiation between the system options.

Appendix R: Escalation Protocol

This is the protocol that will be used by doctors when they determine a need for teleconsultation for a particular case. The start point is indicated by the red diamond, and blue rectangles indicate the end points.



The first section of the protocol determines the track that will be taken. Initially, pre-existing conditions, which are designated by clinic doctors individually as automatic referrals, are removed. Teleconsultation is useless for these automatic referral conditions because clinic doctors have already determined that their clinics do not have the infrastructure or expertise to treat them. Next, cases that are not automatic referral conditions are designated as either emergency conditions or non-emergency conditions. A partial list is found on the Escalation Protocol itself based on an eye emergency manual but the designation is also left to the doctor to determine whether or not the condition is emergent (Sehu, 2009). The dashed lines around the box of automatic referral conditions indicates that it is up to the doctor to use his or her best judgement rather than following the Escalation Protocol exactly. From here, the protocol splits into two tracks: one for emergencies and one for non-emergencies.

The next section of the protocol contains the preliminary actions, which are similar for both tracks and involve a list of ophthalmologists which will be explained later in this section. The non-emergency actions are, in order, sorting the list by specialty then location, selecting a doctor based on the list, obtaining the doctor's contact information, then scheduling a consultation, by the Polycom if possible but otherwise via cell phone. The emergency case has most of the same steps, but they are in a slightly different order. After the patient's condition is determined to require emergency treatment, the doctor stabilizes the patient and then begins the preliminary actions. The provider list is sorted by location, then by specialty; then a doctor is selected with their contact information and called via the Polycom or a cell phone. The distinction in the order of the preliminary actions is due to the differing priorities of the two tracks. Time is less of a constraint for the non-emergency track, so specialized doctors can be contacted with less regard to location; but emergency cases require a consult immediately so sorting by location before specialty helps ensure that a doctor is contacted within the time zone and is thus more likely to answer the phone.

The third section of the protocol is the call decision loops. This is basically the process a doctor goes through to make a satisfactory consultation call resulting in a diagnosis and treatment plan. Each decision is indicated by a diamond with "Yes" and "No" circles coming off it. All the sequences eventually lead to one of three outcomes, which are depicted by blue rectangles. The outcomes are listed below with their desirability:

Outcome	Action	Desirability
Refer to Yerevan	The patient is referred to either the Malayan Ophthalmological Center or one of the AECP’s subspecialty clinics	This is the least desirable option because it can be expensive for the patient to travel to Yerevan, so this is only the outcome when no other option is available
Email	The provider emails the desired specialist to set up a time to consult	This option is better than referral because the patient will not have to travel to the capital city; but the patient also might have to come back to the regional clinic for the teleconsultation process.
Treat patient	The consultation occurs immediately and results in a diagnosis and treatment	This is the best option because it minimizes waste of the clinic doctor’s time, and it is the most cost-effective option for the patient. This increases the doctor’s productivity while remaining practical for the patient.

Appendix S: Provider Contact List

As part of our teleconsultation deliverables, we began to compile a list of AECP specialists and other doctors who are not members of the organization but have made themselves available for consultation. We did not have access to the complete list of physicians and contact information, so this document was provided to the AECP as a template to be updated as more doctors volunteer their time and their contact information is received.

Personal contact information that is not voluntarily made public is protected by the AECP's privacy standards and Armenian privacy law. The preliminary contact list we generated is therefore not included in this document, and any party seeking access to this information should contact the AECP at aecp@aecp.am.

Appendix T: Provider Contact Letter

This letter will be used by doctors to increase the teleconsultation network. AECP ophthalmologists can distribute this letter to their contacts as both an informational document and a consent form for data use and sharing. This will thus expand the provider list in Appendix S and provide even more professionals for doctors to contact.

Dear Dr. ____,

The Armenian EyeCare Project (AECP) is a non-profit organization based in Newport Beach, California, and operating out of Yerevan, Armenia. The mission of this organization is to eliminate preventable blindness in Armenia and make quality eye care accessible to all. We currently operate through a five-point program, made up of direct patient care, medical training and education, public education and awareness, research, and strengthening the eye care delivery infrastructure. The Malayan Ophthalmological Center is the main ophthalmological hospital and is in Yerevan, and associated with our organization we have several subspecialty clinics in the areas of Retina, Glaucoma, Corneal-Uveitis, Neural-Orbital, Pediatrics, Eye Bank, Retinopathy of Prematurity, and Low Vision. The Armenian doctors running these clinics completed fellowships at prestigious American institutions to become even more specialized in their fields.

Even with these clinics, there is still an issue of accessibility, as many of the residents of rural regions are unable to travel to Yerevan for treatment. To address this issue, we are halfway through implementing five regional clinics around the country. Doctors in these clinics are able to treat most of the patients they encounter, but patients with more advanced ophthalmological diseases are sent to Yerevan. To reduce the burden on patients having to transport themselves, teleconsultation is often used, as a way for patients to receive the care they need within the regional centers. Doctors from the subspecialty clinics are often consulted, as their expertise is quite applicable to these conditions. However, some cases require a second or third opinion as well in order to provide the best treatment possible to the patient.

