Mobile Evidence Delivery: Dashboard for Clinical Support

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ABSTRACT
Timely and comprehensive access to a complete patient record is critical in a clinical setting, and even more so in a mobile environment such as a triage center. Unfortunately, current practices demonstrate that a typical patient's longitudinal record is comprised of a large amount of heterogeneous data of varying modality spread across multiple proprietary systems, and accessing it in its entirety within or outside of clinical settings is challenging.

We present the MED (Mobile Evidence Delivery) application, an easy-to-access mobile dashboard that integrates a physician's calendar with the patient record to provide a quick overview of the important information. It aggregates patient data based on chronology, conditions, diagnoses, prescriptions and treatments, and presents a unified view to the physician. This solution is applicable both as a "morning dashboard" that enables physicians to get an at-a-glance view of their schedule and patient histories, and as a "mobile record" for on-the-go situations such as triage centers. In this paper, we describe the MED mobile application, showcase select screenshots from it, and present observations and feedback obtained through physician interviews.

Author Keywords
Healthcare; Mobile; Dashboard; Visualization

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design; Experimentation

INTRODUCTION
Clinicians are meeting with increasing numbers of patients every day. The increase in care-teams means that a clinician may be meeting with a patient who has seen multiple other clinicians, specialists and care-givers in a non-clinical setting such as a nursing home, all of whom may have commented on the patient. Patients may be returning for follow-up or to consider new treatment options.

In the business world, providing the information for a busy professional is often presented in the form of a calendar or as a dashboard [3], often with relevant data attached (e.g. attachments of presentations for meetings). A glance at one's calendar and email over breakfast and one has a snapshot of the day in mind. This allows for optimizations, back ground thinking and preparation, etc. to allow the professional to make better use of their day and time.

Our clinical dashboard seeks to provide the same kind of functionality for the medical world, and for clinical as well as non-clinical settings. We use the model of a calendar as it is a familiar paradigm. Instead of attached PowerPoints containing a compilation of the patient data, we seek to provide summaries and links into the patients' electronic health record. In doing so we need to address the various kinds of appointment classes; different information is needed and/or appropriate for each. We pick three to illustrate: a new patient (which covers the emergent case as well), a referral patient, and a follow up patient.

In addition to clinical information, physicians have given the feedback that simple "recollection" information is also helpful – a photo, prior correspondence, any biographic background information, etc. helps the clinician call the particular patient to mind.

What's wrong with an EHR?

Electronic health record systems seek to provide a complete and comprehensive collection of all the clinical information on a patient. Initially this was a great service to the clinician – having one place to find all the information on a patient is extremely helpful[1]. However, especially with patients suffering chronic conditions, the size of this record quickly becomes daunting. In all cases the clinician needs to know what information is relevant, while having the ability to see a summary of non-relevant information that can be expanded if required. For example, a cardiologist may be less interested in an ingrown toe-nail and more interested in a history of Diabetes.
Thus, using the EHR for a "summary" is not the right answer. We need to develop clinical "at a glance" summaries to allow rapid understanding of the patient condition, for the purpose the clinician is seeing them.

In this paper, we present the MED (Mobile Evidence Delivery) application, an easy-to-access mobile dashboard that integrates a physician's calendar with the patient record

[1] Most hospitals have legacy data outside of EHRs that stills needs to be accessed via alternate logins.

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to provide a quick overview of the important information. The mobile element allows usage of MED both inside a clinical setting at point-of-care, as well as in non-clinical settings such as nursing homes, senior centers etc.

RELATED WORK

Electronic Health Records have gained popularity in recent years, not in the least due to government incentives aimed at moving away from traditional paper based recordings of medical events [5]. Availability of data in electronic forms has made it possible to view it over mobile devices. There is now a section in the Apple iTunes Appstore dedicated towards "Apps for Healthcare Professionals", and includes everything from Point-of-care apps to EHR apps to Education to Personal (health) care apps [6].

Although their number is growing, the total number of all healthcare apps across the various dimensions (education, reference, EHR etc.) is only about 50. Most EHR apps simply provide a "view" on top of an underlying (comprehensive) EHR implementation. Other apps are dedicated towards providing (for instance) access to imaging data stored on proprietary systems.

In large healthcare institutions, there exist different types of medical data that is stored in a variety of systems and in multiple formats. To stitch together a single patient's entire medical record may require accessing more than a dozen data-types and access to several dozen systems, especially if the patient has lived in different geographies over time.

For a physician, one of the day-to-day challenges is familiarizing oneself with the medical records of patients that have been scheduled for a visit. Another, and perhaps a more critical challenge, is handling emergent cases such as that of a trauma victim being wheeled in for an emergency procedure – a patient the physician has never seen prior and whose entire record he/she needs to quickly scan through. Currently, much of this work is performed in an ad-hoc manner, with nurse practitioners scouring the various systems to "stitch" the complete patient record, and putting together an informal presentation for the physician to quickly scan through. This process can take up to a couple of hours for a single patient record.

