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Supporting Safety in Health Care Transformations

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Abstract. Health care is in dramatic transformation due to the rapid development and massive implementation of (high- and low-tech) technologies. But not all transformations are as intended. Research in health transformation has disclosed new sources of risk and unpredictability, which require more research and organizational adjustment, i.e. learning. However, unintended consequences and effects occur at different levels of interaction and collaboration, requiring corresponding adjustment and learning strategies. – On the background of an ethnographic study of support-work in surgery in different Danish hospitals, this paper analyses cognitive-socio-technical health care practices as learning ecologies, giving special attention to the intentional and unintentional roles of technologies herein and their context dependency. The paper argues for an increased awareness of support at different contextual levels of use, presenting three examples from the study as learning cases. The three cases exemplify instances of disruption of the workflow and the collaboration among clinicians. They display how these instances are taken as challenges requiring learning at different levels in order to live up to the overall purpose, which is to reestablish safety – in the team and for the patient.

Keywords. Transformation, HIT, patient safety, unintended consequences, infrastructure, learning, support, ecology

1. Introduction

Technologies play a decisive role in health care transformation, but not always as intended by developers and implementers, or wished for by users. This has led to a new research agenda for patient safety, as hospital information technologies (HIT) have induced new kinds of errors, and unintended consequences [1-4]. These hazards to clinical work have subsequently been studied as human factors in system design, with an emphasis on cognitive user aspects of interacting directly with the system, or as socio-technical challenges from a poor 'fit' between system and the work process of the organization. A more holistic view is advocated within a three-level framework, integrating both cognitive usability tests with social-technical analysis of communication and interaction in simulation studies in order to improve the design of the system prior to implementation [5]. Trends in HIT show, though, that the literature focusing on technology-induced errors continues to grow. More research is recommended to better understand and mitigate these types of errors [6]. There is a wide acceptance among researcher and policy makers that errors have many sources, and that research in software engineering, human factors, sociotechnical and organizational perspectives all are important to ensure safety in HIT [6]. One important approach is to see "errors as opportunities to learn from with the focus of improving HIT across the system

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development life cycle" [6:72]. One might also see errors as a source for organizational learning in order to improve workflow and to develop educational competencies that ultimately prevent errors and ensure quality in the long-term. Educating health and HIT professionals thus becomes important to fully disclosure and understand technology-induced errors [6]. Future directions of research are to "create organizations where there is a culture of HIT safety" [4]. This paper takes an organizational learning perspective, seeking to support HIT and health professionals' understanding of the contextual and cognitive, socio-technical nature of safety, and health care infrastructure [1,5]. An ethnographic study of support-work in surgery is chosen [6,12,13] to demonstrate the challenges of safety and learning in technology-dense health environments were predictability and team-collaboration is mandatory to patient safety.

2. Learning ecology

The three level framework of studying technology-induced errors in health care can be explained within the cultural-historical tradition of Activity theory, which discerns between three contextual levels of interacting with technology as an activity system, and the learning ecology of Gregory Bateson [7-11].

Human activity is object- and goal-oriented, conditioned by operational skills, embedded into existing practices, mediated by tools, and motivated by collective rules, values and division of labour. Interruptions or breakdown of activities fx from technology implementation can be identified as different levels of learning in the ecology. The 1-level of learning relates to the subject's operating skill and direct interaction with the tool, i.e. cognition and usability. The 2-level learning relates to contextual awareness and utility, when collaboration is mediated by artifacts, then adjusting and integrating different contextual understandings in the system and between users becomes essential. The 3-level learning is provoked from the experiences of double bind between divergent contextual understandings. If they contradict, and mutually exclude each other, then radical learning and creativity are demanded in order to establish a new organizational order. Accordingly, 0-level learning denotes the true ideal state, which is sought, not because of organizational laziness, but as an expression of harmony, the concordance between tasks, competences, motives and resources; the seamless fit between users, systems and activities. 0-level learning expresses the equilibrium of the ecology, and thus the safety and stability of the activity system as such.