We would like to ask your permission to have you included on a list that will be distributed to AECP doctors around the country. Doctors on this list will serve as an additional source of expertise, and may occasionally be contacted as a teleconsultant on a particular case. Most communication takes place through either email or smartphone, particularly through the Polycom People + Content IP app, depending on the nature and urgency of the situation.

For more information on the Armenian EyeCare Project, please visit eyecareproject.com. To add your name to the teleconsultation list, please email me at nune@aecp.am. Thank you for your dedication to providing the best eye care possible!

Sincerely,
Nune Yeghiazaryan
AECP In-Country Director

Appendix U: Polycom Proof of Concept

The goal of this appendix is to detail the proof of concept testing for the Polycom System that will form the AECP's teleconsultation network. The specific details are grouped into the setup at the COE, Malayan Ophthalmological Center, and Spitak Regional Clinic.

Setup at the Center of Excellence

The first part of the COE installation process was to switch the Polycom System that was currently being used, the RealPresence Group 500, with the system not being used, the RealPresence Group 700. To do so we had to detach the Group 500 from the surgical microscope, TV, camera, and microphone and attach all of these to the Group 700. Fortunately, the Group 500 and Group 700 have nearly the same back Input/Output Panel, as shown below, and the cables to all the devices were simply reattached appropriately. The second part of the installation was to run through the Group 700 software to get a general understanding of how Polycom systems are designed. We were able to successfully turn on the Group 700 and navigate through some of the screens as shown. This allowed us to collect information like the system's IP address and the DNS servers' addresses. This information is important when connecting two or more Polycom systems together as they require the IP address to send and receive calls. The third and final part of the installation was to test a call from a mobile device to the COE Polycom System. Using the Polycom People+ Content IP software (available for smartphones and computers) and the COE Polycom IP address, we were successfully able to call the COE Polycom System from a different area of the clinic using a smartphone.

Setup at Malayan Ophthalmological Center

The first part of the Malayan installation process was to bring the RealPresence Group 500 system from the COE to Malayan Ophthalmological Center. To do so we drove from the COE to Malayan and unloaded the Polycom System and the necessary equipment in a predetermined room. To set up the Polycom system, we had to bring the Polycom System Box, the Polycom Camera and Microphone, a TV, and the RealPresence Group 500 Series TouchPad, as well as the appropriate cables for all them. The second part of the installation was to set up the Polycom System. After attaching all the cables to the appropriate inputs and outputs, the system was able to turn on and begin running the software. Unfortunately, we could not go further with the setup as the ISP crashed, which was required for any sort of call connection.

Setup at Spitak Regional Clinic

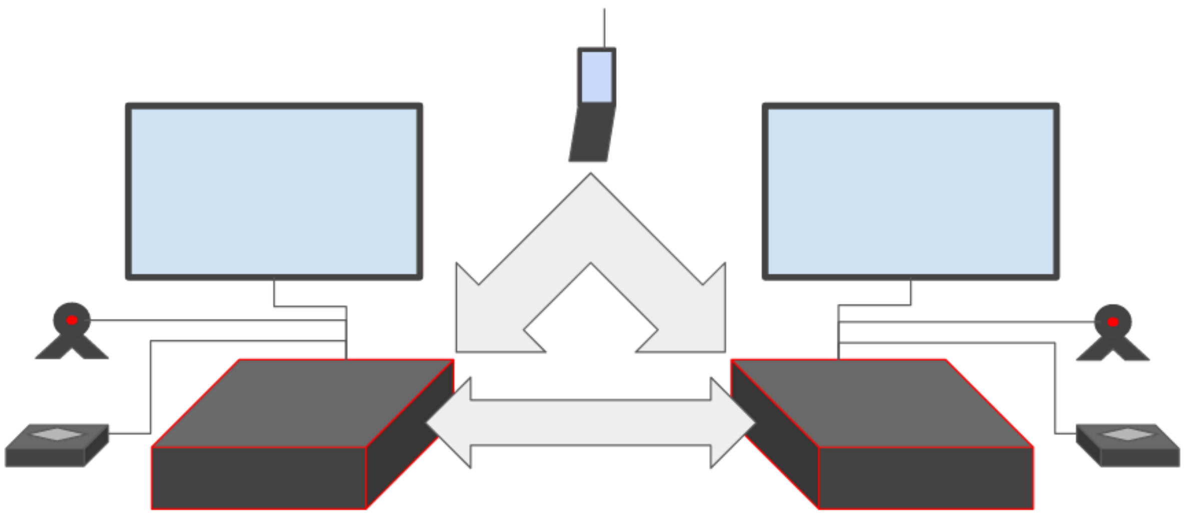
The first part of the Spitak installation process was to ensure that the Polycom HDX 6000 System that was at the clinic was functional. We made sure that the Polycom System had power and was connected to the camera, microphone, TV, and router before powering it on. The Polycom System turned on successfully and we were able to navigate the software to make sure it was working properly and to note the system IP address and the DNS server address. The second part was to check the call capabilities of the Polycom System. First, we tried calling the Polycom System at the COE and were able to connect with them. We checked the video and voice quality to make sure that both were usable for providers. Second, we again used the smartphone application to join the call between Spitak and the COE. The video quality on the smartphone was not good but the audio quality was very good. The third part of installation was to try connecting the Polycom System to the surgical microscope, which was across the hospital. To connect the device, we had to run a very long Cat. 5 cable through the ceiling and then convert that signal to HDMI before plugging it into the Polycom System. Fortunately, the connection was successful and we were able to make out some blurry images under the microscope. The blurriness was likely due to either the distance of the cable or the quality of the input plugs on either end.

