EyePACS: An Open Source Clinical Communication System For Eye Care

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Abstract

Purpose: *EyePACS is an application for communicating and archiving eye-related patient information, images, and diagnostic data. We studied how users adopted the system in diverse clinical settings.* ***Methods:*** *53 clinicians and 142 students uploaded cases over 2.5 years from 6 pilot sites: a university teaching clinic, a university glaucoma clinic, an urban private optometric practice, a rural elderly care facility, a diabetic management program, and an eye hospital in India.* ***Results:*** *EyePACS collected 1122 cases. Users employed it for informal "curbside" consults in 17% of cases. Other uses of the system were: 1) to replace telephone and fax referrals to a retinal specialist (10%), 2) as part of ocular teleconsultations and diabetic retinopathy screening (31%), 3) for education via digital grand rounds and evaluation of students (32%), and 4) for research (10%).* ***Conclusion:*** *EyePACS has been used successfully for consults and education in diverse settings. The resulting database of digital cases serves as a searchable reference for clinicians.*

Keywords*: ambulatory care; communication; referral and consultation; telemedicine*

Introduction

Clinicians frequently communicate with each other about patients. Coiera reported that information exchange among clinicians about their patients is approximately 40% of all information transactions that occur in outpatient settings [1]. Referrals for specialty care, reports on patient status, and informal "curbside" consults comprise the bulk of these transactions, yet there have been few informatics studies on this topic [2]. Traditional methods for clinicians to communicate with each other (mail, fax, telephone, and face-to-face) are becoming increasingly inefficient and impractical due to increased demand for collaboration, increased workloads, and increased diversity of practice settings [3] Electronic mail (e-mail) and Internet discussion groups have emerged as viable asynchronous mechanisms for colleagues to informally collaborate, but these approaches have several distinct weaknesses.

E-mail use is increasing and e-mail accounts are ubiquitous among clinicians as they are in the rest of the world. For specialties that depend heavily on visual inspection, such as dermatology, pathology, and eye care, communicating with digital images can be a simple task of attaching an image file to an e-mail and sending it to a fellow clinician. Some researchers have even shown that inexpensive telemedicine systems can be set up this way [4,5,6]. There are, however, significant disadvantages to e-mailing images: 1) The size of a series of truly diagnostic quality images can be quite large, even after compression, and may not be acceptable by many e-mail clients, particularly web-mail applications such as Hotmail and Yahoomail. 2) E-mail may take a long time to download (a problem if clinicians are in a hurry). 3) Emails can fill up users' email accounts with unneeded files and those files can end up in inconvenient folders and computers.. The biggest problem may be in tracking the clinical information once it has been downloaded. A single case may be referred to in several e-mails as data is changed, corrected, or enhanced, or when comments and findings are added. Furthermore, because e-mail may not be permanently recorded, this clinical information may no longer be available after a few weeks or months.

Several discussion groups in the field of eye care use digital ocular images in discussion threads. ISurgeon, Ophthal.org, WebEyeMD, OphthalWorld.org, OptCom.com, and Eye Surgeons Message Board on Yahoo are some examples of discussion groups in eye care that accept digital ocular images. Valuable and timely information can be exchanged in these groups and membership is growing. Access to these groups is free. Discussions can be indexed by topics, which then allow them to become searchable resources in the future. Professional discussion groups are almost always only for colleagues within the same specialty, and they are centered on topics, not specific clinical cases. They cannot be used easily for referrals or reports, and can be subject to many of the restrictions of e-mail.

Electronic medical records (EMR) and picture archive communication systems (PACS) are formal applications that can effectively address the needs of clinicians to communicate. Emerging data and knowledge interchange standards show great promise to allow clinicians to exchange comprehensive health care information via universally interoperable EMRs and PACS in the future. At the present time, however, these systems have not been extensively used in outpatient settings due to their high economic cost as well as technical and organizational difficulties with implementation. "Light weight" solutions to clinical communication may offer more immediate accessibility to clinicians, particularly those in small outpatient settings. It is important that these partial solutions eventually be interoperable with more comprehensive solutions that will be readily available, hopefully in the not too distant future.

EyePACS

EyePACS is a non-proprietary, freely accessible, open source web-based application for exchanging eye-related clinical information that addresses the weaknesses of existing approaches to satisfying inter-clinician communication needs. It is known that clinicians adopt systems to aid information exchange only if the systems integrate efficiently into their workflow with the minimum amount of change to clinicians' customary practices [3]. We designed the EyePACS system for exchange of ophthalmic clinical cases. The system's design principles included:

1. Minimal barriers to access and use

   Users of clinical information systems typically have low thresholds for abandoning new health information technologies, particularly when the existing system is perceived as functional. Thus, we designed EyePACS to use only existing platforms and browsers, have familiar formats, and be accessed with minimal navigation.

