

Managing Communication Availability and Interruptions: A Study of Mobile Communication in an Oncology Department

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Abstract. Wireless phones and text messaging are tremendously popular in many areas of society. However, they are still relatively unused in hospitals where pagers are a pervasive communication device that is notoriously difficult to replace. This paper studies pager and wireless phone use at the oncology department at University Hospital of North Norway. Participatory observation and interviews with physicians are used to provide qualitative analysis about the use, drawbacks and benefits of both technologies. A number of important issues are addressed that should aid designers of next generation mobile communication systems for hospitals. In particular, the data points towards specific features that will be crucial for the overall usability and acceptance of an integrated device that supports paging, voice and text services. Of particular importance will be features that allow users to manage their communication availability and avoid interruptions.

1 Introduction

Hospitals are complex organizations that are increasingly pressured to provide their services as efficiently as possible. Coordination and collaboration are key ingredients in the work of nurses and physicians in hospital environments. Healthcare is also a knowledge intensive activity where consulting colleagues is often a necessity [6]. This amounts to numerous interruptions for persons in key roles or who are knowledgeable. The balance between getting immediate access to resources (such as senior physicians) and overloading or causing interruptions in moments where this does not fit in with the activities of the resource has similarities with classical problems regarding collaboration and sharing of resources, such as of disparity in work and benefit, “prisoner’s dilemma” and “the tragedy of the commons” [13].

Knowledge, experience and the power to make decisions (with possible consequences to a patient following a decision on treatment) is a limited resource in many enterprises. Access to such human resources is necessary but at the same time there is a real danger of overloading such resources. If these resources are themselves part of processes involving activities that require concentration or unavailability, we can see the outline of potential conflicts of interest. Like the commons, the knowledgeable

and experienced are resources that may be shared. If overused however, they will not be able to keep updated and remain a resource to their colleagues.

In hospitals this has contributed to a workplace that suffers from a poor set of communication infrastructure and practices [8]. One suggested strategy for improving hospital communication is the adoption of mobile technology [8]. Some initial studies have shown a variety of potential benefits for mobile technology such as wireless phones and text messaging when deployed in a hospital setting [10], [17], [25]. However, despite seeing pervasive use in many other areas of society these technologies see limited use in many hospital environments.

A mobile communication device that *is* pervasively deployed in hospitals is pagers. Pagers offer a cheap and reliable way of contacting staff but suffer from a variety of limitations due to their simplicity. The most obvious limitation is that they require staff to locate a telephone in order to respond to a page. They also create a large amount of unnecessary interruptions [5], [14] and communication overhead since for example, the person that has placed a page is not always near the telephone when the page is returned [25].

This paper focuses on socio-technical aspects of mobile communication in hospitals. A workplace study is presented that includes participatory observation sessions and interviews with physicians at the Oncology department at University Hospital of North Norway (UNN). The study was conducted to serve as input to the design process by revealing the current situation regarding communication on mobile devices in the department. The next phase of the project will focus on the design and implementation of tailored communication devices for the department based on the study and other information.

Qualitative data regarding the current state of communication using pagers and phones is presented in the paper, as well as some relevant attitudes by staff members towards the introduction of new communication technology such as text messaging. These are critical issues because even when technically sound, over half of medical informatics systems fail because of user and staff resistance [2]. While giving each staff member an integrated device that supports paging, text messaging and phones seems to be a straight forward solution, the data presented in this paper suggests that systems based on such a device will need to have specific features that help users control their communication availability in order to avoid overloading the individual physician with too many interruptions.

The rest of this paper is organized as follows. In the next section we present background studies. This is followed the participant observation and interviews at the Oncology department in section 3. Section 4 gives a discussion of implications on design and also presents future work.

2 Background Studies

Coiera and Tombs [8] identified a number of problems with communication in hospitals. A key observation was a tendency of hospital staff to prefer interruptive communication methods. Other studies have also reported unnecessary interruptions to be a specific problem related to hospital paging systems [5], [14]. On a cognitive level this “selfish” interruptive behavior has been attributed to a highly pressured work

environment that leaves workers operating with working memory at full capacity [20]. This results in a prioritization of tasks that will reduce mental burden. Interruptive communication methods are then preferred since common asynchronous methods of communication such as voicemail and e-mail do not routinely offer explicit acknowledgement that a message has been received. A variety of approaches were recommended by Coiera and Tombs [8] for improving communication. These included support, asynchronous communication with acknowledgement, and mobility.

A variety of strategies have been explored for supporting mobile hospital workers. *Mobile information systems* are expected to be widely deployed in the future and may impact communication practices by bypassing the need for human-human communication in certain situations. For example, sending informative alerts directly to pagers [21], [23] may cut out the need for human-human interaction regarding the availability of lab data. However, since information systems cannot entirely replace human-to-human communication [7] pervasive *mobile communication* tools will also be important for supporting mobile hospital work.

