

Reconfiguring Cooperative Work by Visualizing EPR on Large Projected Screens

Jesper Simonsen

Computer Science, Roskilde University
P.O. Box 260, DK-4000, Roskilde, Denmark
simonsen@ruc.dk

ABSTRACT

This workshop paper reports on a recently completed large scale PD experiment where paperbased patient records were replaced with an Electronic Patient Record (EPR) system at Roskilde Hospital in Denmark. The use of large projected screens led to an interesting reconfiguration of the cooperative work among the clinicians. During the nursing handovers and the team conferences, we observed collective investigations of the patient records – this was not observed when using paperbased patient records. The nurses also managed to change the screen for the team conference in order to make their observations more visible – in this way they managed to change the power balance between nurse and physician.

INTRODUCTION TO THE EXPERIMENT

The PD experiment was completed during fall 2005 and involved a close collaboration comprising a neurological stroke unit, the hospital's EPR unit, the vendor, as well as the researchers (Jesper Simonsen and Morten Hertzum, Computer Science, Roskilde University). The experiment was part of a research project on 'evidence-based IT development' as reported on in a paper on this conference [1].

The experiment involved a neurological stroke unit treating patients with acute apoplexy where all paper-based patient records were replaced with a prototype EPR system for a period of one week. The EPR system was a so-called clinical process module that supports clinical documentation and decision making and comprises the on-going documentation of medical patient information made by the clinical staff (physicians, nurses, therapists, medical secretaries, etc.). The aim was to measure and evaluate effects from real clinical processes supported by a fully functional EPR with complete patient records. The experiment thus required thorough planning involving development of new EPR-supported patient trajectories, specification of desired ef-

fects from using the EPR solution, configuration and implementation of the EPR system, simulated as well as real-time integration with other systems, migration of patient data, and training of the clinical staff in using the system and working according to the revised patient trajectories.

The first part of the project (August through October) included five full-day PD workshops where clinical personnel in cooperation with the designers from the vendor, project managers from the hospital's EPR unit, and the researchers designed and configured a prototype of the system. Main parts of the prototype were designed through up to three iterative events: During one workshop, mock-ups were drawn on flip-over charts. During a following workshop, a preliminary non-interactive prototype made with MS-PowerPoint was discussed. During a third workshop, a running prototype was demonstrated, discussed, and evaluated.

In the second part of the project (November through December), the vendor undertook the technical development of the prototype, along with interfaces to various legacy systems currently used at the hospital (ADT system, laboratory system, and medication module). A number of tests and reconfigurations of the system were made in parallel with training the clinical staff in using the prototype.

As part of the PD workshops, a number of effects related to the clinical practice were identified, prioritized, and further specified. The effects requested by the clinical staff focused on improving their overview and assessment of patients as well as on more efficient coordination in three specific and highly cooperative situations:

Nursing handover, which happens three times a day at the beginning of each nursing shift (7am, 3pm, and 11pm) and last about an hour. There is no time for the nurses that leave the ward to discuss patients with the nurses on the next shift. During the nursing handover, one nurse is designated as the team leader and provides an overview of the patients at the ward and manages the necessary coordination and exchange of information. This nurse reviews the patient records and orally informs the others about status and plans for the shift.

Team conference, which takes place once every weekday, lasts approximately 15 minutes, and includes all clinical staff members (physicians, nurses, and therapists). An interdisciplinary assessment of each patient is carried out and

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plans are revised. The current status of each patient is given orally by a nurse and an overview of current plans is available by means of a table on a large whiteboard or, in the prototype EPR system, a full screen projected on the wall.

Medical ward round, which happens once every weekday and lasts for three to six hours. It includes evaluation, reviewing, and discharging of patients. The chief physician visits all patients and reviews the plans for their treatment. Usually there is no time for nurses to follow the physician during the ward round. Information exchange and coordination is obtained through the patient record and by ad hoc communication with the nurses on shift.

