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A New Breed of Electronic Medical Records

Challenge:

Physician Dissatisfaction:

Physicians have become so dissatisfied with existing EMR systems that the phrase "No EMR" has become a recruiting tool in job advertisements [1]. Physicians increasingly complain that EMR systems take up their time unnecessarily and are responsible for burnout [2,3]. Many physicians believe that these systems impede patient care, and many also worry that EMR systems compromise patient confidentiality. EMRs in their current form pose an obstacle to good medicine.

Reasons for Dissatisfaction:

EMRs are essentially siloes of data built on expensive hardware and used predominately to document visits, billing, auditing, quality assurance, reporting, and research. All these activities are administrative or academic in nature; all are unrelated to direct patient care.

EMRs were never meant to remain repositories of data. They were supposed to become an instrument for rapidly sorting and visualizing information relevant to a given clinical problem. Gartner, a reputable consulting company, prognosticated that EMRs would evolve from "collector" to "helper" and finally to "mentor," a system that might not only assist but guide clinicians. These predictions have not come to pass. The data in EMRs remains data—and not especially accessible or useful data, at that. The records generated are voluminous, non-searchable, and cluttered due to irrelevant alerts and boilerplate language affirming the healthy status of various systems and organs. Copied and carried over without much thought, these records contain so much noise that they obscure the clinical picture and obstruct the physician's capacity to make a diagnosis [4]. Physicians are made to act as data-entry clerks, inputting information into a system that does not aid them in solving clinical problems. Asking physicians or specially trained medical scribes to collect data for EMRs therefore adds cost but not value to patient care [5].

Opportunity:

Creating a new, modern-day EMR is a potentially rewarding opportunity both financially and in terms of social impact.

Part of the reason EMRs are failing to contribute to patient care is the underlying technology. All major EMR players have been on the market since the late seventies or early eighties. Their systems are based on old technologies that cost hundreds of millions of dollars. They are supported by armies of '90s-era IT analysts and technicians, which further increases the cost of purchasing and administering them. Cerner, MEDITECH, McKesson, EPIC, and a large number of smaller companies are currently splitting the twenty-billion-dollar pie [6,7]. This behemoth industry is ready for disruption.

Still more importantly, however, an EMR system could catalyze enormously positive changes in the medical field. A system augmented with modern advances in machine learning, natural language processing, and biometrics data collection by means of consumer-driven peripheral devices could truly transform patient care.

EMR as a Living Document:

A new EMR system must, first of all, address the most troublesome element of all EMR systems: the process of data entry. Data entry is not only time consuming but also fraught with duplications and inaccuracies that obscure actionable information and make solving clinical problems more difficult. I propose replacing the current "ledger" EMR paradigm with a "living document" paradigm. Today, EMRs are ledgers: collections of chronologically-recorded transactions. They simply replicate traditional paper-based medical records electronically. A living document, in contrast, is a dynamic document that, like Wikipedia, is continually edited or updated. A living document has several important advantages over the ledger. First of all, it can reflect changes that occur over time—throughout the course of a disease, a period of hospitalization, or the lifespan of an individual—without becoming sprawling and unwieldy. Instead of spending copious amounts of time generating new ledger-style entries, users would quickly edit a document that would remain concise and therefore useful. This type of document would also, of course, allow for tracking all of the typical metadata (e.g., who entered it, where, and when).

Second, the living document could be easily converted into a ledger-type visual representation, which some consumers of data still need (e.g., for billing, auditing, etc.). The reverse process—converting the ledger into a single consolidated document—entails significant technical challenges. Informatics teams now exert great efforts to extract concise information from dispersed patient records using various rule-based indexing and machine learning techniques. But to go from a living document to a ledger is simple.

Third, a paradigm shift from a ledger-like system to a living document model would facilitate greater collaboration among members of a clinical team. Currently, electronic medical systems store data in multiple tables of a database. Such dispersed granular storage makes it difficult to work on the same document in conjunction with others members of the clinical team. For example, there is no way in a typical EMR for two people to edit different sections of a single document. If an individual opens a record, it becomes locked with read-only access to others. A living document system, on the other hand, would allow for non-blocking collaborative access to medical records. It would help to create a layered structure of medical records, as well as the framework for document-level security. It would provide information and metadata for temporal visualization of clinical changes in medical history and observation. And it would create efficient horizontal scalability suitable for cloud-based platforms.

Creating a Living Document via Version Control:

Technologically, the paradigm of a living document can be implemented by using a version control system (VCS). Although this method of storing records is unusual for an EMR system, software programmers have been using VCSs for several decades [8]. For them, a VCS instantly answers two crucial questions: What has changed from one release to another? And who changed it? No programmer reads every line of code to determine what changes were made in it. Neither should doctors read every line of a medical record to see what has changed for a patient. Reading the whole of a patient's medical record was always laborious. But if the concisely-written and clinically germane paper records made this task at least feasible, the current verbose, template-based notes of the EMRs make it near impossible.