Appendix V: Teleconsultation Guide Introduction

The goal of this appendix to be used as a cover page for the Teleconsultation Guide packet. The cover page provides the associated document details (title, authors, etc.) as well as a diagram depicting the concept of a teleconsultation network. The cover page follows on the next page.

Teleconsultation Guide

Armenian EyeCare Interactive Qualifying Project Team



Appendix W: Clinic Polycom Installation Guide

The goal of this installation guide is to instruct technical professionals on how to install a Polycom system at one of the AECP's facilities. For the purposes of this guide, a generic setup will be assumed, meaning that this setup does not apply to one specific Polycom system but should be applicable to all types of Polycom systems. Additionally, it is assumed that a WiFi network is setup with the appropriate Internet Service Provider (ISP). If the WiFi network or the ISP is not set up, then this must be done before setting up the Polycom system.

System Requirements
Setup of a Polycom system will require the following items (which may or may not come with the Polycom system):

1. Polycom System Box*
2. Polycom System Box Power Cable
3. Polycom System Box Remote
4. High Definition Camera
5. High Definition Camera Cable
6. High Definition Microphone
7. High Definition Microphone Cable
8. High Definition TV Screen/Monitor
9. High Definition TV Screen/Monitor Power Cable
10. HDMI Cable
11. Ethernet cable

*A view of a Polycom System's Input/Output (IO) Panel is shown below.

1 2 3 4 5 6 7 8 9 10 11

From left to right, the IO Panel is labeled as follows:

1. Polycom System Box Power Cable Input

2. DVI/HDMI Cable Input (for device input)*
3. DVI/HDMI Cable Input
4. VGA/HDMI Cable Input
5. Component Cable(s) Input
6. High Definition Microphone Cable Input
7. VGA/HDMI Cable Output (for screen/monitor/device output)*
8. VGA/HDMI Cable Output
9. VGA/HDMI Cable Output
10. USB 3.0 Cable Input/Output (for device input/output)
11. Ethernet Cable Input (from router)

* Input devices include High Definition Camera, Computer, Surgical Microscope, etc.
* Output devices include TV Screens, Monitors, Computers, etc.

System Installation

To install a generic Polycom system, follow the steps below. The steps below assume the equipment above is available.

1. Mount the Polycom System Box on the desired surface.
2. Plug the Polycom System Box Power Cable into a nearby outlet and into the Polycom System Box.
3. Mount the TV Screen/Monitor on the desired surface.
4. Plug the TV Screen/Monitor Power Cable into a nearby outlet and into the TV Screen/Monitor.
5. Plug the HDMI Cable into the TV Screen/Monitor and the Polycom System Box HDMI Output.
6. Mount the High Definition Camera on the desired surface.
7. Plug the High Definition Camera Cable into the High Definition Camera and the Polycom System Box DVI/HDMI Cable Input.
8. Mount the High Definition Microphone on the desired surface.
9. Plug the High Definition Microphone Cable into the High

Definition Microphone and the Polycom System Box Microphone Cable Input.

10. Plug the Ethernet Cable into the router and the Polycom System Box Ethernet Cable Input.
11. Plug in any necessary devices via the remaining Input/Output sites (Ex: HDMI Surgical Microscope Cable to Polycom System Box DVI/HDMI Cable Input).

When completed the system should look similar to the image shown here.

System Setup

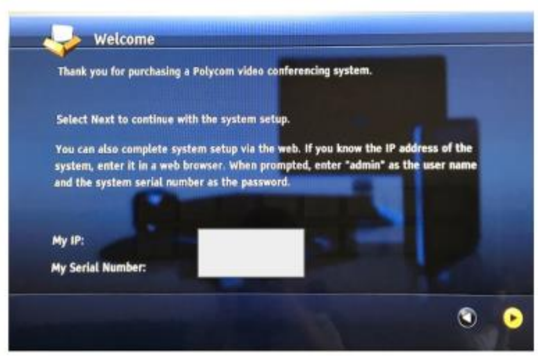
To set up the Polycom System Software and begin using the system, follow the steps below. These steps assume the system has the required parts and is set up as detailed above.

1. Turn on the TV Screen/Monitor by pressing the power button.
2. Turn on the Polycom System by pressing the power button on the Polycom System Box, shown here.
3. Once the Polycom System Software has loaded, follow the initial setup on-screen instructions. These instructions will likely include:

a. Language Selection

b. System Properties (System Name, Date, Location, Time, etc.)