In this paper the focus is on the nursing handover and the team conference. All three situations above were measured before (with normal paper-based practices) as well as during the week in which the EPR prototype was used in order to compare a 'before' and 'after' situation. Measurements were focused on the requested effects and acquired by using various techniques including questionnaires, interviews, observations, and Task Load Index (TLX) ratings [2]. In total, 15 nursing handovers, 8 ward rounds, and 11 team conferences involving a total of 35 patients and more than 20 clinical staff members were included in the measurements.

In the final part of the experiment, the prototype was online 24 hours a day and replaced the paper-based records for all patients during one week in December 2005. Five years of patient data (in total more than 26 million data records from more than 300.000 patients) had been migrated to the prototype and interfaces were established to the legacy systems in order to receive updated data during the experiment.

The prototype included screens projected on the wall during nursing handovers and team conferences, stationary and portable PCs, and PDAs used for obtaining measurements at the patients' bedside (temperature, blood pressure, etc.) All clinicians used the EPR system during this week. Each clinician had a 'shadow' (an employee from the vendor with a clinical background or a person from the hospital's EPR unit) that could instantly be consulted in case of questions about how to use the system and in face of emergency situations.

The prototype simulated a fully integrated EPR system. The prototype thereby simulates an EPR solution that is not expected to be in operational use in Denmark until 2007 or later. In order to simulate a fully integrated EPR system, a 'back office' was established and staffed 24 hours a day. Patient-record entries that involved paper-based transactions were initiated in the prototype. The back office identified such entries and mailed them in the conventional fashion. When results were received, they were immediately typed into the prototype EPR system. Thus the clinical staff experienced the prototype as if all transactions were fully IT supported.

QUANTITATIVE MEASUREMENTS

We identified, specified, quantified, and measured some of the effects the clinical staff was striving for from an EPR system. Although one week of using a prototype is too short of a period to establish a routine usage of the system, some of our data yield statistically significant effects.

At the nursing handover, the effects of using the prototype and the large projected screen varied according to the role of the nurse (so-called significant interaction). For each patient reviewed at the handover, the nurses were asked to evaluate how well they assessed the plan for this patient. While the team leader experienced a significantly worsening the other participating nurses (the 'listeners') experienced a significant improved plan. This result reflects that the team leader (as the only participant) had to manage the new system as well as manage the handover as such. The listeners in addition to listening could see the patient record and request the team leader to show specific and detailed information.

During the team conference, the physicians experienced a significant reduction in their mental workload on all six scales of the TLX ratings. The nurses experienced a significant improvement on one of the TLX scales (own performance). This reflects that the team conference is mainly an activity providing the physicians with multidisciplinary views on the patients. The physicians were the prime participants in configuring the patient status screens used during the team conference. The nurses however were more satisfied with their own performance during the conference. One reason for this was their increased possibility for effectively bringing their own observations into the agenda of the conference.

These results from our quantitative measurements are further elaborated on below. We describe the challenges that the team leader met when managing a meeting with the use of a projected screen. An example is given from a handover that illustrates how the team leader relies on the traditional reading of the chronological nursing record while the other participants interrupt and detect and analyze anomalies. Finally an example is given from the team conference describing how the nurses bring their observations and conclusions into the agenda by means of a window in the conference screen that presents the nursing observations.

QUALITATIVE EVALUATION

The nursing handover and the team conference took place in a small room equipped with a PC. The EPR was visualized by projecting the PC screen on the wall using a standard projector mounted on the ceiling. The use of a large projected screen led to an interesting reconfiguration of the cooperative work among the clinicians during these meetings:

- *From oral information to collective reading.* The traditional way of communicating an overview of a given patient during nursing handover and team conference is

oral: The team leader (holding the patient record in his or her hand) introduce the status of a patient by reading up key information from the paper record. All other clinicians listens to this presentation. The team leader is typically the only clinician looking at the patient record. During the experiment this changed to collective reading since all clinicians present were able to read the record projected on the wall.