2.1 Mobile Communication in Hospitals

The most intuitive approach for mobile communication is to provide users with wireless phones. Several barriers however make the pervasive use of standard cellular phones impractical in hospitals. One technical barrier is interference with medical equipment. Recent studies however have recommended that the potential benefits of the technology in some situations may outweigh the risk created by interference with medical equipment [15], [19]. Other potential problems include increased noise levels, and interruptions during consultations if the public are allowed to access cellular networks in hospitals [19].

Wireless phones designed specifically for in-hospital use should be able to avoid these problems. However, pervasive socio-technical barriers may still be an issue limiting their adoption. Since wireless phones make people more available, they may result in interruptions because of conversations that would not occur otherwise [20]. This issue cannot be ignored in light of the “selfish” communication behavior attributed to hospital workers.

A limited number of studies however have reported positive results when providing nurses with wireless voice services using various technologies [17], [24], [25]. Spurck et al. [25] reported general satisfaction by nurses and doctors as well as efficiency gains and fewer interruptions to patient care when providing a surgical nursing team with wireless phones. Minnick et al. [17] provided nurses with wearable radio transceivers connected to a base station. Hospital staff reported a variety of benefits from the system including quicker updates to patient information, easier location of nursing staff, and a perceived reduction of noise levels. However, concerns were also expressed for the potential to make nurses “fatally available”, with the authors suggesting for “...continued work in designing practice patterns that minimize nurse interruptions.” A more recent study has also reported generally positive results when providing nurses with wireless headsets as a hands-free interface to the phone system [24].

Asynchronous mobile communication has been explored in hospitals using technologies such as mobile text messaging (2-way paging, email etc.) and virtual whiteboards. Mobile text messaging for hospitals has been investigated with generally

positive results, [1], [10] and was shown to be preferred over other asynchronous media such as email [10]. Some limits have been reported however including problems related to character limits from small displays, and reservations from physicians about being forced to carry an additional device. This can lead to doctors routinely forgetting or refusing to carry the device with them [1].

Mendonça et al. [16] describe a strategy for mobile information and communication based on PDAs. Their system combines access to patient data with a virtual whiteboard. The whiteboard allows team members assigned to specific patients to identify each other, and also post and track the progress of routine tasks.

Some additional studies have also examined applying context-awareness to mobile communication in hospitals [18], [3]. These include an architecture for routing messages and data to people based on their location, role, time, and artifact location and state [18], and also a system that supports messaging, voice services, and contextual information about users such as location and user configured status (busy, available etc.) [3].

3 The Study

Medical informatics research usually focuses on measuring the end results of systems on factors such as mortality rates and cost of care. This is critical for guaranteeing that systems help fulfill the principle goal of medical research, which is to improve patient care. This methodology however does not generally provide information on *why* particular systems fail to live up to expectations or *how* they can be improved. Pratt et al. [22] suggest an improved approach for medical informatics would be to adopt techniques such as observation, participatory observation, semi-structured interviews, and analysis using grounded theory from CSCW. These techniques are used in order to gain a deep socio-technical understanding of how systems affect users and how they can be improved.

The fact that wireless phones and text messaging have reached near pervasive use in many areas of society but still have difficulty replacing hospital pagers suggests that this sort of analysis would prove useful for providing better understanding of mobile communication systems in hospitals. The goal of this study was to identify work practices and attitudes that may affect the adoption and overall usability of these systems.

3.1 Methodology

The study was carried out in three stages, about 1.5 years apart, at the Oncology department at UNN. UNN is a university hospital, making it the hospital with the highest level of specialists in its region of the country. The hospital serves a population of approximately 460000 people in wide geographic area that contains around 420 General Practitioners (GP), and 10 other somatic hospitals. In this respect the physicians at the department are responsible for medical advice to colleagues at other hospitals in the region as well as GPs in the primary health care system. The patients of the department are long term patients that receive some of their treatment at the regional hospital, and also at their local hospital or at home through the local GP. The specialists at this department therefore serve, not only the patients that are at the inpatient

ward, but also patients who are receiving treatment at other locations. In addition, the specialists provide medical advice and guidelines for cancer treatment to the medical staff in the other hospitals as well as being part of the oncology community nationally and internationally.

