

# Understanding alarms

## A first step in the development of a new alarm system

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### Abstract

*This paper describes a project aiming at developing a new alarm system for the dialysis department in Karlskrona, Sweden. We'll present the approach we used in order to understand how the alarms was perceived and how the alarms influenced the nurses work practice. Our understanding of the alarm was used as a basis for the design process of creating a new alarm system together with the nurses. The alarm system we will present should not be thought of as the final system to be implemented, but rather as being used for further discussion about how to deal with alarms. The main audience for this paper are those who are interested in what you can learn from a narrow analysis of technology (alarms) in use and how an alarm might effect the way people act. Although we talk about design, that is not the key issue.*

**Keywords:** Interaction Analysis, participatory design, workplace study, alarm, dialysis.

## Introduction

We have, as part of a joint project between the University of Karlskrona/Ronneby, Blekinge Hospital and a medical company developing dialysis machines, done a study of alarms at a dialysis department. The aim of the large project is to develop new ways of conducting dialysis in more distributed settings than today and in such settings alarms are one important aspect to investigate. This far we have studied different alarm situations at a dialysis department in Karlskrona in trying to understand what an alarm was and how it effected the nurses work practice.

Even though alarms were a small part of the daily activity at the dialysis department, much of the nurses' work seemed to be influenced by the alarms. In this paper we will describe how the work was organized around or rather effected by the alarm system, how a suggestion for a new alarm system was developed and how it might effect the work practice. The suggestion we will present has mainly been used as a basis for further discussion about how to deal with alarms. If the device we present here will be build and have the functionality we suggest is hard to say. There are still a lot of issues we have to take a closer look upon which all need to put together. Our suggestion should only be seen as a first step in the development of a new alarm system, and this step is about understanding the characteristics of the alarm system and its effect on the nurses work practice.

When trying to understand what an alarm meant for the nurses in different alarm situations we used ethnographic inspired methods and video-based Interaction Analysis (IA) (Karen & Jordan, 1997). We videotaped alarm situations and performed micro-

analysis of how nurses interacted with one another and their environment. The analysis was complemented with field notes, gathered at the dialysis department, and informal interviews (Blomberg et al., 1993). The advantages of using video-based IA and not only interviews and field observations include being able to capture both what people do and what they say, the possibility of replaying the same situation over again, observing behavior you can't catch in real time, and also seeing what people "really" do in a situation which is not always what people say they do (Karen & Jordan, 1997).

Although IA gives us a fairly deep knowledge about what happens in different alarm situations, we don't think it's enough when we are about to design a new system. The way we used ethnographically inspired methods and IA was much in line with Crabtree's (1998) view on the role of ethnomethodologically informed ethnography in the design process:

"Ethnography's [here meaning ethnomethodologically informed ethnography] task is to develop commonly applicable means of discovering and linking 'what is really going on', why and how in ways that supports the formulation of potential design-solutions"  
(Crabtree, p.99, 1998)