4. When the Local Area Network (LAN) Setup screen appears, make sure that the Polycom System selects the LAN Internet Protocol (IP) **automatically.** Because the Polycom System Box is plugged into the router via the Ethernet Cable, a LAN IP will be assigned to the Polycom System without having to go into the router settings.*



5. When the call connection setup screen appears, make sure that both H.323 and SIP call protocols are selected. This will allow the Polycom System to make calls on both kinds of protocols if one does not work.
6. All other settings should remain as their default, and the Polycom Software Setup should be complete.*

* If the facility of installation has a server and/or a specific static IP address for the Polycom System to use, then that information can be entered manually in the IP Address and DNS fields.

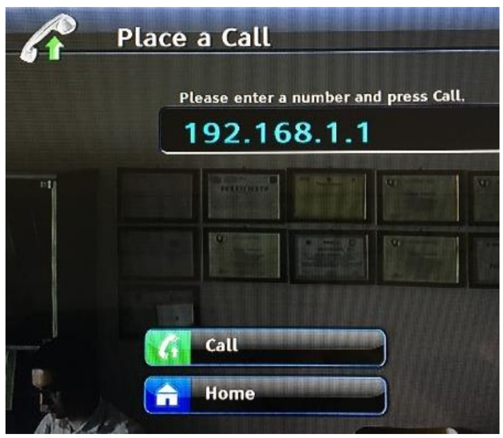
* If the system needs to be restored to its factory setting, the small hole below or near the power button can be pressed and held for 5-7 seconds.

System Testing

To test the Polycom System, follow the steps below. These steps assume the Polycom System has been set up as detailed above.

1. If you are not on the Home Screen (shown here), navigate to it using the Polycom System Remote by pressing the Home Button.

2. From the Home Screen, select Place a Call if you know the receiving Polycom System's IP address. The screen should look similar to what is shown.

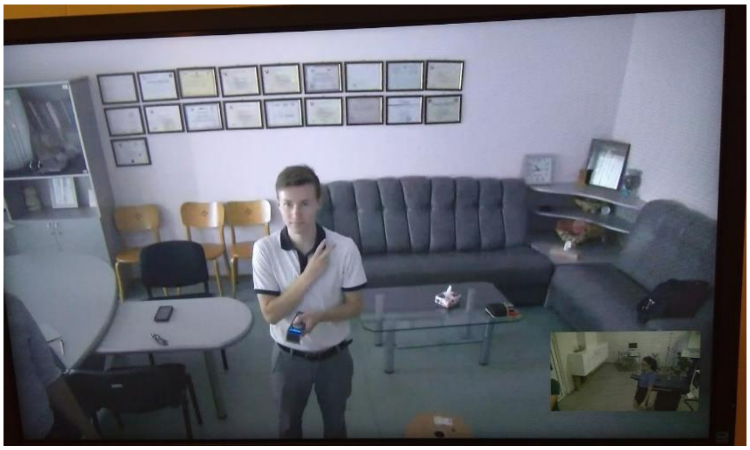


3. Enter the receiving Polycom System's IP address and select Call.
4. If you do not know the receiving Polycom System's IP address or would like to place a test call to a Polycom Test Line, select the Directory option from the Home Screen.

5. Once on the Directory Screen, select Favorites or Sample Sites.

6. You will then see a list of sites to call. Select one to test the call connection.

7. Once the call has connected, you should see a screen similar to the one below, along with a view of the connected site if it has video (and is not a test site).*



* If the call is not received there is a problem with one or more settings and troubleshooting is required.

Troubleshooting

If there are problems placing a call, one or more of the following issue resolutions may be required. This list only covers the basic issues, so if none of these resolves the problem then more knowledgeable IT or Polycom support should be contacted.

WiFi or ISP Problems

- Make sure that the Polycom System is wired to a nearby router and that the router is turned on and functional.
- Make sure that the router is connected to the internet via the ISP.

Receiving Polycom System Problems

- Make sure that the receiving Polycom System is turned on.
- Make sure that the receiving Polycom System is able to receive calls over H.323 and/or SIP protocol.
- Make sure that the receiving Polycom System's firewall is allowing outside systems to call it or that the calling Polycom System is whitelisted on the firewall.

Calling Polycom IP Network or Server Problems

- Make sure that the calling Polycom System's IP address is correct by checking the router settings or with the network manager.
- Make sure that the calling Polycom System's DNS address(es) is correct by checking with the network manager.
- Make sure that the calling Polycom System's IP address is correctly forwarded to the router by checking the router settings or with the network manager.

