Identifying Opportunities for Inpatient-centric Technology

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ABSTRACT
The evolution from a disease-centered model of care to a more patient-centered model presents opportunities for going beyond designing technology to support medical professionals to encompass supporting patients as well. In this work, we conducted interviews with 16 inpatients and 5 visitors in several hospital wards to uncover opportunities for improving the inpatient experience. Findings suggest that a redesign of the call button system could improve nurse-patient communication and relieve anxiety. Providing information about overall progress and upcoming events could help patients maintain a sense of autonomy in a disempowering environment. Helping patients learn more about their health through information access could lead to a greater sense of ownership over health. Technology promoting social connectedness could help patients virtually escape the isolating hospital environment. Finally, novel interaction techniques could make technology more accessible to this unique population.

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Performance, Design, Human Factors.

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Healthcare, hospital, inpatient experience, technology design.

1. INTRODUCTION
The hospital is a scary place for patients unfamiliar with the routine, the vernacular, and the people who suddenly become an important part of life. Inpatients are unaccustomed to the loss of autonomy, and anxious about what is wrong or what might happen to them. Thoroughly enjoying a stay in the hospital seems unlikely, but there are many ways technology could improve the inpatient experience. With over 37 million hospital admissions annually in the United States alone, any improvements are highly impactful [1].

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Quality medical care and safety are the foremost priorities of any hospital and new approaches encourage the patient to be an active participant in their care. In fact, hospitals are beginning to view the patient more and more as an informed consumer of medical services, just as we would in classical retail settings. And just as in retail settings, the notion of patient satisfaction has started to come to the forefront of considerations in healthcare work.

Aside from competitive advantage and higher profitability for organizations when patients "shop" for medical services, there are many important benefits of patient satisfaction. These include greater trust and compliance, increased tolerance for discomfort, reduced stress and medical complications, enhanced placebo effects, and an overall benefit to quality of care [16]. It has also been demonstrated that patient satisfaction is a factor in staff satisfaction, and vice versa, which suggests that affecting either part of this cycle will propagate and self-amplify through the system [17].

While there has been quite a bit of work in the medical and informatics communities developing technologies and techniques to support medical professionals in providing, tracking, and documenting care, it is only recently that the patient has garnered direct attention. Human-computer interaction research has already played a large role in prior work and we believe there is more to do to creating novel, information-rich, and pleasurable experiences for inpatients.

The work we present in this paper represents a small step towards understanding some of the opportunities ripe for researchers in the inpatient domain. We explore current experiences within an inpatient setting, in which patients are admitted to the hospital and stay at least one night. Specifically, we conducted semi-structured interviews with inpatients in several units within a local hospital. We report both current experiences, and the needs and desires expressed by patients and loved ones. For the purpose of discussing patient-centric technology opportunities, we group the emergent findings into several themes. Each of these themes suggest a very concrete technology design opportunity, including improving nurse-patient communication, transparency of progress and predictability of daily events, facilitative access to health information, improving social connectedness, passing the time, and recumbent computing. We hope this will provide a starting point and inspire researchers to leverage our work and apply their own expertise to engage in the domain.

2. BACKGROUND AND RELATED WORK

2.1 Support for Care and Documentation

Aside from core innovations in medical devices, Health Information Technology (HIT) has received considerable attention recently. For example, there is a concerted effort in the United States to adopt Electronic Medical Records (EMRs) to unify medical documentation and streamline coordination [6]. Hospital information systems must serve a variety of people and purposes. Researchers have argued that successful technologies must take into account existing work practices and needs of clinical staff [4]. To this end, they have focused much effort in designing and studying technologies to better support clinical staff. For example, Spence and Reddy compared work practices before and after deploying mobile devices for nursing activities and found that the form factor of the devices did not fit the hospital environment and failed to support work practice [20].

There has also been a significant amount of work looking at collaboration and coordination within the clinical setting. Research within the emergency department on how interdisciplinary teams collaboratively seek information identified opportunities to enhance the gatekeeping role the unit secretary plays, both in locating information resources and coordinating team members [19]. Furthermore, other work in the emergency department has shown that group sensemaking depends heavily on the ability of individuals to access information and share it in group presentations [14].

One technology intervention within a surgical unit used large touch screen displays to help care teams with social, temporal, and spatial awareness, as we as with communication [3]. In follow up work, the authors highlight how the simple act of identifying and sharing "activities" promotes useful awareness [2]. They also identify opportunities to display activities and also to build interfaces that provide access to relevant information resources and communication channels. This is very rich work and we believe similar challenges and opportunities exist for designing technologies that directly enhance the inpatient experience.