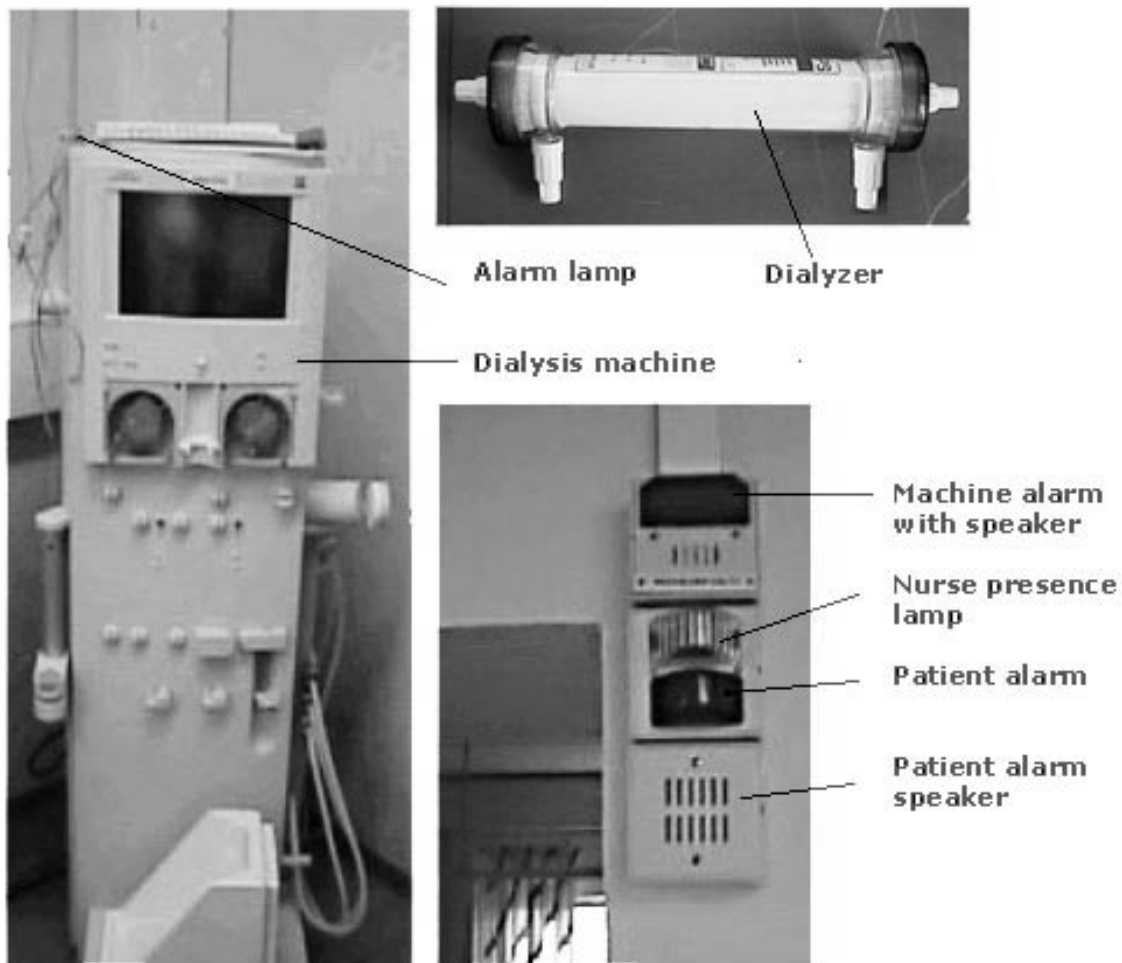
Since our goal was to come up with a design suggestion for a new alarm system we felt we needed to engage the users (i.e. the nurses) of the system in the design process. This because they have practical knowledge about earlier alarm systems and current problems. When it comes to user participation in the design process, the field of Participatory Design (PD) inspired us. PD has its origin in Scandinavia and was oriented towards the democratic ideal that workers should have the possibility to participate in workplace design and a lot of work was done in cooperation with the trade union (Ehn, 1993). Today, PD is a world wide field and has changed from its political focus of design to the practicalities of design with a wide range of techniques to enable user participation (Crabtree, 1998). In our work we have not used a specific technique, but instead been inspired by them and merged different parts to create techniques that fitted our purposes. We'll describe our way of working with the nurses in more detail later, but first we will give a short description of dialysis and the dialysis department.

## **The Dialysis department**

At the dialysis department in Karlskrona (Sweden) 24 patients with renal disease are treated each week. At the department, two supervisory nurses work together with 16 dialysis- and staff nurses, one doctor, and a technician. In a normal shift, four nurses take care of eight patients and each nurse is chief responsible for two of these patients.

Renal diseases are no longer as life threatening as before, but it is a disease that changes the patient's life radically. The patients have to visit the hospital for treatment three days a week for five hours each time.

During the treatment a dialyzer (which purifies the blood, see figure 1) serves as an artificial kidney. The dialyzer is attached to a dialysis machine beside the patient. The task of the dialysis machine is to pump the blood from the patient, through the dialyzer and back to the patient again. Except from pumping the blood, the machine also supervises and controls the process. If the dialysis machine for example detects a vein pressure drop it stops the blood pump and trigger off an alarm.



**Figure 1** A dialysis machine, dialyzer and alarm indicators located in the corridor

Today the dialysis machine sends out alarm signals simultaneously in three ways: by sound, a flashing light on top of the machine and with a textbox on a monitor (also located on the machine). In the dialysis department they also have chosen a fourth way: to propagate the alarm to the corridor where sound and a flashing light indicates the alarm. Each ward has its own set of speakers and lamps in the corridor, so the nurses should be able to see and hear where the alarm comes from. Besides the machines' alarm system, each patient has a "patient alarm system". When a patient presses a special button to call for a nurse, an alarm will get off in the corridor (figure 1). The sound from the patient alarm is different from the alarm of the dialysis machine. Also the nurses can press a button when they need help with a patient. That alarm is also indicated with the patient alarm lamp, but sounds a bit different.