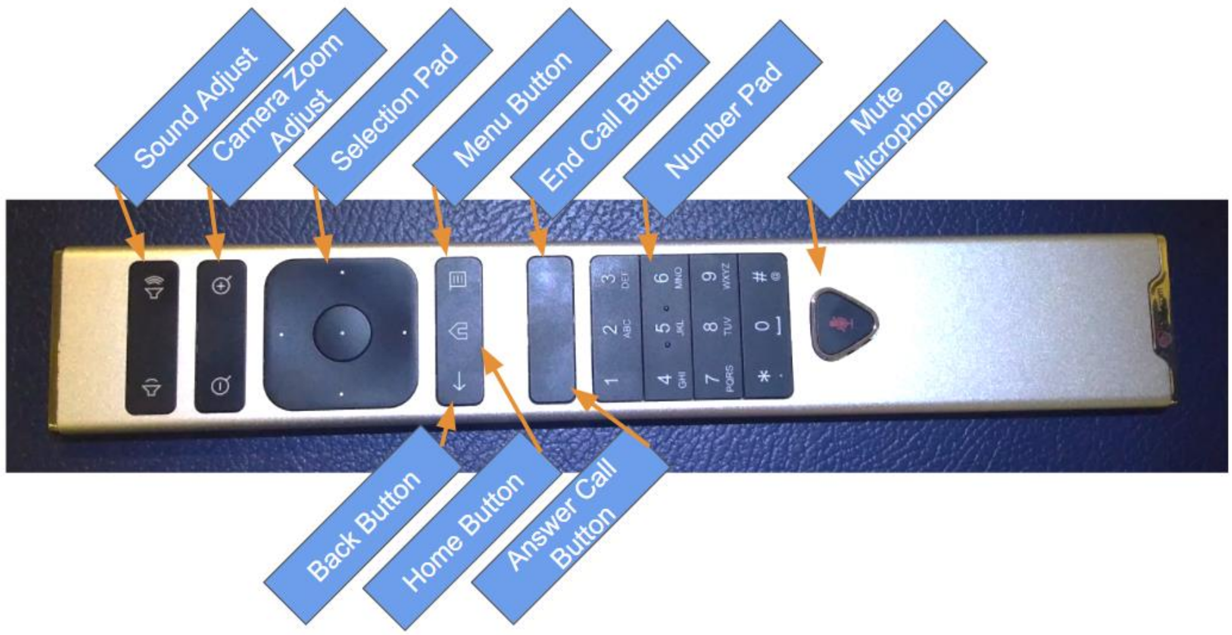
Updated: 7 July 2017

Appendix X: Clinic Polycom User Manual

The goal of this user manual is to instruct medical professionals on how to operate a Polycom system at one of the AECP's facilities. For the purposes of this guide, a generic setup will be assumed, meaning that this setup does not apply to one specific Polycom system but should be applicable to all types of Polycom systems. Additionally, it is assumed that the Polycom System has been set up as instructed in the preceding Clinic Polycom Installation Guide (Appendix U).

The Polycom System Remote

An example of the Polycom System Remote is pictured below with labels for all necessary buttons.



The Polycom System Remote has a rechargeable battery in the bottom, as shown. This battery can be plugged in to a USB input to charge it. The Polycom System Box has a USB input on the back Input/Output Panel.

Turning on the Polycom System

In order to turn on the Polycom system, follow the steps below. If the system fails to turn on, refer to the troubleshooting section.

1. Turn on the TV Screen/Monitor that the Polycom system will display to by pressing the Power Button.
2. Turn on the Polycom System by pressing the Power Button on the Polycom System Box, which will look similar to what is shown.
3. Wait for the Polycom System to load, which will look similar to what is shown.

Placing a Call with the Polycom System

In order to place a call with the Polycom System, follow the steps below. If the system fails to place a call, refer to the troubleshooting section.

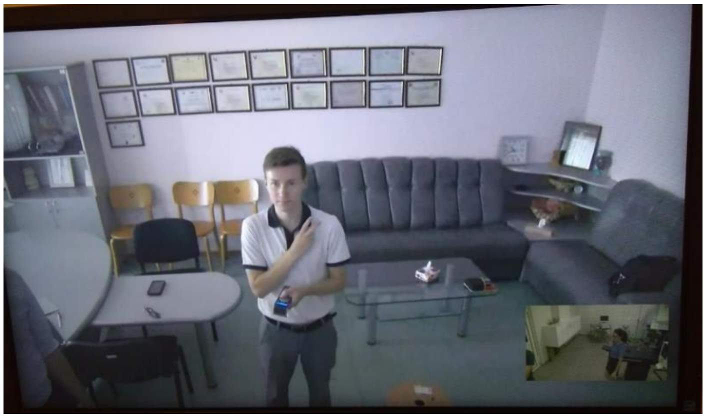
1. Once the Polycom System has loaded, if you are not on the Home Screen as shown, navigate to the Home Screen by pressing the Home Button on the remote.
2. From the Home Screen, select Place a Call if you know the receiving Polycom System's IP address. The screen will look similar to what is shown.*

3. Enter the receiving Polycom System's IP address and select Call as shown.

4. If you do not know the receiving Polycom System's IP address, select Directory from the Home Screen.
5. From the Directory Screen, select Favorites as shown.

6. From the Favorites List, select the location or person that you would like to call and select Call.

7. Once the call has connected, you should see a screen similar to the one below, along with a view of the connected site if it has video.



* Refer to the Provider List for a list of available providers, their phone numbers, and Polycom System IP addresses.

Receiving a Call with the Polycom System

In order to receive a call with the Polycom System, follow the steps below. If the system fails to receive a call, refer to the troubleshooting section.