2.2. Tending to the Whole Patient

A patient-centered approach that supports more than just the medical needs of patients is becoming a more important focus in the hospital. Nursing, as a discipline, has long appreciated the need to care for the whole patient, rather than focusing solely on mechanically monitoring vitals and administering treatments. For example, a 1959 article acknowledges the temptation to, and the harm of, dehumanizing hospital patients, urging nurses to be sensitive to the patient's perspective [21]. More recent findings confirm that patients tend to be as concerned with psychological and social aspects of their stays, as they are about physical factors. Furthermore, this anxiety has been shown to be correlated to negative clinical outcomes (e.g. [8]).

The core concept of 'patient satisfaction' is gaining importance and is employed to rigorously compare the quality of medical care provided across institutions. In the United States, organizations such as the Joint Commission on the Accreditation of Healthcare Organization (JCAHO), and funding sources such as Medicaid, have begun requiring these measurements. For example, the Hospital Care Quality Information from the Consumer Perspective (HCAHPS) survey[1] is a standardized measure used to assess patient satisfaction and is applied at the hospital where we conducted our research. Consumers can even view results from many institutions published at the Department of Health and Human Services website[2].

Much work has been done studying patient satisfaction and providing guidance on improving it. For example, Irwin Press stressed understanding the difference between medical and patient cultures so clinical staff and patients can reduce miscommunications [16]. Press recommends hospital staff "Assume that [patients] know nothing about what is being done, yet want to."

We believe that there exists a relatively large opportunity for designing technologies aimed specifically at enhancing the inpatient experience. As we show in the latter part of this paper, these technologies could provide patients with greater access to medical information, better communication mechanisms, and improved entertainment options. We derived much of our initial inspiration from two pieces of work. The first was a system built and deployed by the Children's Hospital in Arkansas [13]. That hospital used a Microsoft Media Center PC coupled to an Xbox 360 in children's rooms to give patients an Internet connection, games, educational materials, and to allow staff to review medical records in the patient's room on a display that patients, doctors, and family could all view together. The second was a recent study that details overwhelmingly positive response to hospital-room displays that provided patient-centric views of select data from the electronic medical record [23]. The work also highlights needs as well as challenges and opportunities for designing information delivery systems targeted at patients and families.

2.3 Expertise with Outpatient Technologies

Much of the attention patients have received from Informatics and Human-Computer Interaction (HCI) researchers has been in settings outside the hospital. This includes research on health monitoring devices that allow consumers to sense metrics such as glucose levels, heart rate, step counts, and so on. Researchers have started to show the potential of coupling these sensors to persuasive technology to improve health in the outpatient setting (e.g. [7]). Taking a broad look at chronic cancer care, one study opened up several avenues for pervasive computing in the cancer domain [10]. For example, methods for easily gathering and helping patients reflect on data could be used throughout treatment and remission. Mobile technology could also strengthen the connection between patients and social networks.

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[1] www.hcahpsonline.org

[2] www.hospitalcompare.hhs.gov

Figure 1. A private hospital room viewed from the patient perspective. a) left: bathroom, whiteboard, sink, and door b) down: TV and clock c) right: rolling bedside table, fold out couch, chair, and telephone on side table

Aside from influencing behavioral change by providing regular awareness information, technology can also facilitate sharing behavior information and utilize social pressures to positively impact health behaviors such as sleeping or exercising [12]. Other researchers have further leveraged the Internet as a platform for providing connectedness to facilitate healthy decisions and behavior. For example, user generated content on online discussion boards has been shown to be a rich source of information for patients [5]. It is also interesting to watch as the trend of people searching the web for health information continues to evolve [18].

In a parallel push to EMRs, Personal Health Records (PHRs) that provide consumers with access to their complete medical records have seen significant development. However, researchers have just begun to study how people use the medical information they keep now and what kinds of tools are needed to support this use [15]. For the earliest stages of life, Hayes et al. explores parents using technology to keep records about their children's development [11].

In the health domain, there has been substantial research done in the outpatient setting and for clinicians in the inpatient setting. However, inroads are now being made to bring technology to the bedside and into the hands of patients. We take a patient-centric view and consider the whole person's needs in our investigation of the role technology could play in improving the inpatient stay.

3. INPATIENT FIELD STUDY

We conducted a series of in-situ interviews at a local hospital to better understand the nature of current inpatient experiences as well as the needs and desires of patients. Patient satisfaction studies are often done with focus groups of discharged patients, but we believe that being physically present in the wards and interviewing patients while their experiences were still fresh in their minds was vital for garnering an accurate understanding of their situation.

3.1 Study Setting

We conducted the study in a suburban hospital located in the Puget Sound region. The hospital is a level III trauma center, with over 300 beds. It admits approximately 18,000 patients per year, employs over 2,000 people, and has more than 1,000 active and courtesy physicians on staff. The administration at this hospital continues to aggressively enhance the inpatient experience and was excited to provide access to their inpatient population and to work with us on improvements. Conduct of this work was approved by a third-party human subjects review board.

