Appendix A: Supplemental Information on Visioning Framework, Quotes, Creation of Summary Information, Human Subjects

Initial visioning document content

Information seeking goals and context
- patient review and prioritization
- new patient assessment
- review of known patient status, changes, progress
- specific or directed information seeking

Information pull versus information push

Use behaviors that impact design
- speed of information retrieval as most important
- limited use of customization
- sticking with familiar ways to access content
- seeing relevant information together on one screen
- use of a small subset of views available
- training as too time-consuming for the value returned

Opportunities for innovation in patient information organization and prioritization:
- first screen opportunity
- smarter and more informative patient list display
- patient overview display
- patient status, changes, and progress display
- re-thinking progress notes
- intelligent prediction and evidence-based information prioritization
- fewer and/or better display choices and change management (combatting feature creep)
- on-demand context sensitive training
- data tagging

Opportunities for innovation in navigation and search
- faster, more natural links or navigation between levels of detail
- search (natural language or intelligent)
- intelligence and prediction to support navigation
Interviewee quotes to support emerging themes

Goals and contexts of information use

Caring for the whole patient with a focus on acute problems
"As an intensivist, our responsibility is to take care of the entire body. The urologists, they just care about the stream. Cardiologists just care about the pump. ... It's not until you get into critical care that you have to tie all those things together." Attending, Duke University SICU
"You might have COPD, but why they're in the ICU is septic shock." Attending, Duke University SICU

New patient assessment
"... I'd do a search to see if they've been here before, and I would search for admissions, procedures, major things like that, discharge summaries.... I usually would look at an H&P first... And then if I think there are particular things more relevant to that patient, I want to see have they had an echocardiogram [for example]... I'm going to have that first [diagnosis from the patient’s entry point]... then I'm going to see if that jibes with what's going on...." Attending, Saint Alphonsus Regional Medical Center (SARMC) ICU

Known patient status review
"The patient has septic shock, is on a ventilator, has renal failure. I look at information pertinent to those diagnoses. ...seeing if she is improving. Looking at change rather than absolute." Attending SARMC ICU
"...this patient I had the day prior... Usually, by that point I already know what the trends have been so I look at what’s happened the last 12 hours since I left. ’Are we getting better or worse?’ " Nurse, SARMC ICU

Specific directed information-seeking
"So what I was writing on my sheet was ‘follow up INR’ later today. Don’t be fooled by the fact that you have a normal value and stop looking." NP, Duke University NICU

Review and prioritization of multiple patients
"That one is the census in the ICU. ...taking the patients that are the pulmonologists' in the ICU and putting them into a separate census for myself so that I'm not digging through all of the patients all of time." NP SARMC ICU

Representing dynamic data

What's new
"I'm just pulling up the most recent lab results, to see what we’ve had recently, how old they are, look at the time on them...they update these numbers anywhere from 3 am until 6 am, it can take a few hours, so it could be subsequent data that’s come in since they reviewed that patient." Attending, Duke University SICU
**Paper flow sheet reminiscing**

"When we used to have paper charting, you had a desk with a piece of paper this big... I could look and see oh gosh look, this drip was started at this time and this happened... urine output 60 minutes after this drip was started, and this is when they tanked their blood pressure....there were certain things always plotted, and that's been lost in here." Attending, SARM C ICU

**Trends**

"He mentioned alkaline phosphatase is X so I think we both went and looked to see what that trend was, so the number by itself wasn't telling us a whole lot of information." Attending, Duke University SICU

"I do remember it better if I bring it up myself and see the trend. ... Maybe I won't remember the number, but [I will remember] it's coming down or whatever." Fellow, Duke University SICU

"She's talking about changes in liver function studies. I was probably trending that data, just numbers in a row, not plotted graphically, some things you can, but I don't usually bother. It just takes too long." Attending, Duke University SICU

**Labs**

"We spend an enormous amount of time looking at labs. And over and over and over." NP, Duke University NICU

"Stuff in microbiology is all over the place...something new might pop on the middle of the screen, or bottom, or top... can't predict where it will show up." Attending, SARM C ICU

"What's normal and what's acceptable... none of these normal lab studies are ICU patients...so it's never normal in an ICU patient. It's always flagged." Attending, SARM C ICU

**See related information together**

"... I have to look at the vital signs, and then I have to look at what my fluids are, and then I have to look at my drips been adjusted, and then I have to go back and see when I adjusted those drips, what happened to my vital signs..." NP, SARM C ICU

"Take my p02 [partial pressure of oxygen] and fi02 [fraction of inspired oxygen] and my PEEP [positive end-expiratory pressure] which is a ventilator thing, not a laboratory thing ....and you can't do that [see them together] in this system. It's gotta be inferred and that's really hard to do..." Attending, SARM C ICU