2. Open-source, non-proprietary application

   Current proprietary systems for communicating and archiving digital ophthalmic images are typically designed to support a billable service or impose a usage fee. A large proportion of clinical communication, however, is informal and not billable. Any significant cost of entry or cost per use would deter informal use of proprietary systems. Hence, we designed EyePACS to be open-source and non-proprietary.

3. Interoperable with relevant health information systems and diagnostic devices

   Eliminating double entry of patient data and simplifying transport of images and data objects between other applications and EyePACS would minimize the time involved in creating digital cases. An ideal scenario for generating a digital case would be to automatically transfer relevant data, such as age, history, or medications, from an HL-7 compliant patient record and coupling this with automatic transfer of diagnostic objects, such as retinal images and visual fields, from DICOM compliant image capture devices. In reality, the vast majority of clinical eye care settings do not have electronic medical records, and most ophthalmic diagnostic devices only have the Windows API and TWAIN as standard interfaces. We designed EyePACS to accommodate both sides of this data integration spectrum.

4. Extensible to different settings

   While we target the EyePACS system for referring and reporting clinical cases in eye care, the general design of the system allows it to be extensible to other clinical domains in which image data is important, such as dermatology and pathology. EyePACS' focus on clinical communication in general, rather than a particular functionality, also allows it to be useful in a variety of communication tasks, such as international collaboration, screening, research, clinical training, and distance learning.

Methods

System Architecture

EyePACS is a web-based application that uses active server pages to retrieve, send, and manipulate data between a SqlServer database and browser clients. A clinician can access EyePACS through a computer connected to the Internet and create, send or review clinical cases through any web browser. The current version includes a downloadable client side application that captures data from any Windows desktop and uploads a compressed image of the data to the server. This allows interoperation with a wide variety of existing legacy instruments and imaging devices. A workflow of the system is illustrated in Figure 1.

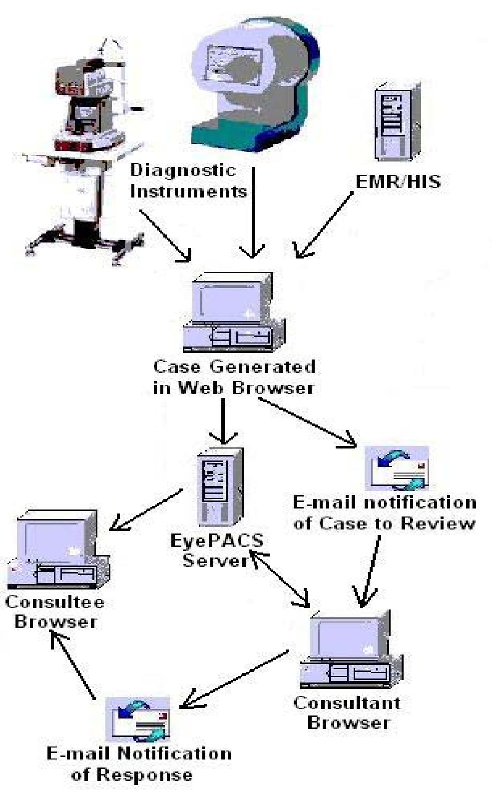

Figure 1. EyePACS workflow

EyePACS Content

Case presentation contents are in free text fields that follow the problem-oriented patient record format. An additional field for the "Clinical Question" improves the clarity of case presentations. An embedded "upload" window allows the user to upload to the EyePACS server most image or document file types from their computer's file system. Thumbnail links to full size images are presented in the case presentation page. In eye care, typical images that are uploaded include those of the anterior eye and retinal fundus, but image files of diagnostic tests, such as visual fields and topography can also be included. Cases can be marked for "public" viewing by all EyePACS users, or they can be marked "private" to restrict viewing only to authorized viewers from individual sites. If a case is particularly interesting or exemplary it can be added to the "Eye Gallery", a collection of such cases for general reference. Currently, cases include only non-identifying patient data. While EyePACS can transmit data using encrypted e-mail and secure socket layers, future versions of EyePACS will be fully HIPAA compliant without having to leave out personally identifying data.

Recruitment and Evaluation

Clinicians at all sites were recruited by word of mouth and participated voluntarily. Sites were formed as clinicians became aware of EyePACS. It was up to the clinicians at each site to adapt the system to their own use. We evaluated expectations, utilization, satisfaction, and perceived strengths and weaknesses of EyePACS using open-ended interviews in person or by phone. Users were also asked how they adapted the system to other specialized uses, and what future changes would be desirable. Users also submitted unsolicited comments.

