Smart-phone Dashboard App for Surgical Oncology Rounding

Technical Details

The smartphone rounding app will use FHIR DSTU2, and will fetch real-time data from clinical systems. We will integrate initially with Massachusetts General Hospital (MGH), which uses the Epic EHR system, and also integrate with Longitudinal Medical Record (LMR), which is the legacy EHR at MGH. We are exploring collaboration with Ochsner Health System that uses Epic, and will seek collaboration with other systems identified during the match making process.

The client framework will use React Native (by Facebook), Go (by Google) and SMART (by Boston Children's Computational Health Informatics Program) and will run on the iOS and Android platforms.

We will use SMART-on-FHIR authentication with enterprise LDAP services to secure the app. We will also provide logging to enable auditing of data access.

Issue Analysis

Adoption of the Electronic Health record (EHR) has unintentionally increased workflow interruptions for surgical staff. EHR vendors have primarily oriented EHRs toward workflows for primary care using the desktop medium. Often patient information needed by specialist providers is not easily accessible or recorded. Consequently surgical teams encounter significant disruption in their workflow **accessing and navigating** patient-charts, which has decreased efficiency of surgical staff. These workflow disruptions for EHR access are especially acute in oncology, as cancer patients are high risk and have co-morbid conditions that require complex management. Hence, there is critical need to develop applications that enhance workflow of surgical oncologists.

The critical issues identified are: 1) Need for accessibility to EHR on the move 2) Need for intuitive chart display to match the surgeon's specialty thought flow, and 3) Need for specialty decision support:

Solution

The proposed smart phone app will facilitate the rounding workflow of surgical oncologists by making the EHR data available on the smartphone in an intuitive format with minimized navigation and decision support that is customized to the specialist workflow.

The app will display an inpatient dashboard to summarize patient EHR, including vitals, fluid intake and output, labs, medications, orders, and problems. The dashboard will provide a rich graphical user interface (GUI), and highlight recent updates to the patient EHR. Unusual trends of clinical interest will be highlighted to provide decision support. The app will be developed on the Android and iOS platforms.

We will augment interpretation of trends in the patient parameters by superimposition of logical groups of data-elements. Without an intuitive display, the surgeons have to read through lists of laboratory parameters and mentally infer trends in the parameters.

To enhance decision making for surgeons, the app with indicate significant trends in patient parameters, either by highlighting the data points in the display, and will allow them to configure more intrusive alerts (like phone vibrations or beeps) for high risk conditions.

Financial Estimates

We estimate that the development and deployment of the application will cost $172K. We will license the app to other health care institutions to recover the development cost, and are considering dissemination of the app in open-source.

Engagement Plan

The app will be developed and deployed, in close collaboration with the Division of Surgical Oncology at MGH. The division has participated in the development of the wireframe, and these will be refined and prototyped by conducting focused-interviews, shadowing and surveys with the surgical staff.

ISSUE ANALYSIS

Adoption of the Electronic Health record (EHR) has unintentionally increased workflow interruptions for surgical staff. EHR vendors have primarily oriented EHRs toward workflows for primary care using the desktop medium. Often patient information needed by specialist providers is not easily accessible or recorded. Consequently surgical teams encounter significant disruption in their workflow **accessing and navigating** patient-charts, which has decreased efficiency of surgical staff.

These workflow disruptions for EHR access are especially acute in oncology, as cancer patients are high risk and have co-morbid conditions that require complex management. Moreover, lack of optimal care of cancer patients is more likely to cause adverse outcomes. Hence, there is a critical need to develop applications that enhance workflow of surgical oncologists.

The development team has collaborated with surgical oncologists at Massachusetts General Hospital (MGH) to examine their workflow issues. The surgeons had approached the Lab of Computer Science, at MGH, with a request for a mobile application that will streamline their workflow during rounding. The following issues were identified:

1. Need for accessibility to EHR on the move: In contrast to ambulatory care providers who consult with patients in their offices, surgeons visit patient-rooms on the surgical floor. Outside of the operating room, surgeons spend majority of the time to manage the peri-operative patients. During rounding the surgeons can access the patient EHR data on workstations that are usually located at a central spot on the floor, on mobile workstations or workstations in the patient room. Mobile workstations are inconvenient to tag along as they are bulky, and often do not fit into the patient room. Many institutions provide workstations in the patient room, but require the surgeon to complete login, which can be tedious for every patient. Consequently, surgeons expend considerable effort walking to the nearest workstation to review the patient chart. Hence, there is great potential to streamline workflow by making the EHR available on a handy device, which allows them to view patient data on the go.