We conducted interviews in four different units: one focusing on neurology and orthopedic recovery, one on post-surgical gastrointestinal recovery, one on general medical oncology, and the last on open heart and vascular surgery and telemetry. HCAHPS survey scores, which represent patient perceptions of their hospital experience, showed a range of satisfaction across these units. This provided us with a diverse set of experiences, opinions, and suggestions.

Physically, each unit was arranged with a central station from which nurses, physicians, and other staff performed their main tasks. Patient rooms surrounded the central station, and there was a mix of private and shared rooms in all four units. In the room, each patient had their own bed, television, phone, and whiteboard, on which the nursing staff recorded information for the patient (Figure 1). All beds had a tethered remote control for patients to manipulate the position of their bed (Figure 2). The remote also had controls for the television, lights, and a call button. Every room had an attached bathroom and private rooms had a small couch that folded out where a visitor could stay overnight. Each unit also had a common sitting area for visitors, with public Internet-equipped computers. The hospital also had an open WiFi network and permitted cell phone usage.

3.2 Participants

The hospital nursing staff assisted us by identifying patients who were well enough to participate and asked if they were willing to be approached by a member of our research team. We approached interested patients in their rooms to provide more information about the study and conduct informed consent if they decided to participate.

We conducted semi-structured interviews with 16 patients during their stay in the hospital. Five of these interviews also included a family member who was present and who chose to participate in the interview. This gave us a total of 21 (eleven female) study participants.

Figure 2: Remote control with large red call button

Before beginning the interview, we collected demographic information to get an idea of their backgrounds. Participants ranged from 24 to 76 years of age, with the average at about 50. They had a wide range of educational levels, ranging from high school dropouts to one graduate degree holder. Occupations were similarly varied and included teachers, a retired nurse, a plumber, an electrician, clerical workers, managers, and a professional artist. All but one of our participants were computer users, and most reported using a computer daily. Participants had a range of household incomes with five participants reporting less than $50,000 and five participants reporting over $150,000.

While our participants came from relatively diverse backgrounds, we are cautious not to over-generalize results. In particular, we note that we only interviewed people well enough to speak with us and results do not represent sicker patients or patients in intensive care settings. Furthermore, while some of our participants had been hospitalized in other places and could speak about past stays in those hospitals, we did only sample from one institution.

3.3 Interview Protocol

Our semi-structured interview method allowed us flexibility to make questions relevant to each participant's unique situation. To ensure that we covered topics of interest with each person, we prepared an interview guide with sample questions grouped into the following topics: medical history and reason for the current visit, daily routine including what patients spend their time doing, awareness of medical progress and events around them, communication with the care team and loved ones, and technology desires.

We conducted most interviews with two experimenters in the room (one male, one female). Most interviews lasted around 40 minutes, though several went quite a bit shorter (e.g. 25 minutes) or longer (e.g. 120 minutes). This variance can be attributed to the fact that we stopped the interview if patients had to go to a procedure, eat, or whenever patients drifted into a less comfortable or coherent state. More than half of the interviews were interrupted at some point by phone calls or by hospital staff coming in for a short time. Being present for these interruptions allowed us to observe the interactions and experiences patients had in the hospital.

3.4 Data Analysis

We took field notes and captured full audio recordings of each interview. We transcribed audio recordings into a Microsoft OneNote notebook, enabling us to maintain a link between the text and the audio. For analysis, both researchers independently reviewed the transcripts. One used Atlas.ti to code emergent themes and the other created a document of themes with quotations under each. This exercise allowed us to extract the key themes that we saw emerging from the interviews. While there were many ways to group comments into themes, we chose a grouping that facilitated discussion about potential technology interventions to improve the inpatient experience.

4. FINDINGS

When people become inpatients, their daily routine changes, the people they see are different, and they usually lose the ability to do many things for themselves. Inpatients do not, however, lose their basic human needs to feel safe, socially connected, and autonomous. These needs pervade our findings and supporting them are at the root of many of the technology suggestions we identified.

4.1 Improving Patient-Nurse Communication

A critical piece of hospital room technology is the call button that patients use to summon help. In the hospital where we conducted this study, the call button was located on a relative complex remote control tethered to the bed (Figure 2). When pushed, the call button turned on a notification light outside the patient's room and at the nurses' station.

Since inpatients are often quite vulnerable, having a mechanism that allows them to call for help is critical not only to summon physical assistance, but also to provide peace of mind. Patients' needs ranged from questions about schedules and medications, to tasks like getting a drink or getting out of bed to go to the bathroom, all the way up to emergencies such as acute pain or increased bleeding. During the interviews, many patients seemed concerned that nurses had very little information with which to prioritize calls. They expressed the desire to provide more signal resolution than the current "single-bit" button.