The methodology for the study was selected in order to get an understanding of actual activities and use of communication devices without having the interviews and observations biased by technologies we had introduced at the department. The first stage consisted of participatory observations including open interviews and informal discussions. The stage was intended to provide an overall picture of the work practice and communication situation in the department for a separate project investigating the introduction of Instant Messaging for inter-hospital communication. Thus, it uncovered a number of issues related to mobile communication that could be used in the study. The second stage was semi-structured interviews of a selected group of physicians at various levels of the hierarchy within the department. The third stage consisted of a second round of participatory observation sessions. This stage was conducted in order to gain further insight on issues uncovered during the first two stages and also to verify that the situation at the department had not changed significantly since the first stage of the study was conducted. This was necessary because the study was conducted over a 1.5 year period due to difficulty coordinating with the department.

The participatory observation sessions also included open, unstructured, and mostly ad-hoc interviews related to a specific situation or observation of activities involving decisions and judgment not immediately understood by the observers. These were not recorded due to the constant change of location and who would be co-present. This made it impractical to inform passers by that we were recording, and would have created a risk that patient-identifiable information inadvertently got into the tapes. Instead notes relevant to the study were taken.

The observers took the role of apprentices [4] and participated in actual work activities as performed by the physicians and nurses they followed. This was agreed upon before the observations and issues of privacy and how to conduct in certain situations were discussed with the head of the department as well as in the research group. Experience from similar observations in previous projects was utilized in order to keep this within ethically accepted behavior. The observers for example, had previously signed contracts regarding the privacy of patient information.

Participatory Observation. Four observers followed the work in the oncology department during half day sessions on four separate days for a total of 43 man hours of observations. Whenever the situation would allow it, the observers asked questions to the physicians and nurses related to the situation or context they were in, and to clarify aspects of the use of communication devices they were observed to be using. The observations were set up by the head of the department. The day-shift (from 08:00 to 15:30) was selected for the observation sessions since other shifts are staffed by a limited number of people in order to handle emergencies. As such, the day shift involves more far intensive communication in terms of complexity and volume.

Interviews with Medical Staff. At the beginning of the first day of stage one an open interview was conducted with the head of the department in order to gain insight into his use of current communication technology. The interview took place in his office

and lasted for 30 minutes. Notes were taken during the interview but it was not recorded. Additional interviews were recorded at a later date with four other members of the department. Two of them were residents and two were attending physicians including one that was serving as the head of the department while the department head that was interviewed previously (during the participatory observation sessions) was on leave. These interviews were conducted with one person at a time in a break room at the hospital and lasted for 30 minutes each. The initial focus of the interviews was the current use of phones and pagers and this was followed by additional questions regarding attitudes towards the introduction of text messaging. The interviews were conducted in a mixture of Norwegian and English. Quotes have been translated from Norwegian to English when necessary. Each quote is labeled to identify the individual source of the quote and their work role.

3.2 The Work Practice at the Oncology Department

This section provides a description of the routine and mobile communication devices used at the oncology department in order to provide the reader with a basis for context of usage for many of the issues discussed in the next subsection.

Description of routine. On the first day the observers met early with the department head and were briefed about routines and some of the main activities at the department. They then conducted the interview with Department Head – A, and afterwards joined the rest of the physicians at a briefing at the Radiology Department. This is where the physicians (and the head nurse) usually begin their working day. During this meeting the physicians get a report on the CT-scans (and other radiology methods) for all patients examined the previous day. After this meeting the physicians and some of the head nurses have a short meeting. This can consist of lectures and/or discussions related to administrative work and assignments.

The department has three sections: The Outpatient Ward, The Inpatient Ward, and the Physics or Radiation Section (both terminologies are used by the staff). The physician(s) with responsibilities at the outpatient post and the radiation section leave to get started. The remaining physicians have a briefing of what has taken place in the evening and night; new submissions, emergency cases, changes to patient's conditions, and other issues related to the status at the inpatient ward are presented and discussed if necessary. The physicians for inpatient ward are then divided into two teams whom each have responsibility for a section of the department. The observers split up and followed the rounds of these two teams at the inpatient ward.

Each team starts with a pre-visiting rounds meeting at the inpatient ward. At the meeting each patient belonging to the team is discussed in detail. The meeting is led by a nurse who is a team leader and attended by a nurse assigned to that patient, a resident, and a physician. Each patient is discussed individually and a plan is laid down for each patient. This plan contains medication, variables that needs to be observed, messages and procedures the patient needs to go through, etc. This is also an opportunity for the nurses to interact with the physicians and communicate observations and evaluations related to each patient.

Visiting rounds follow this meeting. Each patient in the inpatient ward is visited by a physician and a nurse. The team visited approximately 10 patients. The rounds took one to four hours. After this the physician would get back to the office and go through email, mail and other messages. After lunch the physicians disperse to various tasks sometimes in their offices or in any of the specialties rooms.