2. Need for intuitive chart display to match the surgeon's specialty thought flow: Although the institution's EHR system (Epic), provides EHR access on the handheld device (Haiku, Canto) and there are other EHR data access apps (including one developed by the proposal team), the display and conventional design of the user-interface is not optimized to the workflow of the surgeon. It is desirable that the data is displayed in a graphical format to show trends, and the navigation tabs match the thought-flow of the surgeon. The need for intuitive UI that is based on principles of interaction, information and visual design is especially critical on the smartphone, given the smaller screen size compared to the laptop.

3. Need for specialty decision support: Epic provides an advanced decision support platform, which the Partners enterprise team has leveraged effectively using rules developed through several decades of research at its institutions. Hence advanced decision support is available at MGH. However most of the decision support is oriented for ambulatory care, and medication ordering, and there is little assistance for surgeons. The need for decision support in surgical oncology is especially high, as cancer patients are high risk and have co-morbid conditions that require complex management. Moreover, lack of optimal care of cancer patients is more likely to cause adverse outcomes. Hence, there is critical need to develop applications that enhance workflow of surgical oncologists.

Solution

The proposed smart phone app will facilitate the workflow of the surgical oncologists by making the EHR data available on the smartphone in an intuitive format with minimized navigation and decision support that is customized to the specialist workflow.

Two EHRs and two health systems: The app will be installed in production at MGH on the new Epic platform as well the legacy EHR database (Longitudinal Medical Record). Both EHRs are meaningful use certified. We are exploring collaboration with Ochsner health system in Louisiana to test the app in the production version of the Epic platform at Ochsner health system. We intend to collaborate with other participants in the ONC challenge during the match-making process.

Security: The app will be secured using the OAuth 2.0 based SMART authentication, tied to LDAP and enterprise data access logging.

Following are the salient features of the solution to address the identified issues:

1) Accessibility to EHR data-elements required during rounding on smartphone including i-phone and android: The app will display an inpatient dashboard to summarize patient EHR, including vitals, labs, medications, orders, and problems. The dashboard will provide a rich graphical user interface (GUI), and highlight recent updates to the patient EHR. Unusual trends of clinical interest will be highlighted to provide decision support. The app will be developed on the Android and iPhone platforms.

Easy accessibility of the relevant EHR data on the smartphone, will reduce the detours to desktop workstations, obviate interruptions to workflow and save time for the surgeons.

2) Intuitive Graphical display: During rounding, surgeons typically require the recent trends in the vitals and labs for the patient for decision-making. Superimposition of logical groups of data elements will further augment interpretation of trends in the patient parameters, e.g. the surgeons have indicated the value of visualization of the volumes of fluids administered to the patient, against the urine output. Heart rate, pulse and blood-pressure form another group of parameters that are best interpreted in combination.

Without an intuitive display, the surgeons have to read through lists of laboratory parameters and mentally infer trends in the parameters. The use of interactive graphs and intuitive display of patient data will significantly augment the surgeon's interpretation of patient data, and save considerable time of the surgeons.

3) Clinical decision support for Surgical Oncology: The CDS implementations are currently focused on ambulatory care, and medication ordering, and there is little assistance for surgeons. To enhance decision making for surgeons, the app with indicate significant trends in patient parameters, either by highlighting the data points in the display, and will allow the surgeon to configure more intrusive alerts (like phone vibrate or beep) for high risk conditions. The planned decision support rules warning for include:

- Low Urine output
- Inpatient blood pressure based on outpatient blood pressure trending
- High urine output without enough input
- Sustained Pain score

Given the comorbidities of cancer patients, decision support has high potential to improve the quality of care provided by surgical oncologists.

4) Pre-cache assigned patient data, using Bluetooth beacons: A major short coming of the EHR systems, is the time needed to load the context of the patient. Currently it takes several seconds, to refresh the patient context, and the delay is more with wireless devices. To address this problem the app will utilize Bluetooth sensor on smartphone to detect the location of the surgeon on the hospital floor with reference to Bluetooth beacons. Using the approximate location, the app will match the location with patient location and preload the data for patients on the floor that are assigned to the surgeon and hence will be able to provide near instantaneous chart view.

5) Easy login using mobile fingerprint sensor: Repeated logins to common use workstations is time consuming. The app will allow Touch ID (iOS) or fingerprint scanning (Android) login functionality to speed up the time to connect to the medical record.

