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Nurses' methods and their relation to design

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Abstract: This paper is about technology in use and its possible relation to future design. The paper presents three cases taken from an ethnographic study at a dialysis department in Sweden. The observed methods of the participants in the work practices are in different ways related to the development of a remote dialysis system. In addition to giving an understanding of how technology is used in the work practice, the paper also concludes how these different cases can relate to, and inform, design in different ways.

Introduction

Since the earliest days of hemodialysis [1] (HD) treatment there has been a desire to remove chronic dialysis from its hospital setting to the patient's home (Bluemle, 1968). One of the main reasons back then, that is equally valid today, was to reduce costs. Today there are a rapidly growing number of patients that need to be treated within the frame of an overall decreasing budget. One step in making the treatment more cost efficient is to let the patients to a larger extent take care of their own treatment, e.g. in their homes. Home hemodialysis has been conducted over several decades but the information technology of today can provide new possibilities that can take the development of home (or remote) hemodialysis one-step further. There are several ongoing studies where new technologies are tried out in attempts to find new more

[1] A procedure for removing metabolic waste products or toxic substances from the bloodstream by dialysis. Dialysis is the process of separating smaller molecules from larger molecules by diffusion through a membrane.

cost efficient and qualitatively better ways of conducting home or remote hemodialysis (e.g. Winchester, 1999, Moncreif, 1998, Pierratos et al., 1998, Winchester et al., 1997). It has also been shown that more frequent dialysis, which is possible if the patients can treat themselves at home, has a qualitative impact on the treatment and, in turn, on the patients general well-being (Raj et al., 1999).

In a joint project between a hospital, a medical company and Blekinge Institute of Technology, the aim is to develop new design ideas for existing and future hemodialysis equipment and systems. One goal is to increase the possibilities for patients to conduct hemodialysis without the immediate presence of skilled personnel – for instance in their homes or in local dialysis centres.

What the nurses do in their work practices, and particularly how they do it, is important to investigate for several reasons. One is that there is no solid vision about how a future hemodialysis treatment system will be organised. Will the patients manage the treatment by themselves? Is it necessary with some kind of monitoring system when patients are treated over a distance? What should the monitoring system contain? Is it enough with the phone? If there is a need for a monitoring system, how should it be integrated into the nurse's work? The questions are many and there exists no obvious answer for the moment. In any case, independent of what kind of organisation for dialysis treatment one will settle for, it is important to know what dialysis is all about. By that I do not mean from a clinical or medical point of view (which of course is essential), but from a practical perspective, i.e. what work is conducted, and how, in a treatment session.

Why is this important? The main reason is that, when remote hemodialysis of some kind is to become a reality there will be a need for changes on many different levels: organisational changes (e.g. training centres for patients, new 'shift routines', new ways of conducting rounds, logistics for collecting blood samples, delivering medicine and other material for the dialysis treatment and so on), legal changes (who is responsible for the treatment?) and new and/or different tools (e.g. new dialysis machines, conferencing and monitoring systems). It is, in sum, a project which has many ramifications if it is to be practically realised. The various different competencies implicated in such a project need to be recognised and combined before new kinds of dialysis treatment can become a reality.

In the research reported here, I have chosen one aspect of the problem, namely, the nurses' working practices. Different approaches to understand work practice and relating the findings to design have been tried out during the last decade, addressing issues such as how ethnography can form a bridge between observed use and designers (Hughes et al. 1993) and how to engage the users and designers in the analysis to co-construct the relevant parts of work practice for system design (e.g. Karasti, 2000, Blomberg and Trigg, 2000). The place – if any – for workplace studies in relation to a design context has also been discussed on a more theoretical level (e.g. Plowman et al., 1995 and Schmidt, 2000).