1. Ensure that the calling Polycom System User has the proper IP address of your receiving Polycom System.
2. Instruct the calling Polycom System User to call your receiving Polycom System using their Polycom System Call feature or using the Polycom People+ Content IP software on their computer or smartphone.
3. Pick up the call on your Polycom by pressing the Call Button on the Polycom System Remote if the call is not picked up automatically.

Troubleshooting

If there are problems turning on the Polycom System, placing a call, or receiving a call, one or more of the following issue resolutions may be required. This list only covers the basic issues, so if none of these resolves the problem then more knowledgeable IT or Polycom support should be contacted.

Polycom System Power Problems

- Make sure that the TV Screen/Monitor is plugged in.
- Make sure that the Polycom System Box is plugged in.
- Make sure that the facility has power in your location.

* If there is smoke coming from either the TV Screen/Monitor or the Polycom System Box, call IT support immediately.

Calling Problems

- Make sure that the receiving Polycom System is powered on.
- Make sure that you are calling the correct IP address.

Receiving Problems

- Make sure that you have given the calling User the correct IP address.
- Make sure that you are selecting to answer the call when it appears.

Appendix Y: Polycom HDX 6000 Data Sheet

This goal of this appendix is to provide the specific details the Polycom HDX 6000-700 system. The exact data sheet from the Polycom website is included (Polycom, 2017).

Increase productivity and improve relationships

Now you can improve collaboration effectiveness while reducing operations and travel costs. Deliver lessons to students in classrooms around the world from a single location, align project teams in realtime across geographies, speed your time-to market with accelerated execution across departments. With the Polycom HDX 6000 solution, you're as good as there.

Intuitive to use and manage, the HDX 6000 solution delivers telepresence experiences to standard meeting rooms, conference rooms, and other environments requiring simple connectivity. HDMI output allows for quick and seamless integration with high definition displays via a single cable, while powerful standards-based Polycom® People+Content™ technology allows users to easily and quickly share high-quality documents, spreadsheets and multimedia content. Home theater quality audio experiences are delivered by Polycom® Siren™ 22 and Polycom® StereoSurround™ sound, giving users unrivaled acoustic clarity.

Polycom offers the entire solution

The Polycom HDX 6000 series seamlessly integrates with all components of the

Polycom Visual Communication portfolio, including the Polycom® RealPresence®

DATA SHEET Polycom HDX 6000 Series

Specifications

Experience (RPX™) and Polycom® OTX™ immersive telepresence system, Polycom® HDX video conferencing solutions, Polycom® RealPresence® Collaboration Server, and Polycom® Converged Management Application™ (CMA®). Additionally, the HDX 6000 leverages our exclusive Polycom® Lost Packet Recovery™ (LPR™) technology for enabling high quality user experiences, even across congested public networks.

Reduced operating costs and clearer communication across all parts of your organization

Faster decision making and execution on mission critical projects

A quality experience on any network, from a home office to a corporate board room maintained with Polycom® Lost Packet Recovery™ (LPR™) technology

Incredible video quality starting from 128 Kbps

Product specifications
Package includes
• Polycom® EagleEye™ III or EagleEye™
View camera, codec, Polycom® HDX® Microphone Array (not with View camera model) , 2 Mbps point-to-point, cables and remote control
Video standards and protocols
H.264, H.264 High Profile, H.263++, H.261
H.239/Polycom®
People+Content™
H.263 & H.264 Video Error Concealment
Video input
1x Polycom EagleEye HD camera
1x DVI-I
Video output
1x HDMI
People video resolution
720p, 30fps from 512 kbps
720p 60/30fps (RX/TX) from 832kbps
1080p, 30/15 fps (RX/TX) from 1024kbps
4SIF/4CIF, 30 fps from 128Kbps
4SIF/4CIF, 60 (RX) fps from 512Kbps
SIF (352 x 240), CIF (352 x 288)
QSIF (176 x 120), QCIF (176 x 144)
Content video resolution
Resolutions supported: WSXGA+ (1680 x 1050), SXGA (1280 x 1024), HD (1280 x 720), XGA (1024 x 768), SVGA (800 x 600), VGA (640 x 480)
Output: 720p (1280 x 720), 1080 (1920 x 1080), XGA (1024 x 768), SVGA (800 x 600)
• Content Sharing: People+Content and Polycom® People+Content™ IP
Camera
• Polycom® EagleEye III Camera
SMPTE 296M 1280 x 720p60 SMPTE
274M 1920 x 1080p, 60/50
12x optical zoom
72° FOV min
• Polycom® EagleEye View camera
1920 x 1080 EPTZ camera
4X digital zoom
55° FOV min
Internal stereo microphones
Audio input
1 HDX microphone array supported
1x 3.5 mm stereo mini (PC Audio)
Audio output
1x Aux main out (RCA)
Digital audio on HDMI cable
Audio standards and protocols
Polycom® StereoSurround™ technology
22kHz bandwidth with Polycom® Siren™
22 technology
14kHz bandwidth with Polycom Siren 14 technology, G.722.1 Annex C
7kHz bandwidth with G.722, G.722.1
3.4kHz bandwidth with G.711, G.728,
G.729A
Polycom® Constant Clarity™ technology
Automatic gain control
Automatic noise suppression
Keyboard noise reduction
Polycom® MusicMode™
Instant adaptation echo cancellation
Audio error concealment
Siren Lost Packet Recovery™
(LPR™) technology
Other supported standards
H.221, H224/H.281, H.323 Annex Q,
H.225, H.245, H.241, H.331, H.239, H.231,
H.243, H.460
BFCP (RFC 4562)
Network
Polycom® iPriority™ for QoS
10/100/1000 auto NIC (RJ45)
Auto-MDIX
H.323 and/or SIP up to 2 Mbps
Polycom Lost Packet Recovery™ (LPR™)
Reconfigurable MTU size (IP only)