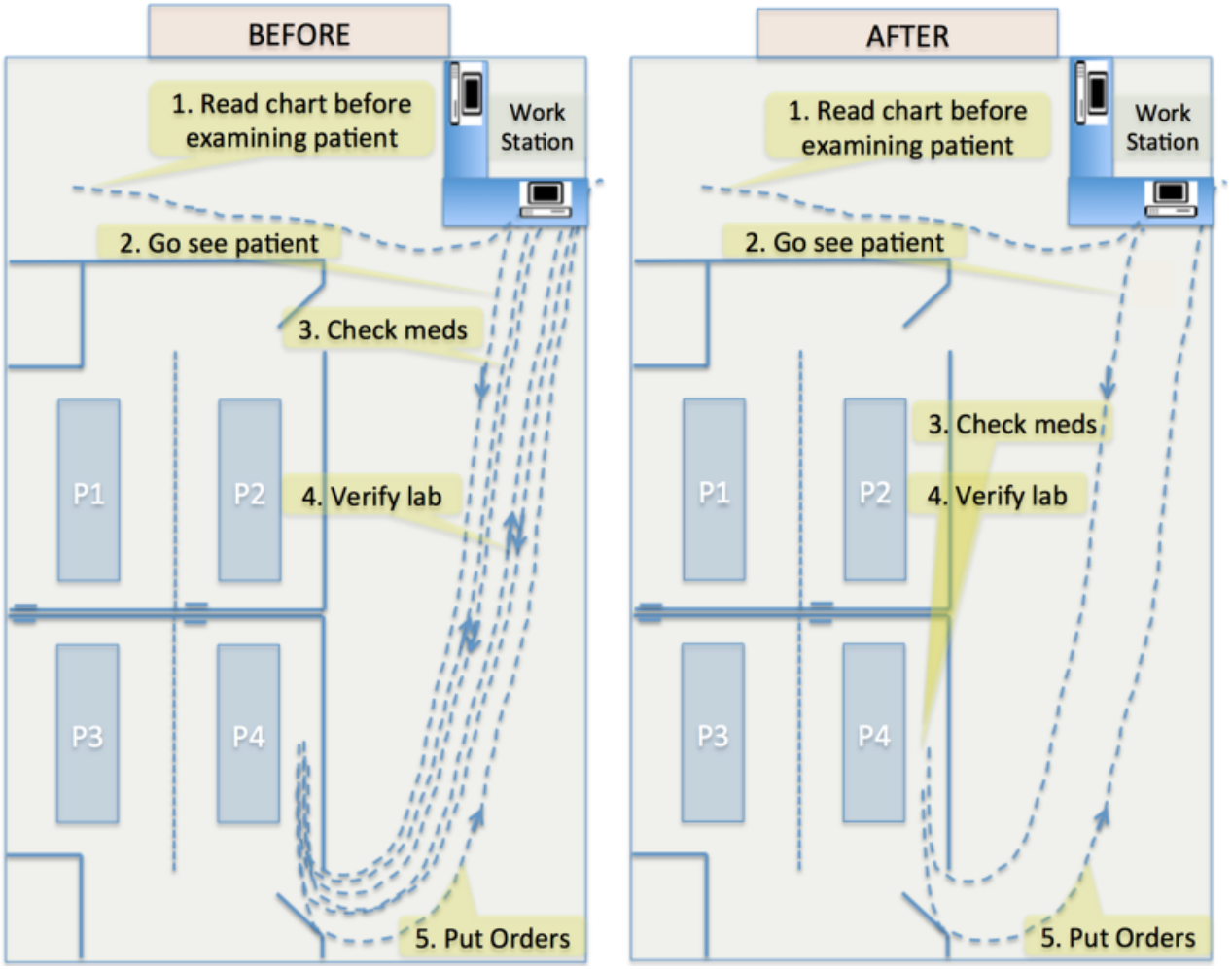


Figure 1. The figure depicts the walking activity path of the surgeons in a section of the in-patient area, while examining a single patient (P4). The figure on the left shows that without the smart-phone app, the surgeons often make several trips to central workstations to look up patient information. The figure on the right depicts a more streamlined workflow with the proposed app where workflow is not interrupted, as information needs are met by the smartphone app, saving surgeons' time.

Financial estimates

The smartphone app will be developed by the Laboratory of Computer Science (LCS), at Massachusetts General Hospital (MGH). LCS specializes in the rapid development of novel, scalable health information technologies that facilitate better, more efficient delivery of care. Industry collaborations and licensing allow us to make these technologies commercially available to the broader healthcare community while maintaining our focus on continued innovation.