## Alarms

Although alarm situations are a minor part of the daily work at the dialysis department, the work is to a large extent influenced by the characteristics of the alarm system. This is not a surprise since an alarm more or less by definition demands action by the nurses. They have to take care of the situation since the patient's life might be at stake.

The design of the current alarm systems and the nurses' responsibility creates a

few problems. First of all there is a lot of “miscoordination” between the nurses, e.g. three nurses reacts to the same alarm when only one of them needs to go. As we said earlier, each nurse is responsible for two patients and it is the responsible nurse that should be the one to take care of the situation. The reason is, they state, that the quality of the healthcare improves if one nurse takes care of her patients all the time.

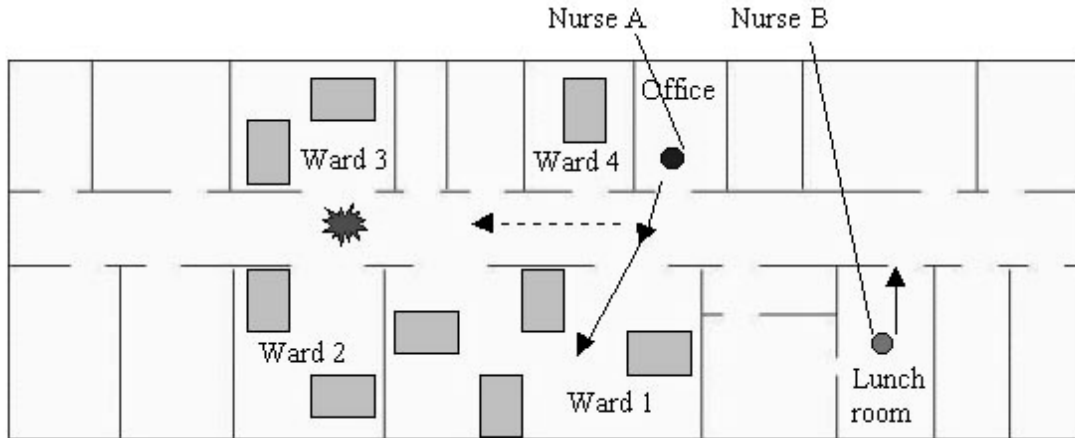
The nurses also experience problems with the alarm as such. In alarm intensive periods they sometimes paradoxically don’t react to the alarms. There are so many alarms from all kinds of places that they sometimes don’t even react to the alarm on a machine they are standing two feet away from. In some cases one nurse can enter a room telling another nurse standing close to the machine that there’s an alarm on her machine. They say they feel “de-sensitized” by all the alarms and it’s hard to know where the alarm comes from. But in other situations they know very well where the alarm comes from. One nurse told us that she could hear that an alarm came far down the corridor and could conclude it was quite likely her patient who was in trouble.

In order to understand the problems better, we decided to take a close look at a few alarm situations to catch what “really” happened and what the nurses “really” did. We tried to understand why they were acting in certain ways and what the alarms meant for them in different situations. In order to do this we decided to use video and perform micro-analysis of recorded material later on. As a complement to the video tapes we took field notes during our visits at the dialysis department. The field notes were later used as a reference for what happened outside the camera, what roles the nurses had in the current shift, what they were currently doing and where they were located. In the analysis of the video clips, the field notes turned out to be crucial for us in our attempt to draw conclusions of what was happening and most of all why people acted as they did. Since we had noticed that a lot of activity was happening in the corridor when an alarm went off, we decided to place the video camera there and to take notes of what happened inside the wards ourselves.

From the IA we did on the recorded material and from discussions with the nurses, we tried to figure out how and why an alarm was perceived differently among the nurses in specific alarm situations. How the alarm was perceived was also effected by the design of the system. In the following section we’ll discuss these issues based on analysis of two video clips. We have also included a video log describing what happens in the situations.

## **Analysis 1**

In this alarm situation Nurse A was responsible for two patients in ward 1 and Nurse B for two patients in ward 3. Right before the alarm went off Nurse A was in the office and Nurse B was in the lunch room (figure 2).