4.1.1 Expressing Non-Critical Needs

On the one hand, several patients felt bad about using the button for minor tasks and wished that they could signal that the call was important but not critical. For example, a retired nurse said that her experience as a nurse influenced her use of the call button. She used the call button,

> *"Judiciously. Judiciously. I don't call for just anything. I call like for help getting out of bed, because I have fallen and passed out. Not for frivolous things."*

She wished that she could signal that she only needed a technician to bring her something and that she did not need the nurse, who she assumed would be busy and in-demand.

A school teacher expressed concern about asking for too much using the call button. He said that his use,

> *"…depends on my comfort with the nurse, if I have a nurse I'm more comfortable with I'm more likely to ring the bell for lesser issues… if I feel uncomfortable with a nurse I'm leery because it's like I'm getting snapped at."*

4.1.2 Expressing Extremely Critical Needs

Other patients wanted more resolution because they had either experienced, or feared, long waits before someone responded to them. One patient, who was in the hospital because of debilitating back pain and an infection, described waking at night with uncontrolled pain that caused him to scream and shake. He and his girlfriend, who stayed with him, perceived responses to the call button to be uncomfortably long. He described the call button as a means of communication between him and his nurses and expressed that he wanted to improve that communication.

One idea for improving the call button system came from a patient who had a traumatic injury to both legs and who was unable to get out of bed. This patient relied on the call button quite a bit. He suggested a system for signaling the urgency of the call. Pressing the button once gets a green light and no urgency; he would use this if he had a question or needed something that could wait. A second press gets a yellow light and signals more urgency and a third press gets a red light signaling that this need is "a priority." Similarly, another patient and her husband suggested a regular call button and an "urgent" or "panic" button to summon anyone who was available.

4.1.3 Providing Information so Nurses can Respond

Another participant suggested improving the call button to help nurses improve efficiency. He observed that when he pushed the button his nurse had to come in and ask what he needed and then usually leave the room to retrieve something and then return again. He suggested that it would be far more efficient if he had a way, possibly using the remote control tethered to the bed and the TV as a monitor, to interact with a "menu system" to signal to his nurse or technician what he needed. Another patient said that he would like to be able to use a voice system to communicate with the nurse before they came in. Not only would this be more efficient, but he felt it would also help nurses prioritize the urgency of the need, *"if you're just helping somebody who just needs a blanket changed… it's better to drop the blanket to save a patient who is dying."*

4.1.4 Uncertainty Makes Waiting Worse

The patient who woke at night in excruciating pain said,

> *"there have been times when I'm hurting really bad, but I know my pain is not going to kill me. But if I'm left here not knowing and suffering. I'm dying because… every time I hear movement I'm jumping up. Even if someone could say 'this is what's going on and we'll be here soon' [that would be good]."*

More transparency about why they are having to wait, or an acknowledgement that their message has been received, could go a long way to making the patient's wait more bearable. Another participant suggested,

> *"…what if on the TV they had some type of little camera operation in the corner so they could see if someone was at the front desk or not so they don't keep hollering out for nothing.… You could see if nurse was busy or not."*

He described a night when his elderly roommate needed help and no one responded to the call button so, *"I helped out by hollering out and I was loud enough that they heard me."*

Patients further expressed that occasionally, even after someone came to the room, they still had trouble deciphering if any action was being taken,

> *"A lot of times if they do come in and they leave to do something, they don't tell you what they're going to do… do I need to push the button again? What are they going to do?"*

This ambiguity left him in more distress wondering whether his request for help had been successful.

4.1.5 Discussion

At the heart of the proposed call button improvements was the notion that nurses will often be pulled in more than one direction at once and if patients were able to communicate their needs better, the nurses would be able to make better decisions about how to spend their time. We expected that patients might simply want nurses to always respond to them as quickly as possible, but we found that patients were quite aware that others might have more pressing needs and felt universally that the most urgent needs should be attended to first. We infer that in part this awareness comes from participants' own concerns about the nurse responding to them quickly in an emergency situation.

The improvements have two basic aspects: 1) a better way for patients to communicate their needs and 2) feedback to the patient on the status of the response. Participants suggested that more transparency and feedback about the state of the call button system would ease anxiety. However, it is also a possibility that a camera pointed outside the room or a more sophisticated system for automatically sensing and displaying activity level might have the opposite effect. A patient who is concerned about the possibility that no one will be available when they need help might be more anxious if they became aware that the nursing staff were quite busy or that other patients were having problems.

The possibility of a call button system that provides patients with a better ways to communicate their needs and also provides reassuring feedback to patients is tantalizing. The complexities of the hospital environment and the many stakeholders involved create a worthy design challenge.

4.2 Providing Predictability in Daily Events and Awareness of Medical Progress

In the hospital, there are many people who work together on a patient's care team. Our participants had doctors, three nurses a day, and three technicians a day. It can be challenging for the entire care team to coordinate and for everyone, including the patient, to know what is going on. One of the ways the hospital we observed kept the patient in the loop was with a whiteboard in each room (Figure 3). The whiteboard has a place for the date, room number, doctor's name, nurse's name, tech's name, goal for the day, potential discharge date, scheduled test or procedures or treatments with an approximate time, and a space for special instruc-

tions. These boards were not completely filled out in any of our participants' rooms, but the room number, date, and nurse's name were filled out in most and several patients also had technician names and a goal for the day.