The object for choosing to study nurse' work practice is twofold:

First I want to understand what nurses do 'moment by moment', 'here and now', and 'in real time', so I can give a reasonable account of what their work practice is about. My attempt is to recognise the patterns nurses address, while simultaneously

constructing them, through actions in their work practice. The reason is that I am trying to understand the practice from the viewpoint of the nurses, and the nurses are relying on these visible patterns. It is through the patterns that nurses make sense of the situation at hand and act accordingly. These patterns and the actions that follows are specific and can only be fully understood in relation to the context of which they are a part. As Coulon (1995) points out, "the actions are continuously interpreted in terms of context, the context being in its turn understood through those actions" (p. 33).

Secondly I hope my understanding of the work practice will influence, guide and/or support the development of new technologies and organisations. The theme of this paper is however mainly about parts of the work practice at the dialysis department and the role of technology, although this will be discussed in relation to design by way of conclusion.

In this paper I will look into three cases I have observed during my ethnographic study at a dialysis department in Sweden. The study has been conducted over a period of two years with the most intensive period during the autumn 1999. Earlier studies have looked into the impact of the alarm system in the nurse's work (Tap and Svensson, 1999, and Sánchez Svensson et al., 2000), at the first attempt to train two patients to set up the dialysis machine (training patients is done extensively at other dialysis departments in Sweden and has so for several years), and at the use of video conference equipment in a remote dialysis setting (Tap, 2001).

Approach to the field

The approach I have used in my attempt to understand what nurses do in this context is ethnographic. The collected material consists mainly of field notes and a few video sequences. As inspiration for how to look at and understand the work I have to a large extent been influenced by ethnomethodology. I am though trying to do something different from an ethnomethodological study of a work practice, e.g. relating my observation to some future design, I find the concepts used in ethnomethodology both useful for my understanding about what I see and how to interpret my material. The use of an ethnomethodological perspective is not new, although far form common, for people working with questions concerning the relation between work practice and design of artefacts and organisational development (e.g. Button and Sharrock, 1997, Randall et al., 1995, Harper and Hughes, 1993).

What follows is a description and analysis of three cases where I have studied the procedures, or the methods, nurses' use in their work practice. I also show how different technology comes into play in the everyday work practice. Finally I initiate a discussion about how these observations can connect to design.

Case A: High arterial pressure

The first case directly involves three persons, two nurses and one patient. Both of the nurses are responsible for two patients each in the room where the situation takes place. Although they help one another they want to take care of their own patients whenever possible. In the example Nurse A is the one who is mainly responsible for the patient with high arterial pressure. The following excerpt from my field notes describes what happened:

> 8:20 Arterial pressure alarm on Patient's machine. Nurse B [who is in the room but with another patient] resets the alarm.
>
> Nurse A enters the ward and walks towards Patient.
>
> Nurse A: "Is it the artery? Is it high?"
>
> Nurse B "No, it's low..."
>
> Nurse B walks back to her patient.
>
> Nurse A to Patient: "It was that needle I was about to rotate, but it seems to be stable. Or? Was it the second time today?"
>
> Patient shakes his head.

Time	QB ml/min	A-pressure	V-pressure
7:25	250	~160	~100
8:50	280	~100	
10:00	300	~110	120

> Nurse A: "Perhaps it only was temporary"
>
> Patient: "We'll see what happens"
>
> Nurse A leaves the ward.
>
> 8:50 Arterial pressure alarm on Patient's machine. Nurse A walks to Patient and resets the alarm.
>
> Nurse A: "I wonder if I shouldn't rotate it? But it looks all right every now and then. But you must be able to move".
>
> Nurse A rotates the needle. Nurse A got good pressure values. Nurse A increases the flow rate from 250 to 280.
>
> 10:00 Nurse A increases the flow rate from 280 to 300. The pressures are still good.
>
> In the dialysis protocol you can read the following regarding the arterial and vein pressure:

After the nurse 'started up' the patient she made a note in the dialysis protocol stating that the flow rate of the blood was 250 ml/min. This particular patient should, according to the prescription, have a flow rate at 300 ml/min but since the arterial pressure was high (~160) the nurse could not set the flow rate as high as prescribed.