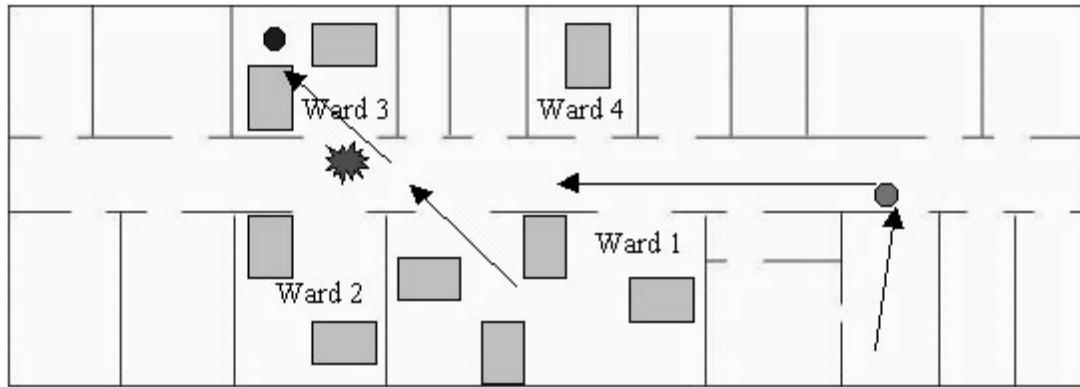


**Figure 2** Setting when the alarm goes off

Below is an excerpt from the video log. We have left out some observations to make it more readable.

Min:sec	Observations	Comments
18:34	Nurse A enters the corridor from the office.	
:35	An alarm trigger off. A sound fills the corridor and a red light outside ward 3 is flashing.	<i>Indicates it's an alarm in ward 3</i>
:36	Nurse A looks down the hall on the flashing light outside ward 3.	
:37	Nurse A continues to move across the corridor in a calm pace and enters ward 1.	
:49– :52	Nurse A steps out from ward 1 through the second entrance. On her way towards ward 3 she throws three quick looks into ward 2.	
:53	Nurse A enters ward 3.	
:57	Nurse B enters the corridor from the lunch room.	
:59	Nurse B increases her speed when walking down the corridor.	<i>She's aware the alarm is from her ward.</i>
19:00	Nurse B has something in her hand that she puts in her pocket. The sound and flashing light indicating the alarm stops.	<i>Nurse B is half way down the corridor</i>
:01	An alarm beeps with just a short sound and stops right away.	<i>Probably the "same" alarm as before.</i>
:06	Nurse B enters ward 3	
:19	Nurse A exits ward 3.	

**Table 1:** Video log for analysis 1



**Figure 3** The nurses' movements during the alarm

The first thing we noticed in the analysis was that Nurse A didn't take care of the alarm right away even though she noticed the alarm when she stepped out from the office. The nurses explained to us later that if they were not responsible for the patients in the ward where the alarm comes from, they wait a few seconds. They do so since the responsible nurse might be in the ward already. They also know that some alarms automatically resets after a few seconds which also makes them wait.

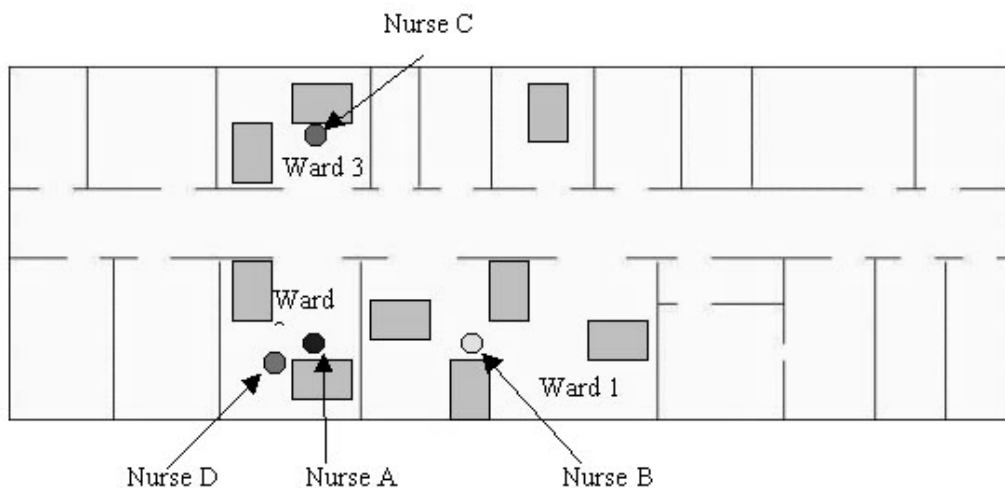
In the situation described above one can say that the alarm is not perceived as an alarm for Nurse A right away. It's first after four or five seconds the nurse decides to take care of the alarm. So, in a sense the alarm "doesn't mean anything" for Nurse A during the first seconds. There's a delay for about five seconds before the nurses perceive an alarm as an alarm.