On the second day the observers went to the physics section of the Oncology Department and saw how the physicists conducted the radiation treatment of the cancer patients after they had been through the simulator. The third day was similar to day one, while day four started as the other days, but instead of visiting rounds, observations were made of the physicians working at the radiation section. Two physicians from the department are assigned to the radiation section daily and are responsible for helping to plan out and simulate radiation treatment for patients from all departments in the hospital. The physics section acts as a self-contained unit and, besides the logistics of schedules for patients receiving treatment, there is little communication directly between the inpatient ward and the physics section.

Mobile Communication Devices. A variety of mobile devices made by the vendors Ascom and Ericsson are used by the staff. Pagers are the dominant mobile device but a few senior physicians also carry a wireless phone with them. A brief description of these devices and their intended use is given below.

Pagers. Pagers are the dominant mobile communication device used at the department with the vast majority of physicians not being reachable by wireless phone on a given day. Each doctor is assigned one individual pager, and occasionally one or more role-based pagers. The use of role-based pagers is interesting because it demonstrates a simple solution at the system level for supporting communication similar to role-based context-awareness as described by Munoz et al. [18]. Some roles that are assigned a pager, such as head of the department, are fairly static, while others are dynamically assigned on a shift-to-shift basis. One physician is always in charge of any emergency calls for example and at least one is in charge of the out-patient ward.

Pagers have unique numbers in the internal phone and pager system, listed in the hospital directory. Pagers are activated by placing a call to the number and allowing it to ring at least three times. The pager's display will then show the number of the caller. The pagers are charged in a special rack located in the nurse headquarters. Usually the same pagers are used for each role daily and the list of who is in which role is printed and hung next to the rack. This allows the rack to serve as a presence awareness mechanism by informing who is assigned to each role on a particular day and who is at work on each shift.

Using role-based devices frees staff members from needing to figure out who they need to locate in order to accomplish certain tasks. One interview participant explained ... *"It is a problem that you never know if that person is available at the hospital or is on leave; on a three weeks holiday. All messages of any importance – they cannot just be sent somewhere to a pager that is not used for a week. That is the problem of connecting a message with a person and not a role."* [Department Head - B]. Dedicated role-based devices also make it easy for staff members to switch roles when necessary by handing their pager to a willing colleague.

DECT wireless phones. Some more senior physicians have a personal wireless phone available to them that is kept in their office when they are not using it. The physician can provide the number to the phone to anyone inside and outside the hospital and can also request that the number be listed in the internal hospital directories, or limit interruptions by keeping the number “unlisted” if they choose.

There are also some roles for which a wireless phone is assigned instead of a pager. This is done for roles associated with being “on-call”, implying that the staff member must be immediately contactable at all times. There are two such on-call roles at the department, one for the inpatient ward and one for the radiation section. The residents interviewed in stage 2 both mentioned having a role-based wireless phone about one day per week. Role-based wireless phones were used at least occasionally by all of the physicians interviewed except for Department Head - B. When asked why she used a pager instead of a wireless phone in relation to her role as department head (Department Head - A used a role-based phone) she replied “*Because I haven’t asked and no one has offered me [a phone].*” [Department Head - B]. This suggests that in her case a phone was not viewed as large enough of an improvement to warrant asking for one.

3.3 Balancing Interruptions and Communication Availability

Interview participants were asked about their use and opinion regarding pagers and wireless phones. As expected some users reported phones to have clear advantages. One of the attending physicians explained “*I have a pager, personal, and I have a wireless phone, as well. I got this [the phone] mainly because I have an office where there was no phone installed. So this is the phone I have in my office. It is this one that I use, always, and I find it incredibly neat to have a wireless phone. It eases – it is a considerable ease in my working day. Simply because there are many places where there are no available phones, so you save a lot of time by having your own phone, I think. Because, if you are on your way to the Radiology department and you need to call someone, or get paged, then you may talk while you are walking through the hallways. You don’t have to search for a phone. For example, when you are at the radiology demonstration it is far to get to the nearest phone, so it eases the work to have your own phone and you can do the work directly – or just outside the door.*” [Attending - A]

The physician explained however that some other physicians did not share this view. “*There are several at the department who ... use the phone only to phone out; where their number is not registered [in the directory]. Who do not want – who wants to get paged - and use the phone to call back. It is the switchboard who prepares the directory and in this case it only lists the pager and the office number and not the wireless phone number.*” [Attending - A] This provides for a great deal of flexibility on controlling interruptions. Some of the physicians had an even stronger view against carrying a phone and refused to carry one even when it was available to them... “*There are some of the attending physicians that absolutely don’t want a private [portable] phone, because they feel they never get to be undisturbed. So there are always advantages and disadvantages with availability.*” [Attending - A]

One of these physicians was Department Head - A. He was adamant about not being forced to carry a phone with him. He expressed concerns that this would lead to a

loss of control regarding his availability, and an environment where he would need to constantly explain why he refused to answer certain calls.

