ORGANISATIE

DORA: Tracking Patients and Devices

Radio Frequency IDentification technology (RFID) can be used to improve efficiency, improve patient safety and reduce costs in operating rooms. To facilitate the design, implementation and effective use of RFID in healthcare, we proposed a practical approach based on Participatory Design presenting which critical success factors to take into account and how to bring these critical success factors in practice. Using this RFID specific Participatory Design approach, two RFID based systems, called DORA-device and DORA-patient, were designed, implemented and tested in two Dutch hospitals.

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The operating room (OR) has been recognized as a site where patient safety issues and high costs often emerge. Despite various initiatives related to patient safety, the progress has been slower than previously projected. In order to improve patient safety and reduce costs, OR processes need to focus on operational efficiency, in which information technology could substantially contribute. An example of information technology is Radio Frequency IDentification (RFID), which can be used to locate equipment, detect instrument use and track patient flow (Kamel Boulos & Berry, 2012; Kranzfelder et al., 2013). However, adoption and effective use of RFID technology in healthcare is still rare, as most projects focus on the technological aspects and overlook the social and organizational context (Berg, Aarts & Van der Lei, 2003; Fisher & Monahan, 2008; Kamel Boulos & Berry, 2012; Yao, Chu & Li, 2012).

To facilitate the design, implementation, adoption and effective use of RFID in healthcare, we combined Participatory Design (PD) principles with the 'Critical Success Factors Framework' of Yao, Chu and Li (2012) into a practical approach. This RFID specific PD approach presents which critical success factors to take into account and how to bring these critical success factors in practice. Secondly, we applied this RFID specific PD approach to design, implement and evaluate two systems that are part of the DORA (Digital Operating Room Assistant) project: DORA-device and DORA-patient.

For more information, see Guédon et al., 2015, Guédon et al., 2014 and Wauben et al., 2015.

RFID specific Participatory Design approach

Figure 1 presents the strategic factors, the actions and the main five PD principles (multidisciplinary team; participation users; focus on early adopters; structured cycles; iterations) used to design and implement DORA-device and DORA-patient in two hospitals.

Figure 1 shows that DORA-device included eight strategic and twelve tactical actions and DORA-patient included six strategic and twelve tactical actions. The most applied PD principles were the 'multidisciplinary team' and 'participation users (active involvement)'. In nine actions no PD principles were explicitly used (within factors 'consider privacy concerns', 'integrate existing IT infrastructure' and 'integrate & manage data'). Seven actions (indicated with * in figure 1) proved to have a key impact on the implementation process in terms of time and costs and especially required the participation of the multidisciplinary team. Nevertheless, the remaining actions also need to be taken into account, as all actions together are required to ensure a successful implementation.

DORA-device

The aim of DORA-device is to intuitively show the safety status and location of OR devices to OR staff. DORA-device is also linked to the hospital's technical facility management system (Ultimo) of the department of Clinical Physics.
DORA-device was designed and implemented in four ORs of the Reinier de Graaf Gasthuis in Delft and contained the following components (see figure 2):

- 94 active RFID tags (869.3 MHz, 10 mW including a button and a LED) attached to OR devices used for laparoscopic procedures (34 anaesthesia and 60 surgery devices);

- 10 readers to detect and localize the RFID tags;
- 1 gateway;
- 1 server that communicated through a Microsoft SQL Server database with Ultimo (hospital's technical facility management system);
- 4 tablets (iPad3, Apple Inc., USA) to interface with the OR staff via a web application (developed by DoubleSense B.V., the Netherlands). A green tablet screen indicates: devices are present in the OR, the maintenance is up-to- date and the devices are tested to work properly. A red tablet screen indicates: maintenance is overdue or a malfunction has been reported. A grey screen automatically opens when the button on the RFID tag of a malfunctioning OR device is pushed. In this screen the reporter's name and explanation of the malfunction needs to be reported. After reporting, the screen turns red and all information is send to the department of Clinical Physics and automatically registered in Ultimo. Once the device is repaired and its status updated in Ultimo, the tablet turns green.

The location and safety status of the OR devices were instantly determined. For the OR staff, DORA-device enabled them to check the safety status of the devices and to notify malfunctions. For the staff of the department of Clinical Physics, DORA-device assisted them to get information about the malfunctions automatically in Ultimo and to get information about the devices' location.