LCS technologies are commercially available through licensing arrangements and collaborations. Utilizing resources available from our Innovation office, we plan to:

- Manage inventions
- Protect intellectual property
- Determine the appropriate commercialization pathway
- Find industry partners and licensees
- Identify technology funding options
- Create marketing plans
- Support academic-industry alliances

Initial Development Costs

Development Phase (6 month period)

2 Clinical Informatics Experts	20% effort	$40,800
2 Senior Developers	70% effort	$105,490
2 Surgical Oncologists	5% contributed effort	None
2 Usability Experts	15%	$20,550
2 Servers		$5,000
Total Development Phase		**$171,840**

Revenue Model:
App will be available in a private marketplace for physicians to download with institutional approval. Cost of the app will be **$5.99/month per physician**. Each client institution is required to manage their own FHIR interface and data.

Operational Expenses:
A developer and/or support service person will be available to respond to any inquiries by clients as well as attend to any bug fixes and support issues. This cost is estimated at $15,000/year.

Engagement plan

Targeted customer base includes all major healthcare institutions that provide in-patient surgical oncology services.

Stakeholders are all surgical staff including surgeons, residents and nursing staff in surgical oncology.

Engagement plan: The development team currently includes two senior surgical oncologists, one of whom is the Chief of the Division of Surgical Oncology at MGH. The initial wireframes have been developed with the surgical oncologists. The wireframes will be iteratively improved by engaging a wide user base. (see letter of support from Chief of Division of Surgical Oncology). Details are as follows:

1) **Recruit user group:** The study team will engage stake-holders like residents, nursing staff and attendings by inviting them by in-person invitations, email announcements and departmental meetings, and obtain their informed consent for their participation in the study. The user participants will be a closed group that the study team will engage for development and evaluation of the app. We anticipated a total of 20-30 users in the user group.

2) **Focused interview and Shadowing:** The informatics team will meet with sub-groups of users from the user-group and conduct focused interviews. Representative user with be shadowed while they are rounding to understand the workflow, and conduct think-aloud sessions to identify data needs of the users in particular points of the round. During the interviews the users will be presented with the wireframes as paper printouts, to solicit their feed-back.

3) **Iteratively revise wireframes with different sub-groups from the user group:** The wireframes will be modified based on the inputs from the focused interviews and user-shadowing, and interactively modified to facilitate the interviews themselves. A series of 3 iterations for wireframe are anticipated before the prototype is developed.

4) **Implement prototype:** The prototype will be made available to a small group of users first, to solicit feedback for improvement.

5) **Decision support rules:** The surgical oncologists that are co-investigators on the study team, will provide a set of 10 rules to highlight trends and events in the EHR that need attention from the surgical staff. These will be programmed into the app, and highlighted in the graphical user interface. An intrusive notification like vibrating the phone or sound, will be implemented if in the user-group.

6) **Deploy in inpatient setting to closed user group:** The app will be deployed in the in-patient setting and made available to users in the closed group for evaluation.

After initial deployment the app will be further refined by surveying the users and by analyzing the activity logs. Detailed plan is as follows

1) **Survey:** Participants in the user-group from Aim1 will be surveyed to measure their perceptions of the clinical impact of the app. Their responses will be measured on the Likert scale, as detailed in table 1.

Table 1. User survey

Provide your responses on scale 1-5: 1 strongly disagree, 2 disagree, 3 cant-say, 4 agree, 5-strongly agree	
1	The app provides accurate information
2	The graphical charts are easy to understand
3	The app improves my understanding of patient condition
4	The app saves my time during rounding
5	The app improves my decision making
6	The app improves patient treatment
7	The app is easy to use
8	The app securely protects patient data
9	The app simplifies login