Thus, although he uses a role-based phone as head of the department he rarely takes the phone outside of his office. Instead, he forwards calls from the phone to his individual pager so that calls to the phone will result in a page that he can choose to answer or ignore. He commented...*“I can imagine that it can be a problem to be accessible at all times. Sometimes it is necessary to have quiet and not get disturbed by phone calls. I do have a DECT-phone, but I don't bring it to the [inpatient] ward because it would disturb and I always have the pager.”* [Department Head - A]

Although attending physicians at the oncology department were able to avoid carrying phones in order to control their availability, this was not always the case with other personnel. The most dramatic documented example of phones leading to over-availability occurred in relation to the use of the “on-call” phone used in the radiation section. The work-practice in the radiation section is run in a highly efficient and assembly line manor with the nurses and radiation technicians having a larger role in planning the overall work practice than in the inpatient and outpatient ward.

As such, they have assigned a DECT-phone to the physicians from oncology that work there to make sure that one of them is always easily reachable to answer general patient questions. One of the residents commented on this phone while being interviewed and stated ... *“when I am down there [radiation section], as I said, there I have the [portable role-based] phone; I get called a lot – we are talking about more than 20 times a day when I get a call on the phone...”* [Resident - B]. Observations conducted in the radiation section that were completed after the interview revealed the phone to be something that is viewed as extremely interruptive by the physicians working there. This has resulted in a policy where the least senior of the physicians assigned to the radiation section is always assigned this phone.

A resident (that was not interviewed) observed to be carrying the phone during observation sessions even referred to it as *“the interrupter”* phone when asked about it. She commented that she felt the phone was unnecessary and that it resulted in her constantly being *“nagged”* about small things related to patients such as a headache etc. that could easily be handled without contacting a physician. She explained that these interruptions often significantly increased the amount of time needed to plan out radiation treatment because of the high degree of concentration needed to complete this task, in combination with the frequency of interruptions. The other physician assigned to the radiation section during the observation session was in general agreement with these statements.

Such a negative view was not associated with the on-call phone used at the inpatient ward however. This phone was used specifically for handling medical emergencies, and for calls related to external relations with GPs and physicians from other hospitals. These calls are viewed as something that necessary must be handled by a physician. The problem of being *“nagged”* had been avoided at the inpatient ward because the doctors had a larger control over the work situation there, and as such had made it clear to the nurses that they should only contact them with the on-call number in the case of an emergency. This illustrates how physicians will accept a loss of control over their communication availability as long as the associated interruptions are limited to those that are justified by medical necessity.

Interruptions from Calls. An issue further exasperating this problem is that individual calls are deemed to cause a greater interruption than a page. This opinion was shared by all of the participants, including those that prefer a phone over a pager in many situations. There were several reasons given for the higher level of interruptibility associated with a call. One issue was design differences between pagers and the DECT-phones used by the department. A pager has a screen and button located on the top of the device so that a user can easily interact with it without removing it from their coat pocket. A phone on the other hand requires a user to pick up the device in order to view who is calling them, and to locate the button used in order to reject a call. Another issue is that DECT-phones made for hospitals are relatively simple in comparison to standard cellular phones. The phones used by the department for example do not contain a “meeting mode” feature that allows users to limit calls to one ring. One user explained this by using hand gestures to illustrate how much easier it is to deal with a page while saying ... *“the pager I can with pressing a key once turn off the calling sound, while the phone rings and rings”* [Resident - A].

Issues that are not be so easily attributed to specific design differences between phones and pagers used at the department also seem to be an issue. Department Head -A explained that his preference for a pager instead of a phone is based on the belief that individual calls result in a more severe interruption than a page. He forwards phone calls to his pager instead of carrying his phone with him while in the inpatient ward because he feels that each call forces him to immediately make an active decision about whether or not to answer it. This creates more stress and greater mental interruption for him than a page because he can still wait to finish what he is doing before deciding if he will answer the page promptly or not. Another physician made a similar comment and explained ... *“with a phone it is easier to take the call and explain that you will call back later. I think I would do so, if I have a phone. So, that could be a disadvantage with the phone; that you may get interrupted and allow yourself to get interrupted. You get more easily interrupted by a phone than a pager.”* [Resident - B].

Another problem associated with phones was that callers tend to call back repeatedly in a short period when a call is not answered, even if it is not for an important matter, whereas this behavior was not typical with pagers unless the page was for a serious problem that needed to be dealt with immediately. This suggests that carrying a phone can automatically imply to others that you *should* answer, at least in order to tell them you are busy and will call back later. It also shows how one advantage of pagers is that they make it easier for a person to keep a certain communication distance by delaying or refusing response to certain pages.