4.2.1 Awareness of Medical Progress

In general, our participants could describe the event, or series of events, that needed to happen before they would be well enough to go home. In some cases there were unknowns that needed to be answered before further decisions could be made, but these patients still knew what they were waiting for. One participant did wish that his board, if electronic, could provide a sort of progress bar,

> *"something like the bar you see… that just goes across and tells you kind of where you're at, just on average, nothing specific or guaranteed… more information is better."*

This would be a big picture view of his overall progress with important steps or events marked along the way and approximate times between these points.

4.2.2 Anticipating Daily Plans and Events

At a lower level, there was uncertainty about how any particular day would unfold. To some extent, the patient is in the hospital for treatment and things will happen when they happen, but more transparency about when certain events are likely to happen could be helpful. Losing control over every aspect of life, even the daily schedule, can be stressful. Furthermore, knowing what events are coming up can help individuals prepare for those events and can help family members be present for important events.

One such event is a visit from the doctor. A patient's girlfriend said,

> *"we're always asking the nurse when the doctor is coming in."*

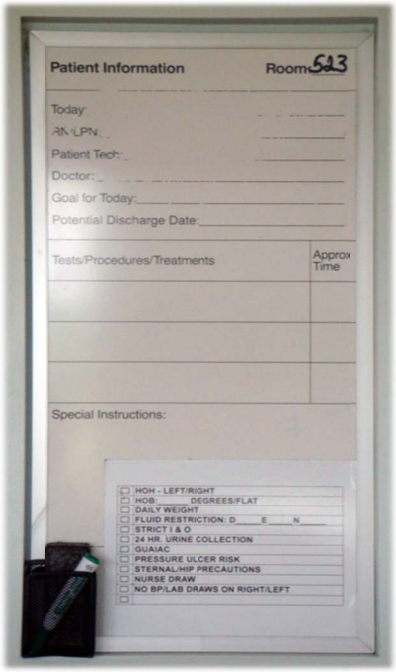

Figure 3: Whiteboard on the wall in every patient room

> *The patient added, "It would be easier because a lot of times when the doctor does show up, they ask 'do you have any questions' and it's kind of hard on the spot, but if we knew it was in 3 hours we would have time to think about it."*

P13 had a similar experience, *"When you're in a lot of pain and a question comes into your head you need a way to jot it down."* Given a chance to ask the doctor questions, most participants tried to think of them or remember them on the spot. Occasionally this strategy led to forgetting to ask something and having to try again the next day. P3 and his wife had worked out a solution for this problem. They kept a pad of paper on the tray by his bed where they *"write down random questions because the doctor is only in here once a day so that way you remember them."*

Other people wanted to know upcoming events so family could be there. P4's wife said, *"it would be nice too to see when you'll see your doctor, because I want to be here, but I wasn't sure when he'd come in."*

While we were doing the interviews in the hospital we had the opportunity to observe participants who were surprised by events they did not know were coming or who were not up to date on the latest plan regarding diet or medications. When we interviewed P16 she thought she was done for the day. However, we ended up cutting the interview short when patient transport showed up to take her to have a test done. Her nurse was aware that she would be picked up for the test, but somehow the participant was not told or did not remember the plan. We witnessed two cases where participants were brought their meal and thought there had been a mistake because they thought their doctor had told them one thing about the diet being ordered for them and the nursing staff had different information. We also witnessed a participant receiving a medication when he thought the plan for his pain control dictated a different medication. It was explained to him that what the previous nurse had told him had been changed, in consultation with his doctor, while he was not present. In all of these examples, the mix-ups were not discovered until the last minute. It is hard for patients to feel like part of the team if they are out of the loop and are regularly surprised by the plan that others are aware of.

4.2.3 Discussion

One of the privileges of adulthood is making decisions about what you will do and where you will be. One of the characteristics of the hospital environment is unpredictability because unforeseen problems regularly arise and must be dealt with immediately. The people who work in the hospital are flexible and adaptive as the situation dictates and the inpatients must be too. That said, there are routines that develop in the hospital that patients, who do not spend every day in the hospital as the staff do, are not aware of.

Participants identified reasons they would benefit from knowing more about their schedule, including the ability to plan for upcoming events and providing an opportunity for family to be present. We hypothesize that more information about the plan and where patients are in the larger recovery process might have a broad impact. Participants who expe-

rienced unanticipated events or changes in our presence were caught off guard and at least temporarily confused. Each time, the first thing they did was try to establish whether a mistake was being made or whether someone had changed the plan without including them. Finding better ways to keep patients in the loop would give them back the ability to know where they will be and what will happen to them, which is important in an environment where they are not empowered to make those decisions.