That would only cause alarms and constant interruption in the treatment. It is quite normal to have high arterial pressure in the beginning of the treatment. The blood vessels sometimes contract, as a reaction to the unknown material the needle consists of, and hinder the blood flow, and which results in higher arterial pressure. The vessels then de-contract after a while when the body gets 'used' to the needle. Although this might be the cause of high arterial pressures in the beginning of the treatment, it is not the only possible explanation. Perhaps more often the needle can have an unfortunate position in the vessel that does not allow the blood to pass into the needle as required. Further, the arterial pressure is a negative pressure so the arterial needle sometimes sticks to the wall of the vessel and results in a high-pressure indication on the dialysis machine (and often an alarm). Alarms are common not only in the beginning of the treatment but also towards the end when the patients are getting 'dry' and the arterial needle has a tendency to more frequently stick to the wall of the blood vessel.

As seen in Case A the nurse uses tools and other people (colleagues and the patient) when making sense of what is going on in the current treatment. What is interesting to identify are how they, the tools and people, come into play.

Let us go through the example in more detail and see how the nurse interacts with tools and other people.

> "8:20 Arterial pressure alarm on Patient's machine. Nurse B [who is in the ward but with another patient] resets the alarm."

The first thing that happens is that the machine indicates an alarm by a flashing light on top of the machine and a sound. Both the flashing light and the sound is propagated into the corridor, with the intention to let people outside the ward hear and see where the alarm has its origin. Nurse B, who is in the ward, gets notified that there is something wrong with Patient or his machine. Since she is the only nurse in the ward and is able to easily end her current task, she decides to take care of the alarm. When she looks at the machine she sees a red flashing border around the artery pressure value indicator on the machines monitor (you can do this from several meters) which she recognises as an indication of a high arterial pressure. She presses a reset button on the monitor and the alarm terminates.

> Nurse A enters the ward and walks towards Patient.
>
> Nurse A: "Is it the artery? Is it high?"
>
> Nurse B "No, it's low..."

At the same moment as Nurse B resets the alarm, another nurse, Nurse A, steps into the room and walks towards Patient and Nurse B. Instantly when Nurse A enters the ward she asks if it is something wrong with the artery pressure – "is it the artery? Is it high?". She sees that Nurse B is already by the dialysis machine. Nurse A cannot see the screen on the dialysis machine from her position but still has an idea about what could be causing the alarm. When you read in the dialysis protocol (see the field notes above) you can get a hint why. Nurse A is the one who started the patient and she has made a note stating that the artery pressure was ~160 at a flow rate of 250

ml/min. Almost an hour has passed since she wrote the note and her reaction to the alarm – "is it the artery? Is it high?" – indicated that she is fully aware of the high pressure and prepared for the eventuality that it could cause a problem.

That Nurse B says the pressure is low needs a comment since it seems to contradict Nurse A's guess. When Nurse A asked the question "Is it high?", Nurse B had just reset the alarm. What happens is that the hemodialysis starts again and the arterial pressure gets new values. It seems at least possible that Nurse B's answer is based on the new value of the artery pressure and not the value it had when the alarm went off. The pressure probably decreased when the hemodialysis continued. That Nurse A later says "but it seems to be stable" and "perhaps it only was temporary" strengthens the idea that the pressure got back to normal or lower values. On the second alarm incident at 8:50 she also says the artery pressure "looks alright every now and then". So, the arterial pressure was high enough to cause an alarm but then got back to 'normal' when the hemodialysis continued.

When Nurse A is standing next by the dialysis machine she studies the artery pressure values and asks the patient if there have been other alarms before, on the same day.

> Nurse A to Patient: "It was that needle I was about to rotate, but it seems to be stable. Or? Was it the second time today?"
>
> Patient shakes his head.
>
> Nurse A: "Perhaps it only was temporary"
>
> Patient: "We'll see what happens"

Here the nurse talks to the patient to get more information about what has happened earlier during the treatment when she has been busy with other tasks. The negative answer from the patient makes the nurse wait (perhaps she would anyway) before taking any measures – "perhaps it only was temporary". Although the nurse has an idea about what could cause the problem – "it was that needle I was about to rotate" indicates she suspects a bad needle position – she does not seem to be sure. Is it the bad needle position or is it the vessel that is contracting? Perhaps both? To find out more the nurse uses one commonly used resource: time – "we'll see what happens". In this case it is the patient who articulates the phrase but that can be heard as evidence that the patient also is aware about the procedures in these kinds of cases. The nurse can wait since the treatment can continue without any immediate complications (although things are not 'perfect').

