

ELECTRONIC HEALTH RECORDS AND PUBLIC HEALTH INFORMATICS

Kevin M. Jackson, OD, MPH, FAAO, CDR, MSC, USN

Chapter Overview

The digital revolution is transforming pencil and paper medicine. Increasingly, health information is being recorded, stored, and analyzed using computerized tools. This information conversion has significant public health implications.

Public health informatics: The systematic application of information science, computer science, and technology to public health practice, research, and learning(1).

This chapter describes public health informatics and the key role that individual optometrists can play in the care of populations through the use of electronic health records (EHR). A case study will be examined illustrating the use of EHRs and the public health implications of the shift to digital health records.

Objectives

On completion of this chapter, the reader should be able to:

- Define what is meant by public health informatics.
- Understand the promise and pitfalls of the conversion to electronic health records.
- Explain the importance of standards in public health informatics to enable data collected in individual medical care practices to be used by public health practitioners.
- Identify an array of tools used in public health informatics.

Introduction and Background

One of the primary products of clinical medicine is the patient medical record. Practitioners use the record to capture their findings and conclusions for each clinical encounter and to guide future care of that patient. Knowledge of an individual's physiologic norms is a great advantage in safeguarding his/her health. For example, a patient with an intraocular pressure of nineteen would not seem anomalous independent of any other information. The knowledge that this patient's historical norm is below ten, however would change the clinical picture.

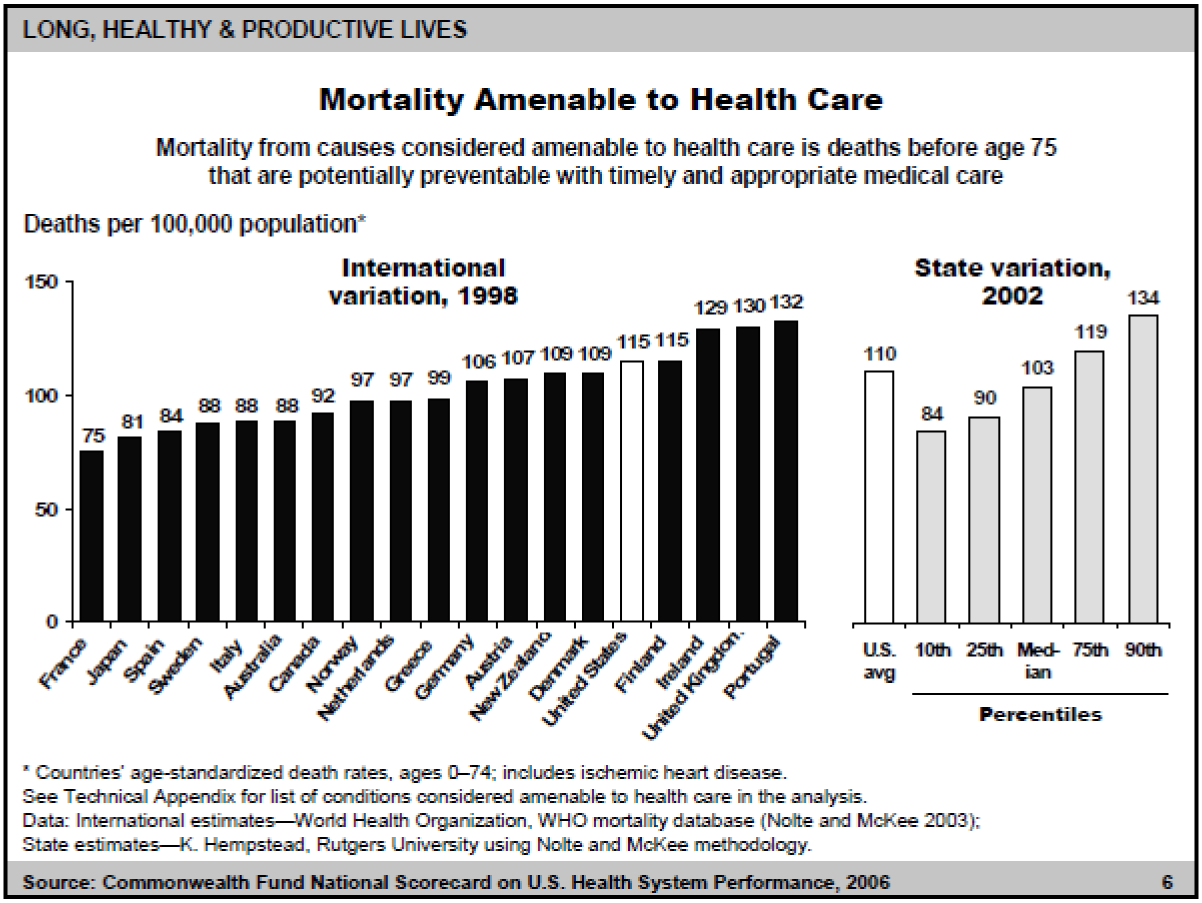
Over time, the patient medical record has evolved due in part to medical advances, liability risks, and changing administrative requirements for care reimbursement. Relatively unchanged though have been the means and media for recording and storage of these notes. Until recently, medical records have been captured on paper, largely by hand, and have been the property of the recording provider. Over the last twenty years most other industries have transitioned to digital record keeping(2) while medicine continues to embrace a dated incumbent paper system. EHRs have been available for well over a decade and yet they are utilized by only a quarter of practicing optometrists and only about an eighth of practicing ophthalmologists(3, 4). Why this reticence to adopt an EHR? Is there a compelling reason to transition from paper to an electronic system?

Driving the movement to convert to a digital record keeping system is the promise of improved quality and anticipated cost reductions(5). The landmark analysis by the Institute of Medicine "To Err is Human"(6) pointed out that our healthcare system is error prone. These errors result in part from incomplete and erroneous information. Digitizing records will allow computerized tools to aid in error reduction. Despite mediocre results(7) [See Box 1], the U.S. healthcare system is by far the worlds' most expensive(8). EHRs that can efficiently allow sharing of patient record information with authorized doctors, health care administrators, and public health professionals should reduce redundant medical testing and administrative costs, and improve cost avoiding prevention efforts. These greater efficiencies at the local level should reduce costs of the nation's healthcare system overall.

Box 1:

