Business/Sustainability Plan

Dash

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1. Issue analysis

Government incentives within the HITECH act have successfully increased the adoption of electronic health records (EHRs). Despite tremendous cost, this digitization effort has failed to improve patient outcomes. Andy Slavitt of CMS echoes this sentiment: "The health IT industry has made a great start, but we're still at the stage where technology often hurts rather than helps physicians providing better care."

One recent example from our hospital was that antibiotic orders were expiring without provider awareness, leading to missed doses and undertreated infections. In one review we performed earlier this year, 3% of doses for an antibiotic were inadvertently missed due to this problem (abstract submitted).

Why has digitization of medical records failed to live up to expectations? We propose that, until now, priority has been given to security, documentation, and billing. As enterprise systems, EHRs have been less equipped to handle the nuances of the diverse workflows of each subspecialty. Digitization is merely the first step in leveraging data enough to improve the quality of care, and further work must be done to help consolidate, interpret and act on the abundant data now available digitally (Figure 3-1).

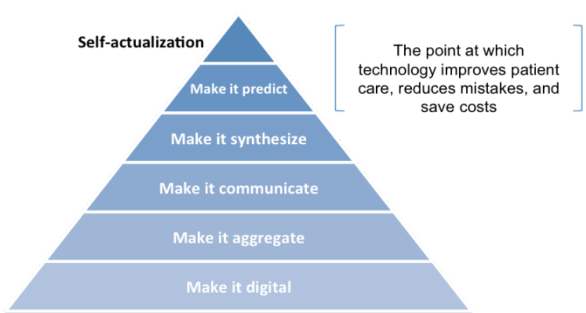

Figure 3-1: A pyramid represents the levels of ascending needs in order to maximize the benefit of health information. The HITECH act has been successful at encouraging digitization (bottom layer), but more work is needed to improve care. (Do, The Health Care Blog 2014)

Clinical situational awareness requires more effectively organized patient-based displays

Current systems silo data according to method of collection--such as labs, radiology, microbiology, and notes--rather than displaying data aligned with the problem- or system-based models that providers are trained to use (Figure 3-2). Therefore providers face the burden of data transformation and translation, contributing to significant cognitive load.

Efficient workflow requires task management across a patient census

As workload demands have increased dramatically, providers are in greater need of tools to assist in identifying and prioritizing tasks. Many types of census-level information are difficult to effectively consolidate using current EHR systems.

Digitization has laid the foundation for a more sophisticated use of technology to improve patient care. New interactive interfaces are urgently needed to facilitate workflow and productivity. The best method to improving care using technology lies in extending the EHR to fulfill these customized needs. Therefore the ability to build custom clinical software through standardized APIs and shared security features with EHRs is critical—to harness their power as definitive sources of robust data, reporting, and administrative capabilities.

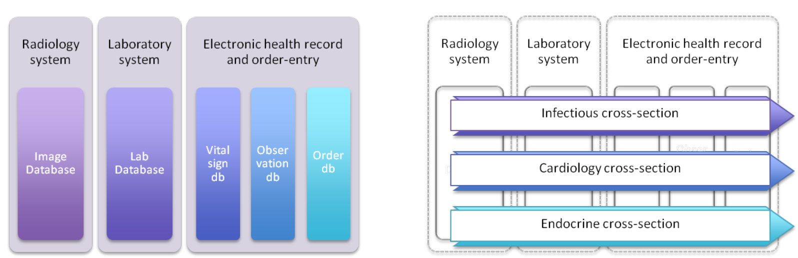

Figure 3-2: Most views of clinical data in EHRs are organized by the way they were captured in *verticals* (left), however providers use and interpret data in the context of problems and organ systems, or *horizontals* (right)

2. Solution description

Contextual inquiry

We engaged clinical service lines at our pilot hospital to better understand the problems they face and ask them to draw the views that are most relevant for clinical decision-making. While the problems listed were quite diverse, we found several common themes:

- Teams felt that a single patient-centered view could answer several key clinical questions they identified. Many of them routinely created these views by hand for every patient they saw.
- These specialty views were not only useful but could be *instructive* to providers outside the specialty area
- Subspecialty providers could also identify quality indicators for which they were unaware of how they were performing

We extracted the common elements of these views to build a design methodology and a software platform, which we call *Dash*. In the next section, we highlight three clinical groups we have engaged to solve high priority problems using *Dash*. Pilot studies are already under way and early findings are shared below.