				PD principles				
Factors	DORA-Device	DORA-Patient	Actions	Multidisciplinary team	Participation users	Focus on early adopters	Structured cycles	Iterations
STRATEGIC FACTORS								
Support of top management	√		- Support of head of OR complex, head of Department of Clinical Physics					
		√	- Support of CEO, Quality & Safety Consultant					
Establish clear objectives & vision	√		- Establish by staff and research project group *					
		√	- Establish by top management and research project group *					
Establish project plan & timeframe	√	√	- Define structured project plan					
	√	√	- Establish expected timeframe *					
Choose reliable & experienced vendor	√	√	- Co-develop with experienced RFID R&D company (not particular healthcare)					
Consider privacy concerns	√		- Do not use patient data					
		√	- Use anonymous patient data					
	√		- Use secured internal network					
	√		- Use secured access points for integration with other systems					
TACTICAL FACTORS								
Start with small & customized project	√		- Focus on specific rooms and specific devices					
		√	- Focus on specific rooms and specific patient groups					
Integrate with existing IT architecture	√		- Communicate with internal technical facility management system					
		√	- Use stand-alone system (no integration, communication with other systems)					
Perform site survey & performance testing	√	√	- Perform workflow survey *					
	√	√	- Perform site survey for installation of hardware in OR complex *					
	√		- Perform interference testing *					
Integrate & manage data	√	√	- Process data by RFID R&D company					
	√		- Limit information saved in internal technical facility management system					
		√	- Use stand-alone system (no integration, communication with other systems)					
Support effective communication	√	√	- Support communication between departments					
	√	√	- Design graphical user interface *					
Train & educate	√	√	- (Repeatedly) Perform instruction sessions and distribute instruction documents for different stakeholders					
	√	√	- Be present during first days of implementation					
	√	√	- Distribute newsletters and progress reports					
		√	- Inform patients					

Figure 1. Actions taken and Participatory Design principles used to implement DORA-device and DORA-patient (* actions having an important impact on the design and implementation process)

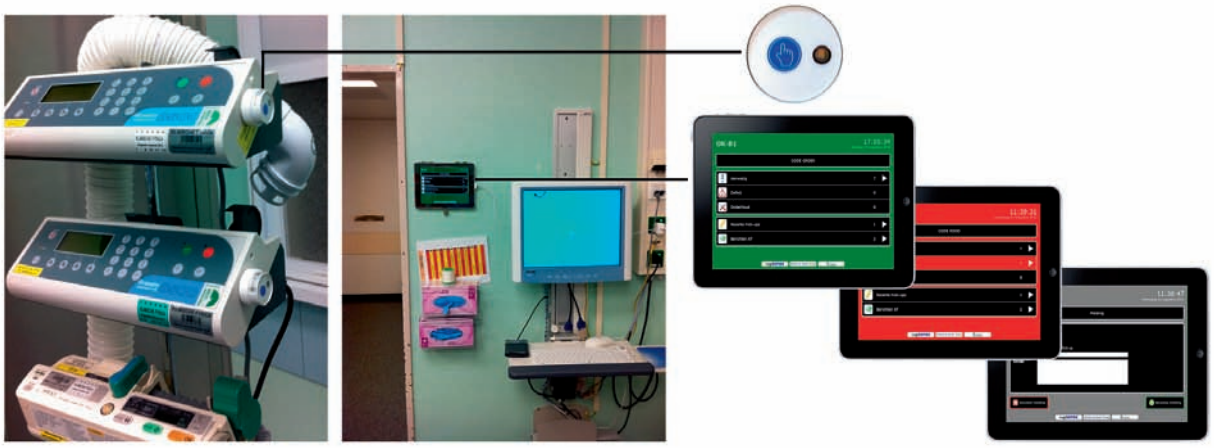

Figure 2. DORA-device. Left: RFID tags placed on OR devices. Middle: the tablet in the OR. Right: the tag, the graphical user interface with green and red screen and the grey screen for notifying malfunctions.

Data collection

DORA-device was tested during a pilot period of six months. Its feasibility was tested by semi-structured interviews with OR staff and staff from the department of Clinical Physics, and by determining the tags' location accuracy. The effect on the number of notifications and the way of notifying malfunctions was studied as well.

Results

Usability

All OR staff members (n=13) said they looked at the tablet at least once a day. When the tablet was showing a red screen, the nurses and the medical specialists had different reactions. The nurses looked further on the tablet for more information and the medical specialists did not, but consulted the nurses about it.
Regarding the notification system, the majority of the users found it easy to use. Finally, all four members of the department of Clinical Physics and ten out of 13 OR staff members would like to continue using this system in the future. The other three OR staff members did not have a clear opinion.