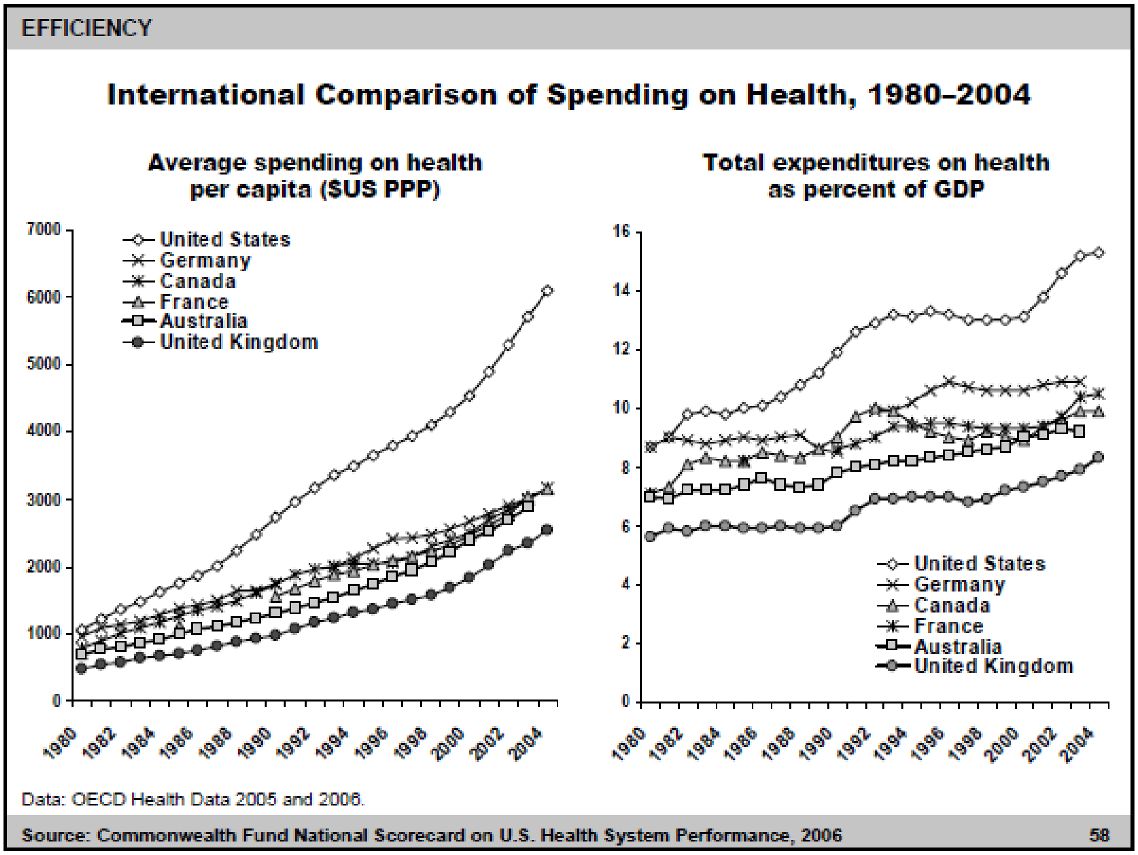
A decade ago the World Health Organization published The World Health Report 2000(62) which included a comparative analysis of the world's health systems based upon efficiency and effectiveness. The US healthcare system was ranked 37th , ranked lower than nations such as Morocco, Dominica, and Canada. This raised some controversy in the United States and the methodology of ranking was scrutinized. Many similar analyses since that time have generally reinforced the findings that the US healthcare system produces results that generally lag other wealthy nations. One excellent example of this type of comparative analysis is seen here compiled by the Commonwealth Fund(63).

Box 1 continued



In terms of cost there is no controversy, the high cost US healthcare system is a significant outlier(63).

Box 1 continued



The US Healthcare system has also been slower to adopt EHRs than its industrialized peers(64), in some cases by as much as 12 years. Although possibly a contributor, no analysis exists that establishes a relationship between the relative quality and cost advantage these other healthcare systems have over the US system, and their degree of EHR utilization.

If the EHR is such a boon, why has it not enjoyed more widespread adoption? Concern for loss of revenue, a local vs. global perspective, security, learning curve, and an over-confidence in personal physician skills all contribute to the EHR's slow acceptance. In most industries the executive mandating use of data input software is not an end user. For example, the executives from Sears Roebuck & Company are not personally impacted by their mandate to use a particular cash register or inventory control system. In outpatient medicine however, the person writing the medical record is also typically the doctor who makes the decisions for the practice, so software that does not reduce the burden of data entry is not likely to be adopted(9). If the doctor was going to realize significant cost savings with use of the software, it would aid conversion. However, outpatient clinics are paid based upon procedures performed (fee for service). A major way that electronic health records would reduce our nation's healthcare expenditures is by eliminating unnecessary procedures. Clearly this would not financially benefit outpatient clinics. Increased administrative efficiency in billing typically does improve the bottom line. These functions are covered by practice management software which does enjoy widespread use in eyecare and other medical disciplines. It is unlikely that aiding public health efforts will inspire a conversion to electronic health records. Historically poor participation in reporting to registries and even mandated infectious disease reporting(10) illustrates the disconnect between doctors and our public health system. Although most providers acknowledge that the medical system is error prone, there is a lack of urgency to enact change in their own practice as it is unlikely they feel *they* are practicing unsafely.

Despite its sluggish pace, the United States is in the midst of a conversion from paper to digital records. President Bush set a goal for the conversion to electronic health records by 2014(11). To encourage adoption of an EHR the Department of Health and Human Services' quality incentives (12)(Physician Quality Reporting Initiative) program financially incentivized use of an electronic health record by adding a bonus of an extra 1.5% to federal reimbursement of care provided with an EHR. Likely to sweeten the pot, President Obama's American Recovery and Reinvestment Act of 2009 will provide $20 billion for the development of health informatics targeting electronic health records adoption. These efforts will likely move a critical mass of health care facilities to EHR use. Ultimately it seems likely that a mandate or financial penalties will be used to move technology laggards accepting payment from a federal government source to EHR conversion. Most medical practices cannot live without the federal payer so federal leverage will likely drive conversion.

The changing expectation of both new doctors and patients regarding the use of technology in the office is aiding the move to electronic records. Almost half of the optometry schools are now using an EHR in their school's clinic. Expectations of practice will not involve paper charting for this cohort. Patients increasingly conduct their financial transactions electronically, shop online, and even discuss their car trouble with a computer wielding mechanic. As time goes on the use of paper and pen will seem more anachronistic in a world where all other information transactions are conducted digitally. Medical practices sticking to the old ways will be at a marketing disadvantage.

EHRs are important to public health because the conversion of patient data to a digital format allows for greater coordination and data sharing. EHRs store their information in a database. With the use of secure networks and standardized categorization of information, this data could be sent for use to other doctors, public health professionals, public health departments, the CDC, researchers, etc. The implications are significant and will be explored in this chapter.

Public Health Principles of Eyecare Informatics

Recording health information into a computer has many far-reaching public health implications. Properly designed EHRs can be interactive, intuitively formatted, and capable of sending large volumes of data over a network rapidly. EHRs can have helper applications that provide patient specific feedback in real time, alerting the doctor to health needs or relevant research to guide care. Information from the EHR can also empower the patient in self management of chronic diseases. At the core of any EHR is a database which allows for manipulation and analysis of data facilitating researchers to help drive medical practice forward. With the use of secure health information networks and data standards, information can be easily shared with widespread positive public health repercussions.

Intrinsic disadvantages of paper records

The very nature of recording information on a computer has certain advantages over recording medical data on paper. Traditional paper charts are not interactive. Although the record may have printed reminders or cautions, these are easily ignored or overlooked. Physicians are notorious for poor handwriting. Studies have shown that as little as 65% of written medical charts are fully legible(13). The written record, even if shared outside the practice, may be useless to anyone other than its creator. (Assuming he or she can decipher their own notes!) Written records exist solely in their file jacket in the provider's office. Disorganization, the dissolution of a practice, or a disaster in the office can easily result in the irretrievable loss of patient data. Both electronic and paper records record health information, but an EHR has added capabilities.

Tools within EHR for Provider

Electronic Health Records typically come with a suite of tools designed to increase the safety of the patient and safeguard the patient's medical data. These tools analyze data input into the medical record. Based upon this information and a repository of reference information, clinical guidelines and the existing patient record, the software interacts with the provider to remind them of appropriate evidence based guidelines, relevant research, and pertinent drug interaction information. [See Box 2]. These interactive helper applications are incorporated into the electronic health record where they assist in reducing medical errors and increasing the quality of healthcare. In addition, daily or weekly backups of the data in the EHR can be easily sent to a remote location offsite improving data security in the event of failure.