Almost one hour later there is another artery pressure alarm on Patient's machine. This time Nurse A decides to rotate the needle with the object of preventing further artery alarms and allowing a higher flow rate. There are several reasons why she decides to take measures now that were not valid earlier.

> 8:50 Arterial pressure alarm on Patient's machine. Nurse A walks to Patient and resets the alarm.
>
> Nurse A: "I wonder if I shouldn't rotate it? But it looks alright occasionally. But you must be able to move".

The most obvious reason is that it is the second time there is an alarm. The more problems you have, the more reasons you have to take some action. Secondly it was about one and a half hours since the patient was started and still the arterial pressure did not seem to get lower. If the problem had been caused by for instance contracting vessels the body ought to be 'used to' the needle by now. The nurse also suspects the alarm is trigged in relation to the patient's movement – "you must be able to move" – and since you can not expect the patient to lie absolutely still for a five hour period it is important that the needle has a position that allows some movements by the patient. It is not considered 'good nursing' if the patient is not able to move his arm. A fourth reason for intervention is related to the clinical quality of the hemodialysis. The patients has a flow rate prescription for 300 ml/min and currently they have only been able to reach a flow rate at 250 ml/min. Roughly, the greater flow rate one can have the better quality of the hemodialysis one will get [2].

When the nurse decided to rotate the needle to get a better flow rate and arterial pressure, she used the arterial pressure monitor on the machine to see if the needle got into a better position (in relation to the required flow rate). In this case the arterial pressure value became much lower and the nurse could increase the flow rate from 250 to 280 ml/min. Later, since everything continued to proceed as desired, she increased the flow rate to the prescribed level, 300 ml/min.

> Nurse A rotates the needle. Nurse A gets good pressure values. Nurse A increases the flow rate from 250 to 280.
>
> 10:00 Nurse A increases the flow rate from 280 to 300. The pressures are still good.

Case B: Dry weight [3]

One of the main problems for the most dialysis patients is that they are more or less unable to urinate. Fluid is accumulated in their body and has to be removed during the dialysis process. This removal process is called ultrafiltration (UF). When removing the fluid a series of complications can arise such as hypotension, nausea, vomiting, and cramps, which limit the possible UF-rate. These symptoms, or the absence of some of them, sometimes force or 'stimulate' the nurses to take some action. For example, if a patient gets cramps, which is an indication that the patient currently has a low fluid level in the blood vessels, the nurses often lower the UF-rate as a coun-

[2] The theory behind this argument is that the higher flow rate you have on the blood the more waste products will be removed. This is mainly true to small molecules, like urea, which easily can pass through the dialyzer membrane. Since the membrane barely hinders the molecules, an increased flow rate will allow more molecules to pass through since more molecules will be exposed to the membranes surface. The smaller molecules the greater is the benefit of increasing the flow rate. Removal of bigger molecules is mainly dependent on the properties of the membrane. Generally you can say that the thinner membrane you have, the less resistance it will offer for passing molecules (But it should also be noted that if the patient can be treated more frequently and for longer sessions a slower flow rate seems to be the best treatment (Raj, Charra et al., 1999).

[3] The case presented in this section is used in another paper too, but serves a different purpose (see Tap and Sutter, 2000).

termeasure. In a sense, indications of cramp are a good thing since it under some circumstances indicates that the patient has removed all overloaded fluid. Cramp is also common towards the end of the treatment when most of the fluid is removed.