**Usability**

**Speed of information retrieval**

"I don't know why, but you bring it up, it's slow to come up. I try not to bring it up because it will crash the computer. But it's got some stuff I can't get anywhere else." Attending, SARM C ICU

"...gone back to the chart because I know it takes a long time to load." Attending, Duke University SICU
System and navigation complexity
"You want to find out whether or not they pooped... when you're busy you don't necessarily want to go through 6 screens to get to the stuff." Attending, Duke University ICU

"I guess there are more than 20 [alternative display formats].... I use [lists 6 of the possible page alternatives]", SARMC ICU

"The EMR here has at least 3 separate places where infusions are listed and if you don’t look at them all you may miss ‘em." Attending, SARMC ICU

Display clutter and hidden information
"You just want the number of that value, 98.5, you don’t want it buried in the whole popup note that has 12 other pieces." Attending, SARMC ICU

"But I just don’t like [this system] because you can only see this much of it at a time and you have to scroll this way to that." Fellow, Duke University SICU

Pop-ups
"I think they can be useful, but often times the system automatically generates these things and it’s too much. We need to be able to see the popup, deal with it, and then have it not pop up again." Nurse, SARMC ICU

Cross-system integration
"I don’t have access to nurse’s notes. In the provider charting, you can’t go back and look at assessments, which I have found myself wanting to do a lot of times." NP, SARMC ICU

Processes for recalling and sharing information and for tracking tasks

Summary information for team work
"... we have to have a way of keeping ourselves up to date on all the tests and all the things that have happened. So, what we decided to do is put a lot of [effort into creating a good summary], I mean these sheets take hours out of your day every day, especially if you get a new admission..." NP, Duke University NICU

"So what I do is use it [resident created rounding/signout sheets] as a guide because it has a good summary of the patient." Fellow, Duke University SICU

Summary information for personal use
"I usually write a brief narrative about what happened. And then what are the major issues on that patient and that's all I keep. When you have 12 or 15 or 20 patients, they can start to blend. You have 3 intracranial bleeds or 3 patients with sepsis." Attending, SARMC ICU

"...writing things down helps me remember. Or it might help me get organized to do a note or remember when I talk to a physician that these are the important things about this patient." NP, SARMC ICU
Progress notes

"A lot of times you see stuff carried forward and ... it isn't even true. They get diagnosed with a cardiomyopathy when one time they had an echo to rule out a cardiomyopathy and then all of a sudden they get the diagnosis..." Attending, Duke University SICU

"One of the problems ... doing your notes, is that it auto-populates a lot of stuff... A lot of people don't [edit it]...they just leave it in there...labs, and vitals, and I&O's, weights... You have to look under every heading to either get it to, or get it not to [include that information]." NP, SARMIC ICU

Task tracking

"It may be time to decrease their steroid dose, or we can transfer them out. So we scribble those things in during rounds... photocopy that...today's bucket list." NP, Duke University NICU

"My ’brain’... write when my meds are due, so I can see the sequence of my day." RN, SARMIC ICU

Visioning future IT to support critical care

Rapid access to new information

"I'm thinking I want an exclamation point if a new lab comes back..."

"Even something that might be simpler is a display that says 'changed vs. unchanged' .... no new data to look at. ... Where if you could just glance or a [symbol] turns red or the name turns red."

Separating patient history from acute patient data

"...basically 2 views to accommodate what you're talking about. A historical view... Then an ongoing acute [view]... and some way of blending the two, or accessing the two, so that you can put the information into context."

Organize by human body systems or problems

"Intensive care is very much focused on systems. Bringing the patient back to balance."

"I actually do like it [systems organization]. One of the reasons is that I think it goes towards decision support because in helping remind people...to look at these other things."

Progressive detail

"...if I can click on a picture and start going down to the information I want, that's a lot more efficient use of real estate on the screen as well.... Then you would be able to drill down to the numbers like you've shown us."

"Your respiratory rate falls under your vital sign flow sheet. ...you could click on it and it would open up a respiratory parameter that would have your last AVG your vent settings...."

Applications for intelligence, general comments and caveats

"I would be totally fine with a machine doing some of that preliminary work to notify me that it thinks something is out of the ordinary. But, I would want to confirm it and do my own digging."