MED APPROACH

MED leverages Mongoose [1] technology to gather and aggregate the patient data. At its core, Mongoose is a software library with supporting code that enables monitoring and control of data flowing through the system, rapid analysis and correction. It is built on the premise that failure is inevitable, and is designed for rapid and efficient failure detection and correction for optimal gathering of content from heterogeneous data sources.

The data required for the MED dashboard was also used for the AALIM [2] project, a clinical decision support tool for Cardiology. It includes multi-modal data such as EKGs, Echocardiograms, Catheterization data, associated reports, progress notes, visitation notes, technician notes etc. Some of the views populating the dashboard were derived from the AALIM work.

Data Acquisition

Mongoose [1] ingesters were used to collect data of different modalities stored across numerous heterogeneous sources. As we collected electronic data going back about two decades, some of the data was stored on legacy systems with suspect availability and uptime, and as a result required multiple reconnects. Certain data types were obtained from "live" systems – systems that were being actively used in clinical settings – and therefore necessitated rules to schedule data access. Yet another type of data was spread across about two dozen geographic locations and hosted on heterogeneous systems, and required ingesters to perform a broadcast probe.

Calendar Integration

Physician calendars were used drive the workflow for the Data Acquisition module - patients who were scheduled for an appointment were automatically added to the Data Acquisition work-queue. This allowed for the entire patient medical history to be fetched and ready in time for the patient appointment.

SCREENSHOTS

Below, we include some of the screenshots of the MED application on an iPad device – a larger selection was demonstrated to the physicians, and their feedback is included in the following section.

The "Calendar View" (Fig. 1) is the entry point to the application, and provides a physician with a quick overview of their schedule. Color-coding is used to indicate the appointment-type, e.g. follow-up visit, consultation, annual/regular checkup etc. The data for this view is automatically collected and populated from an existing scheduling system that is managed by nurse practitioners. Clicking on a patient appointment entry takes the physician to the various views for the patient.

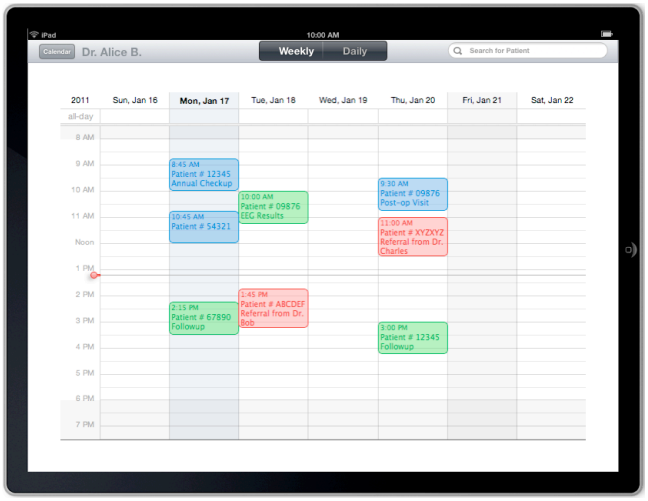

Figure 1. Calendar View

Common to all patient views are the following items:

- Patient MRN (Medical Record Number) and or name (as dictated by hospital requirements), gender, age, height and weight (per the most recent measurement)
- Chronic conditions (e.g. diabetes), social history (smoking, drinking etc.)
- Tabs on the bottom of the screen allow physicians to navigate between the various views for a patient
- A button on the top left leads back to the calendar view
- Physicians can search for a given patient using a search box on the top right

The different available views in the MED application are:

- Health Indicators – core health indicators
- Recent Activity – most recent events
- Longitudinal View – summary of entire patient record over time
- Comparable Cohorts – aggregation over similar patients
- Literature – relevant journal articles
- KPI – Key Performance Indicators relevant to patient
- Patient Correspondence – Any prior correspondence (email etc.) with patient

Fig. 2 shows the Recent Activity view for a patient. It summarizes the recent events, visits, test results, reports etc. for the patient.

Figure 2. Recent Activity View that summarizes relevant visits, tests and reports

Figure 3 is the Health Indicator view. It summarizes the disease distribution in the patients' history by way of color-and-pattern coded circles – the size of the circle is proportional to the number of "events" in the patient history with that disease. ICD9 (International Classification of Diseases – [4]) codes are 3-5 digit numeric identifiers that describe a diagnosis or medical procedure, and are used for grouping diseases in this view.

Figure 3. Core health indicators summarized for patient

Drugs that the patient has been prescribed over time are indicated in the Drug Distribution view (Fig. 3). Various measurements taken over time are graphically depicted, including blood pressure, heart rate, ejection fraction, and weight.