Box 2

Tools that Augment the Functionality of an EHR

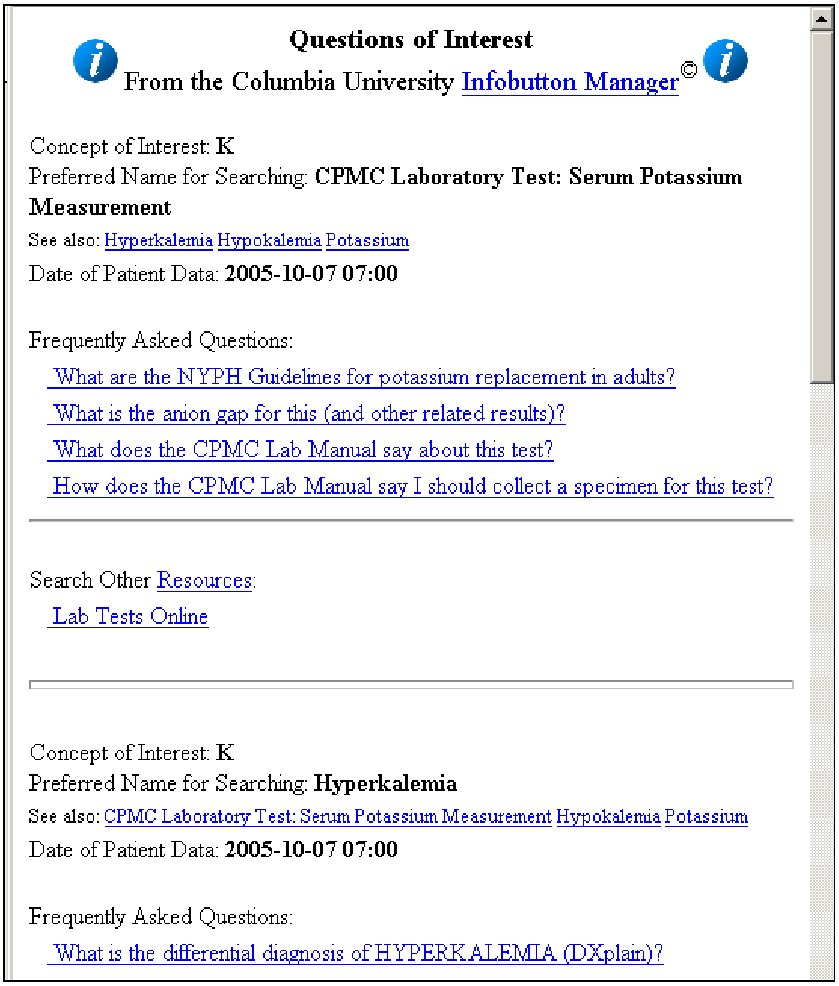
Infobuttons(65) : "Infobuttons" are context-specific links from one information system (such as an electronic health record) to some other resource that provides information that might be relevant to the initial context. Infobuttons are used to anticipate users' information needs and provide them with easy ways to obtain answers to resolve those needs."

Computerized Provider Order Entry (CPOE)(22): This is an application that is used to electronically "write" provider orders either in the hospital or out-patient settings. This has the benefit of helping to eliminate handwriting misinterpretation as a potential source for errors. CPOE is most often used in tandem with the next tool.

Clinical Decision Support (CDS)(66): "Refers broadly to providing clinicians or patients with clinical knowledge and patient-related information, intelligently filtered, or presented at appropriate times, to enhance patient care." A common example of a CDS application is a drug – drug interaction alert system designed to alert the ordering provider in the event a medication is ordered that would interact with a medication currently used by the patient.

During the course of everyday practice, questions arise in a clinician's mind whose answers could potentially improve their patients' outcomes(6). Research has found that only about 30% of these sorts of information needs were met during the patient visit (typically through consultation with a colleague) (14). When documenting findings in an EHR there is an opportunity to link the physician with electronic resources that might be useful based upon the context of the information being input into the record (15). These clickable links to relevant research are called Infobuttons (see Figure 1). Infobuttons have been found to significantly increase the percentage of met information needs at the point of care(16). Infobuttons are not widely used in EHRs as of this writing, but evidence at this point indicates they are gaining some momentum and could positively impact patient care.

Figure 1: Infobuttons in Medical Record



Throughout the EHR concepts of interest would be accompanied by the infobutton icon. Clicking on the icon would initiate the above infobutton manager(67) screen. This resource dynamically builds itself based upon anticipated questions for that term in the context of patient care taken from the patient record. This puts reference information relevant to patient care at the provider's fingertips.

Although medicine is an art and each patient's case must be considered individually, outcomes research has established guidelines that should be considered for specific clinical entities. For example anti-oxidant vitamins should be considered for those patients with dry age related macular degeneration (17). Quality of care evaluations have noted that these guidelines are adhered to significantly less frequently than would be predicted to be medically appropriate(6). While the clinician is inputting information into the electronic health record, software can retrieve evidence-based guidelines based upon context that is appropriate for the patient being examined. This allows suggestions to be presented reminding the clinician about appropriate interventions and cautions. Software designed for this function is called Clinical Decision Support (CDS). Public health and preventative medicine interventions are often neglected in the doctor's office and adherence rates stand to improve with the use of this CDS software. Research indicates that these systems have a positive impact on guideline adherence and thus should improve the quality of care(18-20).

Numerous medical errors occur during the translation of orders for pharmaceuticals, labs, and radiological tests.(21) Directly communicating these orders in a legible, standardized format from prescribing provider to pharmacy, laboratory or radiological facility reduces the chances of miscommunication. Software designed to perform this task is called Computerized Provider Order Entry (CPOE) software. Well designed CPOE software also assists the provider in making the correct dosage choice, and avoiding look-alike sound-alike medications. In most cases CPOE software works in tandem with CDS software to ensure that this patient is being treated appropriately, evaluating drug interactions and contra-indications, allergies, appropriateness of dosage for this specific patient, etc. CPOE/CDS systems have been found to improve communication and reduce medication errors significantly(21, 22). Recognizing the quality and cost-saving advantages of this system, in 2009 the federal government started paying a bonus of 2% to those providers utilizing E-Prescribing (with CPOE) in the care of Medicare patients.

Clinical informatics tools integrated with the EHR such as Infobuttons, CPOE and CDS have great potential to improve population health through increased quality of care and reduced frequency of medical errors in the hospital or clinic setting. With the increasing prevalence of chronic disease in our population, emphasis has shifted from provider centered care to patient centered care(23). Informatics also provides some promising tools that enable a patient and doctor to work more collaboratively in treating their disease.

Disease Management

Chronic disease management is dependent upon sustained efforts by the patient. Empowering the patient to be actively involved in managing their disease improves outcomes(24). Computer and internet based tools have proven themselves to be quite effective in educating and involving the patient in management of their disease(25-27). A major patient centered tool is the Personal Health Record(28). This tool allows patients to keep track of their own personal health information, provides educational material to assist in self management of chronic disease, and can even take inputs from home monitoring devices such as glucometers, blood pressure monitors and more(29). Although personal health records do not have to be computerized, the added interactivity and disease management tools that an informatics solution provides aids in patient engagement.