Multidisciplinary Design

Working with the director of the medical ICU, we learned that ventilator weaning protocols had low adherence rates, despite widespread understanding that prolonged ventilator use could lead to expensive complications like pneumonia. An analysis by the ICU suggests that ideal weaning could potentially lead to extubation 30 hours earlier per patient. We designed a panel for ventilator management that aggregated disparate data sources (including labs, vitals, and observations) to enable the frequent progressive adjustments involved in weaning. We paid particular attention to the organization of data, to represent “ventilation” on the left and “oxygenation” parameters on the right (Figure 3-3). In this way, the visualization allows a physician to update ventilator settings by looking at a single view, and the layouts are instructive for trainees to learn the heuristic for ventilator management.

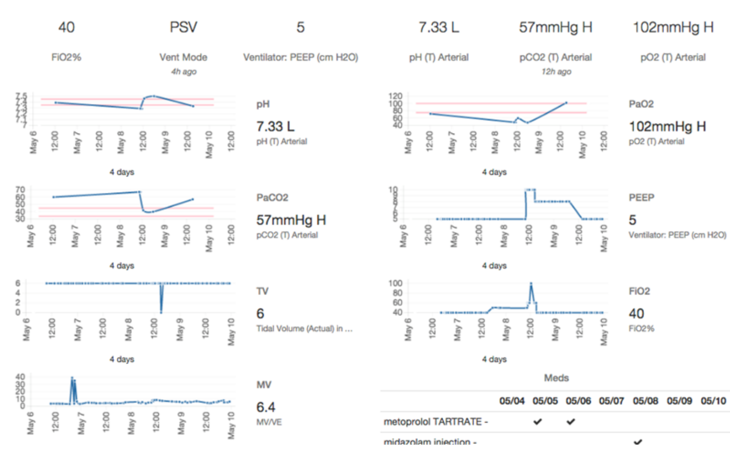

Figure 3-3: The patient view for ventilator management

In another case, we worked with infectious disease specialists who described to us the non-trivial task of determining the course of remaining antibiotic treatment upon hospital discharge. Existing views were sparse matrices that required scrolling in multiple dimensions and neglected to prioritize important medications (Figure 3-4), and in its current state resulted in incorrect regimens (either wrong antibiotics or wrong durations) 70% of the time. After several iterations and test cases, we arrived at an efficient and informative view (Figure 3-5) that at-a-glance allows the physician to understand the antibiotic course, and recognize missed doses or incomplete regimens.

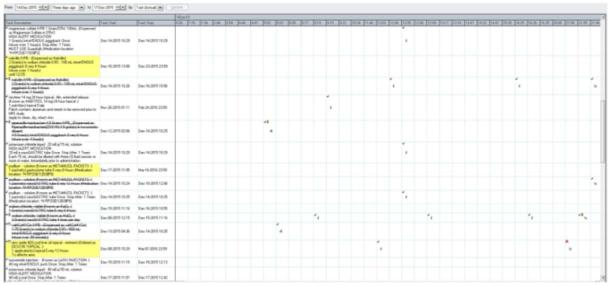

Figure 3-4: Existing EHR view used to obtain medication administration histories, antibiotics interspersed with other medications.

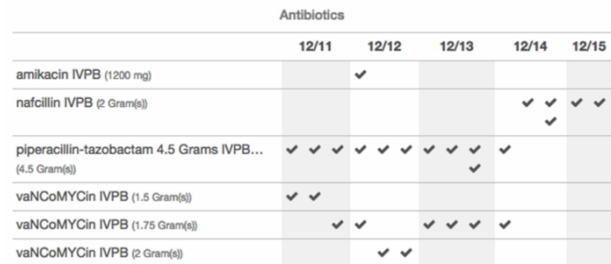

Figure 3-5: The improved medication view, with selected antibiotics and consolidated administration history.

In yet another case, we worked with providers in the Neuro ICU who described a very manual checklist process that is reviewed for every patient daily (Figure 3-6). Further, incidences of catheter-associated UTIs were increasing over the past one year. After observing the process first-hand for several days, we found inaccuracies in up to one-third of the information that was being reported. We created an automated grid that displayed the desired metrics with a red-green color scheme to represent which tasks were satisfied (Figure 3-7), drawing attention to tasks like Foley catheter removal (with annotations for indication and duration). This visualization can help the ICU reduce time spent enforcing compliance with quality metrics.