The amount of fluid that is supposed to be removed from the patient is calculated in relation to the patient's dry weight, i.e. how much the patient should weigh when she does not have fluid overload. The practice is such that when the patient comes to the dialysis department she weighs herself. Then the nurse subtracts the dry weight from the patients' current weight and adds the amount of water the patient will get through the food during her visit. The sum of these parameters corresponds to the patient's fluid overload and in turn corresponds to the amount of fluid that should be removed during the treatment (UF-goal). The doctor prescribes the dry weight value and it is the nurses' responsibility to make sure the patient reaches the specified weight level. Although it is the doctor who decides the weight, the nurses often address the issue of changing it. We will see one instance of this in the coming example. It is also worth pointing out that the dry weight value is not easy to state. It cannot be measured directly, because there is no everyday occurring 'normal' weight state of the patient. The dry weight value has to be estimated, by taking into account the patient's weight before the sickness, if he or she has lost 'normal' weight, and so on.

At the dialysis department one dialysis machine is equipped with a product that continuously measures the hematocrit [4] level in the blood. The result can be viewed in real time in two different graphs on the dialysis machine. One graph shows the hematocrit level and another shows the blood volume. When analysing the graphs you get different indications about the dialysis process. What you want to see when looking at the hematocrit level is a graph that raise the closer you are towards the end of the treatment (figure 1, left, is one example). If you view the blood volume graph you want to see the opposite behavior, i.e. the graph should decline towards the end (figure 1, right).

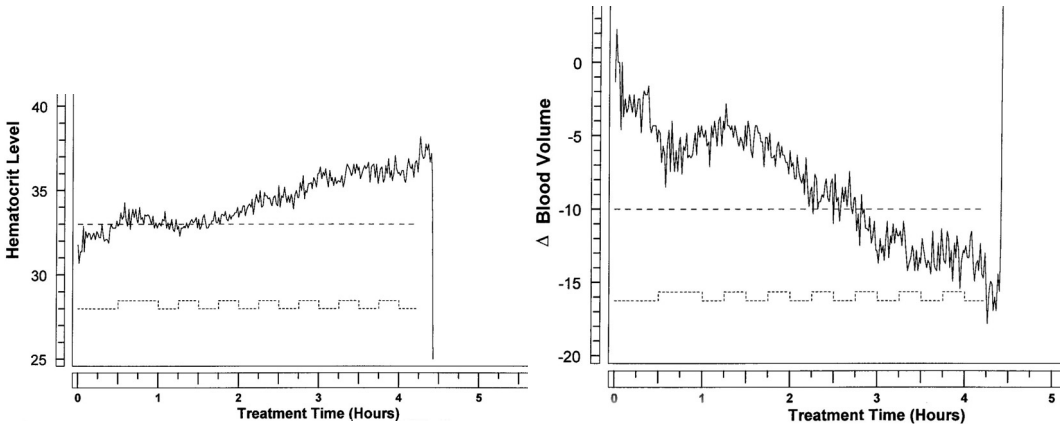


Figure 1: Hematocrit (left) and blood volume graph profiles (right)

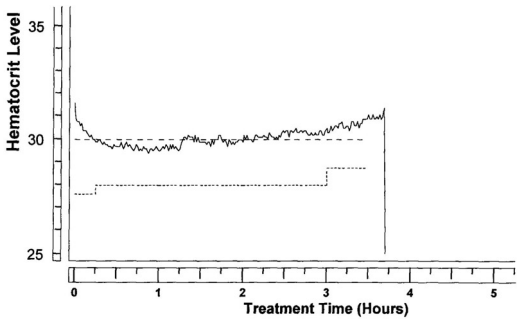
Lower blood volume means you have reduced the extra fluid that the patient had in her body, or to be more specific the fluid she had in her blood vessels. High hema-

[4] Roughly, the concentration of red blood cells in the blood vessels.

tocrit level indicates that the blood currently has a high concentration of red blood corpuscles which in turn means that the concentration of blood is getting higher in relation to the concentration of fluid. In a brochure from the firm producing this technology they state that the "technology provides a window into the patient to help manage and control patient fluid overload caused hypertension under control."

What follows is a description of a situation observed during the field studies at the dialysis department.