4.3 Getting Access to Health Information

4.3.1 Access to Medical Records

Just as transparency regarding the plan and daily events could contribute to a patient feeling more autonomy, some patients maintain their autonomy in the hospital by continuing to be involved in their healthcare. For example, P7 declared, *"I am a take charge person, because I do a lot of research online."* She researched her procedure, got second opinions, and compared advice to make her own treatment decisions. After a long and difficult diagnosis process, P2 said,

> *"I basically am my own main practitioner now and I find that I am continually doing things that put me in a position where I am more knowledgeable than the person who is in charge with my health, and that's a good thing. You should be."*

When asked what he would like to improve about staying in the hospital, P13 said,

> *"some people kind of have that sort of mind where they want to be slightly in control and want to know what's going on. So if the information is open to you, whatever they deem, there's probably some information that they think it's better off that the patients don't know… If [the rest of it is] open to you, that would really encompass the whole lot for me."*

He wanted more information, but did feel there might be information doctors would prefer patients not have.

Conversely, one participant took comfort in turning over her care to the hospital professionals and felt that some information was better in the doctor's hands. She said,

> *"I don't think it's a good idea for patients to have access to their health information at all, because they understand nothing and they will begin panicking and do stupid things. … It's a wrong idea to bother people all the time about their physical condition and make them think about it too much."*

For her it was more calming to not think about and try to control her health situation, but instead to trust the doctors.

In some cases, people actively monitored their health in the hospital, even though the hospital staff are presumably responsible for that. Several were interested in monitoring their vital signs or blood sugar and routinely ascertained the values whenever the nurses ran tests. In these cases, we asked if participants would be interested in seeing their values on a board in their room. P 17 responded, *"I would love to see my blood pressure. They just tell me, they don't show me."*

Other examples of information participants wanted to track included medications, pain scale data, and billing information. Three participants mentioned trying to keep track of pain medication and two had occasionally had nurses write their pain medications and dosages on the board. P12's girlfriend wished the nurses would continue to put that information on the whiteboard because without it they were unable to track medications on their own, especially when she had to occasionally leave the hospital. P13 suggested that tracking his pain scale data would be helpful,

> *"they ask you to name your pain 1-10. I think that when you're in a lot of pain you kind of forget what you'd said before and may give them the wrong information. I think I, once or twice, I said a little high... If that was recorded somewhere you could refer back and give them better information."*

In this case, P13 wanted to be an active part of the medical team and provide accurate data, but did not have access to all the information he needed. Two participants said that they were interested in tracking billing information, *"a running tab"* so they could see what they were being charged.

4.3.2 Health Information Seeking

As with access to medical records, some participants actively sought and wanted information while others wanted to rely on hospital staff to provide them with information. On the side of seeking information, several participants said they would use a computer in the room for looking up medical information from their hospital bed. After experiencing an unexpected side effect one man wanted Internet access,

> *"If you got onto a certain med, you don't know what the side effects are and you could just look up, these are the side effects you might experience. For instance, without getting too personal, I couldn't wee earlier because of one of my drugs and I was in quite a panic."*

P7 used the computers in the hallway to look up health information during her stay. *"Absolutely. That's how I've become knowledgeable about my condition. I know a great deal because of the Internet."* Other patients had family members who looked up information on their behalf. P10 had print-outs of information her husband had looked up online at home and brought into the hospital and P14's Mom spent hours reading about his condition, surgery, and doctors. P3's wife said that she looks at blogs and medical message boards while her husband is in the hospital because, *"real people's experiences are a little bit more informative than the doctor's clinical experiences."*

4.3.3 An Opportunity to Learn

There was a desire among many participants to have more to do than watch TV while they were in the hospital and some participants suggested that there should be opportunities for self-improvement. One idea for self improvement was to learn more about living a healthy lifestyle and about the patient's particular condition. P6, who did not think patients should have access to their medical records, thought that being in the hospital was a good opportunity for self-improvement and education,

> *"programming that would enhance/promote healthy lifestyle via programs. … People who get in hospitals have a lot of time to look at the screen and listen to what they don't know… Staying at the hospital, there is a lot of time to think and learn about how to become healthy."*

P8 suggested his time in the hospital could be spent finding out more about *"how I can make a change in my life to simply have a real good physical gain"* instead of watching television.

4.3.4 Discussion

Many of our participants tried to be actively involved in their care and sought information about their health condition. The two ambulatory participants who went to the trouble of standing at the computers down the hall in order to search for information made an impression on us because getting up and moving around was a substantial production for them. Our findings lead us to believe that a computer with Internet access in the room would be used, and likely in part to search for health information. Furthermore, based on our data, we now believe that patients' visitors might be as likely to do these searches as the patient is.