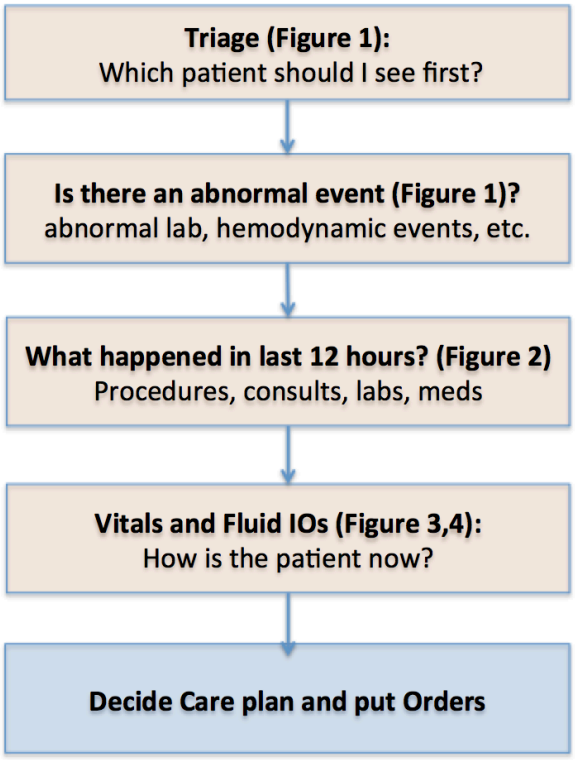
2) **Analysis of user logs:** We will record the timestamps, data-elements, ids of users and patients. The user logs will be analyzed to track usage of the apps.

3) **Analysis of accelerometer and GPS sensors:** The data from accelerometer and GPS sensors from the rounding residents will be recorded, when the phone is detected to be in the vicinity of the patient floor. This information will be corroborated with the data access logs to identify time-points when rounding occurs, along with open-source classifiers to detect walking activity of the residents. We will test the hypothesis that the app reduces the surgeon's trips from patient bedside to workstations (see Figure 1), and saves time and increases efficiency during rounding.

Wireframes

We are exploring several alternatives for UI and will finalize our decision based on ongoing feedback and focus group testing from the clinical collaborators. We present some of our ideas below (note: graph data is not real and is only for illustration purposes).

Overview: We have designed the app screen flow to match the thought flow of the surgeons as indicated in the following figure:



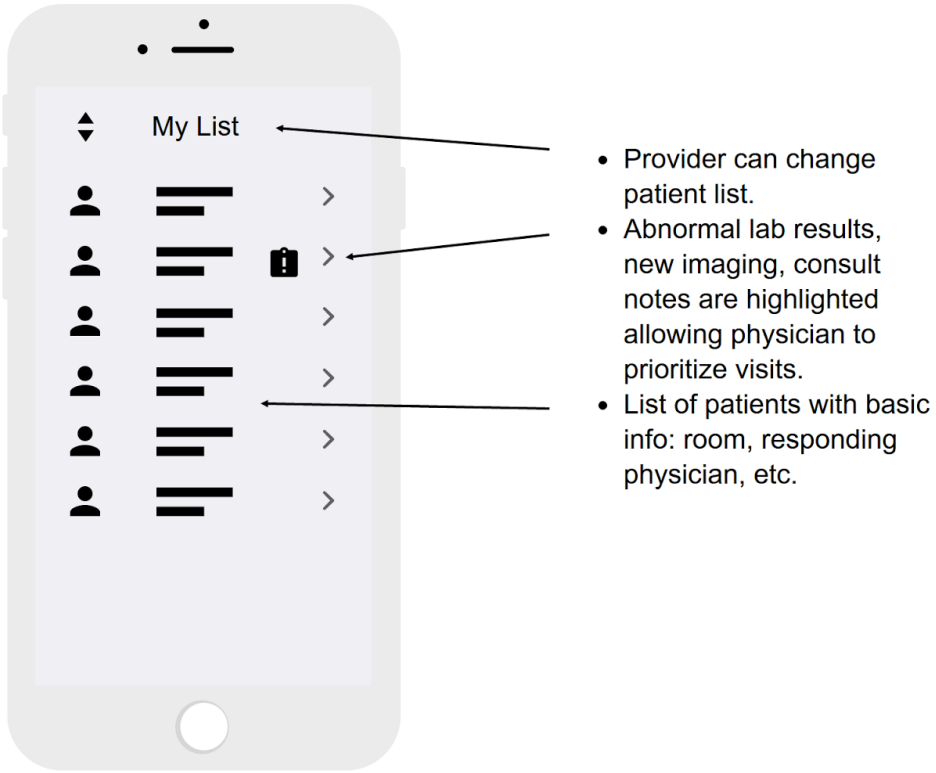


Figure 1: Triage lists

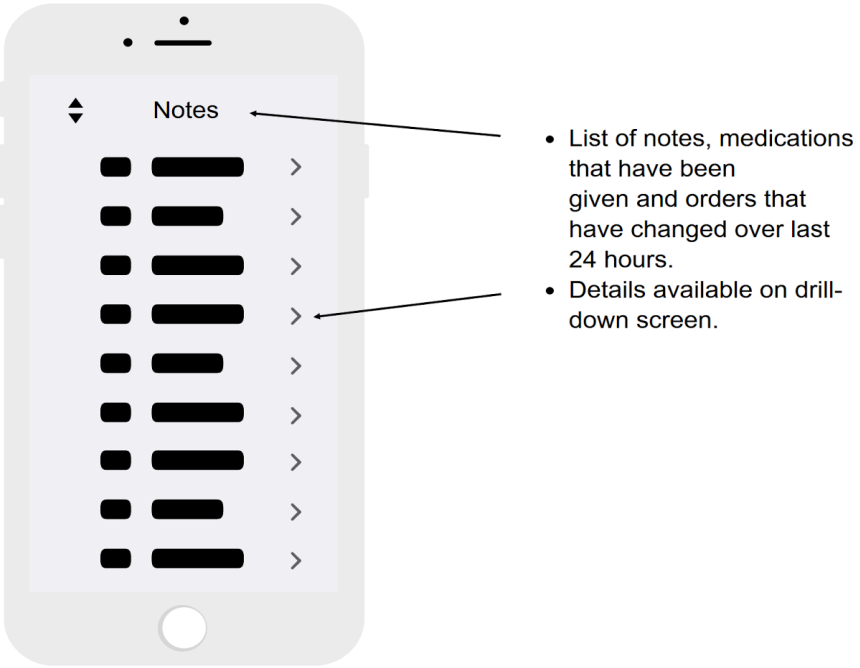


Figure 2: Highlighting the most recent events for a patient

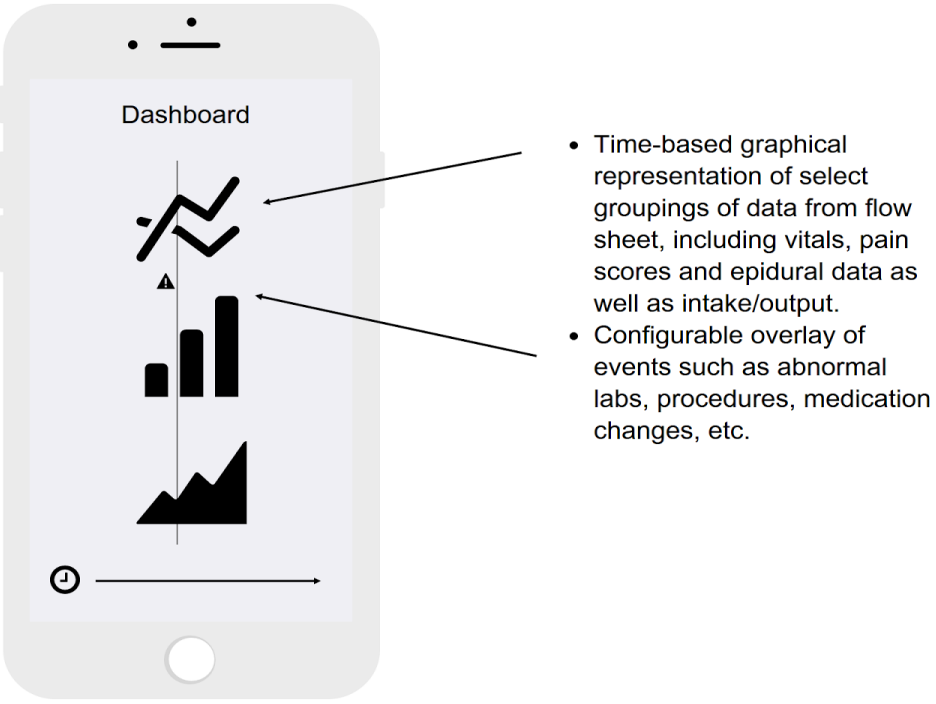


Figure 3a: Patient dashboard overview

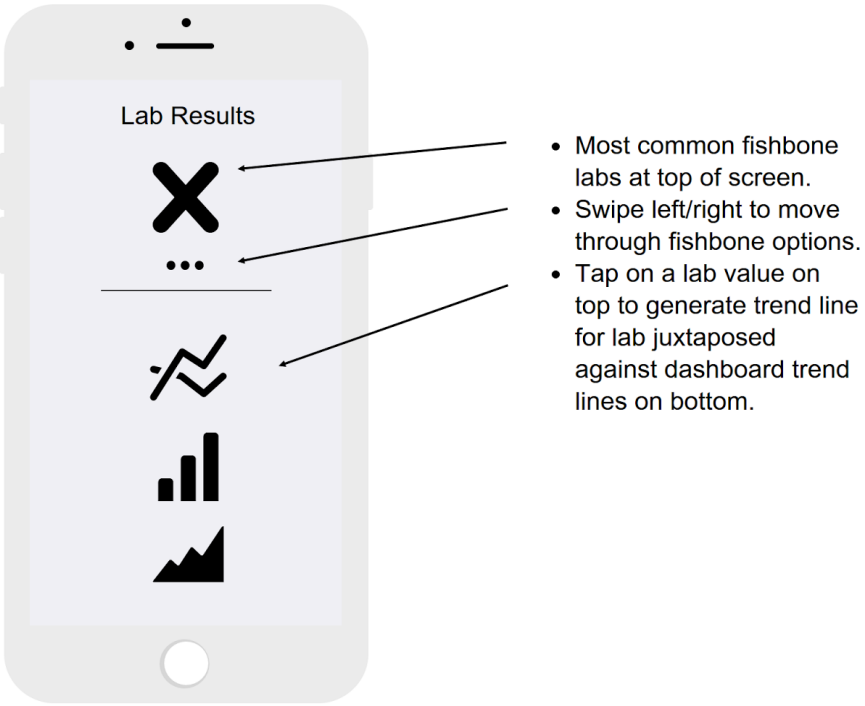


Figure 3b: Patient dashboard overview

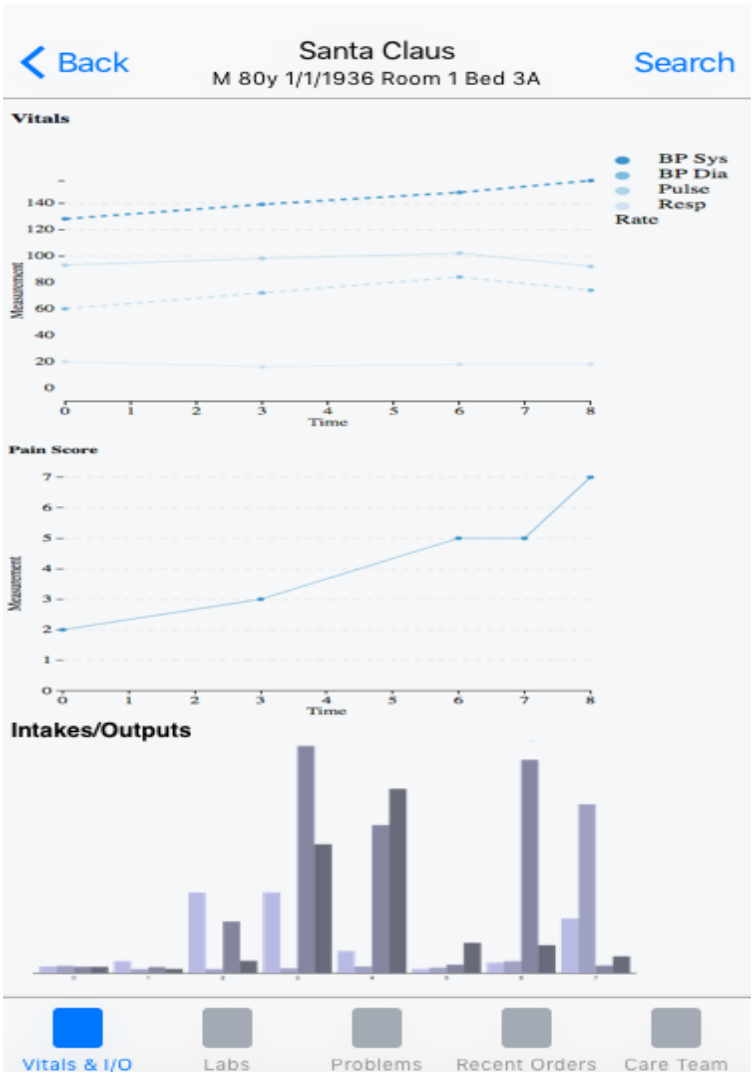


Figure 4: Patient dashboard detail

Technical specifications

Data and Sources

Real-time data will be sourced from clinical systems at the MGH. We have identified and obtained access to the data required for this application through existing EHR web services. The following is a list of data elements the application will require:

- Patient demographics
- Flow sheet data, including:
    - Vital signs
    - Inpatient fluid intakes and outputs
    - Pain scores and epidural information
- Lab results
- Medications
- Orders
- Notes
- Provider patient lists

Our application will be the first to access to Epic FHIR web services at Partners.