Home monitoring devices allow patients to monitor their own disease state; this information can also be provided to their doctor to enable telemedicine. Telemedicine involves communication of medical information to a remote provider for consultation. Depending upon the influence of the item measured on the disease state, positive or negative trends might dictate frequency of required appointments for a patient. For example, a patient with diabetes would require less frequent care when their blood sugar is tightly managed, and a negative trend in blood sugar levels might demand an earlier visit. Catching a negative trend early enough could save the patient an adverse event (such as a hypoglycemic emergency room visit). This telemedicine approach has been used successfully to monitor patients with chronic diseases such as diabetes(25), and is being investigated for use in glaucoma(30). An at-home intraocular pressure monitoring device has been developed and might aid in future telemedicine applications(31). Telemedicine monitoring has the potential to improve our ability to continuously track populations of chronic care patients improving the quality of care, and reducing costs through cost avoidance.

Internal research and HEDIS tracking

Electronic health records store a large amount of health data in a database (or clinical data repository, CDR). From a public health perspective use of this data for observational studies is desirable. Design of the database and the means of inputting the information will determine the ease of data retrieval(32). Difficulty gathering data from paper records often limits the scale of retrospective studies. Currently, when large scale data sets are needed, digital administrative information is often used (e.g. coded billing information) due to the relative ease in manipulating electronic information. In clinical outcomes research, clinical data extracted from an EHR is far superior to administrative data(33). Large scale studies using EHR data have been effective in recent years, such as Graham’s study looking at the effects of cyclo-oxygenase 2 selective and non-selective non-steroidal anti-inflammatory drugs on myocardial infarction rates(34). This study was able to examine 2,302,029 patient life years of data using electronic data; this would have been essentially inconceivable if paper records had to be evaluated. Eyecare researchers are also beginning to use EHR data for observational studies, Imrie’s evaluation of optometrist referral patterns of glaucoma patients used information from their home-grown glaucoma-specific EHR(35). Well designed EHRs should lower the barriers to observational outcomes research, increasing the analyses possible to determine which interventions lead to better outcomes for patients.

When outcomes research derived clinical evidence is strong, these preferred practices should be translated into standard practice. Evaluating the frequency of adherence to these evidence based guidelines can be done with easy access to the data from the clinical data repository for quality assurance purposes. For years the Healthcare Effectiveness Data and Information Set (HEDIS) guidelines have been used by health plans as benchmarks which allow them to gauge the quality of care being rendered to their beneficiaries. More recently the Federal Government's Centers for Medicare and Medicaid Services (CMS) have developed the Physician's Quality Reporting Initiative (PQRI) which gives incentive pay for providers who validate their adherence to the PQRI quality of care standards(12). Using data from the CDR for these quality assurance activities (often presented to healthcare decision makers on a report card or graphically as a "dashboard") is becoming commonplace. Some providers warn of cookbook medicine, enforcing the same solution on patients with very different circumstances. In macular degeneration, for example, to receive the PQRI, vitamin supplementation should be recommended, but if a patient has a history of smoking, it may be inappropriate to recommend vitamin supplements containing beta carotene. For a patient with dry macular degeneration without drusen, the efficacy of vitamin supplementation has not been demonstrated, but if macular degeneration is diagnosed, the provider has to document vitamin supplementation discussion. There are legitimate fears of doctors shying away from tough cases preferring to keep their report cards clean(36). If a patient has diabetes, macular degeneration, and glaucoma, and one visit fails to include documentation on any PQRI, the provider may lose reimbursement. In other words, the patient may be in for a check of intra ocular pressure after starting a new glaucoma medication, but the diagnoses and documentation have to be repeated for vitamin supplementation and blood sugar goals. These concerns are credible and must be addressed, but on the whole these quality initiatives will better our population's healthcare.

Information generated in the patient encounter does not need to leave the doctor's office for the EHR to provide public health benefits for the care of populations of patients. Box 3 summarizes the many advantages that EHRs enjoy over paper records without network connection. However, the ability to share information beyond the walls of the originating healthcare organization takes the next step, and amplifies the benefits of an EHR, making it a great leap forward for public health.

Box 3	Advantages	Disadvantages
Paper Health Record	1. Speed of Data Input 2. No change required. 3. Low upfront costs. 4. Ease of designing own paper form to fit practice's workflow.	1. Paper chart records take a lot of space and require expensive chart pulls. 2. Difficulty in backing up information makes vulnerable to fire/flood/loss. 3. Difficulty in sharing data between offices. 4. Legibility of record increases risk of error in care.
EHRs	1. No file room to maintain. 2. Patient information available at all your office locations for each patient. 3. Ability to backup EHR data in remote location through network to prevent data loss . 4. Ability to use helper applications such as CPOE/CDS and Infobuttons to improve quality of care rendered and reduce liability risk. 5. Ability to more easily analyze practice's data to determine best outcomes. 6. Interactivity encourages patient disease management. 7. Ease of integration with telemedicine applications allowing for close monitoring of chronic disease patients with resulting better outcomes. 8. Legible records.	1. Expensive software and computer purchases upfront. 2. Software maintenance expense. 3. Practice dependent upon reliable computer operation.

RHIO and Standards

Similar to paper records, medical information stored in the database of an EHR has limited value if the information is confined to one doctor's office. A patient's medical record from their cardiology office would benefit the primary eyecare provider managing the patient for ocular ischemic syndrome. In order for the data to be successfully moved and arrive in a form that is readable by the eyecare provider's electronic health record a few important barriers must be overcome. Permission must be obtained from the patient for this sharing of medical information as delineated by the Health Insurance Privacy and Portability Act (HIPPA). A secure network must be in place to allow the transfer of the information without compromise. Finally, both the sending and receiving EHR must adhere to standards to ensure that the data is readable upon arrival. If these criteria are met, the data stored in a compliant EHR can benefit the health of individual patients. These benefits can be extrapolated to entire populations and help to fulfill the public health promise of EHRs.

Health information recorded at individual medical encounters has enormous public health advantages if it can be transmitted over a network to those who need it(37). President George W. Bush established the Office of the National Coordinator of Heath Information Technology (ONC HIT) to act as an advisor to the Secretary of Health and Human Services on Health Information Technology. One of the ONC HIT's (Office of the National Coordinator) first priorities was the establishment of the Nationwide Health Information Network (NHIN). The NHIN is under development, with a goal of secure exchange of standards-compliant data to enable better coordination of care. The NHIN will be made up of many smaller networks called Regional Health Information Organizations (RHIOs)(38). Despite this decentralized approach the goal remains the same: New York doctors treating a vacationing patient from California would have access to his electronic medical record transmitted from his RHIO via the NHIN.

Receiving an email attachment that you cannot open is wasteful and frustrating. Creating a network to exchange health information will be fruitless if the data delivered is not readable. Readable data is dependent upon adherence to data standards. Standards have been developed for adoption by EHR vendors and RHIO members to allow data to be exchanged between systems in the RHIO(39). Maturation of standards is an ongoing process due to the enormous complexity of medical care and the vested interests involved. It is not uncommon at this point for two software systems to both be compliant with current standards (for example, see Box 4) and still require a piece of software called an interface, to specifically translate between the two systems(40). The importance of development, acceptance and adherence to robust standards cannot be understated. Not only is it a practical necessity in order to enable the public health benefits that we have discussed, the absence of robust standards could undermine the benefits of EHR adoption altogether. Consider the loss to a practice if their EHR vendor goes out of business and they are unable to neither support their EHR system nor convert their records to a new EHR system. For those deciding upon which EHR system to adopt, standards compliance should be a high priority.