This desire for more health information was exciting because we had anticipated that hospitalized patients might be too overwhelmed and sick to want an active role in managing their health. On the contrary, the people took great interest in their health condition. Participants appeared to be well primed and motivated to listen to lessons about healthy behaviors, a combination of informational and motivational technology could help patients take more ownership of their health and work towards new behavior change goals.

4.4 Seeking Social Connectedness

Loneliness and a feeling of social isolation were pervasive themes in our data. In the hospital, inpatients are physically isolated from their normal lives and from other people. P5 put it well, *"You feel isolated in here, actually, because you have to have help getting out of bed, you've got to have help doing everything."* Her loneliness was exacerbated by not being able to call most of her family when she wanted to because they lived too far away to be a local call. Participants kept up with the outside world by watching TV and reading newspapers. *"I read the newspaper now and then … it contemporizes a person that's here, does not make them feel like they are closed off from society."* Although both his girlfriend and Mom were with him in the hospital, P12 felt a sense of social isolation because his social network could not really understand and relate to what he was going through,

> *"it is very lonely, I mean I'm not alone… but unless you see it… I don't think people know what I'm going through… I've cried out so loud they could hear me eight rooms down… People don't really understand unless they see it."*

The most extreme case of isolation was P15 who had been injured while on the job far away from his home and his entire social network, *"Basically I'm 2100 and some miles out in the middle of nowhere with jack crap."* Unfortunately, P15's cell phone was dying and he described trying to make arrangements and communicate with family and friends quickly for fear it would fail completely.

4.4.1 Looking and Reaching Out

Participants raised a few strategies for alleviating the sense of isolation inpatients feel. First, they wanted better means of communicating with members of their social network who were unable to visit the hospital. Three people suggested that some form of videoconferencing would be a good way to communicate with family and friends, *"just like they're coming to see you, they're right there."* Although one person who suggested this was reluctant to be watched in his hospital bed, P15 pointed out that family might be comforted by being able to see their relative in the hospital.

Another suggestion was using security cameras or webcams to view other parts of the hospital. P4 said it would be,

> *"neat too if you could tap into their surveillance cameras to see what the outside looks like, and what's going on in the halls… from in the room it broadens your view…or I could check the hall to see if I want to go on my walk right now."*

Someone else suggested watching the lobby fish tank,

> *"maybe it would be nice to focus on one of the fish tanks or something, maybe you don't like to watch TV, but fish are so calming. And they're out for people to see, but we're in here! Like a screensaver."*

Finally, participants appreciated simple acknowledgements from their social networks that they are in the hospital. P12 said that a phone call, a gift, a message on Facebook, or any other means of letting him know that friends and family were thinking of him was appreciated. Technology in the room could lower the barrier to this kind of acknowledgement and has the potential to open a wider band of communication between the hospital room and the outside world.

4.4.2 Spreading the word

A more directed form of needing to communicate with the outside world was the process of getting the word out that the person was in the hospital and spreading news about their latest progress. Most participants relied on someone else in their family to be the point of contact within their social network. Both P4's wife and P12's girlfriend used Facebook to post progress updates.

One of the issues that patients encountered with updating their networks was whether the information was best coming from them. Two participants suggested that it might be better for their doctors or nurses to update their family and friends. One of these participants felt that the information would be taken more seriously coming from the doctor. The other participant felt that the information would be more reliable coming from the hospital staff. If technology was being used to disseminate this information she would also want to add her own status messages about how she was doing in addition to their updates about her health status.

4.4.3 Discussion

Reflecting on the isolation our participants experienced during their hospital stays, several opportunities for technology support stand out. Communication technology could be designed to bridge the gap between patients and their social networks. Images, videos, and sounds could expand their daily sensory experiences beyond their stark hospital room. Technology could provide social networks the opportunity to push their own content to the patient's room. So-

cial networks pushing content into the room would provide views of the outside world, acknowledge the patient's situation, and help the patient maintain their connection to their lives outside the hospital. While these are certainly areas that have been explored in the general context of the web, the hospital environment has the unique property that patients have no other outlet and helping their mental health can improve their physical wellbeing.

4.5 Passing the time

The people who were well enough to be interviewed in our study frequently said that their previous days in the hospital were spent trying to sleep and being sick or in pain. After they started to recover they were more awake and alert, but did not have much to do. P10 observed, *"Time goes by incredibly slow. When my husband comes in I will have to have him figure out how to turn the television on."* We observed that most of our participants were watching TV when we arrived for the interview. We asked participants how they passed the time and many of them spent most of their waking hours with the TV on. One lady remarked that,

> *"I would think it would be better for everyone to have some kind of stimulation... enough to keep a person from lying in dark and vegging. Maybe a series of age-appropriate things. I know some people love crossword puzzles. Some mental kind of fun challenges and that kind of thing. And for very elderly, I'm wondering what kind of therapeutic music… geared towards being mentally more alert or challenged."*