Refusing or Delaying Response to a Page. Selective response to pages based on their origin and frequency has been noted previously as a screening procedure used to limit interruptions [8]. During the interviews participants were asked about situations where they may choose delaying or refusing response to a page or call. The participants explained that this behavior was most common when meeting with patients because this was a situation where being contacted was considered to be particularly interruptive. One participant explained ... *“If, for example, you are in an important consultation with a patient, talking with the patient about serious issues, then it would be wrong to interrupt that conversation to answer a pager that may not*

be important." [Resident - B]. An important clarification is that this behavior only occurred when contacted on devices assigned to them as an individual, or for certain roles such as department head where being immediately contactable at all times is not viewed as an aspect of the role. This was considered unacceptable however for devices attached to a role which required them to be "on-call" as explained by one of the attending physicians... *"In general you can say that if you are on call or have the secondary on call duty, you are obliged to respond immediately. Otherwise, I don't think there are any special [rules]."* [Attending - A]. This suggests that this behavior will be much less common in departments where emergencies are more common than the oncology department.

Selective response was not generally viewed as negative by the participants as there was a clear understanding of the need for others to ignore some pages in order to control their availability. The participants were asked if they knew of any hospital policy requiring them to answer pagers within a certain time frame. No such policy was known to any of the participants and they often took a defensive tone when responding to the question. One of the participants explained ... *"I don't think any would invent such a rule. It can't be like that. ... there are no such rules that you need to obey. I hope not, and I have never heard of such, and it is not reasonable to have them."* [Resident - B]. This further emphasizes that clear need of the staff members to manage their own communication availability.

Prioritization of pages received on a dedicated role-based device illustrates that one advantage of using multiple devices is that it enhances the ability of users to discern the importance of certain pages and calls in order to manage interruptions. It also suggests that a mechanism allowing users to quickly identify which number has been called in order to contact them (i.e. a role-based number or their individual number) will be a critical feature of any pervasive device that integrates role and individual based contact.

The "Tragedy of the Commons". One important trend that showed up in the interviews was the perception that, as a physician gained more responsibility, interruptions from calls would become a larger problem. The two residents both commented that while they would prefer to have an individual phone now, they are unsure if they would still want one once they have more responsibilities. When asked if he would prefer a phone one resident explained... *"It is easier with a phone. I think I would have selected the phone, but I think one may change one's opinion when you have been here, in 'the game', a while, perhaps as you rise in position and get more responsibility and more people are interested in getting hold of you to consult with you, then it may – I think there may be a lot of bothersome requests."* [Resident - B]

The other resident stated ... *"I see that the attending physicians that carry a phone get an extreme amount of calls. Whether this is because they are more easily available to others, to other physicians, or to other people in the hospital who know that you just need to punch in the number and then you get hold of them immediately and you don't have to wait for the person to reply on the pager. It is good to be available, but if it is too easy I think you would get a few requests that are not necessary to deal with then and there."* [Resident - A], and when asked if she thought that she would be interrupted more if she had a phone she jokingly stated... *"No, as a resident I*

wouldn't mind having a phone. Then I could give it away when I become an attending. No, I wouldn't do that." [Resident - A]

This may further explain why Department Head - A was so against carrying a phone with him at all times.

Text Messaging. As stated earlier Department Head - B was the only person we interviewed that never had a wireless phone available to her. When asked about the possibility of being provided a phone her initial response was "*I think I would prefer a phone or a pager with possibility to have more messages.*" [Department Head - B] She continued by stating that she would prefer to have a phone instead of a pager if she were forced to choose, but her response clearly showed that mobile text-messaging was a technology she was more interested in being provided than wireless phones. Text messaging is an interesting technology to explore because it may serve as a nice "middle ground", allowing for a wider variety of communication than a simple page without creating interruptions similar to that from a call.

After discussing the use of phones and pagers the interview participants were engaged in a discussion about the introduction of mobile text messaging. Many of the staff interviewed viewed the idea positively although a few had reservations. Interestingly the participants that were positive about text messaging expressed that its main advantage would be that it could help them manage availability and more effectively deal with pages and calls. One participant explained ... "*...if you could give a message that you are occupied for a quarter of an hour, or let them know what you are doing – I think that could be useful. It seems to be of some help. Absolutely! Then you would know what the situation is and when you can reach that person, and how long that person is unavailable. That would have been progress, if you had managed to something like that.*" [Resident - B].