Box 4

<u>Data Standards to Look For in an EHR and Clinical Equipment</u>.

<u>Certification Committee for Health Information Technology (CCHIT):</u> The only certification body endorsed by the federal government to evaluate EHRs for adherence to standards. The first Eyecare EHRs should be earning their CCHIT seal of approval in 2011. Participation in federal incentive plans will require purchase of a CCHIT endorsed EHR.

<u>IHE Eyecare Connectathons:</u> These very practical events test the interoperability of equipment and EHRs to determine how well they integrate.
<u>Health Level 7 (HL7):</u> A series of standards designed to allow data exchange and interoperability of EHRs. Many standards and versions exist so a vendor's claim of HL7 compliance can be meaningless. CCHIT uses HL7 standards to evaluate EHRs.

<u>DICOM</u>: Standards centered on medical imaging. IHE and CCHIT use DICOM standards to enable product interoperability and data exchange.

Electronic health information transmitted over a network is a great deal more portable than the same information on paper. This added mobility spurred the creation of rules to address privacy concerns and protect personal health information. For this reason the Privacy Rule was written into the Health Insurance Portability and Accountability Act (HIPAA) by the Clinton administration. HIPAA helps to protect a patient's personal health information primarily by requiring the patient's informed consent prior to use. In order to allow governmental public health agencies to use patient data for public health uses, a specific exception was written into the Privacy Rule that drops the requirement for informed consent for public health agencies (the public health exception). All uses of data, even if it would have a positive public health effect, are not exempt. For example, outcomes research can have positive public health impact, but it is rarely granted immunity from HIPAA. The result of this is that many public health applications can benefit from the transition to digital information without HIPAA's overhead(41), while other information applications must overcome the admin burden of the HIPAA Privacy Rule to enjoy the superior access that digital health data promises(42).

The unintended consequence of the structure of our healthcare system and the lifestyle of our citizens is fragmentation of medical care. A number of factors reduce the opportunity for the continuity of care that logically would be beneficial for chronic disease management. Our medical reimbursement system and the rapid expansion in medical knowledge has encouraged specialization (and sub-specialization). As a result a normal 65 year old patient might see three or four specialists per year in addition to their primary care provider. Communication, if it exists, between these providers would typically be through written and mailed consult reports. This is an administrative system with many layers prone to failure. Each year health plans negotiate with employers to renew their contracts to cover their beneficiaries. Employers change health plans routinely resulting in patients changing doctors to ensure they are covered by their insurance. Our reimbursement system strongly encourages doctors to address only one problem per visit, resulting in the need to return frequently. The expense of office administration and malpractice insurance has driven most outpatient medical providers to practice in groups vice solo practice increasing the likelihood that a patient returning to the same practice will not see the same provider. The United States is known as a mobile society with individuals moving relatively frequently often leaving their paper health records behind. Doctors have a feeling of ownership of the health information they generate about their patients, indeed when a practice is sold the medical records are often conveyed as the principle tangible asset. As a result of this proprietary notion, obtaining one's own health records is often an inconvenient and expensive proposal. Together these factors reduce continuity of care. Continuity of care has been shown to improve the quality of care(43). An EHR is not a panacea to this fragmentation, but if each of the providers were able to see the notes generated by the others as well as the drugs, labs, and imaging studies ordered and resulted, the ability to manage the care of the patient would likely improve. The EHR connected to a RHIO should allow the provider to see the notes generated on the patient by other members of the healthcare team improving the continuity of care.

Clinical Data in the Hands of Public Health Professionals

Many of the impacts of the shift from paper to EHR discussed thus far have been within the realm of the individual clinician. Moving beyond the clinic to the more global perspective typical of public health, digital data provides new opportunities here as well. Registries, disease surveillance systems, and geographic information systems are public health tools that would benefit from access to the data aggregated in an EHR's CDR.

Registries are databases used to track patients with a particular disease, exposure to a risk factor, or those who have undergone a certain procedure. They are used in a variety of ways: estimating incidence, providing a population for researchers to study, trending a disease's impact over time, etc. Organizations that maintain registries typically are active in gathering data on their target population. Clinicians who encounter a particular disease or clinical entity are asked to report the case to the involved registry. Compliance by providers with these requests, similar to reporting of the specifically mandated nationally notifiable diseases is generally poor(10). In eyecare there are a number of registries.(44-48). For example the US Eye Injury Registry attempts to capture eye injury cases to aid in epidemiological research and to evaluate prevention measures. Reports to these registries could be automated in an EHR, utilizing a background helper application that would evaluate data entered to detect specific clinical entities and use standardized health messaging to report to approved registries.(49). These tools are still in development currently. An early example has been used to help populate a glaucoma registry(40). The value of a registry is enhanced by both the depth of information provided, and the number of reports, EHRs are well positioned to aid in both respects.

Public health surveillance is defined as an “ongoing, systematic collection, analysis, and interpretation of health-related data essential to the planning, implementation, and evaluation of public health practice, closely integrated with the timely dissemination of these data to those responsible for prevention and control.”(50) Surveillance information is used to evaluate threats to public health, detect epidemics, generate research questions, assess current attempts to control health threats, as well as stay on top of changes in infectious agents or health practices. The type of health related data that is monitored has a significant impact on the information derived. Typical surveillance makes use of information such as reports of the mandatory notifiable diseases, lab results, vital records, and disease registries. Utilizing data from cases that have been definitively diagnosed is reliable as is appropriate given its usage.

When the objective of surveillance is to detect outbreak or identify a biological warfare strike, waiting for definitive diagnosis information increases exposure of the public to harm. Syndromic Surveillance is a type of surveillance that uses multiple streams of preliminary data to allow an adequate sensitivity to outbreak in a more rapid fashion.(51) The types of data streams used in syndromic surveillance can include health related web searches(52), the chief complaint data element from a hospital emergency room EHR(53), pharmacy sales of specific over the counter remedies and many similar repositories of information. When these disparate streams of data are aggregated in volume they can sensitively detect disease outbreaks.

Data pulls from an EHR CDR are a relatively untapped resource in disease surveillance with little utilization beyond use of ICD-9 CM data (diagnosis code). This is likely to change in the near term as access to usable data from CDRs is enabled by communication and data standards. The National Electronic Disease Surveillance System (NEDSS) is a Centers for Disease Control (CDC) data standard established with the goal of unifying disease surveillance systems nationwide. One of the principle tenets of this system is to enable the transfer of data from clinical information systems (such as EHRs) for use in public health. With time and greater sophistication constellations of pathognomonic exam findings could be pulled from EHR data to rapidly predict variances in disease incidence.

John Snow's classic study documented cholera cases tracking them relative to their location from the infamous Broad Street pump. This illustrates the importance of geography in public health investigation(54). Technological advances in the use of GPS navigation and ubiquitous mapping software have been leveraged in public health through the use of Geographic Information Systems (GIS). These systems ease spatial tracking in public health. GIS is used in infectious disease tracking of course, but it is also used in many other applications where spatial information is relevant such as Sheen's evaluation of the costs and benefits of optometric referrals in Wales(55). An EHR that can provide clinical data already integrated with patient address information is an ideal data source for GIS systems. As an example of an EHR fed GIS system a query could map all patients with clinical signs of allergic conjunctivitis enabling evaluation of population densities of allergy sufferers, and perhaps pinpoint the source of an allergen.