- *Collective investigation of the patient record at the nursing handover.* In the 'before-situation' (using the paper record) we observed that the patient record was seldom seen by others than the team leader, except in cases for example where the handwriting was unreadable. During the experiment the patient record (projected on the wall) was repeatedly inspected by all nurses present at the handovers, and they collectively participated in interpreting the immediate status of the patient status and condition.
- *Nurses adds their observations to the team conference screen.* The nurses experienced how the information on the team conference screen formed the agenda for this conference. Halfway through the experiment the nurses initiated a change in the team conference screen – adding a panel specifying their observations relevant for the conference. In this way, the nurses' observations became more salient to the clinicians as they were forming their overview of the status of the patients. The nurses themselves were in charge of which of their observations were to be communicated to the other clinicians present at the team conferences.

In the following, these three reconfigurations are further described and exemplified with situations and transcriptions from the conversation between the clinicians (as indicated with *italics*).

From Oral Information to Collective Reading

Using a projected screen was a new and unaccustomed way of carrying out the team conference and especially the nursing handover. Several parts of the patient record were reviewed at the nursing handover (where each patient was reviewed for approximately 10 minutes). Only one single screen was designed for the team conference (where each patient had only 1-3 minutes). Though most clinicians had received training in using the system (on a PC with test-data), none of the clinicians were given training in using the projected screen in meeting-like situations prior to the experiment. The reconfiguration of the nursing handover and the team conference occurred during the 5 days when the prototype was on-line.

The clinicians were accustomed to using a table on a large whiteboard during the traditional team conference. During the experiment, the whiteboard was replaced by one single projected screen for each patient. The team leader for the conference is the same nurse that is the team leader for the nursing handover, taking place about 1 hour before the conference. When the nursing handover ends, the team leader

prepares a summary for each patient to be presented at the upcoming team conference. The nurse made his or her own keywords for this presentation on a piece of paper, i.e. this was the same during the experiment as well as during the traditional team conference. In this way the team leader used a routine from the beginning of the experiment where the presentation of a patient was similar to the before-situation: The team leader selected the patient to be displayed on the projected screen and then this patient was presented by means of the key-words on the team leader's paper – not by using the system. When questioned, one team leader answered that she did "as she usually does" because she did not know how to do it otherwise. Even though the team conference is intended to be interdisciplinary, it is dominated by the physicians. The conference only lasts for 15 minutes, and the (app.) 10 participating clinicians are eager to get on with their busy day. Therefore there was no immediate room for further experimentation at the conference.

During the first days of the experiment, this routine changed. The team leader's presentation of the patient became shorter or no oral presentation was given at all: The data on the screen managed to give the clinicians (especially the physicians who participated in designing the screen) a quick and effective overview of the patient. The clinicians were studying the data on the screen as illustrated in the following example:

On the fifth day of the experiment, a new patient (where no one except the team leader knew the patient record) was presented at the team conference. The condition of the patient was rather complex as the patient was a diabetic and suffered from a number of problems due to this diagnosis. In addition the patient was now being observed for a stroke. The team leader displayed the patient and for a few seconds there was silence until two clinicians right after each other exclaimed "Gosh!" - "Oh my God!". The team leader continues by saying "And she is only 32". They then started discussing the plans for treatment and no further introduction to the patient was given. This example demonstrates how the screen provided the clinicians with an instant overview of the patient in a matter of a few seconds without any accompanying oral presentation.

Contrary to the team conference, there was more room for learning and experimentation at the nursing handover: During the experiment, the neurological unit was not overbooked with patients and the nurses had time to investigate the different screens and experiment with different strategies for navigating around in the system.

During the first day of the experiment, the nurses experienced problems in getting an overview of what had happened at the shifts prior to the handover. The traditional way of getting this overview is to read the nursing record written by the nurses from the earlier shifts. In this way, they get a chronological view of the observations made by the nurses. In the system, observations were structured dif-

ferently. They were ordered according to the categories suggested by Virginia Henderson [3] into different types of observations, with the newest observation first on the different lists. The system was therefore changed (on the second day of the experiment) in order to make it easier to establish a chronological overview by adding the date and time to each record and observations and by allowing to sort chronologically.

The nurses could then from the second day of the experiment conduct the handover in a "usual" fashion by reading through the nursing record chronologically. By using the projected screen, they experienced that it might be difficult to read up information from the patient record when all 'listeners' present can see this information at the same time – it seems somewhat superfluous. But if the information was not read aloud, then the participants were focusing on different parts of the screen and no collective review of the patient data was obtained. Also, the nurses did not read the information at the same rate and thus it could be difficult to find a shared 'scroll-pace' that satisfied all participants.