No difference in time to search for devices in the hospital was noticed during the pilot, because the periodic maintenance (when the search for devices can be time consuming) did not take place during this period.

Accuracy

For 86.6% of the total time, the tags location was considered accurately.

Malfunction

62 malfunctions were reported during the pilot period, versus 50 malfunctions in the previous year. Overall, 21 malfunctions were reported using DORA-device and 41 notifications were made in the usual way of notifying malfunctions (by calling the OR team leader or the department of Clinical Physics and by marking the device as defect).

DORA-patient

The aim of DORA-patient was to track patients admitted for surgical day care in order to measure wait times and length of a hospital stay. Secondly, a DORA-patient user interface was designed to show the patient's location to staff and family.

Table 1. Duration surgical procedure and total time spent in hospital [hh:mm].

	General anaesthesia (n=405)	Local anaesthesia (n=217)
Duration surgical procedure		
Average (STDEV)	01:05 (00:33)	00:35 (00:17)
Median	00:57	00:31
MIN - MAX	00:17 – 03:59	00:06 – 02:16
Total time spent in hospital		
Average (STDEV)	07:01 (01:47)	04:17 (01:29)
Median	06:46	03:54
MIN - MAX	01:51 – 14:26	01:22 – 10:50

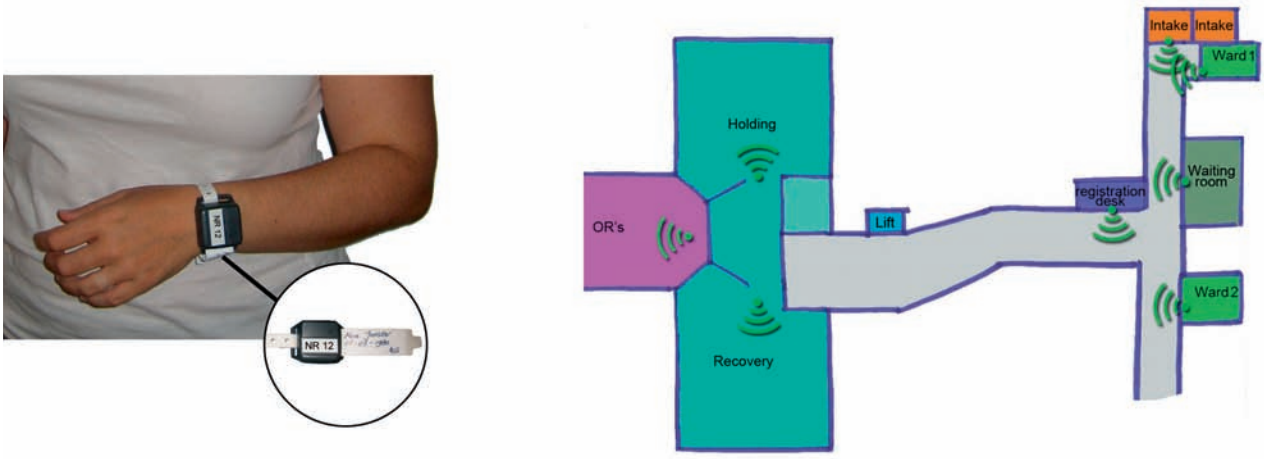

Figure 3. DORA-patient. Left: active RFID tag attached to the patient's identification wristband. Right: layout of the surgical trajectory and location of the RFID readers.

RFID technology was implemented at the main surgical centre (including four ORs) of the Rotterdam Eye Hospital and contained the following components:

- active RFID tags (pulse rate 0.8; frequency 433.92 MHz; power 1 mW; weight 24 g) attached to the patients' wristbands (see figure 3, left). Patients received the RFID tag at arrival at the registration desk and the ward nurse collected the tags during the checkout meeting. After their use, the tags were cleaned with alcohol and used again;
- 8 readers (GW3D, RePoint, the Netherlands) and controllers (to store the data locally) placed at 8 locations along the surgical trajectory (see figure 3, right). The readers were integrated in the ceiling and connected to the hospital's wired network;
- 1 stand-alone server (Dell OptiPlex 790) to store the rough data.

Data collection

Interviews

Semi-structured interviews with escorts (family or friends accompanying patients), ward nurses and holding/recovery nurses were conducted to question them about current information flow and future wishes. The interviews were conducted before the next 'tracking patients' part.