> 08-20
> 17:25 A patient is soon about to end his treatment. Nurse A is standing next by the dialysis machine looking at the hematocrit level graph. The graph does not raise as much as Nurse A wants it to. Nurse A tells the patient (and me) that the profile is rather flat.
>
> Nurse A: Do you have cramps when you are at home?
>
> Patient: No
>
> Nurse A: Do you have the same appetite as before?
>
> Patient: Yes I do.
>
> 17:40 Nurse A says she is interested to hear how much the patient weights after the treatment. The weight confirms if they have reached the patient's dry weight or not. Nurse A says further that she suspects the patient has more fluid to be removed. When the patient tells Nurse A the current weight Nurse A says they should try to remove more fluid next time. The patient's current weight (73,8 kg) was below the specified dry-weight (76 kg).
>
> In the dialysis protocol the nurse writes:
>
> "[The graph] + the patients general condition shows that we can lower his weight further. Weight was 73,8 when going home. Good blood pressure, feels well."
>
> 08-26 Nurse A tells me that the patient now has a lower dry weight than before and that he feels more alert and also gets cramps towards the end of the treatment.



A brief summary of what happened: The nurse observed that the hematocrit graph profile deviated from a 'good' one, and it was probably a significant deviation (since she continued to investigate the matter). She asked the patient a few questions about his condition. She knows for instance that if patients get cramps this is often an indication that they are 'dry' – there is no more surplus fluid to be removed. The opposite seems to be the case here, the patient does not have cramps which indicates that the patient might have more fluid to be removed from his body. The low weight of the patient, low in relation to the specified dry weight, is a third indication that

the dry weight needs adjustments. Thus, on this occasion of dialysis treatment, the medical team has gone below the prescribed weight and still there are indications of fluid overload.

It is important to note that there are more 'parameters' that could have influenced this situation. The nurse has for instance known this patient for a long time and is most likely already aware of a possible weight problem since previous treatments (but it is in this particular situation where her suspicion gets articulated). She is also using tools in other ways than described here. For example she has read the notes from previous treatment in the patients dialysis protocol before starting up the patient which also might have directed her attention to the patient's dry weight.

Case C: Changing tubes

It is not always the case that access problems can be handled as smoothly as in Case A. This third example will show how the activity of remedying an access problem can take other forms and extend into other activities.

> 09-02 One patient had strange vein pressures and the nurses could not find any logical explanation (also stated in the documentation). They tried to rotate the needle but it did not seem to work. One nurse thought the strange pressures might be caused by coagulates in the vein chamber since there was a slight indication that the blood was dark in the bottom of the chamber. To solve the problem two nurses changed to a new set of vein tubes. Unfortunately the problem did not go away.
>
> 10-05 They use a different kind of treatment, single-needle, on the patient because he has had strange vein pressures. His arm has also been x-rayed but the results did not show any stenosis of any kind so there should not be any problems with the blood flow.
>
> 10-14 The patient is using two needles again and his vein pressure is fine. The nurses says that the good vein pressures are a result of the single-needle treatment period which let his arm rest a bit.

This case starts out in a similar way as Case A. There is a strange pressure, this time vein pressure, and the nurses tries to resolve the problem by rotating the needle. Contrary to Case A it has no effect – the strange pressure remains. The nurses are of course not satisfied with the situation and start to investigate the matter further. By taking a closer look at the tubes one nurse recognises a darker region in the bottom of the vein chamber. He suspects there are coagulates stuck in the filter in the bottom of the chamber. The coagulates could hinder the blood from passing and in turn give rise to a higher pressure in the vein chamber (the vein pressure gauge is connected to the vein chamber). After a moment of reasoning the nurses decided to change the vein tubes (including the vein chamber) to a new set of tubes. When the treatment continued they noticed that they still had the same problem with the pressures. One

[5] With single-needle treatment the blood get out from and into the patient from the same needle. The machine alternates in a few seconds' intervals between removing and giving back blood from the patient. The quality of the dialysis is though reduced with this kind of treatment since a lower volume of blood passes through the dialyzer during the treatment.

nurse suspected that there could be a stenosis in the vein higher up in the patient's arm that could hinder the blood flow. After consultation with the doctor they decided to send the patient to x-ray and look for a possible stenosis in his arm. The x-ray did not show anything of that kind so it had to be something else that caused the problem. A few weeks later they had changed the treatment method to a single-needle treatment [5] and the vein pressures were 'normal' again. After a few weeks of single-needle treatment they tried to go back to the traditional method and now everything worked fine. The explanation from the nurses was that the arm 'rested' during the single-needle treatment and that the problem was resolved that way.