As early as on the third day of the experiment, we observed that a routine was beginning to form: The team leader managed the pace and now highlighted the text on the projected screen along with reading it for the other participants. During the handover, the participants continuously negotiated browsing pace as well as where and when to open records and get more detailed information.

Collective Investigation of the Patient Record at the Nursing Handover

Along with the continuous negotiation on how to navigate through the patient record, all nurses present at the handover collectively participated in inspecting and interpreting the status and condition of the patient. A similar activity was not observed at any of the 6 nursing handovers previous to the experiment: At these handovers the team leader was the only person holding the paper record, choosing which information to bring forward, and reading up for the other participants.

During the experiment, an interesting collective inspection, interpreting, and learning situation was formed. An example of such a collective investigation was a review of a patient on the last day of the experiment. The handover was attended by 5 nurses, the team leader and nurses A, B, C, and D.

The patient record concerned an elderly woman from Pakistan who did not speak Danish. The review lasted for 12 minutes and 30 seconds and started with the team leader reading up information from the preceding shifts:

Team leader (browsing through the patient record in chronological order and highlighting the text in the different open windows as she reads): "... seems a little fatigued but awake; follows request that she understands; nice and free respiration; gets her usual inhalations with asthmatic inhalator; blood pressure is fine; had eaten yoghurt this morn-

ing; drinks well; feels thirst; urination in toilet; dry diaper; bladder scanned to 250 [milliliters] hereafter, but the patient does not feel any need for urination. Son informs that the patient at home did have frequent urinations which points to usual flow of urine. We continue the control after each urination and observe need for SIP [a scoring system for Stroke Intervention Parameters that indicates the scope and level of severity from an acute apoplexy]. Needs to be followed by 1-2 persons when getting to the toilet; did brush her teeth herself; washes her hands herself; can use her arms for miscellaneous activities ... the patient has during the past 12 hours had an increasing creatinine - observe [this]; she is quite asthmatic; heart rate was 100 at 1800 hours; she is not influenced by this - observe; patient had still low blood pressure in the beginning of the shift; she has been given [drug] which increases the blood pressure; physician in attendance will inspect patient; sodium chloride is installed for slow infusion over night; fluid control started ... because of increasing creatinine the infusion of sodium chloride is increased ... patient eats only sparsely; in the evening shift she gets 150 milliliters soup and a banana; is helped by her son; must be urged to drink ... fluid control attempt at 2100 hours as patient had over 325 [milliliters] when bladder scanned, but control failed; unknown when patient urinated; diaper was wet; physician in attendance attempts a catheterization, but without success ... contact made to Gyn [the gynecological department] ... they will come and make a catheterization."

At this point a discussion is initiated about the fluid control and the problems of catheterization. Patients with acute apoplexy are routinely observed with regards to bladder dysfunction, since a stroke often effects the nerve paths controlling the urination.

Nurse A makes the remark that the patient is very hard to scan: "*I would say that it is difficult to scan the patient because [her tissue] is a bit adipose and I find it difficult to assess what it really is [that I am scanning]: Is it the stomach that I scan or what it is – and what way it [the scanner] should turn – well I must say I had troubles scanning her, so maybe we are scanning her wrong?*"

Nurse B adds that: "*But the frequency? It could of course be a bit of a bladder dysfunction when she does get frequent urinations but it might also be that she is intolerant to this?*" ... Team leader: "*[You mean the] catheterization?*"

The team leader continues: "*Catheterization done by physician at 1200 hours; at 1330 urine in the bag; a little urine in the tube; bladder scanned several times with different results: From 13 milliliters to 400 milliliters; awaits urine in the bag ... And this morning; one new liter of sodium chloride has been put up as arranged with physician in attendance as there is suspicion of possible dehydration. Only 100 milliliters in the bag at 600 hours; complaints from pain in stomach and bladder region; Bladder scanned to 8 milliliters...*"

Nurse D interrupts by saying: *"That sounds suspicious"* but the team leader continues undisputed: *"... and the sodium chloride has entered, physician in attendance informed, agrees on giving 1 gram of 'Pinex' in day shift, awaits further planning..."* Then the team leader is interrupted once again this time by nurse B: *"Honestly ..."* Nurse D adds: *"Where is she depositing it? – that's insane."* Nurse B continues: *"That's really a lot of hours with that catheter. Well I don't know if it works but it did work - a little came out."* Nurse D: *"Can we read if there was something [in the bag] when she was catheterized [the second time]?"*

The team leader opens a window in on the screen and checks for this but there is no further information on this in the patient record.