Figure 4 displays the Comparable Cohorts view. In this view, clinicians are shown data aggregated across comparable cohorts of the patient. Comparable cohorts are patients that exhibit commonality with the patient under consideration.

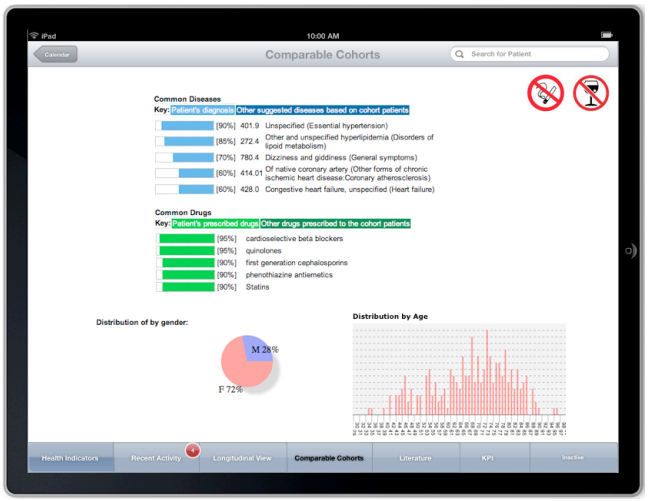

Figure 4. Comparable Cohorts View that aggregates data across patients similar to the one under consideration

In addition to showing the cohort distribution by age, gender etc., common diseases and common drugs across the cohorts are summarized by listing the most frequent diseases diagnoses and drug prescriptions (Fig. 4). These views enable clinicians to consider referring their patient for diagnostic tests (e.g., if their patient isn't suffering from disease X but 95% of the cohorts are), or consider prescribing a medication that is being used by a vast majority of the cohort.

INTERVIEWS AND DISCUSSION

The care provider feedback consisted of two common themes of what they liked. The first was the mobility theme providing freedom of access to patient summaries without the restriction of physical office time or the chaotic uncertainty of shared public terminals. They especially liked the concept of a personal device that could be accessed anywhere according to their schedule while also providing a more natural experience for patient face-to-face interaction when reviewing patient records and results.

The second theme was transparent data integration that masked the onerous complexity and logins to over a dozen or more physical systems to populate the patient summaries. During the interviews, a physician noted that it would have taken him roughly two hours to replicate the data access completeness presented in the mobility application. In addition, very positive comments were received on leveraging the user experience of the native touch screen applications to interact with the densely populated data as opposed to instrumenting the mobile application in a standard browser.

The care providers highlighted concerns that the seamless access to the numerous sources systems would not fulfill the data governance requirements unless the access control rights of the data and care provider were specifically matched, logged, and adhered to. They also shared general mobile data security concerns associated with a lost or stolen mobile device.

Taking lessons learned from popular social networking applications, the care providers were interested expanding the mobility prototype into a full fledged application server capable of delivering numerous specialized applications to mobile devices. Also suggested was Multi-vendor support of mobile phone and tablet devices capable of delivering a consistent set of applications and user experience without severely impacting support.

CONCLUSION AND FUTURE WORK

The MED Application showcased the viability of using mobile devices to rapidly access patient access in clinical settings. Integrating the physician calendar with patient records allowed for a quick overview of the relevant and significant artifacts, with the capability of drilling down into aggregated and or summarized data for a more complete picture.

Future work includes development for departments beyond Cardiology, across different hospitals, and possible consideration for the Federal Government's "Meaningful Use" certification [5].

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REFERENCES

1. Varun Bhagwan, Tyrone Grandison, Alfredo Alba, Daniel Gruhl, Jan Pieper. MONGOOSE: MONitoring Global Online Opinions via Semantic Extraction, Service Quality and Assurance Management (SQAM) workshop at the IEEE International Conference on Cloud Computing (CLOUD-II 2009), September 21-25, 2009.
2. D. Gruhl, A. Amir, D. Beymer, G. Julia, H. Greenspan, A. Hobbs, K. Pohl, T. Syeda-Mahmood, J. Terdiman, and F. Wang. "Aalim: A cardiac clinical decision support system powered by advanced multi-modal analytics" In International Medical Informatics Conference (MedInfo), Cape Town, South Africa, 2010.
3. Daniel M. Russell , Andreas Dieberger , Varun Bhagwan, Daniel Gruhl. "Large Visualizations for System Monitoring of Complex, Heterogeneous Systems". INTERACT 2005 : 938-941
4. International Classification of Diseases (ICD), http://www.who.int/classifications/icd/en/
5. Center for Medicare & Medicaid Services (CMS) EHR Meaningful Use Overview, https://www.cms.gov/EHRIncentivePrograms/30_Meaningful_Use.asp
6. Apps for Healthcare Professionals, http://search.itunes.apple.com/WebObjects/MZContentLink.woa/wa/link?path=healthcareprofessionalsipadapps