SIP Firewall Traversal (Acme Packet)
API Support via Telnet
Microsoft® Office Communications Server integration
Microsoft® ICE support
Microsoft® Lync® support • IBM® Sametime™ support
User interface
Directory services
Polycom® SmartPairing™ technology
System management
Web-based
SNMP
Polycom Converged Management
Application (CMA solution)
CDR
International languages (16)
Wildcard language tool
USB software update
Security
Secure Web
Security mode
AES FIPS 197, H.235V3 and H.233/234
FIPS 140-2 Validation Certificate (#918)
IPv6 (DISA)
Secure password authentication
Options
Polycom® Touch Control
Polycom® EagleEye™ Director
1080p
Polycom® SoundStation® IP 7000 speakerphone integration
Polycom® HDX® Media Center options
RTV/CCCP
Electrical
Auto sensing power supply
Typical operating voltage/power
189VA @ 115V @ 60Hz @ .67PF

Appendix Z: Polycom RealPresence Group 700 Data Sheet

This goal of this appendix is to provide the specific details the Polycom RealPresence Group 700 system. The exact data sheet from the Polycom website is included (Polycom, 2017).

The Polycom® RealPresence® Group 700 solution is designed to be integrated into larger meeting rooms, training rooms, classrooms, and other workspaces that have more complex requirements. Such rooms demand additional flexibility in video, audio and content collaboration, and often need to be closely coupled with other room components for a fully integrated experience.

RealPresence Group Series is the only standards-based group video conferencing system that is certified with Skype for Business and Office 365, making it easy to connect without changing the way you work. The Skype interface is instantly familiar for an intuitive experience that needs no training. And because RealPresence Group is also standards-based it's easy to connect with customers, partners, and others outside your organization.

Polycom® RealPresence® Group 700 is a top of the line collaboration platform, with a high-performance architecture that meets your most demanding needs today and into the future. Simultaneous 1080p60 video and content sharing is ideal for applications that demand no compromises in clarity and experience.

For advanced content collaboration, connect to Polycom® Pano™ for easy wireless sharing from up to 4 users at the same time plus annotation and whiteboarding when using a touch display.

Multiple camera, content and audio inputs and outputs gives you the flexibility to design a solution to meet any application requirements. For example:

Connect multiple cameras to capture both the students and lecturer in a large classroom

Use multiple microphones to cover every seat in a large training room, or add Polycom® SoundStructure® for more complex audio requirements

Connect up to three monitors so everyone in the room can see clearly, even in very large spaces

Flexible camera options ensure all participants can see and be seen, no matter where they are sitting.

Polycom® EagleEye™ Producer uses innovative facial-tracking algorithms to accurately frame all room participants, or focus on the person speaking—whichever you prefer, eliminating the "bowling alley" view that is all too common in video calls

For a more immersive feel, Polycom® EagleEye™ Director II offers the highest performance speaker tracking experience, transmitting facial expressions and body language for higher impact and more productive video collaboration

For more details on the benefits of the RealPresence® Group 700, please see the RealPresence® Group Series family brochure.

Bring high-impact video collaboration into larger rooms and workspaces that have unique requirements

Simple to use, with one-touch dial from the integrated calendar and the Skype for Business

interface on the optional RealPresence Touch

Deliver great experiences for every person in the room, ensuring that everyone is involved in all aspects of the conversation

Flexible design, performance and camera options so you can build a solution for the specific application or use case rather than relying on a “one size fits all” approach

High-performance architecture for the best in video, audio and content clarity now and into the future

Integrate with Polycom® SoundStructure® for the ultimate audio experience in large meeting spaces

Built-in interoperability unlocks access to popular cloud video services while delivering Polycom’s unmatched group collaboration experience

DATA SHEET Polycom® RealPresence® Group 700

Specifications

Host calls with other groups, plus mobile and desktop users, with optional 8-way HD multipoint