3. Case-study of Support Work in Surgery

The case is developed from ethnographic field work with document analysis, 90 hours of observation, and twenty-six interviews [14,15]. It was conducted in three different hospitals located in the Capital Region of Denmark, two of which are university hospitals, with research as part of their practices. All of the hospitals have 24-hour emergency surgery and elective day surgery from 7:30 a.m. to 3:00 p.m. The study was undertaken at four surgery centers, covering the specialties of obstetrics, gynecology, gynecological oncology, orthopedic surgery, urology, abdominal surgery, pediatric surgery, pediatric oncology, and vascular surgery. The elective day programs in nine operation rooms (ORs) were observed, with a special focus on programs of action [16] in operational support work. The support work of nurses, social health care workers, and technical assistance was observed in the ORs, documented through photographs and detailed notes on type of operation, action sequences, relations to humans and nonhumans, and modes of communication. Field notes and interviews were analyzed according to the theoretical frameworks of human–computer interaction and expansive learning in activity theory [11,17,18].

4. Intentional activities in surgery

The many sequences of action, interactions, and communication in the ethnographic study can be summed up as two programs of action (16) that explain the meaning and motives of operation support work in the activity system of surgery: first, and foremost, ensuring safety and second, efficiency. The following presents the first program of action.

4.1. The Program of Action: Ensuring Safety

The first program of action is concerned with ensuring safety in the care pathway for individual patients entering and leaving the OR. Ensuring safety is paramount to surgical support work, as it is not only concerned with the patient, but also with the surgeon's need to feel safe to concentrate on the operation itself and the general safety in the team as a group, with its interdependencies and shared responsibilities. There is a wide range of techniques, guidelines and rituals to ensure smooth and safe collaboration in the OR.

The room is divided into two zones; a sterile zone and a non-sterile zone to manage the continuous risk of infection. The sterile zone in the OR is constantly encroached by various kinds of disturbances that challenge safety in different ways: for example, by increasing the risk of the patient's wound being infected or breaking the surgeon's concentration. A chief surgeon sums up:

> *There is always a risk. We are in a sterile environment. Everything takes place in a sterile environment. This means that I can't just go to a cupboard and get what I need. Everything has to be in place from the beginning. We can plan 90 per cent, but something will always happen that wasn't planned for [...]. It's a balance that means that you have to send people (non-sterile) in and out of the OR/room to fetch the things you need. Or you find out that it's really another type of operation the patient needs, and you have to re-saddle. Doing emergency surgery also amplifies this. These are the terms.*

Operation support work is thus concerned with ensuring maximum safety, knowing that absolute predictability is impossible to attain. There will always be a small amount of risk to learn from, chance to be aware of, and adjustments to make [19].

The "90 percent" predictability of an operation is achieved by the team in a process with three phases: the preoperative, intraoperative, and postoperative phases. These are elaborated in [12], and point to team collaboration in the OR as non-verbal "ping pong" in coordinated movements in and out of sterile and non-sterile, zones to be an ideal.

5. Unintentional transformations from disruptions of interaction, flow and safety

The unanticipated "10 percent" that is impossible to predict and plan for in advance, is always a threat to safety in the OR. Below are examples of disturbances at different levels of interaction, leading to different kinds of breakdowns that challenge the role of the surgery support in the team, its resilience, and the safety of the patient.

5.1. Disruption Caused by a "Burner with No More Lives"

This example comes from gastrointestinal surgery. In many cases, open "low-tech" surgery using a scalpel and suture is replaced by endoscopic, high-tech surgery (i.e., laparoscopy, also called keyhole surgery), where operations are performed through small incisions in the body. A burner is used instead of a scalpel inside the abdominal working space to burn, instead of cutting out, affected tissue. The burning prevents the tissue from bleeding. In this example, the burner stopped working during the operation and, thus, interrupted the flow. The nonsterile supporter had to send for a new burner from the storage room. The surgeon became annoyed with the support workers because the "knife time" of the operation was prolonged by the wait for the new burner.