Nurse B ask: *"Is there ordered any blood tests this morning?"* The team leader responds *"Let's see..."* and opens a window for this. Looking at the laboratory results nurse C remarks: *"And the creatinine is on its way up"*. Nurse B says with a low voice *"There is something wrong"*.

They continue studying the laboratory results. Team leader: *"...it's here, fluid and lymphocyte balances this morning..."* Nurse D requests the team leader to open another window with graphs showing the fluid balances: *"Would you try to look at ... no that one ... the one you had up there ... can you click at the answer ... up there ... try making a right-click on the result up there ... what does that say?"* They investigate the curves where the figures are presented when using a mouse-over function. They note that one of the fluid controls has been recorded wrongly.

After investigating the recent laboratory results and the fluid balances they continue by investigating the SIP scores. This investigation is done in order to investigate if the observed bladder dysfunction can be due to a stroke.

Team leader: *"She is scoring 2 on legs and she has top scores on the other ones except language where she gets a 3. She has a blood pressure measured to 108 over 82 and a heart rate on 118 and her temperature rose to 37.6 this morning."* Nurse D continues: *"... the language, I mean you might question if [the score is due to] they couldn't do otherwise. Without mobilizing [one of the SIP scores] it adds up to 6."* Team leader: *"I did score her and I got a [language] score reading 6 because the son told me that she had problems in mobilizing words."* Nurse D: *"Then it's a question if she got 3 because they were in a night shift [where the son was not there] and they could not do anything else?"*

The result of this investigation confirms a hypotheses that the bladder dysfunction is not due to acute apoplexy. They end the investigation by checking the patient's weight measurements in the system to see if they show a congestion of fluids but they end the investigation noting that the patient's weigh was not recorded during the past 24 hours.

The investigation resulted in a decision to control the patients fluid balance (measuring all fluids getting in and out)

every second hour. The hypotheses that the investigation led to (that the patient suffers from a potential acute bladder dysfunction which is not due to her acute apoplexy) would be brought forward at the upcoming team conference (further described below).

Nurses Adds their Observations to the Team Conference Screen

The nurses active role as (orally) presenting the status of a patient on the team conference was reduced during the experiment as a result of the collective reading described above.

During the workshops it had been discussed that the EPR could support interdisciplinary work by making it more easy for the users to read information recorded by different types of clinicians – for example that the physicians could be more aware of the observations made by the nurses. The physicians however noted at several occasions that they would very much like to read the observations made by nurses but it had to be "coded" somehow as they do not want to read the long prose texts that characterize the traditional nursing record.

As a result of having experienced how the projected screen (designed by participation of the chief physician) determined the agenda and discussion during the team conference, the nurses proposed that this screen was added a window in the upper right corner indicating observations done by nurses. This change was agreed to by the chief physician and implemented during the third day of the experiment. The result was that important observations done by nurses during their shifts was instantly visible – with no need for a nurse to kind of raising his or her hand during the conference to orally add an observation to the discussion of a patient. In order to make entries to this window the system was reconfigured so that the nurses (as a further structuring than the experiments Virginia Henderson categories) could add observations as a problem type.

During the past three days of the experiment we could observe how the nurses' entries at the team conference were advocated in parallel with the data and observations on the screen chosen by the chief physician. The effect was that the nurses observations affected the agenda of the discussion and that their voice and role became a more peer-like. An example is described below.