Results

As of September 11, 2003, EyePACS contained a total of 1,122 cases. 946 cases were collected from 31 clinicians, and 176 cases from 124 students. These cases were collected through EyePACS in six diverse settings for a variety of purposes during a two-year trial. Figure 2 below charts the number of cases uploaded by clinicians per month vs. months (with trend line). Student cases were not included due to the short duration of their scheduled classes.

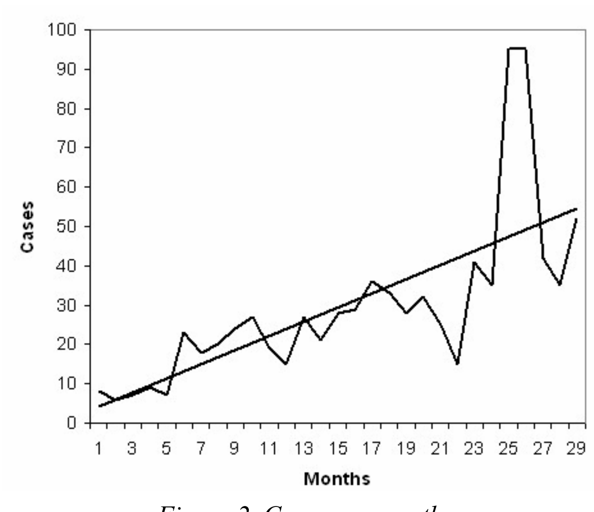

Figure 2. Cases per month

We now summarize the EyePACS deployment and experience for each purpose in each of the settings.

Subspecialist Referral in an Urban Optometric Practice

A 3-clinician, urban private optometric practice used EyePACS to replace telephone and paper referrals to ophthalmic specialists. The optometrists generated 112 digital cases in EyePACS using ophthalmic digital images and clinical data, excluding personally identifiable information such as name and social security number. These cases were transmitted via encrypted e-mail and secure socket layer to a retinal specialist instead of faxed referrals.

16 of the responses from the retinal specialist resulted in changes in referral process: 3 required more immediate referral, 3 referrals were diverted to a different specialist, and 10 required no referral at all and could be followed in the optometric office. Thus, referral accuracy was improved over the previous method. In several cases the referring optometrists and patients discussed procedures that the specialist would perform, such as fluorescein angiography and retinal photocoagulation, prior to their scheduled visit with the specialist, thus improving clinical communication with patients. Users commented that they planned to enlist other specialists to convert to EyePACS-generated e-mail referrals.

The optometrists also unexpectedly used EyePACS to create their own reports to primary care physicians (PCPs) about their patients. Since many of the local PCP's did not accept e-mails professionally, a feature was added to EyePACS that allows high quality photographic printing of the reports that could then be mailed or added to a patient's paper record.

Rural Elderly Care Centers

Two nurse practitioners from a group of 5 rural elderly care facilities generated 335 cases that a remote ophthalmologist used for subsequent teleconsultation with patients. The teleconsultations included examinations for diabetic retinopathy, glaucoma, and skin lesions. Approximately 12% of cases resulted in referrals to local physicians for secondary care. The nurse practitioners and assistants who acquired patient information requested more structured data entry fields, such as check boxes for smoking, diabetes, heart disease, as well as specific fields for findings like pupil reactions and visual acuities. Nevertheless, the program directors of the facilities plan to enlist other elderly care centers and primary care clinics to use EyePACS.

Optometric Education

The University of California, Berkeley Optometric Eye Center (UCB) used EyePACS as an educational tool in three clinical courses. In the first course, a clinical skills evaluation course, optometric interns uploaded 176 clinical cases that they captured using ophthalmic imaging devices in the clinic. Instructors were then able to use these EyePACS cases to evaluate the students' diagnostic skills. Instructors uploaded an additional 12 cases in order to demonstrate interesting lesions to students in the general eye care clinic. The greatest limitation reported by the instructors was delays caused by an insufficient number of imaging devices in the clinic. EyePACS is now part of the permanent curriculum of this course.

In the second course, 6 grand rounds style presentations were formulated with threaded discussions making it possible for all students to participate, including those students (approximately half at any one time) who were on distant rotations. Students replied with comments from locations throughout the U.S. and Canada. HTML links to web-enabled attendance records and evaluation forms were incorporated as site specific comments to assist in other teaching functions. This course was recently expanded to include other schools of optometry.