Product specifications
Package includes:
RealPresence Group 700 codec
RealPresence Group Microphone Array
EagleEye IV camera
Cable bundle
Remote control
Rack (19”) mounting ears
Video standards and protocols
H.261, H.263, H.264 AVC, H.264 High Profile, H.264 SVC, RTV
H.239/Polycom®
People+Content™
H.263 & H.264 Video error concealment
Video input
2 x HDCI
3 x HDMI 1.4
1 x YPbPr component
1 x dual RCA composite
1 x VGA
Video out
3 x HDMI 1.3
3 x VGA
People video resolution
1080p, 60 fps from 1740 Kbps
1080p, 30 fps from 1024 Kbps
720p, 60 fps from 832 Kbps
720p, 30 fps from 512 Kbps
4SIF/4CIF, 60 fps from 512 Kbps
4SIF/4CIF, 30 fps from 128 Kbps
SIF (352 x 240), CIF (352 x 288)
from 64 Kbps
QSIF (176 x 120), QCIF (176 x 144)
from 64 Kbps
w288p from 128 Kbps
w448p from 384 Kbps
w576p from 512 Kbps
Content video resolution
• Input
HD (1920 x 1080i)
HD (1920 x 1080p)
WSXGA+ (1680 x 1050)
UXGA (1600 x 1200)
SXGA (1280 x 1024)
WXGA (1280 x 768) (1024 x 768)
SVGA (800 x 600)
• Output
WUXGA (1920 x 1200)
HD (1920 x 1080)
WSXGA+ (1680 x 1050)
SXGA+ (1400 x 1050)
SXGA (1280 x 1024)
HD (1280 x 720)
XGA (1024 x 768)
VGA (640 x 480)
• Content Frame Rate
- 5–60 fps (up to 1080p resolution at
60 fps)
• Content Sharing: People+Content™ and People+Content™ IP
Audio input
2 x RealPresence Group microphone array input ports (supporting a total of 4 microphone arrays)
USB headset support
2 x HDCI (camera)
3 x HDMI
2 x RCA line-in
Audio output
1 x HDMI (to in-room audio system)
1 x HDMI (to conference recording device)
USB headset support
1 x RCA pair stereo line-out
Other interfaces
2 x USB 3.0 (back)
1 x USB 2.0 (front)
1 x RS-232 DB9
Audio standards and protocols
22 kHz bandwidth with Polycom® Siren™ 22 technology, AAC-LD (TIP calls),
G.719 (Live Music Mode)
14 kHz bandwidth with Polycom®
Siren™ 14 technology, G.722.1 Annex C
7 kHz bandwidth with G.722, G.722.1
3.4 kHz bandwidth with G.711,
G.728, G.729A
Polycom® Constant Clarity™ technology

Automatic gain control
Automatic noise suppression
Keyboard noise reduction
Polycom® NoiseBlock™ technology
Polycom® Acoustic Fence™ technology
Live music mode
Instant adaptation echo cancellation
Audio error concealment
Polycom® Siren™ Lost Packet Recovery™ (LPR™) technology
Polycom® StereoSurround™ technology
Other supported standards
H224/H.281, H.323 Annex Q, H.225, H.245, H.241, H.239, H.243, H.460
BFCP (RFC 4582)
TIP
Network
IPv4 and IPv6 support
2 x 10/100/1G Ethernet Switch
Auto-MDIX
H.323 and/or SIP up to 6 Mbps
Polycom® Lost Packet Recovery™ (LPR™) technology
Microsoft® Office Communications Server integration
Microsoft® ICE support
Microsoft Lync and Skype for Business certification, including Skype for Business Online / Office 365
IBM® Sametime™ support
Zoom Meetings interoperability
Security
US DoD UC APL Certified (see the *Polycom US Federal Government Accreditation site* for details)
Media Encryption (H.323, SIP): AES-128, AES-256
H.235.6 support
Authenticated access to admin menus, web interface, and telnet API
FIPS 140-2 Validated Cryptography (Validation Certificate #1747) • PKI/Certificate Management:
SSL 3.0, TLS 1.0, 1.1, 1.2
Self-signed and CA-signed certificate support
CRL and OCSP-based certificate revocation
Network intrusion detection system
Local account password policy configuration
Security profiles
Web UI/SNMP Whitelists
Local account and login port lockout
Options
Polycom® Pano™
Polycom® RealPresence® Touch
Polycom® EagleEye™ Producer
Polycom® EagleEye™ Director II
Polycom® SoundStation® IP 7000 conference phone integration
Polycom® SoundStructure® integration
Software options
Skype for Business and Lync Integration (including Skype for Business Online / Office 365)
TIP interoperability
1080p license, providing up to 1080p60 for people and content
Multipoint license for up to 8 sites at
720p30, or 4 sites at

Reconfigurable MTU size
RS232 with API support
checking
About Polycom
1080p30

Electrical
Auto sensing power supply
Typical operating voltage/power
85VA @ 120V @ 60 Hz
85VA @ 230V @ 50/60 Hz
Typical BTU/h: 280
Environmental specification
Operating temperature: 0 to 40 °C
Operating humidity: 15 to 80%
Non-operating temperature: -40 to 70 °C
Non-operating humidity (non-condensing): 5 to 95%
Maximum altitude: 10,000 ft
Physical characteristics
• RealPresence Group 700 base box
17.2" H x 2.6" W x 12.8" D
11.45 lbs
Warranty
• One-year return to factory parts and labor