Another comment was ... "*Yes, that could be useful. You could use this [a messaging device] if you are in the outpatient ward and dismiss any calls or send a message to say you will call back later.*" [Attending - A]

Other comments suggested that this could be accomplished by using the messaging system in order to provide meta-information about the origin and urgency of pages. One comment was ... "*Today we only get a number. If you don't know that number it is not possible to know where the page comes from. If you could get a more of – at least what department it comes from or which room the call is made from, then you would, often, get a notion of what this is about.*" [Resident - B] and another was "*One thing I have thought of is that it would be nice if I could get some more information [when paged] to understand the urgency of the call: If this must be replied to immediately, or can wait 10 minutes or needs a reply today. ... to have some priority – do you understand what I mean?*" [Resident - A]

Some participants were skeptical of the idea but this seemed more because they were worried about being bothered by messages from patients or with having to carry an additional device. One respondent stated "*It is our experience that new systems that come as an addition to existing systems are not going to be used. We don't want it to be so that we get a solution in parallel with the existing systems, it must be integrated in what we already have. Let me take an example: We participated in testing [an experimental service] where we got an additional email client [for secure email] – and it was never used.*" [Department Head - A]

Another explained *“It depends on who sends the messages. Should that be the switchboard or the administrative personnel? I think that it is important that it is filtered as we don’t want the patients to be able to send us messages directly. We are in general opposed to the idea that the patients should be able to send us email directly. It would be very much to reply to. Then they would expect an availability – then you are committed to reply. I think that some would consider this useful and some who definitely don’t want it, just as with the phone.”* [Attending - A]

The association with being contacted by patients is understandable since text messaging is an increasingly pervasive way of communicating and interacting in private situations but does not see much professional use in hospitals. Using technologies that are internal to the hospital and not directly compatible with popular personal devices should create a clear distinction between professional and private devices, and thus avoid this problem.

An additional topic covered related to text messaging was if participants thought that menus of short predefined messages would be a useful feature. Previous studies have estimated that standard messages would be sufficient 90% of the time for hospital workers [3]. While the quotes above suggest that standardized messages for coordinating communication and controlling availability would be useful the people we interviewed were skeptical that they would be able to fulfill other communication needs. One participant explained ... *“To be able to send a text message could be nice. But I think it should be so that you type the message each time. There are so many situations...”* [Resident - B]. Another comment was *“I don’t think we could answer by predefined messages. If I don’t get hold of a person, then: ‘Call me back’. I don’t think we can reply these kinds of requests by two or three words.”* [Attending - A]

4 Discussion

Previous studies of wireless phone use in hospitals have focused on settings where the technology is introduced to nurses [17],[25], [24]. These studies reported generally positive results but did mention the possibility of making nurses “fatally available” when deploying the technology in practice [17]. This study has used participatory observations and semi-structured interviews of physicians at an oncology department that have independently started to adopt the technology in their work practice. This has allowed for a more in-depth study of the problem in a naturalistic setting in order to identify effects on physicians, which are a hospital’s most valuable information source.

The interviews and observations conducted at the oncology department revealed a general concern among the physicians about wireless phones leading to more frequent and more severe interruptions than pagers. This suggests that if not carefully deployed, they may have negative overall effects on the work practice for at least some physicians. One specific instance of over-availability was documented for example, where physicians had been assigned a phone by the team of nurses and technicians at the radiation section of the department in order to make it easier to access them for general questions. This “interrupter phone” was viewed in an extremely negative way by the physicians assigned it. They stated that it was not justified in terms of improving patient care, and that it constantly interrupted work that requires a high level of concentration.

Whenever possible the physicians at the department adopted various strategies for obtaining benefits from wireless phones while avoiding interruptions. This included limited phones to use for outgoing calls by refusing to provide other staff members with their wireless phone number. Some physicians also showed a general preference for pagers by avoiding carrying a wireless phone altogether.

This suggests that, while wireless phones do provide certain advantages, further study is needed on how hospitals can use them most effectively. For example, it is becoming increasingly common for workplaces to switch completely over to wireless phones, since the cost of deploying and maintaining wireless networks can now compete with landline phones in many situations. Our data suggests that abandoning office phones in favor of a “pervasively wireless” hospital could have risks, and that this should not be recommended without further study. In particular this may create problems with over-availability, especially for more senior physicians.

The limited functionality of the paging system does suggest however that the staff would benefit from increased use of messaging and phones. This could provide a number of benefits including improving the ability to discern information about the urgency and origin of pages, making it possible to contact other staff members directly without needing to locate landline phones, and making it easier to quickly inform others about their communication availability by sending messages such as “Call you back in 15 minutes.”

Clear resistance to non-integrated solutions requiring users to carry additional devices however suggests that a single device integrating text, voice and paging services would be advantageous. The critical nature of hospital work however will require that such a device have a high quality of service reputation if it is going to replace pagers. This limits the choice of hardware to vendors that create specialized equipment that has a reputation for reliability when deployed in hospitals. One example of such a device that does support voice, text and paging is the “Ascom 9d24” wireless phone.