Functionality Details:

1. **Non-blocking collaborative access to medical records:**
   The proposed system, unlike a traditional EMR, would allow a team of physicians and nurses to work, when necessary, on a single document without losing ownership of the information they entered. All new statements and edits committed by a user to VCS will be stored and documented. The new VCS-based system will also enable an instant review of all changes on a timeline, which is something that existing EMRs do not allow one to do.

   a. Multiple physicians will work simultaneously on a discharge summary over the entire course of a patient's stay in a hospital and will be able to clearly see each other's edits.

   b. It will be easier to assess the credibility of the information in a patient's past medical history with a system that clearly indicates who made any given change as well as when and where it was made.

   c. Surgical teams will be able to update the system to make and edit requests for pathological consultations (biopsies, resections, intraoperative consultations, etc.) during an ongoing surgery. The system's ability to respond to new informational needs is particularly important in the surgical context since surgeries frequently last for hours and the surgical team's needs may change over the course of the surgery.

   d. Academic hospitals will be able to use this VCS-based system as a training tool for residents and fellows by letting them see how attending physicians modified their entries.

2. **Layered structure of medical records:**
   VCS technology combined with text-compare tools allows one to rapidly distinguish critical information from boilerplate text that describes unremarkable findings. Moreover, VCS allows users to distinguish statements on the basis of authorship (i.e., which member of the clinical team added which statement). More proactively, a user can intentionally save records to VCS in a stepwise fashion, descending from the

most important information to the least important. A term—"commit changes" or simply "commit"—is used to distinguish an act of saving to VCS from a standard saving of a document to a disk. The commit process saves a new entry in VCS and automatically adds a number of important attributes, including where, when, and by whom the entry was created. Each new commit adds an additional layer of information. Committing the most critical information first and incrementally adding less critical information next allows the end-user to trace the same steps. The end-user thereby sees the most important information first and can then choose to continue to zoom into the details only if and when it becomes necessary.

A user will be able to toggle between a brief digest of new and essential information and an unabridged in-depth discussion of a medical condition or history. In current EMRs, the inability to zoom in on the most critical part of a large medical note dissuades doctors from reading the note. This feature will make the previous notes more likely to be read and used to solve clinical problems.

3. **The framework for document-level security:**
A VCS system allows for more granular control over the ability to see patient records than do scattered databases, thereby making it easier to secure individual documents. Databases do, of course, have a mechanism for controlling low-level access. But the fact that a medical record in a typical EMR is stored in a large number of interlinked tables makes the management of access on that level impractical. As it stands, anyone with access to any part of a patient's record generally has access to the whole of his or her medical history—though there is no medical reason why a patient's podiatrist should have access to his or her psychiatric records. Current EMRs have vastly increased the number of people who have access to the totality of a patient's data, which ought to raise serious concerns over privacy.

The document-based security mechanism in a VCS-based system would, by contrast, allow for the creation of confidential documents that a patient could share only with their gynecologist, urologist, psychiatrist, etc. The documents would be inaccessible to anyone else. The proposed system will restore the security that patients felt before the advent of EMRs, when their whole medical history was accessible only to their primary care physician and when they could participate in the decision about when and with whom to share that information.

4. **Temporal visualization of clinical changes in medical history:**
Documents committed to VCS with the time, the source, and the location of each new statement or edit would be readily analyzable using modern visualization methods. Current EMRs typically do not make use of information visualization functionalities (aside from the occasional line chart for laboratory values). The proposed system will use timelines with brief descriptions of major events and visual clues for minor events with "mouse-over" style expanded descriptions and zoom-in capabilities.

This interface design is more conducive to clinical problem solving. It keeps the big picture in immediate view while allowing the user to move from one relevant detail to another. It gives a user access to a cross-linked network of information as opposed to a linear narrative, which might be appropriate for billing or auditing but not for clinical care.

5. **Horizontal scalability:**
   Horizontal scalability will be achieved, similar to modern NoSQL databases, via clustering and sharding on low-cost cloud-based commodity servers. A vast literature already exists on this subject, and the system adds nothing new to already proven techniques of using commodity computers for providing access to a vast number of indexed documents. A document-based storage is more suitable for parallelization than a database-powered type of design.

Conclusion:

Clinical problem solving is the primary purpose of medicine. The superfluous and redundant information that pollutes current EMRs is inimical to that purpose. Data entry, as was evident from the very inception of EMR systems [9], still remains their weakest point and a main contributor to polluted patient records.

The purpose of the new system is to streamline data entry, reduce redundancy, add credibility markers, and restore rapid access to networked, relevant clinical information.

A VCS-based EMR will allow doctors to rapidly retrieve and process relevant clinical information and use it to care for their patients.

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