Nurse B on the other hand was the one who ideally should take care of the alarms since she was responsible for the patients in ward 3. When we talked to her, she said she could hear that there was an alarm in the end of the corridor. Since she was responsible for patients far down the corridor and since she knew she had a patient who often caused alarms, Nurse B concluded it was likely her responsibility to act upon the alarm. The reason it took some time for her to get to the patient was that she had to finish what she was doing for the moment. One can clearly see at the video tape that Nurse B is in a hurry when she eventually gets out in the corridor. She knows it's her responsibility.

In the alarm situation described above both nurses knew where the alarm came from. That's not always the case. In the following example we'll discuss that particular issue.

## **Analysis 2**

In this case Nurse A and B are responsible for two patients each in ward 1, Nurse C is responsible for ward 3 and Nurse D for ward 2. Before the alarm goes off Nurse A is assisting Nurse D with a patient and Nurse B and C are taking care of their patients.

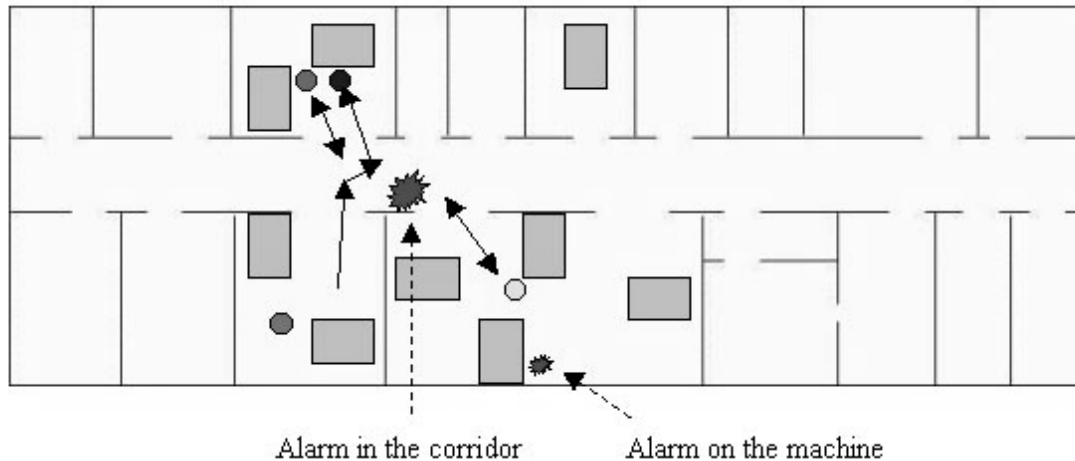


**Figure 4** Setting before the alarm goes off

Below is a video log describing the alarm situation.

<b>Min:sec</b>	<b>Observations</b>	<b>Comments</b>
28:31	An alarm goes off in ward 1	
:37	Nurse A moves towards the corridor	
:38	Nurse A enters the corridor from ward 2 and heads towards ward 3 while looking to the right, down the corridor	
:39	Nurse A turns towards ward 1. Nurse C enters the corridor from ward 3	<i>Nurse A has observed that the alarm comes from ward 1.</i>
:40	Nurse B enters the corridor from ward 1. Nurse A points into ward 1.	<i>Nurse B doesn't know the alarm is from ward 1. By pointing, Nurse A is "telling" Nurse B the alarm is from ward 1</i>
:41	Nurse C enters ward 3. Nurse B enters ward 1. Nurse A turns towards 3.	
:42	Nurse A enters ward 3.	
:44	The alarm ends	

**Table 2:** Video log for analysis 2



**Figure 5** The nurses' movement during the alarm

What we find interesting in this situation is the way Nurse B is acting. Although the alarm goes off in her ward she still enters the corridor to figure out where the alarm originates from. She obviously does not know the alarm is from her own ward. This might seem a bit strange at first since the dialysis machine indicates the alarm with sound and a flashing light, but since the alarm in the corridor is of much higher volume than on the dialysis machine she did not hear the alarm in her ward.