Advances in public health informatics will dramatically change the way both clinicians and public health practitioners practice. The EHR will provide a tool to practitioners to create records that are more legible and useful both to themselves and other practitioners. Tools integrated into the EHR will help improve patient safety as well as function as an aid to clinicians in keeping up to date with the latest in evidence based practice. The EHR's data repository (CDR) and its network (RHIO) will act as a bridge: to other clinicians enabling informed teamwork in patient care, to researchers providing volumes of patient care data to power outcomes research, and to public health professionals to assist them in safeguarding the population from outbreaks and guide health care policy. As this new field develops many more applications will be found for this new abundance of easily accessible data.

CASE STUDIES

It's Friday afternoon and you are running a little behind schedule as you usher in your last patient of the day. Daniel Brouder is a seventy two year old white male with a twenty five year history of glaucoma. This is his first visit to your office as his health insurance is no longer accepted at his prior provider's office. Speaking with him regarding his history of glaucoma treatment; compliance on his current medications seems credible, but his memory of previous medications or surgical history is very sketchy eliciting responses like "I was on one drop that gave me a serious rash around my eyes…" and "we just changed my drops six months ago because one of the one's I was using was not working anymore". His IOPs are twenty in both eyes and his optic nerves reveal obvious glaucomatous damage. While you are deep in thought attempting to determine the best course, Mr. Brouder relates that he and his wife are leaving for a three month round the world cruise next week.

Public Health Problems

1. Glaucoma is a common sight threatening asymptomatic condition in older Americans. These patients may require care from multiple providers due to changes in insurance coverage, changing residences (southern residence in winter, northern residence in summer), and other systemic conditions which may impact glaucoma risk and treatment and vice versa. What are the advantages and disadvantages electronic health records and public health informantics bring to this case?

You are wondering why you see patients Friday afternoon when your office manager Jackie informs you that the download of Mr. Brouder's medical record has just finished. Luckily since both you and Mr. Brouder's previous caregivers use standards-compliant software, the data that arrives is properly displayed in your electronic health record. A quick perusal reveals that Mr. Brouder has had pressures in the low twenties for years now. Neither his optic nerve, visual field nor his OCT results have changed in the preceding four years. In fact his most recent reliable OCT and visual fields were completed just two weeks ago. Reviewing the EHR's clinical practice guideline that pertains to open angle glaucoma you feel confident that based upon his stability Mr. Brouder can safely go off on his vacation with only a medication refill. When you enter in the medication refill into the CPOE module of the EHR an alert pops up (CDS) indicating that Mr. Brouder's cardiologist just put him on a beta blocker last week that is the same medication class as the beta blocker eye drops you plan to renew. Upon querying the patient he notes that the last couple of days he been feeling out of breathe frequently. Reviewing his vital signs shows a slow (bradycardic) pulse rate. Conferring with Mr. Brouder's cardiologist you decide to keep Mr. Brouder on the beta blocker eye drops. You will send him back to his cardiologist for a new systemic medication prior to his trip. In order to better manage Mr. Brouder's glaucoma your staff instructs him on the use of a home intra-ocular pressure recorder. This disease management tool encourages the patient to engage in self-care improving medication compliance by closing the feedback loop for the patient. The device can post its results to the patient's personal health record when it is plugged into a computer. The PHR software allows information sharing at the patient's discretion enabling data to flow to your office's EHR so you can monitor his pressures while he cruises the world, enhancing patient safety. Satisfied that Mr. Brouder is well taken care of, you send him off to his cardiologist allowing you to escape the office in time for dinner.

2. Are there tests or aspects of case management you would add or subtract from that presented above? Why or why not?

Monday morning: The week gets off to an interesting start as patient Mark Bayne reports to the clinic. Mr. Bayne is a contact lens wearer who comes in with a red eye. His right eye had been bothering him for a week, and it was slowly getting worse. When examined, the right eye exhibited peri-limbal injection of the bulbar conjunctiva and a corneal defect. The corneal defect was a dense anterior stromal corneal infiltrate with diffuse borders overlying a subtle focal area of corneal thinning 2mm eccentric to the visual axis. Using the electronic health record to look up Mr. Bayne's previous eye notes you determined that his right eye was clear at his last examination two months ago.

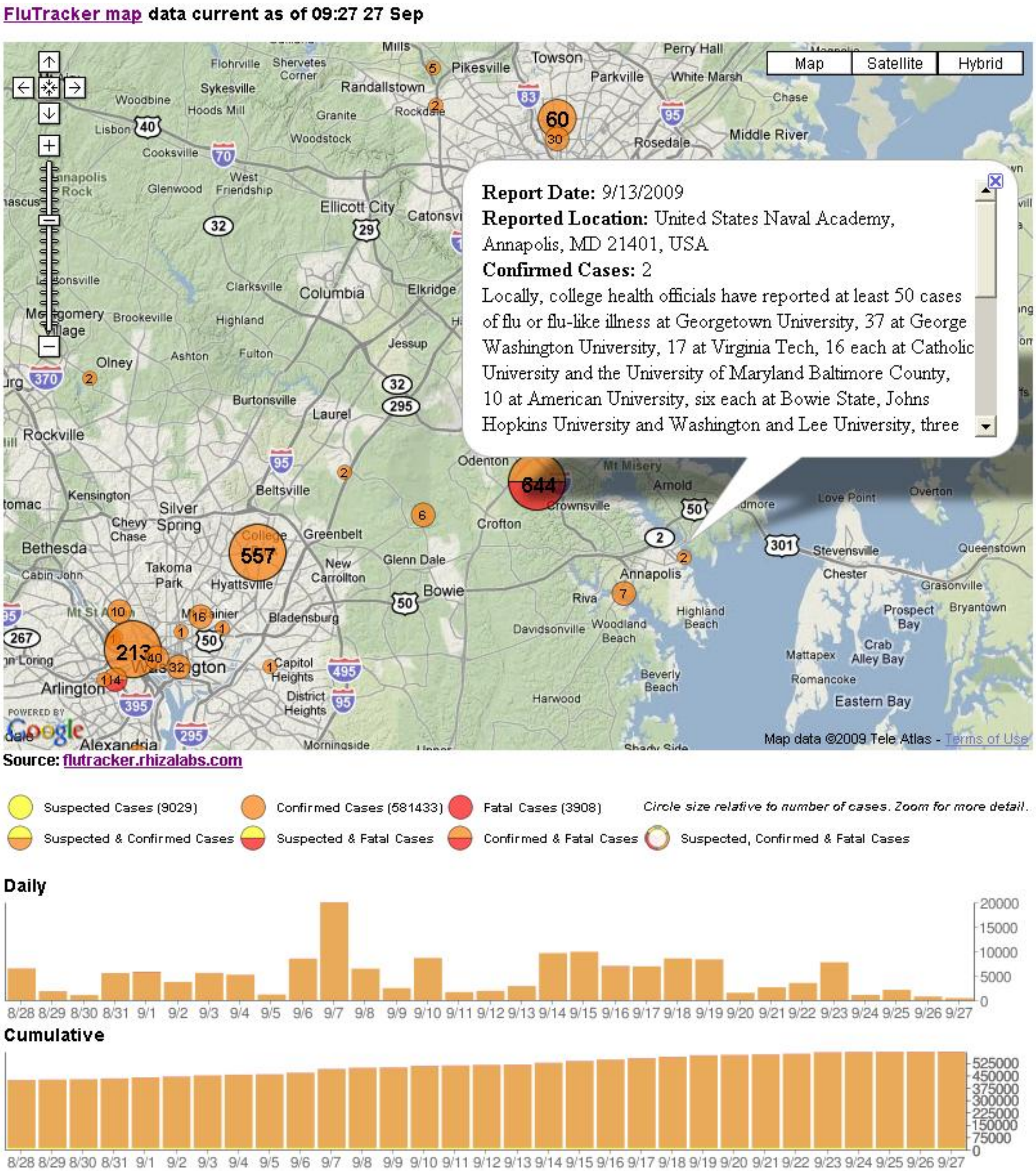
Public Health Problems

1. What conditions could be present that are important from a public health perspective?
2. What tests, patient advice, communication, and management should be initiated?