"The system starts guessing what you need and it has a completely different behavior... You need a very consistent behavior ... the prediction could be focused on being smart about prioritizing."
Detecting and representing change and urgency
"A heart rate of 80 in a healthy patient is different than in a patient with CV disease. You really need ...the context somehow to interpret the acute values...The [specificity of the] algorithm would be key."
"...it would be nice to know if they are changed or unchanged from the last level. For change that is out of proportion to what you might expect for this problem... It's not only the presence of the change, it's the magnitude and in some instances the time course, the direction of change."

Smarter and more informative patient list display
"...something like an iPad with just the name of the patient and a picture with different colors of the representation of the different systems are acutely changing."
"Then you can drill down so I can look at all the patients on the ward at one time and see what's red. If someone has multiple areas that are all red... I know I need to divert my attention...That would make life a thousand times easier."

Integrate evidence-based content and decision support
"They've gotten rid of a bunch of those [popups]... now they sit in the corner, it's on the first screen... I think I like it better there than having all the popups, but it is easier to miss a lot of the stuff."
"[Alerts in a message list] are not prioritized...long... no visual cues in terms of whose responsibility it is, how late some measure is...The delivery mechanism, the prioritization, that's off. The reminders are completely agnostic of each other."
"CDS is seen as a separate beast in the EHR. The entire EHR should be a CDS... they are not conceptually integrated into the entire concept of the application..."
"Exactly, in a visualization, that is exactly what I was imagining as well. The foley, if it's there for 2 days it stays yellow. If it's there for the third day it turns orange, on the fourth day it might turn red... I think that would be great."

Rethink progress notes
"What people end up doing because all these different modules don't work well, they end up using the notes as the EHR. They copy and paste everything..."
"I agree. They should be used primarily for the qualitative interpretation of what is going on...the kind of things that quantitative data, structured data, cannot provide."
"It [high quality asynchronous communication] needs to be emphasized, the importance of it. ... For a lot patient care, this is the only type of communication between one provider and another... Sometimes I'll send an email, but short of that I have no way of putting it out there to the people who are caring for the patient right then. Sort of like a little blog, or a facebook wall."
Details of information creation practices

Summary information to support team work

At both Duke University ICUs, NPs and residents developed summary information documents to support team activities. At the Duke University SICU, residents use a Word document template to create a local "rounding sheet" (one page per patient, front and back) that includes:

- brief history of present illness, 24-hour events, problem list, home medications,
- key laboratory values,
- intake and output,
- brief review of systems,
- lists of medications, lines, drips, cultures, and antibiotics,
- systems-based assessment and plan.

These sheets are shared with care team members, and provide information and structure for rounding reports. At the Duke University NICU, NPs create and maintain summary information in the form of a dynamic progress note (with similar content as the SICU rounding sheet), and a blank rounding to-do sheet that is completed by hand and covers all patients. Summary information is gathered from multiple data sources, re-entered into a computer system, printed a few hours before rounds, and is updated with handwritten notes, which may or may not be updated in the computer. Dynamic data are frequently double-checked at the time of rounding. The documents, in general, are for local use and do not become part of the patient record, although they may serve as the basis for a progress note in the patient's record. On both units, providers described the process of creating the team documentation as time-consuming. We did not observe this practice at SARMC (with a more fully functioning EHR and less academically focused practice model).

Summary information for personal use

Most clinicians in our study develop paper-based summary information for personal use. Providers routinely maintain a list (or cards) with notes for each patient. Using paper notes, clinicians create a personal "dashboard" with important patient-specific information that is portable. Nurses, with one or two patients, may have one sheet of paper with one patient represented on each side (their "brain"). For multiple patients, providers frequently start from a printed page with a list of patient names and, sometimes, key information about each patient. Providers add: 1) cues or reminders of patient’s major problems and distinguishing characteristics and 2) relevant concerns, data, tasks, or goals to follow up on to ensure progress. At Duke University, some clinicians use the team summaries as an initial framework, to which they add personal handwritten notes. The quantity of information documented varies by role and...
experience, with attending physicians maintaining shorter notes than trainees. At the SARMC ICU, where there were no shared team summaries, the nurses described using their "brain" as a framework for guiding handover and rounding presentations. Many interviewees said that the process of creating their documents is important for developing and maintaining a good understanding of the patient, even if they do not reference the notes later.

Additional information on humans subjects, consent, and permissions
The research plan and consent process was approved by the Duke University Health System and Saint Alphonsus Health System Institutional Review Boards. Interview participants signed informed consent. Providers who were captured in recordings incidentally provided verbal consent. Because the eye tracker captures audio and video in a semi-private environment, we took steps to protect the privacy of patients and other providers, including posting signs that recording was in progress, turning off recording in patient rooms, and obtaining verbal consent from other providers captured on video or audio. The resolution was not sufficient to allow interpretation of patient-identifiable data from the video.