What you also see in this situation is that, once again, more than one nurse acts on the same alarm. It takes about five seconds before anything happens and then three persons act more or less simultaneously. No one knows where the alarm comes from but they all know (or believe) that the alarm is not from the ward where they are themselves.

One conclusion of the analysis is that the same alarm has different meaning for the nurses depending on where the alarm comes from and who's responsible for the patients in the ward. In other words: if the nurse is not responsible for the alarm, she awaits a few moments before she acts upon the alarm even if she know where the alarm comes from (see Analysis 1). Further, the design of the alarm indication makes it sometimes hard for the nurses to know where the alarm comes from, and if it is there responsibility or not.

The both analyses of the work practice concerning the current alarm system were used as a basis for a suggestion of a new alarm system for the dialysis department<sup>1</sup>. In the rest of this paper we describe the design work and reason about how a future implementation of the system could change the work practice.

## Changing the alarm system

To come up with a new alarm system with better support for the work at the department, we involved the nurses in the design process. As earlier mentioned this was influenced by the field participatory design.

We conducted three different workshops during a couple of months. At the first workshop (actually it was more of a kick-off) we invited nurses, medical doctors,

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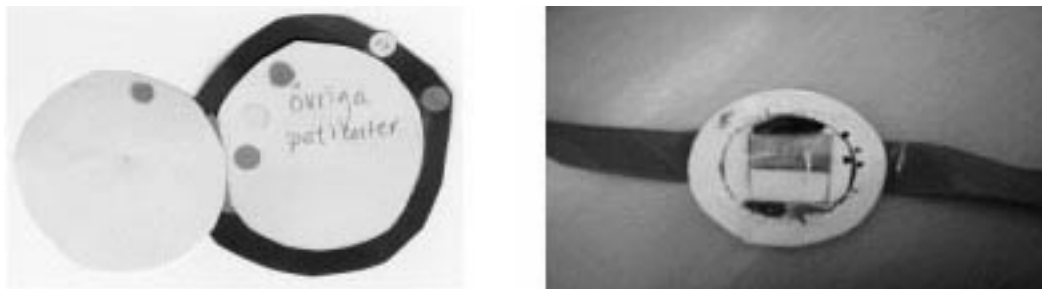
<sup>1</sup> We have of course studied a lot more than these two examples, but we have chosen to present only these two in the paper.



technicians, managers of the medical company and the chief of hospital. The purpose of the workshop was, besides informative reasons, to present some ideas about how to work with design and show what the latest technology had to offer. We wanted them to realize that there is more to computer technology than the traditional desktop-metaphor.

One member of our research team made a few sketches consisting of scenarios related to the nurses work practice. In the scenarios he used all kinds of every day things to represent different technological devices. We found it important not to use “real” technology in the presentation since we didn’t want the participants to believe we already had a solution in our hands (which we of course didn’t either). It was important for us that they all stayed open minded towards all kinds of solutions.

In the second workshop we had the opportunity to work together with the nurses from two different dialysis departments and in contrast to the first one it was primarily the nurses who were acting and creating. The nurses worked in two groups, where one of them focused on digital journals<sup>2</sup> and the other one on the alarm system. The participants working with the alarm system received a design task in the beginning of the workshop. We described an alarm situation we had observed at their department and the task was to come up with some ideas about how to distribute the alarm in a better way than today and to build mock-ups of the tools they thought they would need. One of their ideas was to use a personal “alarm watch” for each nurse responsible for a patient. Figure 6 shows one of their mock-ups they presented at the workshop and a modified version done by us.



**Figure 6** Two early versions of a personal alarm device. To the left is the one done by the nurses, to the right is a modified version done later by us.

The third and last workshop was located at the dialysis department in Karlskrona. This was in the end of the project and at this point we had come up with a design solution based on the material from our fieldwork and the previous participatory design activities. The design was handed over to the nurses as a basis for further development. The nurses worked in two groups, where one group criticized the design while the other tried to find alternative solutions. One advantage of locating the workshop at the dialysis department was that the nurses were able to try out the mock-up in its intended context.