Your electronic health record's Infobutton application suggested several relevant topic information links in response to the information you input into the medical encounter. Selecting the infobutton corresponding to fungal keratitis (one of your primary rule outs), you are reminded that using a simple KOH +CFW smear preparation for the light microscope as well as culturing in Sabouraud 2% glucose-agar (without cyclohexamide) would yield the best chance of detecting fungal keratitis. Armed with this information you take the correct corneal specimens prior to treating the patient, as medication might contaminate your results. As you write the patient's orders in your EHR a reminder pops up indicating that this patient is due for a periodic visual field examination in one month to monitor for glaucoma. You mention this to Mr. Bayne and prior to leaving he sets up that appointment hopeful that the current malady will have resolved by then. Having taken your specimen and recorded your results you send the patient off to the corneal specialist confident that your notes will be available to her. The next day Mr. Bayne is seen by the corneal specialist, and the results from the laboratory of your initial scraping indicate that with light microscopy hyphae were detected. Although the results of this testing were sent to you they are available to the corneal specialist using a compatible medical record and the regional health information exchange (RHIO). As a result the specialist is able to move forward with the most up to date information for the patient improving patient care.

Your lab order for Mr. Bayne and EHR notes are available through the RHIO to those entities with permission to view them. Governmental public health agencies monitor lab testing and other early indicators of disease outbreak. Public health surveillance picked up on your lab order. Tuned to detect increases in particular lab tests the software noted there has been an increase in your state of the use of corneal cultures utilizing fungal specific Sabouraud's medium this past week, (normal incidence of 3 to 4 per week up to 10 this week). This increase in the number of these cultures alerts public health officials to the possible increase in fungal infections of the cornea. When the state agency matches the lab orders with the patients' address information obtained from their providers' EHR they are able to feed this information into a Geographic Information System which pinpoints the location of the patients on a map such as seen in figure 2. In this case, the map makes it obvious that the problem is isolated to the area surrounding Yonkers, New York. An alert is then sent out to eye doctors, primary care doctors and laboratory personnel in this area informing them of the situation and asking for them to report episodes of suspected fungal keratitis. As a result of this request an outbreak is detected and its source is located resulting in the recall of an isolated lot number of a particular contact lens solution.

Figure 2: GIS images can provide granular data with associated geographic information opening new doors in data analysis.(68)



Discussion

As noted the advantages in shifting from paper record storage to a digital database are numerous. Yet there remain a number of hurdles that stand in the way. Matching the flexibility and efficiency of recording notes on paper with an appropriate database input interface that strikes a balance between the efficiency of data input with ability to retrieve specific findings has proven difficult. The primary public health benefits derived from EHRs assume that information stored in the EHR will be easily accessible. Unfortunately, standards to allow simple data extraction from the electronic health records are immature and compete with vendors' proclivity to develop proprietary formats for commercial advantage which erect walls around the data. To move a patient's data between two EHRs requires an information exchange (RHIO); RHIOs in operation are primarily supported by short term start up research funding; unfortunately most lack a viable long term economic model. Finally, many psychological factors have impeded the widespread adoption of EHRs in eyecare despite their availability on the market for over a decade (56). The use of EHRs could be a great boon for public health, but much of their promise has yet to reach fruition.

A standard optometric examination is filled with many small tests whose results are dense with data. As an example, pupil testing evaluates size, shape, equality, speed of response, relative quality of light detection between the two eyes, and possibly pupillary response to a near target. On a paper form the normal result is typically annotated with a checkbox for all normal results with unformatted space for notes if necessary. [See Figure 3] When annotating this in the EHR we must determine how this will be represented in the database. [Figure 4] If each of these items has its own database field this will enable us to more easily recall this information in the future. For example, if I was doing research on glare it might be useful to be able to recall my patients with a misshapen pupil. Including this level of granularity in the database can be quite time intensive on the input side. Typically this means the doctor spends more time inputting results and less time in patient care costing him lost revenue and reducing his productivity for the population served. To save time, pupil testing could be recorded with a single checkbox (normal or no). Abnormal findings could then be detailed in a single textbox. This increases efficiency of input but reduces the granularity of the data and reduces the ability to retrieve the results. A simple query for patients with misshapen pupils would require culling abnormal findings from the free text which would require a processing heavy software decoding technique called natural language processing (NLP). Currently NLP is imprecise and slow but it is improving. On the positive side many providers find this approach to be much more efficient for data entry reducing the disruption in work flow and time impact of EHR data entry. Obviously a balance has to be reached between the need to have easily retrievable data and the efficiency of data input. A number of current EHRs fail to strike the right balance between these competing interests.(57)