5.1.1. New task and guideline to keep count of use of burner

In the future, support staff members are expected to keep count of the burners' limited lifetime of twenty operations. This is a new task for the support workers, and they would have to agree on the development of a new "tool," a guideline to control it. Keeping systematic track of burners' lives through a guideline becomes an attempt to handle the high-vulnerability context in which surgery takes place, in a way that attempts to prevent any disruption to safety and efficiency. The technology must work according to plan.

5.2. Change of Direction in Mid Operation

The second example is also from abdominal surgery, on a patient with a gastrointestinal stromal tumor. Lack of access to the digital information system (with the patient's radiology scans) forces the surgeon to switch from the planned endoscopic operation to open surgery. In endoscopic surgery, the working and viewing space is provided by a laparoscope, a long, fiber-optic cable system, and carbon dioxide gas, which inflates the abdomen and thus makes it possible for the surgeon to see inside the patient's body. The image from the laparoscope is displayed on monitors placed above the surgery bed for the surgeons to look at and navigate by. However, they need additional information from the radiology scans to get a better overview to predict the location of the tumor and to navigate between the organs of the abdomen. However, as the information system remains inaccessible on this occasion, the surgeon was forced to change plans, and, thus, the whole operation was converted to traditional, open surgery, where the team members rely on their senses to observe and navigate directly inside the patient's body using their eyes and hands. This conversion of operational procedure increased safety because the nonworking HIT had made the planned procedure unsafe, but it also increased the operation time, the time the patient spent in anesthesia, and the size of the patient's operation scar.

5.2.1. Destabilization of Teamwork Because of an Inaccessible Information System

After the shift to open surgery, the team's spirits were low. There was no "ping-pong" between the team members, just a hostile atmosphere in the OR that was made worse by the knowledge that the patient would have a large operation scar, which in light of the events, became unavoidable—sixteen stitches for an incision of 14 cm. In the end, the surgeon, clearly dissatisfied with the support workers, stated that they were “not a team.” The support workers, on the other hand, had neither the skills nor the administrative user rights to solve HIT barriers. Therefore, the resilience of the teamwork, as well as the sustainability and efficiency of the operation program of the OR, depends on HIT infrastructures, and the organizational support of these.

5.3. Risk in Technology-Driven Research

Image technologies have also opened up new research possibilities between radiology and vascular surgery. Interventional radiology in vascular surgery makes minimally invasive image-guided diagnosis and treatment of disease possible. In this example, a young woman with leg pain from poor blood circulation is diagnosed with narrow veins, using image-guided diagnosis, and is offered treatment via the insertion of a stent to increase the diameter of the troublesome vein. She received only a local anesthetic and expected to participate in the image-guided surgery, holding her breath to improve the quality of the X-ray images, and so on. The stent was inserted after 2 hours of surgery, but after that, a blood clot (vein thrombosis) developed in the leg being operated on. The surgeon monitored developments continuously, viewing new images, and, in consultation with a radiologist, decided to continue with the operation, to prevent paralysis in the patient’s foot. The stent was to be removed, after which, the blood clot would be sucked out to allow the blood to flow through the vein again. This prolonged the interoperational phase by several hours.

5.3.1. Ethical Patient Dilemma: “Hold Your Breath”

The patient is awake, holding her breath every time the accelerator takes an image. The X-ray radiation alarm—which monitors the amount of radiation the patient is being exposed to—goes off several times and is repeatedly turned off manually by the supporting nurse. At the same time, a team of four works intensely on finding and removing the clot by drawing out blood with a tube, called a venous access catheter. The surgeon needs total silence to concentrate. The work of the team requires fine motor skills and many coordinated movements, which are repeated in successive steps: patient holds her breath, X-ray, adjusting tube, drawing blood out, examining it for clots, cleaning instruments, and then again, holding of breath, tube adjustment, and so on, for more than 2 hours. The patient gradually becomes uncomfortable, cries quietly, starts shaking and sweating, and asks when this will be over. In the meantime, the personal assistant of the surgeon is called in, and two extra nurses come in to calm the patient. The patient complains that this was not what she was informed of and consented to. She wants to go home! A senior surgeon tells her that she has to spend the night in hospital.