Listening to music and drawing were both suggested as things that might have a positive impact on people in the hospital. One participant said that she would like to listen to classical music in her room and P16 told us that the hospital has *"a young man and a woman who play piano each day out in the lobby. And I think that's wonderful. I've never known a hospital to do that."* Since two other participants had suggested webcams as a way to look out on the world, we asked this participant if she would be interested in being able to watch the musician from her room –she said, *"That'd be nice."*

For the purpose of passing the time in the hospital and providing something else to think about, movies and other recorded programming were frequently suggested. P14 had been watching TV shows on his friend's laptop and suggested that a *"kind of database with retro cartoons and favorite shows… That would be cool, that would really make people feel better."* A couple other participants had also been watching DVDs on laptops brought in by friends and family.

Video games were a popular suggestion from younger inpatients that played games at home. Others expressed interest in crossword puzzles, word searches, and jumbles. One couple played cribbage in the evening. A woman suggested that with a computer in the room she could play solitaire, but commented, *"I guess that's not the primary purpose of being in here, it's just a diversion."* One lady said, *"I love Jeopardy. For me it tells me my mind is still pretty darn sharp, 'cause I do very well at it."* When asked if she would be interested in playing with other people in the hospital she said, *"I think it would be lots of fun, Jeopardy."*

4.5.1 Discussion

Finding ways to pass the time in the hospital is not just about a patient avoiding boredom, it is an important component of their quality of life. With no other outlet for mental idle time, it would be easy to become fixated on pain or prognosis. A challenge is to enable people with limited mobility and a wide range of ages and backgrounds to use their time awake in a bed for personal enrichment. We were intrigued by two participants who described their time in the hospital as an opportunity for reflection and self-improvement. Designs that encourage introspection and help guide patients through meditation or relaxation techniques could both help patients relax and teach valuable skills for a healthy lifestyle patients can take home.

4.6 Recumbent Computing and Ergonomics

"Think about somebody lying here and being able to see crosswords," P7 mused. A key phrase in her statement is "lying here." The posture of a hospitalized patient is unlike that of an information worker at a desk or a mobile user on the go. Inpatients are mostly stationary in a reclining position with the hospital beds providing the ability to sit up more or lie all the way down. The TVs in the hospital where we interviewed patients were flat panels positioned beyond the foot of the bed. They were mounted high on the wall or hung from the ceiling. The whiteboards in patient rooms were often on the wall to the side of the bed.

While pointing up, P6 said the TV needed to be more, *"across from the patient's eyes." "Most people here are in bed for a long time… This is a comfortable spot only for those people who walk and can sit up."* P17 had trouble seeing her clock because it was too close to the head of the bed for her to comfortably twist around and see. Any technology designed for inpatient rooms will have to be designed for limited motion and for reclining postures. P14 had to lie flat in his bed because of his injuries. He suggested,

> *"I've seen computer screens that travel on rails so you could put it at regular desktop height or you can lift it up. So if I was laying down here like this, it would be sitting more like where the TV is. Because one thing I'm noticing is my eyes are getting shut when I'm lying here looking at people."*

He indicated that if people, or a screen, are too low he has to try to lift his head to look down his hospital bed at them.

Input methods will also need to be adapted for the inpatient environment and the inpatient population. P1 was able to have his bed in a more upright position and suggested he would do fine with a wireless keyboard on his lap, but another participant, P14's Mom, said, *"if you're flat on your back something like a cell phone would be nice, like my phone you turn it to the side and get a keyboard."* Other participants suggested that talking to the computer would be easier than traditional input devices. P7 said, *"If you didn't have to use the keyboard and you could just talk, I've thought about that for years."* She thought this would be particularly useful for elderly people. P10's husband envisioned using voice recognition to say *"Shade. Light."* and be able to control the physical environment. The limited range of motion in-

patients experience when hooked up to monitoring and treatment devices will impact input devices. P8 had difficulty writing because if he bent his arm too much, he pinched the IV in his arm and cause the pump to beep. If he cut off the flow for too long the machine would go into a mode where only a nurse could stop the beeping.

4.6.1 Discussion

Physical limitations frequently inhibit motion and the range of postures inpatients can achieve comfortably. Innovations in interaction techniques are necessary to enable inpatients to utilize technology. A hand- and head- orientation independent mechanism for input and output would enhance computing possibilities from a hospital bed. We believe this offers a new human-computer interface worthy of pursuit.

5. CONCLUSION

Our research illuminates several challenges for inpatients, which we view as opportunities for the research community. We assert that new technologies could improve communication and overall awareness, support social connectedness, as well as provide better entertainment and means of passing time while healing. We have also articulated several challenges and sensitivities that are unique to the hospital environment and that do not show up in traditional desktop computing. Throughout this work we were struck by the humanness and vulnerability associated with the hospital stay and look forward to seeing more human-computer interaction researchers engage in this highly impactful space.

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