Besides being a place for creating design suggestions for a new system the workshops was also a forum for thorough discussions. Especially interesting was the way the nurses related to older systems they had worked with. The workshops were the main activity where we as outsiders got to know about the history of the work in relation to the technology they had been using at the dialysis department. The historical information was very useful since some older systems had positive properties that the nurses felt they had lost. By combining the new ideas with the knowledge of experienced nurses we hoped we

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<sup>2</sup> Issues concerning digital journals for dialysis departments is another project that one of our colleagues is working on.

would be able to come up with a suitable alarm system. In the next part we'll describe some parts of how the new alarm system works.

## **A new alarm device**

When it comes to the design suggestion for a new alarm system we focused on the functional aspects of the design i.e. what functional properties the system should contain and its usability. Other aspects of design, that we will leave behind for now, are structure, how the artifact should work from a technical point of view, and the form of it which refers to "the look and feel" of the artifact (Lundquist 1992).

The design decisions we've made are based on the results from the workshops and our own analysis of the alarm situations. We will present parts of the system that we find relevant for further discussion in this paper. All properties of the alarm system will not be described here.

We should also mention that it is not at all certain the design we will present here will be developed. As we mentioned before this is a subproject in a project focusing on distance dialysis. The results we will present here are used mainly for discussion and to show possibilities and problems concerning alarms at the dialysis department. Before it is realistic to build a new system there are a lot of other issues to consider. For instance, one ought to take a closer look at what kind of alarms the machine indicates and reduce them altogether by, for instance, implementing more flexible alarm limits. What is certain, is that our rather deep understanding of how the alarm system influences the nurses work practice will be important when a practice for distance dialysis will become a reality.

The main idea with our improvement of the alarm system is a personal alarm device for each nurse. One can think of it as a pager. The device will only receive alarms from patients the nurse are responsible for. We also suggest not to propagate the alarm to the corridor right away which we will get back to soon.

The device (pager) works like this: Sound, vibration or both indicate alarms and a display on the device tells which patient/machine is causing the alarm. We suggested the text format 3:1 on the display, where 3 is the ward number and 1 is the bed number in that ward. We've done this because the nurses in Karlskrona refer to the different beds in this way.

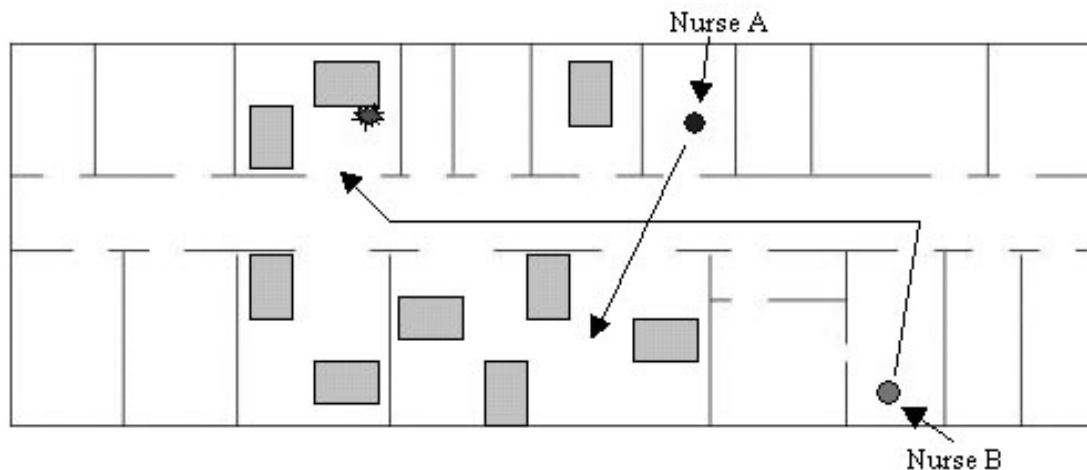
When a nurse gets an alarm there are three options. She can either press one button confirming she's aware of the alarm and is able to take care of the situation, or she could press another button indicating she can't take care of the situation or just ignore the alarm which eventually (after about 15 seconds) will have the same effect as if she pressed the button telling she's unavailable. If the nurse confirms she can handle the alarm the device temporarily halts the alarm indication. The dialysis machine will also halt its alarm sound and the lamp on top of the machine will end flashing and switch to a steady light. This is an indication for the patient that a nurse is aware of the alarm and is on her way. Today there's no way for the patient to know if someone is coming or not. If the nurse press the other button or ignores the alarm, the old alarm system will be activated i.e. the alarm will be propagated to the corridor in the same way as today.