6. Conclusion: Unintended Transformations in Surgery

Technologies are transforming health care and patient safety, also unintentionally. Technology-induces errors continues to rise [6]. The errors have many multiple sources and demand research into a range of knowledge areas from improvement of technology design to organizational learning [6]. This research draws on ethnographic methods and meta-theory to explicate and draw attention to different levels of interaction [4-6] and learning in health care organization in order identify risk and secure safety [4,9]. The three examples point to interruptions of use that effects the safety in the OR. They transform the activity system at *different levels of interaction*: i.The broken burner at *the direct level of interaction, ii.* The inaccessible Information System at *the mediated level*, as the operation plan gets subverted to knife surgery, disturbing team collaboration, and iii. The role of the patient at *the infrastructural level*, as patient safety which is the core value and motive of surgery is jeopardized, and transformed, when the patient becomes co-responsible for her own safety during the operation. An awareness of these different, contextual levels of interaction is essential to a safer HIT culture. Support of usability and utility problems in cognitive-socio-technical practices are thus sources towards learning ecologies [10] that secure intentional transformation of health care.

7. Discussion: Intentional Transformation in a Socio-technical Learning Ecology

Following the learning ecology [1,2,7-11], errors and interruptions can be addressed as different levels of learning, that the organization can attend to in order to adjust and prevent unintended transformations of its health care practices.

7.1. Supporting Safety from different levels of learning

The overall purpose of the surgery as an activity system is patient safety and efficiency, which is achieved by planning, "ping-pong" and flow in teamwork. This corresponds to the 0.level of the learning ecology; it is a system in equilibrium with optimal use of its resources. This is experienced in the OR as harmony, because everybody knows his or her place and how to fulfill his or her role. It is the team as a predictable and stable "clock-work" with adequate competences and mutual trust, and thus safety.
When the broken burner occurs, the harmony and flow is disturbed, and a 1.level learning situation arises. The obstacle is solved by the non-sterile support worker, who leaves the OR for the storage to replace the burner. Future problems are prevented by creating a guideline for keeping account of the number of times the burner has been used.

The inaccessible information system is a more complex, 2.level learning situation, as the collaboration of the team is not mediated, neither the endoscopic operation, nor the collaboration of the team, as the support workers fail to solve the it-problem. This learning situation is not only an information problem, like in case of the broken burner in the 1.level learning. It is a contextual knowledge problem of understanding how the information system works, and for the support workers to be given administrative user-rights to the system, so that they can support the surgeons in getting access to the radiology scans. This kind of user support in relation to information technologies, that the safety and efficiency of operations depends on, is absent to the team, and outside the competences and jurisdiction of the support workers (all nurses by training). Lack of it-competences and/or it-support becomes a risk to efficiency (from prolonged operation time and anesthesia) and to safety. It also puts the support workers in a double bind, and thus 3.level learning position as the angry surgeon, who leads the team, see it as their task to solve the it-problem.

The third examples points to an ethical dilemma in technology-driven research as the understanding of patient safety in surgery transforms when the patient becomes part of the team, its efficiency and safety. The patient is in a double bind situation of becoming a risk to herself. She wants to leave the operation table while she is undergoing a prolonged operation (from the unexpected blood clot) she has not consented too. The awake patient herself becomes part of the unpredictability, and puts the safety of the team and herself at risk. She has to stay on the table and keep her breath when signaled in order for the operation to be carried though successfully. Her leg is saved, but her patient right is violated, as well as the relationship of trust between patient and health care system, which leave both, patient and the team, in a borderline position.

This 3.level learning situation is not solved by information, like the 1.level, nor by new contextual understanding, the 2.level, but transcends established understandings. It is therefore an unpleasant, stressful position, only to be solved creatively, by thinking out-of-the-box, so to speak. In this case, there is no right answer, but seems to be the backside of research: unpredictability and thereby risk, rises for the patient and for the team, when developing new forms of surgery from new technological possibilities. The 3.level learning opens up to the ethical, and thus the bio-political nature of social-technical ecologies, including research agendas and motives hereof.

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