The example is from the team conference following the nursing handover described in the above section with the Pakistan woman. The team leader from the nursing handover added their observation on the urine problem prior to the team conference. There was then three observations (the first two from the day before) appearing at the upper right window of the conference screen:

- Fluid balances
- Apparently reduced strength in right arm

- Urine retention, catheter [new problem added in between the handover and the conference]

At the team conference he patient was reviewed for 2 minutes and 20 seconds. The conference was attended by 9 clinicians: 2 physicians (including the chief physician), 3 nurses (the team leader and nurse D from the earlier handover as well as the administrative head nurse) a neuropsychologist, 3 therapists (physio-, occupational-, and speech therapist), and a medical secretary. The team leader initiated the review by stating the problem the nurses identified at the nursing handover:

Team leader (right after bringing the patient on the screen): *"There is something wrong [with regard to this patient] because there is not coming anything out of the other end..."* Nurse D adds *"...of urine."* Team leader continues: *"Attempts were made to SIP-score her yesterday; she has been catheterized and SIP-scored again, so there is a lot [to do] for the ward round and we are a bit ... [concerned] ... the CT [scanning] showed an infarct but it was hard to see on which side it was..."* The physiotherapist objects *"No not quite – sorry but..."* Team leader continues: *"When we are [SIP] scoring her then it is hard to assess – she can hardly lift any of her arms"*. Nurse D interrupts [addressing the new problem added to the nursing observation list]: *"What's new is the urine retention that we are not able to take action on"*. The physiotherapist continues and returns to former issue: *"When we [the therapists'] assess her [we observe that] she is generally weakened but it is the right arm that's the problem [indicating an infarct in the left side of the brain]. She can hold a glass but she has reduced functionality from the shoulder – that's where the immediate symptoms were... But it [her general weakness] has increased during the past two-three months. I talked to her son [and he told me that] in between she have had two periods with a very high fever and she has gotten a rash all over and he told that she, among others, had gotten new skin on her feet..."*

Now the chief physician interrupts the physiotherapist and returns to the issue forwarded by the nurses: *"There is apparently something wrong with her [fluid] system. Do we know anything about her past [diagnoses]?"* The team leader opens a window with a list giving an overview of the patients hospitalizations from the past 5 years. The chief physician looks at the screen and continues *"She did previously have an infarct..."* Nurse D adds: *"It's one year old"*. Chief physician: *"... And a little hypertension – but that does not explain the issue of her [fluid] system."* Nurse D: *"I am quite concerned since she is not producing urine – as far as we can..."* Team leader: *"So she might have to be prioritized so that eeh..."* Chief physician: *"Yes, she must be highly prioritized"*.

In the example there is no detailed summary of the discussions from the nursing handover. The nurses are confident in their analysis and introduces the patient by pointing to their new observation. All three observations in the 'nursing

window' is touched upon while the nurses emphasizes the new problem of urine detention. The chief physician recognize this as an urgent problem, checks for earlier diagnoses (that do not bring any further explanation) and the session ends by giving the patient high priority: This means that the patient is the first on the list for the following ward round. The other physician present at the conference saw the patient at her ward round and the patient was in less than one hour after the conference moved to a nephrological ward under suspicion of an acute kidney failure. Follow-up interviews with clinicians indicated that this decisive action might have saved the patients life.

CONCLUSION

Our PD experiment visualizing EPR on large projected screens led to some interesting reconfigurations of the cooperative work among the clinicians present during nursing handover and team conference. These reconfigurations include the change from oral information to collective reading, collective investigation of the patient record, and the nurses increased communication means at the team conference. We have demonstrated that reconfigurations leading to positive effects on clinical cooperation can be obtained by such large scale PD experiments. At the workshop I would like to present examples based on video clips and recordings of the screen interaction from the nursing handover and the team conference that illustrates the reconfigurations and effects discussed in this paper.

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BIOGRAPHY

Jesper Simonsen study work practices of users and designers for the purpose of offering theories and methods for systems design in an organizational context. He is a co-author of the book "Participatory IT Design - designing for business and workplace realities" (MIT Press, 2004). Since 2004 engaged in the HealthcareIT (HIT) research program and 'Evidence-based IT development' investigating how the effects of the use of a system could play a prominent role in the contractual definition of IT projects.