Tracking patients

Adult patients admitted for surgical day care received the RFID tag at arrival at the registration desk of the ward. The patients were tracked along the different locations via the RFID tags, which represent the different phases:

1. Pre-operative ward: including the locations registration desk, waiting room, intake room and ward 1
2. Holding
3. Operating Room
4. Recovery
5. Post-operative ward: including the locations ward 1 or ward 2, and the waiting room

Patients were tracked during 52 successive weekdays. Data on the location and time spent at each location were collected and calculated. Based on these data, length of a total hospital stay as well as phasic lengths of stays and wait times were generated.

User-interface

Based on the interviews and the results of the 'tracking patients' part, a user interface for DORA-patient was designed to show the patient's location to staff and escorts.

Results

Interviews

30 escorts, 9 ward nurses (out of 15) and 8 holding/recovery nurses (out of 10) were interviewed. The results showed that in the future, most escorts would like to receive progress information about: progress at the surgical centre (n=19) and arrival time at the postoperative ward (n=22). The ward nurses would like to receive progress information about: patient's registration (n=7), intake meeting conducted (n=9), patient ready to go to the holding (n=8), patient ready to be picked up from the recovery (n=8) and patient ready for checkout (n=8). Finally, most holding/recovery nurses would like to be informed about: patient on his/her way to the holding (n=7) and ward nurses on their way to pick up the patient at the recovery (n=6). Six nurses also indicated that a digital information system could replace the phone calls to and from the ward.

RFID tracking

Data of adult 622 patients were collected and consequently included in the analysis. Patients were

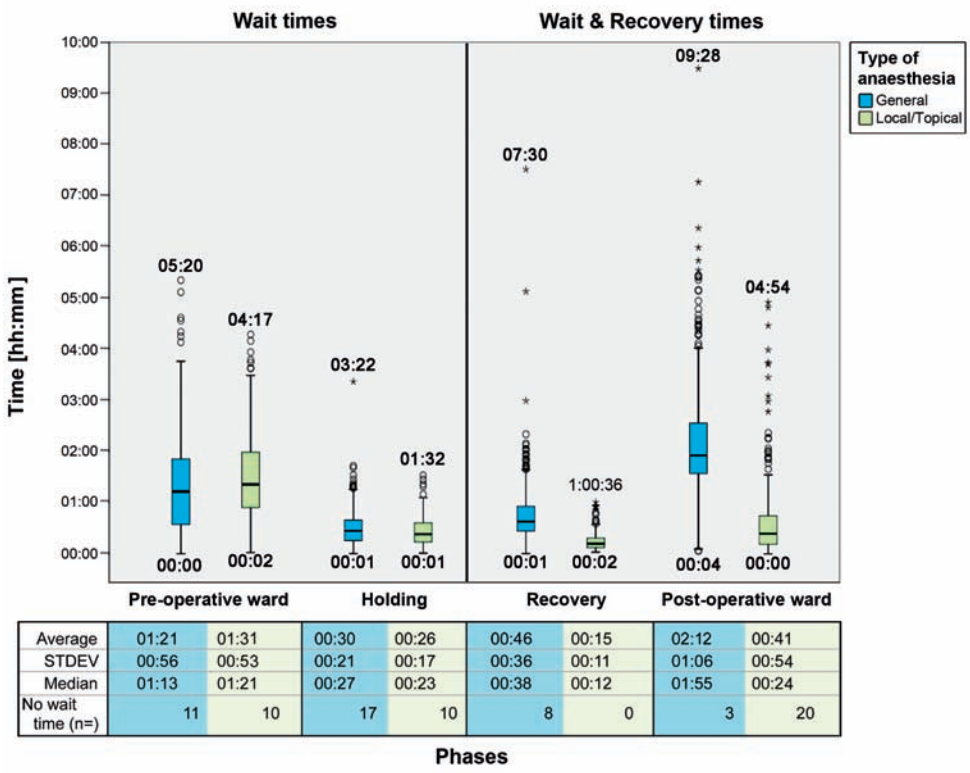

Figure 4. Wait time and wait-recovery time per phase (o=outlier, *=extreme case).

grouped based on the type of anaesthesia: general anaesthesia (n=405) and local or topical anaesthesia (n=217). The type of anaesthesia influences the recovery in the postoperative phases (recovery and postoperative ward) as patients under general anaesthesia have to recover longer than patient under local anaesthesia.

Surgery performed under general anaesthesia took on average 01:05 and surgery performed under local anaesthesia took on average 35 minutes (see table 1). On average, general anaesthesia patients spent 07:01 in hospital and local anaesthesia patients 04:17.