Design considerations

When thinking about a future remote dialysis setting is it hard to state what to design from the kind of analysis presented here. I do however believe, and that is what I will show in this section, that there are some interesting considerations.

The unfolding events seen in Case A happen more or less everyday. The nurses' procedures are routine and there is nothing strange or unusual going on. The nurse is able to solve the problem partly since she has been constantly updated about what has happened during the current treatment – she has put the needle in the patient, she knows about the initial high arterial pressure and so on. In a future situation where the patient is in a remote location and handles more of the treatment himself the case might be different. The nurse might not be involved during the progress of the treatment which hinders her from getting constantly updated in the same way as described above. When the patient needs to consult the nurse for some reason the nurse may not have an updated idea about what has happened. There might be a need for some kind of support system that helps the nurses make sense of what has happened. For instance, today the arterial pressure is indicated with a number and a column. One could suggest a similar solution in a support system for remote hemodialysis, i.e. present the current pressure with a number, and perhaps that is the best solution. But, before one arrives at such a conclusion there are aspects revealed in the analysis of the case that needs to be attended to. It is clearly seen that the nurse uses other resources than the specific arterial pressure figure. *The pressure is not interpreted in isolation*. The current arterial pressure number is juxtaposed with the prescribed value of 300 ml/min, how she believes the needle is positioned and the previous pressures. As seen, this is done continuously. The nurse waits and sees how the pressure develops over time. The nurse builds up a history of the arterial pressure that she uses as a resource for making sense of the situation and as a basis for her decision. In a remote setting there will be a need to do this instantly. This is an activity that is not supported by the machine but might be important to include in a future support system. There might be a need for providing the historical development of the arterial pressure that spans over at least one treatment session. A single, current value of the pressure might be useful, but combined with the historical development of the arterial pressure could be even more useful.

What makes the observations in Case B interesting are how the different 'resources' (heamatocrit graph, patient, weight and so on) are juxtaposed by the nurse in order to make sense about what is the case and eventually making a decision about what to do. For instance interpreting the hematocrit graph by itself seems not to be enough. I think it is hard to relate the analysis of this particular case to design in any specific concrete way. But I believe a detailed study of information technology (here the hematocrit graph) serve at least as sensitising design about an understanding of in what way information technology is used. As I said before, the graph is not treated in isolation, and how the tool is integrated in work practice is, according to my opinion, important to understand.

Now, how does Case C relate to design of remote hemodialysis? I do not believe it does in the same way as Case A and B where one can observe the use of interaction resources in a more straightforward way, because of the level of description. The other cases display more of the nurses' methods. The notes representing Case C are on a less detailed level, but last on the other hand over a longer period of time. I do though believe there are important aspects to be considered in Case C that can influence the design of a support system in a rather tangible way. Let us consider the example once again and imagine that the patient is in a remote location.

The first thing that needs to be attended to in some way is the strange vein pressure. This is probably the easiest part since there are gauges measuring the pressure the output of which easily can be visualised. But what becomes interesting is how and to whom this visualisation should be presented for. And that decision is related to how the responsibilities will be distributed between the nurses and the remote patient. Is it the patient's responsibility to recognise the strange pressures? If that is the case then the patient must have learned what a strange vein pressure is. Often when a patient has high vein pressure there are 'routine' explanations. So the patient needs to be able to distinguish a 'normal' problem from a 'strange' problem. When observing what the nurses do in attempting to find a logical explanation, one can see that they conduct several 'experiments'. They rotate the needle, change the tubes, send the patient to x-ray, and tries another treatment method. Everything done with the object of finding an explanation to the problem so they can take measures (and of course sometimes the experiment is the measure). The questions to be answered relate to how this could be supported in a remote setting.