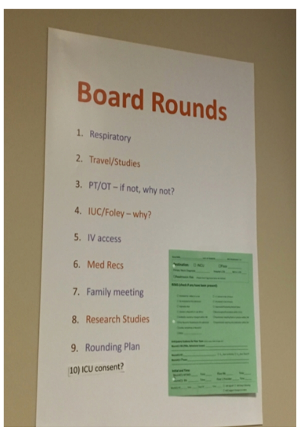

Figure 3-6: A poster showing the manual rounding process in the Neuro ICU

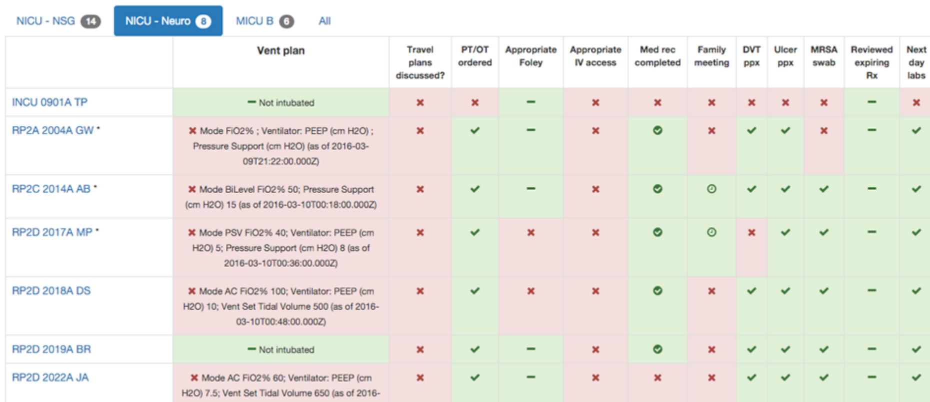

Figure 3-7: A grid showing a new, automated rounding process that reveals deficiencies at a glance

Building a Platform for Patient and Census views

Using these and several other use cases, we factored out the common elements to design a flexible software platform that could host these views and allow a user to build new views within the framework. *Dash* allows users to quickly generate dynamic live views of patient data. It is built on modular architecture that separates the data from interface and allows the interfaces to be shared between services or different institutions using the platform. *Dash* supports two types of views:

- Patient views - patient-specific data that leads to management decisions

- Census views - quality indicators that are required across a cohort of patients

Patient views help providers interpret the clinical state, a process that currently requires data to be synthesized by providers. Numerous sources, formats, and types of data are necessary, and salience of pertinent and critical values is key to enabling rapid synthesis.

Census views provide a high-level view of a cohort of patients. When cohorts are organized by disease process, deficiencies can be quickly seen and corrected. The application shows a grid with patients as rows and metrics as columns. The cells represent whether or not tasks have been satisfied, based on EHR data.

EHRs limit productivity by providing a rigid structure that may not fit providers' workflows throughout the day when they manage high task volumes. The opportunity exists to automate the manual data-collection and translation processes that are currently required for high quality care. As these scenarios illustrate, both patient-specific clinical decision-making can be strengthened by systems- and problem-based views, and population-level adherence to quality metrics can benefit from aggregated views and live tracking of adherence.

3. Financial estimates

We propose a staged implementation plan: 1. Perform early pilots demonstrating improvements to productivity and local cost- or time-savings. 2. Extend pilots to measure impact on length of stay, clinical outcomes, and complication rates. 3. Scale high-impact use cases to multiple hospitals. The *Dash* framework's utilization of standardized APIs will allow it to be installed in other institutions with minimal configuration. In the current early stage in the product life cycle, focus will be on defining need for the product and integration into existing workflow.

The Value Proposition for Hospital Partners

The development of a successful app relies on cooperation with an institution that will invest in early pilot studies to demonstrate value for each clinical scenario. Examples of the value proposition are shown below (Table 3-2).

Potential improvement	Example	Implemented as	Potential value
Metric compliance leads to fewer complications	Catheter-associated UTIs are prevented by ensuring catheters are removed if no indication	Dash Census view, which can highlight presence of catheters	A single catheter-associated UTIs can cost $900, while ventilator-associated pneumonia can cost $20,000-28,000 http://www.cdc.gov/hai/pdfs/hai/scott_costpaper.pdf
Clinical detection rules lead to earlier diagnosis	Detecting sepsis earlier can lead to early treatment and avoidance of ICU transfers	Dash Census view, which can track whether sepsis criteria is met	Can be demonstrated by length of stay or avoidance of ICU bed ($5,000-10,000)
Reduce length of stay	Some medical workup is done serially, and studies ordered later in the day are pushed to the following day. A live results panel can lead to a more streamlined process, potentially completing workup earlier	Dash Census view, which can act as a progress board showing steps remaining before discharge	The daily direct cost of maintaining a patient in a hospital floor bed is about $1600 (includes $200 variable cost)
Metric compliance for Joint Commission certifications	To meet the qualifications to be a Primary Stroke Center, institutions must meet several key measures, like giving patients aspirin within 48 hours of stroke onset	Dash Census view, aggregates tasks across a service	$100,000, equivalent cost of a full-time coordinator who would otherwise facilitate compliance
Time-savings	A dashboard containing the right information for rounding could allow consult services to effectively see, document, and bill for more follow-up visits that currently are not seen due to time constraints.	Dash Patient view	Each additional patient seen in follow-up each day may be worth $10,000 per year. ($30 visit x 365 days)