Figure 4 shows the wait times and wait-recovery times per phase. The total wait time for general anaesthesia patients during the entire hospital stay ranged between 0-87.0% with an average of 68%. For local anaesthesia patients, total wait time ranged between 21-86% with an average of 64%.

Interface

A user interface for DORA-patient was co-designed with the ward nurses, patients/escorts and the hospital's management (shown in Figure 5), automatically displaying the phase a patient is in. This interface aims to provide transparency for patients and staff into the surgical trajectory and is expected to reduce recurrent communication between departments, improve process efficiency between departments and improve patient and staff satisfaction.

Conclusion and discussion

The RFID specific PD approach was effective in guiding and supporting the design and implementation process of both DORA systems. It showed which actions had a key impact on the implementation process in terms of time and costs.

Both DORA modules were co-designed with the relevant stakeholders to fit the current organizational structures and the complex workflows of the multiple users group. The design and implementation of both systems met the six key attributes of successful innovations described by Greenhalgh et al.: Relative advantage, Compatibility, Low complexity, Trialability, Observability and Potential for reinvention (Greenhalgh et al., 2004). Incorporating these attributes resulted in a positive feedback on the usability of DORA-device by most users. The users of DORA-device also mentioned that it provided a better overview and information facility, an easier and faster notification system, and a faster detection of problems. DORA-patient provides transparency about the surgical trajectory. A nurse stated: 'DORA-patient allows me to have more time to provide patient care instead of answering questions', and a patient stated: 'DORA-patient allows me to know when we can go home.'

Both DORA modules are now in place and used daily. We will continue to monitor the hospitals to study the rate of adoption of the DORA systems and we will continue to improve and adapt the DORA systems to more ORs, more departments, more devices and more patients.

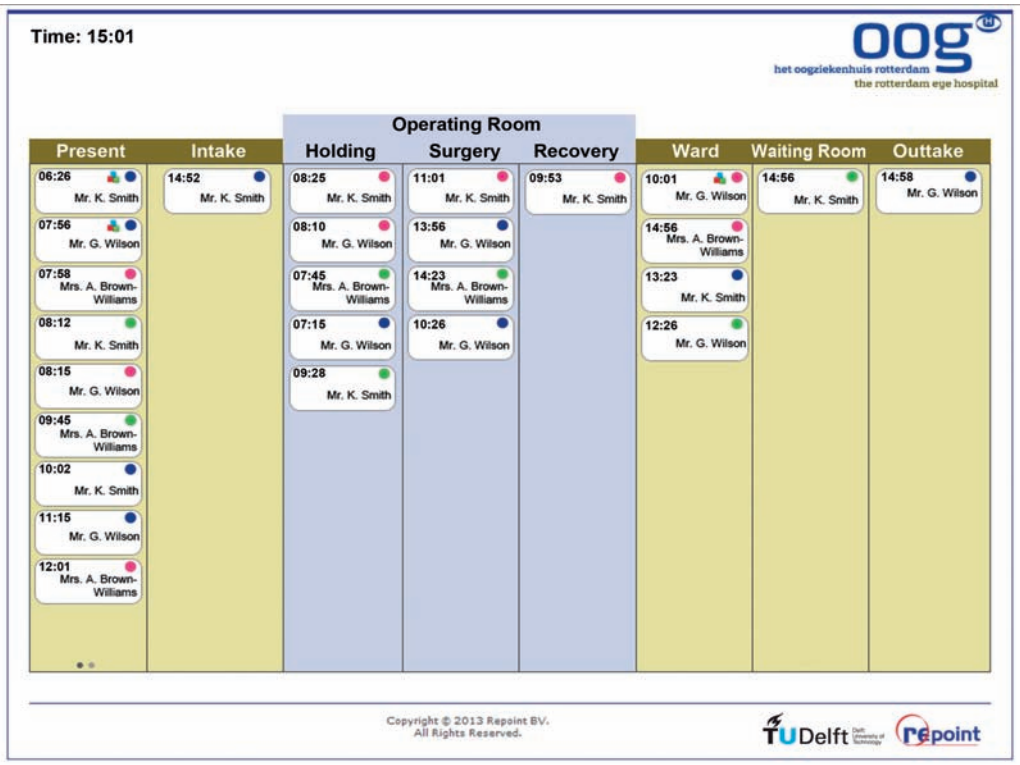

Figure 5. User interface of DORA-patient. The patient cards include the patient's name, the time a patient arrived in a specific phase and a coloured dot representing the responsible ward nurse for that specific patient.

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