It is important to mention that the actual design cannot be derived from these kinds of observations. The result is a set of questions to be considered, but the solutions are to be found elsewhere. For instance when considering a remote dialysis setting, one has to ask if the patient will have the ability to do similar experiments and how to train the patient for the tasks. How independent should the patients be? If one wants independent patients there is of course a need to build up an extensive organisation for patient education. Considering the limited growth in the economy within the health care system– which also is a reason for our project – it is hard to see a future where one educates patients to be as skilled as the nurses before they begin their remote treatment. From my point of view, a more realistic view is to have the nurses supporting the patients in cases like the one described here. If that is the path to go then there are some interesting design considerations. Mainly it is

about what should (and could) be supported by artefact design and what needs to be supported through the organisation of work, and there are many levels to be considered. How will vein chamber inspection be conducted (one example can be found in (Tap, 2001), how will patients be able to move from remote to 'in department' treatment, how should patients be trained, and how to support patients in 'real time' when they are remote?

Conclusion

I have looked at three cases in order to understand nurses methods, i.e. how they use artefacts in their everyday work practice when making sense of what is happening and what to do next. I have also opened up for some design considerations that are results from these three cases. In the table below I have roughly summed up the cases.

Case	The nurse's resources	Action	Relation to design
A: Arterial pressure	● Patient ● Other nurse ● Arterial pressure ● Knowledge about start up of patient	● Wait and sees ● Rotate needle	● Support historicity
B: Dry weight	● Patient ● Hemocratic graph ● Weight after treatment ● Speified dry weight	● Juxtapose information from resources ● Decrease specified dry weight	● Learn about how a tool (hemacrotic graph) is used in relation to other resources
C: Changing tubes	● Vein pressure ● Colour of blood vein chamber ● X-ray	● Rotate needle ● Change tubes ● Single-needle treatment	● Chamber inspection ● Move between home and hospital

The three cases show different ways of relating to design (some aspects identified in one case also is visible in the others, but often more visible in the particular case I refer to). In Case A one can see the importance of historicity within one single treatment session. The nurse is constantly updated about what is happening from the start to the end of the treatment. She also waits and sees in order to find out more about the current situation. This is something that I feel needs to be supported in a remote setting if one requires the nurse to be able to support patients when they are

in a treatment session. It will be hard for the nurse to be constantly updated, so one idea is to produce a 'snapshot picture' of the development of the particular session for the nurse.

The second case relates to design in a very different way. I want to show how a certain technology is used in order to learn more about the integration of tools in work practices. The case shows how the hematrocrit graph is juxtaposed with other resources (dry weight, interview of patient, weight after treatment). How different resources are related to one another is important to recognise when deciding where things are to be located and trying to predict who needs what resource and when. I believe this might be particularly interesting when developing a remote dialysis treatment where (at least) two parties will need resources and share some of them, although they are not at the same physical location.

The last example, Case C, becomes also most interesting, when it comes to design, when relating the activity to a future remote setting. The relation to design is on a level that has to do with skill and organisation issues – at least as I chose to present it here. In the case one can see how a nurse conducts a vein chamber inspection and sees that the blood seems to have a darker colour in the bottom than is 'normal'. Deciding on the colour is not an easy task and often nurses call a colleague to get a second opinion. How will this knowledge be preserved in the future? Is it reasonable to require the patient to be able to do this (they probably learn eventually, but how long does it take?), or should there be some possibility for the nurse to remotely conduct this activity?

Case C also points to organisational issues due to the particular problem it contains. When the nurses decide to use a single-needle treatment they need to change the settings on the dialysis machine. Is it reasonable to require the remote patients to be able to know how to move from one treatment method to another (it is rare that one needs to move between treatment methods)? If not, which I believe is the most reasonable answer, there might be a need to have additional beds in the department where normally remote patient can have their treatment over a limited period of time (e.g. until the arm has 'rested', along with the explanation given in case C).

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