Table 3-2: The potential value proposition can be demonstrated in several ways

Phase 1: Local Small Wins

We will design and pilot views with a focus on monetizing the use cases that offload work and allow increased productivity of existing providers, and those that directly translate to cost-savings. Therefore it will be easier to convince clients (i.e. department leaders) of a return on investment. Example: In our pilot studies detecting missed dosages of antibiotics, we identified 2 to 3 premature cessations of antibiotic courses every day, potentially leading to undertreated infections. By identifying these before they occur, sepsis incidence can be prevented, thereby reducing ICU days and length of stay.

- Revenues
  - $10,000 for design and one year of maintenance of each *Dash* view during the pilot phase. Many of the views (~1 in 3) can be reused for more than one department.
  - Pricing reflects the value offered to hospitals by use of Dash:

        - If we target hospital services that already pay for a dedicated person to enforce compliance with process metrics, we could automate part of that work using Dash Census views. If automation can replace 20% of the work, there is potential value of $20,000 per use case per year.
        - If we target hospital services that have flexibility in the number of patients they see, e.g. consult services, we can allow providers to see more patients per day. Each additional patient seen in follow-up each day may be worth $10,000 per year. ($30 return visit x 365 days).
- Costs
    - Front-end Developer - We will utilize a full time developer to build and iterate on the platform. $10,000 per month.
    - API Developer - We will utilize a part-time developer to iteratively improve the application programming interface. $2,000 per month.
    - Clinical Designer - We will utilize a full time designer to work with clinical teams to customize views. We expect that each view would take four weeks to develop and obtain basic metrics. $8,000 per view.
    - Server cost - covered by institution
- Profit: Assuming 10 clients in a single hospital during the first year, we would expect revenue of $100,000. Expenses would be minimal because the authors serve the developer and designer roles listed above and will invest their time.

Phase 2: High-impact use cases

In our second year, we will try to use data gathered in the first year to demonstrate reduced length of stay or outcomes. Measurement of length of stay, patient outcomes and reduction of complications require time and large sample sizes, but once demonstrated are potentially more rewarding.

- Revenues
    - $250,000 to $400,000 to a hospital system to deploy a hospital-wide intervention that has evidence for reducing length of stay or reducing readmission rate. Estimates based on:
        - If merely 1% of patients are discharged one day earlier because a test was done or process was expedited, the hospital system could see increased profit of $4.6 million per year. (800 beds, a hospital usually at or near capacity, $1600 direct cost to hospital per patient per day)
        - We are aware of existing software interface solutions that offer $200-300,000/year for 150 bed hospitals.
- Costs: Research coordinator - $60,000 per year. Otherwise, same as Phase 1
- Profit: If we are able to demonstrate one high impact use case and sell one hospital-wide view, expenses may be $240,000 and revenue $250,000-400,000. (Profit of $10,000-440,000)

Phase 3: Enter the market with several high-impact use cases

- Revenues: Similar to Phase 2. Optional $100,000 for API development
- Costs

- API development & Integration/Quality Assurance - Each, $30,000 per hospital (full time developer, 3 months per hospital)
- Sales team - $60,000 per year.