Figure 3

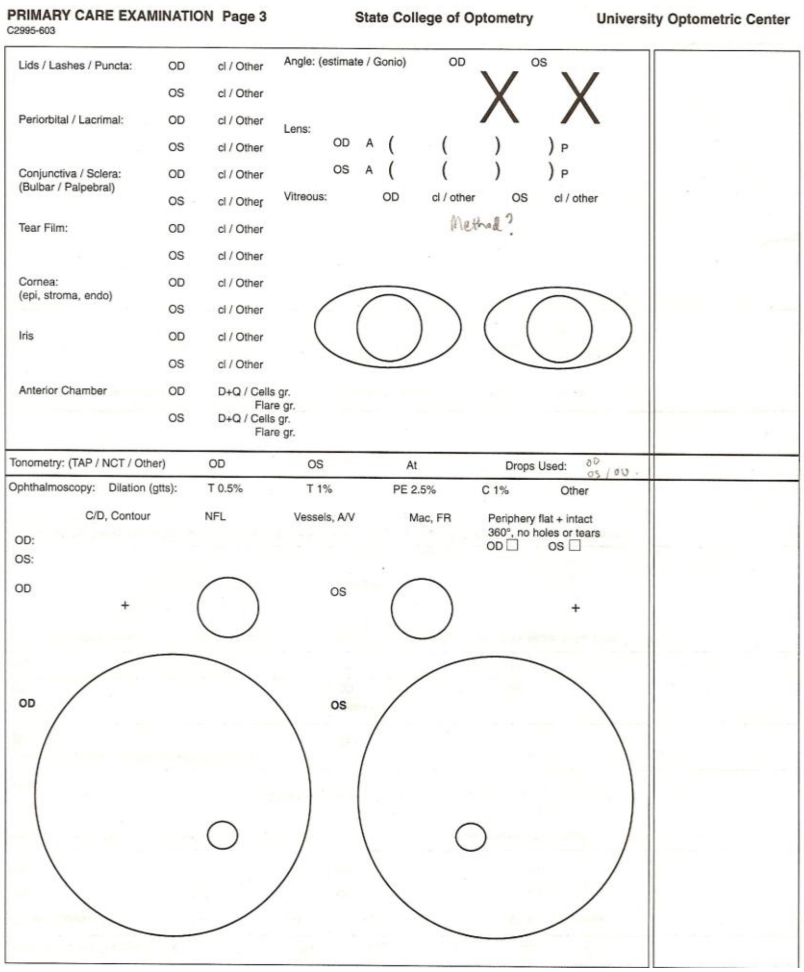


Figure 4

	Result	Units	Flag
OD lid/lash			Normal
OS lid/lash			Normal
OD periorb			Normal
OS periorb			Normal
OD ConjScl			Normal
OS ConjScl			Normal
OD tear film			Normal
OS tear film			Normal
OD Cornea			Normal
OS Cornea			Normal
OD Iris			Normal
OS Iris			Normal
OD A/C			Normal
OS A/C			Normal
OD Angle			Normal
OS Angle			Normal
OD Lens			Normal
OS Lens			Normal
OS A/C			Normal
OD Angle			Normal
OS Angle			Normal
OD Lens			Normal
OS Lens			Normal
OD vitreous			Normal
OS vitreous			Normal
Method			Normal
Attend Notes			Normal

On the left we see the paper form previously used in the clinic at SUNY State College of Optometry. On the right is a snippet of their current EHR a customized version of Allscripts Touchworks.(69)

Another means of enabling data retrieval is to encode information using a standard vocabulary such as SNOMED CT or ICD 9CM (or 10). Coding vocabularies have tradeoffs as well; often the meaning that you wish to convey does not fit neatly into one of the terms used in the coding vocabulary. As a result a best fit code is used which results in a loss of information. There are potentially negative repercussions when these data are interpreted and used in the future.(58) The EHR must be well designed to maximize the information that can be easily and rapidly stored in a retrievable fashion.

EHR systems are only as good as the software architecture they are built upon and the company that supports it. Shifting your practice to an EHR whose database is proprietary, does not export data in a common file format, or whose vendor is on shaky ground is a very risky proposal. EHR software is mission critical, any downtime or slowdown of the software reduces productivity and utility of the system. This software must be maintained and supported to remain viable; this can be quite expensive. One would hope to have the flexibility to switch systems if the support payments became onerous, the system was not performing as required, or the software vendor left the business (a common problem in the nascent EHR market). Transferring legacy records to a new system can be quite challenging and often requires a custom made interface if it is reasonably possible at all. Vendors have an incentive to make transfer of records from their system somewhat challenging. Standards that are currently set for EHRs including HL7 and CCHIT are loose standards that maintain only minimal requirements. These standards were launched with low compliance hurdles to allow existing EHR products to easily adopt the standards, but many EHRs have not kept pace with standards development. *(I made significant edits to this sentence. Is it still correct? Stan)* The standards have become iteratively more stringent in later versions as they mature. Compliant EHRs reduce the complexity of the interface required and potentially could eliminate this requirement in the future. Market and standards maturation will ultimately reduce the risk of EHR adoption assuming that vendors are pushed to cleanly adopt mature standards. Customer demands coupled with government or third party payer pressure will drive this.

Health information exchange is necessary to allow data to flow beyond the bounds of the provider's office. The economic model that will maintain these exchanges and "encourage" hospital systems and competing healthcare organizations to share data has not been established. An early model, the Santa Barbara RHIO led by the first National Coordinator of HIT Dr. Brailer, recently ceased operations due to the research seed funds running dry.(59) Despite its exalted status as a national model it failed to raise the necessary funding to continue operations. Exchange of information must generate revenue or at least be expense neutral to enable a viable economic model for exchanges that support these information transactions beyond the research funding stage.

Financially rewarding quality in medicine is a desirable goal. Assessing quality of care is famously difficult; integrated data accessible through an EHR are anticipated by some as a solution. In his salient commentary in the British Journal of Ophthalmology Dr. Chris Canning(36) points out the power and potential abuses of integrated data. Acknowledging the wonderful epidemiological advantages of having this amount of data at your disposal he also points out the potential for a ranking of ophthalmologists based upon their cataract surgery outcomes from best to worst surgeon in the country. The beguiling simplicity of matching provider to outcomes is dangerously flawed. Medical care outcomes cannot be assessed without taking into account patient mix and risk levels due to pre-existing conditions. Our nation's best doctors who take on the most challenging cases will likely fair very poorly in these ratings due to the complexity of cases taken on. Similarly consumer websites are evaluating doctors based upon customer feedback similar to plumbers or toasters. Despite doctor resistance, this type of internet enabled customer feedback will likely grow (60) (http://www.medicaljustice.com) The reality is patient's rarely know the true quality of the medicine they receive; they do however accurately perceive quality in customer service and hotel services. Rankings are likely to be skewed to reflect quality in these areas but this will likely be extrapolated to indicate total quality of care. Quality of medical care is still difficult to objectively determine. Changing our medical reimbursement system to truly financially reward quality would be an enormous boon to public health; however the temptation to use easily attained but flawed surrogates for medical quality should be resisted.

The move from paper to electrons will be revolutionary. Although we have discussed many informatics powered applications utilizing liberated medical information, there will likely be many more in the future. For example, although spyware is generally despised, the technology that makes it useful. An inferential engine that infers and transmits knowledge about the computer user from watching the user's interactions, could have healthcare applications.(61) The same way Amazon determines what you might like based upon what you look at on their site, we may soon be determining what diseases you are pre-disposed to and what custom treatments would work best for you based upon a combination of otherwise normal health indicators. It is time to usher in "Health 2.0".

Study Questions

1. You are considering purchase of a new EHR for your practice; discuss the importance of standards in purchasing decisions?
2. Continuity of care improves health outcomes; discuss the factors that disrupt continuity and the role that Electronic Health Records play in improving it?
3. Why has the adoption of EHRs been so slow in the United States?
4. Electronic Health Records do more than simply receive and store information, they process the information received for the benefit of public health. Discuss ways the data is processed and the public health impact of each?
5. Give an example of the type of optometric exam data that you would like to track longitudinally? Explain the possible public health consequences of your ability to retrieve this information with a simple query to your clinical data repository?
6. What is the current condition of data standards in eyecare related informatics?
7. Has the promise of Electronic Health Records been realized? If not, why not?

Take Home Conclusions

- Health care is in the beginning stages of a shift from paper to electronic recording. This paradigm shift will have a profound effect on individual and population health.
- Data collection from medical care of the individual, long sequestered in dark and dusty file rooms could soon be liberated, empowering new tools for managing population health and providing large repositories of data for epidemiology and outcomes research. In order for this to happen a standards based framework of data sharing must be devised and universally accepted.
- The Electronic Health Record and Personal Health Record must enable accurate efficient capture of individual medical encounters. Information recorded in these records will be encoded to allow the information contained to be stored in a database for easy retrieval by authorized parties furthering public health.

Acknowledgements

The author has no financial interests or conflicts of interest with any of the corporations or products mentioned.

The author would like to thank Michael Chiang (Columbia University Department of Biomedical Informatics), Jerome Feldman (SUNY State College of Optometry), Ron Gimbel (Uniformed Services University of the Health Sciences), the American Academy of Optometry Public Health Section, the US Navy, and my wife for supporting my work in this area.

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