The data suggests however, that some specific technical and organizational features will need to be considered when deploying such a device. A critical component of such a system will be mechanisms that allow users to manage their communication availability. Without such mechanisms devices that support voice services will be resisted by many staff members, and if widely deployed may have negative consequences on work practice.

In addition, the study also revealed some surprisingly rich elements of the existing paging infrastructure including the use of role-based devices that provide functionality similar to role-based context-awareness, and a public charging rack that provides basic presence information about who is assigned to each role. These features will also need to be considered in any future system.

4.1 Design Issues

From the perspective of pervasive computing it is interesting to discuss potential design features for a single integrated device for paging, voice and text services that would be pervasively deployed in the place of the current system based on office phones, and multiple mobile devices for each user. This would free users from having to keep track of multiple devices, and reduce the total number of devices that need to be purchased by a hospital. This could bring significant cost savings until the cost of

more complex mobile devices drops to a level similar to that of pagers today. A system based on such a device would need to retain features of the current system while allowing users to effectively manage their communication availability and interruptions. Some features that may help reach this design goal are:

- The ability to configure the ringer separately for individual and role-based communication. This will allow users to continue screening calls and pages in a similar way to the behavior noted with multiple devices.
- The ability to configure the ringers separately for voice, paging and text messaging. This will allow users to control their availability by for example, turning the ringer off for voice services while still being reachable via the paging system.
- The ability for users to control the distribution of their individual number for voice services. This will require the use of a separate number for voice services than pages or messages so that the person can still be contacted by those that do not have access to their voice number.
- A presence awareness mechanism that allows users to easily identify who is assigned to each role on a daily basis. This functionality would be similar to that of the charging rack that is currently used at the department.
- An easy way for users to transfer role and have communication requests for the role re-routed to the new person. Today this is possible by simply handing off a role-based pager. One possible way of accomplishing this with a system based on a single device for each user would be to create wearable role-associated “badges”. Using this method the system would automatically route calls to a person’s device once they clip the badge on their clothing, allowing staff members to hand off a role by giving the person the role-associated badge. If desired this also could serve as a presence indicator since the badges could give a visual indication of the roles each person is assigned to. Electronic methods for role transfer that do not require handing off of a physical device may also be interesting to explore. This may introduce a number of new issues such as handling of electronic confirmation of delivery, and acceptance of responsibility.
- Predefined short messages for managing availability and coordinating communication. This would include messages such as “Call you back in X minutes” and messages that improve the ability to identify the origin and urgency of pages.
- Support for at least some limited interaction without removing the device from a coat pocket.

An additional strategy that may prove useful for managing interruptions and coordinating communication is to augment the system with context-awareness. Context-awareness is closely associated with ubiquitous and pervasive computing [9] and can be applied to communication systems in a number of ways. The data from our study suggests that one of the most useful applications of context-awareness in mobile communication for hospitals would be to apply it in order to limit interruptions from calls. Previous work suggests however, that users tend to use contextual information regarding the availability of others as a presence awareness tool instead of to reduce interruptions [12]. This suggests that in order to manage interruptions effectively context will need to be applied in a way that automatically configures devices, for example by turning the call ringer on/off when appropriate.

Statistical models based on sensor systems that collect information such as position, time of day, the number of occupants in a room and the existence of speech have shown to be as effective as people at estimating interruptibility in office environments [11]. These metrics have not been investigated in a hospital setting however, and further studies are needed in order to measure how effective they will be for managing interruptions during real use.

Automatic detection of communication availability may also be advantageous when used in combination with the messaging system in order to send status messages such as "Busy. Call back in 20 minutes" when blocking calls. This would provide presence and among other things discourage multiple call back attempts and/or pages for non critical matters.

4.2 Future Work

Our eventual goal is to design a communication system based on a single pervasive device for voice, paging and text that can be deployed hospital wide at University Hospital of North Norway. This will require consideration of technical, social and organizational aspects of the system. The data collected in this study points to a number of interesting directions for future work in this regard.

As a first step we plan on deploying and studying the use of text messaging services. This is viewed as a first step since a basic implementation without advance features controlling interruptions would not introduce as many risks as wireless phones. Many of the design issues described above can also be viewed as future work and will need to be investigated before recommendations about their affect on usability can be made. For example, a wearable badge system for switching roles may create problems if users end up forgetting badges more often than they forget communication devices. Another interesting problem worth investigating is the necessary level of accuracy needed when detecting the appropriate moment for interruptions.

In addition, we will need to expand this study to include the input of other staff members at the hospital including nurses, technicians and individuals from other departments. Another aspect of mobile communication in hospitals that is not examined in this paper is the impact that the introduction of wireless phones may have on the privacy of patient data. Allowing doctors to communicate via wireless phones walking down the hallway for example increases the possibility that someone may overhear a discussion that would interfere with doctor patient confidentiality.

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