Technical Approach

We have started developing a Java middleware layer that will wrap the web services and exposes the data to our application as FHIR services. (All services exposed will conform to the FHIR DSTU2 API.) As development proceeds, we will incorporate actual FHIR web services to the extent possible.

Most of the required data elements are common and have been explored in previous FHIR work (e.g., Argonaut). Some elements will require new approaches, however. For example, in order to retrieve, aggregate and display much of the flow sheet data, we will need to catalog the LOINC codes which correspond to each flow sheet row ID and assign the appropriate category (e.g., Intake/output, Pain). What this means is that although the data will be retrieved as a series of FHIR observations, the client will need a schema in order to assimilate the individual observations in a practical manner.

We anticipate having to extend FHIR resources in a number of ways as well. For example, Epic allows a provider to group patients into ad hoc lists as well as the sharing of patient lists among providers. The Patient resource, however, only allows for a simple search by provider name.

User interface

To address the pressing need of end users to access patient data rapidly and to present this data in a clear way we will implement the following features:

- Enable fingerprint scanning login functionality when available on a device. This would include enabling Touch ID for iOS apps.

- Present ICU patient trends on vital signs and other measures using graphing libraries that provide easy-to-read visualizations and allow providers to narrow down or zoom in on time ranges with easy swipe, pinch, pan and tap gestures on their phones or tablets.

Technology

Mobile-specific software and SDKs

React Native (by Facebook), Go (by Google) and SMART (by Boston Children's Computational Health Informatics Program) will be explored as a means to build an application that ports to multiple mobile devices, focusing on iOS and Android.

React Native provides the means to develop a mobile application with a common code base for multiple mobile device platforms by wrapping features in each platform in with a common JavaScript library. One potential downside of React Native is that the application content must be rendered using WebView, which has performance ramifications.

Another technical approach would involve isolating common logic such as FHIR calls, data manipulation, etc. as a Go package and generating bindings for each mobile platform (i.e., objective-c/swift for iOS or Java for Android). Platform specific (native) user interfaces can then be built on top of the common logic layer. We will be exploring the tradeoffs inherent in these two technical approaches.

SMART on FHIR

SMART is an open standards-based framework for building reusable applications. It uses HTML5 for user interface (UI) design, OAuth2 for application authorization, and FHIR as a standard API to access data sources.

It will be used in our front-end and middle-tier software stacks. We have developed a SMART OAuth2 based authentication front-end, and are working on linking it to the LDAP service at the institution.

Security

In addition to leveraging the security infrastructure provided by SMART, all web services will be available only via secure HTTP calls and will be firewall protected. Security will be further constrained by Enterprise LDAP authentication, and role-based authorization. Our application will be audited and monitored by the Partners IS security team using Veracode on a regular basis for compliance to HIPAA regulations.

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May 26, 2016

Officer-In-Charge, ONC Challenge
ONC
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Dear Officer:

I am writing to indicate my participation in the development of the Smartphone app for Surgical Rounding, in collaboration with the Laboratory of Computer Science (LCS) at Massachusetts General Hospital (MGH).

I have an active clinical practice focused on surgical oncology in which I routinely provide care for surgical patients pre- and post-operatively in the hospital on surgical floors, ICUs, and non-surgical floors. I routinely use in my clinical practice several different EMR systems that are used in the different hospitals in which I operate and see patients. I have a strong clinical working knowledge of EMRs, and served as a peer-educator and "super-user" for introduction of the EPIC EMR into our institution. And through daily inpatient rounds (both teaching rounds with house-staff and non-teaching rounds) I have become extremely facile with several mobile applications that draw data from these EMRs.

A smartphone app customized for the surgical rounding has tremendous potential to save time of the surgical staff during rounding and improve their quality of care. This acute need has led me to **initiate the collaboration** with LCS for development of the Rounding app, and I am glad to see the wireframes and workflow designs that have resulted from the collaboration. I will continue to provide inputs to drive the design of the app and to help the development team understand the "real-world" needs of clinicians. And as Chief of the Division of Surgical Oncology and Deputy Clinical Director of the MGH Cancer Center, I will be able to offer cooperation and support by many clinicians in development of the SMART phone app. I will facilitate the testing of the prototype and the deployment of the app.

I eagerly look forward to work closely with LCS, to develop and deploy the app in the Division of Surgical Oncology at MGH.

Sincerely,

Ken Tanabe

Kenneth K. Tanabe, M.D.