The third course was to certify faculty to treat glaucoma. The course instructor requested a standard template for reporting glaucoma patient data into EyePACS. 56 cases were uploaded and used by about twenty reviewers to supplement paper chart reviews. Before using EyePACS, these reviewers had to share paper charts but could now conveniently view clinical history, visual fields, and ophthalmic images from any browser at any time. Comments were added to discussion threads as new patient information was added to these cases.

In addition to these three courses, UCB faculty uploaded 294 cases for informal consults and second opinions.

Diabetic Retinopathy Screening and Education

A university affiliated community clinic in Fresno, California has recently recruited UCB to participate as a member of a comprehensive diabetes management program. In this program professionals involved in the care of diabetics, such as diabetic educators, dieticians, psychologists, and podiatrists, are located within the same clinic and are in constant contact with each other in order to provide highly coordinated care, UCB is involved as a remote participant receiving data and responding from the UCB campus 200 miles away via EyePACS. The three aims of UCB's involvement are to: 1) discover sight-threatening diabetic retinopathy that would otherwise go undetected. 2) train primary care staff and residents to appropriately triage diabetic patients and to use retinal images in their own assessment of systemic disease, and 3) to educate diabetic patients at the point of care about their own vascular complications.

Data is available for 24 cases from the pilot project. Preliminary results have prompted UCB to seek funding to expand the diabetic retinopathy screening program.

Remote Glaucoma Detection

113 cases were uploaded from the University of California, San Francisco Glaucoma Clinic in a preliminary evaluation of EyePACS's effectiveness at supporting remote glaucoma detection. Ten glaucoma specialists from California, New York, Florida, Colorado and Texas evaluated these cases using EyePACS, after an average training time of seven minutes. In response to user requests in pilot testing for viewing ocular images in stereo to enhance depth perception, a novel method of viewing high resolution stereoscopic images had been devised without using expensive hardware or any loss of illumination or spatial resolution. With these stereoscopic images, all ten reviewers reported that over 90% of images were of sufficient quality to make accurate interpretation very likely.

Telemedicine

Aravind Eye Hospital, a large hospital in India, used EyePACS to study the feasibility of linking satellite clinics before investing their limited resources in their own system. Difficulties were encountered in deploying image capture devices in the satellite clinics, but the hospital successfully uploaded 18 cases. They discovered that the best use of the system was for triaging only those cases that would require patients to travel long distances. The original expectation was that all cases should be entered and transmitted. Based on this feasibility study, the hospital has a better understanding of its needs as they plan their own system development.

"Curbside Consults" and Shared Cases

Of the 1,122 total cases in EyePACS, 436 (49%) were entered for communication and curbside consulting about interesting or difficult cases. 190 (17%) were exclusively used for this purpose and not as part of a referral or as a course or study requirement. 371 (33%) of all cases were marked as "public" allowing any user to view them.

Site Type	C/S*	Cases	Description
	(n)	(n)	
Urban Practice	4	112	Referral for retinal care
Rural Elderly Care	4	335	Eye and dermatology exams
Teaching Clinic	27/124	520	Clinical grand rounds, student evaluation, faculty training
Retinopathy Screening	4/18	24	Diabetic retinopathy screening and education
Research Clinic	10	113	Study on remote glaucoma detection
Foreign Eye Hospital	4	18	Remote consultation from satellite clinics

Table 1. Summary of cases

*Clinicians / Students

Discussion

The most prominent systems that currently support formal exchange of eye care cases among clinicians are PACS and EMR systems that are either proprietary or have a high cost of implementation. This creates barriers to informal communication among clinicians and may deter clinics with limited resources from installing these programs.

By designing EyePACS as a lightweight system that is easily deployed and used, we can promote clinical communication and study the way that clinicians communicate. We suspect that there is a substantial amount of informal and non-billable, but important communication, that systems such as EyePACS can facilitate. Furthermore, the Eye Gallery and other EyePACS cases become an ever richer repository of clinical cases. EyePACS serves as a dynamic searchable clinical resource for evidence-based medicine.

Demand for systems such as EyePACS are expected to increase substantially as digital cameras and other image acquisition devices become more commonplace in health care and as clinicians learn to communicate with images. EyePACS will continue to gather clinical cases and innovative uses among its expanding user community.

Conclusion

EyePACS is an open source, web-based application for communication and archiving of ophthalmic patient information, images, and other diagnostic data that has been successfully used for multiple purposes including referral management, telemedicine, education, screening, and research.

Acknowledgments

The authors would like to thank all of the participants for their willingness to innovate and for their candid comments and guidance.

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