- Profit: $600,000-700,000

		Item	Quantity	$ - Phase 1	$ - Phase 2	$ - Phase 3
COST						
Staff	per month	Front-end Developer (David Do)	1	$0.00	$10,000.00	$10,000.00
		API Developer (Eugene Gitelman)	0	$0.00	$10,000.00	$10,000.00
		Integration & Quality Assurance	1			$10,000.00
	per view	Clinical Designer (Katherine Choi)	1	$0.00	$8,000.00	$8,000.00
	per year	Research coordinator	1		$60,000.00	$60,000.00
		Sales manager	1			$60,000.00
Equipment	per month	Server hosting		$0.00	$1,000.00	$1,000.00
	<u>Phase 1 year</u>	# views	10			
		# unique views (/3)	3			
		Total cost per year		**$0.00**		
	<u>Phase 2 year</u>	# views	10			
		# unique views	3			
		Total cost per year			**$240,000.00**	
	<u>Phase 3 year</u>	# views	30			
		# unique views	10			
		Total cost per year	for 3 hospital clients			**$512,000.00**
REVENUES						
Price	per view (phase1) or client (phase 2+)	Custom Dash Interface	1	$10,000.00	$250,000.00	$400,000.00
		API development	optional			$100,000.00
Volume	<u>Phase 1 year</u>	# views (within single hospital)	10			
		Total		**$100,000.00**		
	<u>Phase 2 year</u>	# hospital clients	1			
		Total			**$250,000.00**	
	<u>Phase 3 year</u>	# hospital clients	3			
		Total				**$1,200,000.00**
		Total with API				**$1,300,000.00**
PROFIT						
	<u>Phase 1 year</u>	**Total profit**	= Revenue - Cost =	**$100,000.00**		
	<u>Phase 2 year</u>	**Total profit**	= Revenue - Cost =		**$10,000.00**	
	<u>Phase 3 year</u>	**Total profit**	= Revenue - Cost =			**$688,000.00**
		Total with API	**=**			**$788,000.00**

Table 3-3: Financial estimates for a 3-staged implementation plan.

4. Engagement Plan

Our first step will be to engage departments in a single hospital in order to design the necessary Patient and Census views. We will utilize existing partnerships with the Neurology, Medical Intensive Care, Infectious Diseases, and Endocrine Departments in our pilot hospital, which is a major academic center. Our early surveys with these clinical partners, identified several key needs for monitoring and enforcing process metrics (Table 3-4).

Process metric	Automatable measurement?	Baseline compliance can be obtained easily?
DVT prophylaxis ordered?	✓	✓
Ulcer prophylaxis ordered?	✓	✓
ARDS detected? -> Low stretch protocol		
Delirium detection (RASS>3)		
ARDS detected? -> Prone positioning		
Spontaneous breathing trial done?		
Sedation interruption trial done?		
MRSA swab completed?	✓	✓
Physical therapy consult ordered?	✓	✓
appropriate central venous access		
weight drop since admission detected? -> nutrition assessment	✓	
glucose repeatedly elevated? -> insulin gtt	✓	
medication reconciliation done		
pain assessments done regularly?	✓	
RASS assessments done regularly?	✓	✓
travel plans off-unit		
foley in place?	✓	✓
family meeting done?		
research studies eligible		
ICU consent form complete?		
expiring medications		
AM labs ordered	✓	✓
TPN order (for pts with one yesterday)	✓	✓
warfarin order (for pts with "warfarin therapy" or a warfarin dose yesterday)	✓	✓
ventilated patient receiving ABG at sufficient frequency?	✓	
post-intubation order set compliance	✓	
extubation risk screen compliance		
restraint order accuracy and validity		
incidence of mobility		
skin breakdown prevalence		
device regular dressing changes		
VAP prevention (CHG, HOB 30deg, suction tubing changes)	✓	✓
communication plans in place for nonverbal patients?		

Table 3-4: Feasibility analysis of potential process metrics generated from survey results of our clinical partners

Working closely with clinical partners, we will determine the potential intervention, impact, and feasibility for each need. We plan to pilot select interventions on the *Dash* platform and collect data on patient outcomes, usability, and time-savings for 2-4 weeks before and after the interventions (along with data from a control population).

In many conversations with hospital administrators, there is desire to invest in technologies that align with the core initiatives of providing value and continuity in patient care. Once department-level value is demonstrated in several use cases, interventions will be scaled institution-wide. We would utilize existing partnerships with clinical champions across the University of Pennsylvania Hospital System.

- CMIO William Hanson III, has prioritized building an app infrastructure at the University of Pennsylvania Health System. He endorsed the first version of the clinical API, and has demonstrated interest in use cases affecting length of stay and patient outcomes.
- MICU director, Barry Fuchs, MD, has previously developed technologies for early diagnosis of sepsis and acute respiratory distress syndrome. He has partnered with our team to develop new live algorithms for protocol adherence. He has welcomed testing of tools during clinical rounds, involving his teams of residents, interns, nurses, and respiratory therapists.

Interventions for which value is demonstrated can also be deployed on the Dash platform at other hospitals. To expand beyond the pilot hospital, we will engage similar academic institutions as our target customer base. We hope to increase visibility by publishing results from larger-scale pilot studies, and begin our collaborations with those already affiliated with our local institution in informatics work. The authors also have relationships with Children's Hospital of Philadelphia, The Johns Hopkins Hospital, University of Washington, New York Presbyterian/Columbia University, Washington University in St. Louis, and UCSF.