By introducing a new alarm system, the work practice will of course change to something slightly different. The role of the old alarm system, which is part of the new solution, will also be different and the nurses will act in new ways when it gets activated. The alarm device will give the old system a new meaning.

## A hypothetical scenario of a future work practice

In trying to understand how the future work practice might look like, we have used alarm situations from the current work practice and reconstructed them in scenarios where our suggestion of a new alarm system has been implemented. The example we'll present here is based on the first situation we described in the analysis part of this paper.

In this future scenario Nurse A is responsible for two patients in ward 1 and Nurse B for two patients in ward 3. Just before the alarm goes off Nurse A is in the office and Nurse B is in the lunchroom.



**Figure 7** Nurses movements in a scenario with the new alarm

We assume the following scenario (see figure 7):

*An alarm goes off in ward 3. Nurse B:s alarm device starts to beep, and a lamp on the dialysis machine causing the alarm starts to flash. Nurse A walks across the corridor and enters ward 1 not knowing there's an alarm in ward 3. Nurse B ends her current task and presses a button on her alarm device (perhaps in the reverse order). The device stops beeping and the flashing light on the dialysis machine switches to a steady light. Nurse B walks down the corridor, enters ward 3 and takes care of the alarm.*

As you notice the scenario is quite different from the original situation we studied. The question now is what this scenario tells us. First of all there's a few obvious advantages compared to the original situation:

- The responsible nurse, Nurse B, takes care of the alarm.
- There's no annoying alarm in the corridor.
- The patient becomes aware that the nurse is on her way when the flashing light switches to a steady light.
- The nurse knows immediately that the alarm is her responsibility.
- The nurse knows where the alarm comes from and which patient is in trouble.

If we consider the same setting but assume Nurse B can't take care of the alarm, the situation will of course be different and more difficult to predict. Still we have a few ideas of what one might expect.

First of all the old alarm system that propagates the alarm to the corridor will be activated. Everyone in the department will hear there's an alarm and they'll know that the

responsible nurse wasn't available. What will happen in a situation like this is probably quite similar to what happens today (e.g. more than one nurse acts upon the alarm but more rarely). Although one difference might be that the nurses who are not responsible act a bit faster since they know the responsible nurse isn't coming.

## Concluding remarks

This has been a project with a narrow focus: to understand how alarms from dialysis machines at the dialysis department in Karlskrona influence the nurses work practice, and to come up with a design suggestion for an alternative alarm system.

Our approach has been to look closely at concrete alarm situations by doing Interaction Analysis and field observations. One could argue this approach only enables us to say something about the specific situations we have studied. We believe that is true, but by working close together with the nurses we also believe they can relate our suggestions to other situations and thereby "verify" if the system might be useful or not. Our approach of focusing on specific situations in a work practice requires user participation if we want to do more than just understand the specific situations as such. What we were trying to do with our analysis was to figure out how the nurses acted. We used this as basis for further discussions with the nurses and noticed that they began to reflect about their work in new ways. This was helpful throughout the whole project. During our visits at the department, they often came up to us and discussed different topics they had been thinking about since our last visit.

The nurses' participation was a crucial part of our work in other ways also. The workshops, for instance, gave us insight to aspects of their work that we weren't able to see for ourselves. The nurses told narratives about how the work was done several years ago and how the alarm system worked back then. When they reasoned about an improved alarm system, a lot of problems with the current alarm system became visible. By combining the insights from the workshops and our own analysis, were we able to give a suggestion for an improvement of the alarm system with qualitative motivations for our design decisions.

Apart from what we described in this paper there are also other differences between current work practice and a future one that might be of a more negative nature if they are not taken care of. For instance, it might be good to know about the other nurses alarms to get a feeling for the overall "rhythm", e.g. if someone has a lot of trouble with their patients. We have to identify what aspects of the old alarm system will be lost when a new one is implemented, and what consequences it might have on the work. It might be important to support the kind of awareness the old alarm system delivered. How this will be done is something we'll take a closer look upon further on. One can imagine solutions with discreet indications of alarms to give the nurses not responsible some kind of peripheral awareness of what's happening in the different wards. This work will continue as one part of the joint project "Distance dialysis".

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