

Medication, integrations and practice

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Abstract. To ensure quality in medication management, the electronic medication management system (EMMS) must communicate and collaborate with other IT systems in the hospital, particularly the electronic patient record (EPR). To achieve those integrations is not purely a technical task, and the aim of our paper is to contribute to the development of a socio-technical understanding of integration in health care, and to conceptualize infrastructures with the help of boundary work and translations. Empirically, we have studied the implementation of a new EMMS in the Northern Norway Regional Health Authority. Our case shows that the integrations are affected by the existing IT systems in the region. Work tasks that had originally been planned for inclusion in the EMMS were shifted to the EPR due to existing functionality. In addition, differences in the contracts with the two vendors of the systems played a role. Most of the patient pathways and treatment plans extend across both the EMMS and the EPR and the boundaries between the two systems are sometimes blurred. To achieve integration based on this is hard. In addition, some integrations lead to additional work for clinicians, because data from one system to another must be translated between the different contexts, and the clinicians have to approve each translation. Integrations include crossing boundaries, which implies translation and negotiation. These concepts thus need to be considered to achieve successful integrations in health care.

Introduction

Medication management is an iterative and complex process that encompasses all steps in providing medication to a patient: how medicines are selected, procured, delivered, stored, prescribed, prepared, administered and reviewed. The process includes a collaboration between different health care providers and the patient

him(her)self. Ensuring high quality in medication management is a pressing issue for health authorities. In a 2000 US Institute of Medicine report, the Committee on Quality of Health Care in America estimated that medical errors (e.g., errors in administering drugs or planned treatments) were the leading cause of death in the United States (Kohn et al. 2000). Such errors are generally associated with an increased burden of illness for patients and increased expenditures for hospital treatment (Roughead & Semple, 2009; Governmental report, 2005). In Norway, 5-10 % of admissions to internal medicine wards are caused by improper use of drugs (Governmental report, 2005), and medication errors occur in 20 % of all patient treatment pathways, which is associated with expenses estimated at NOK 5 billion each year (Governmental report, 2005). At least 1000 patients die each year from adverse drug reactions and improper drug use in Norway (Norwegian Pharmacy Association, 2014).

Due to the complex and collaborative nature of medication management, it would be difficult for one single stand-alone IT system to incorporate all the needed data, information and processes involved in medication management. Therefore it is crucial, to ensure quality in medication management, for an EMMS to communicate and collaborate with other IT systems in the hospital. It is particularly important to have well-functioning integrations between the EPR and the EMMS, because much of the data collected from the patient is needed in both systems, and because the border between medication management in the EMMS and other treatment that should be documented in the EPR is sometimes blurred.

A principal aim of our paper is therefore to contribute to the development of a socio-technical understanding of integration in health care. Particularly the paper aims to conceptualize infrastructures with the help of boundary work and translations.

We proceed with the following research question: What characterizes integration between an EMMS and an EPR? First, we analyze the different meanings associated with integration in healthcare. Second, we discuss how the existing ICT portfolios and stakeholders' interests and policies shape the process of establishing integrations. Third, we analyze how integrations do not happen by themselves come freely, but depend on the commitment of skilled health personnel.

Empirically, we have studied the formative stages of a large-scale electronic medication management system (EMMS) project in the Northern Norway Regional Health Authority that was initiated in 2012. We focus particularly on the integration challenges between the EMMS and the existing electronic patient record (EPR) system in the northern healthcare region.

Theoretically, we draw on the concept of information infrastructures (Hanseth and Lyytinen 2010; Bowker and Star 1999; Star and Ruhleder 1996). In the rest of this paper, we begin by conceptualizing integration in health care. We then elaborate on our methodological approach. Next, we describe the large-scale EMMS project, followed by some empirical case vignettes. We conclude with a discussion.

Integration of medication data in hospitals

Patients' drug treatment is increasingly complicated. Hospitalized patients generate high volumes of data that are challenging to compare and evaluate. These might include physiological data (blood pressure, body temperature, etc.), results from various blood tests (C-reactive protein (CRP), blood counts, electrolytes, drug plasma concentrations, etc.) or data from medical devices (infusion pumps, etc.). Presently, an overview of medication linked with such data is lacking. This makes it difficult and time consuming for health professionals to make well-founded decisions regarding patients' treatment.

Today, medication management in hospitals is often handled by a paper-based system, and this leads to some obvious issues. Data is either handwritten or stored in another system, for instance the laboratory system, hence the relationship between data entries and medication can be difficult to uncover. The handwriting may be difficult to decipher. The paper with the data and information, in which the clinicians, too, are supposed to document their actions, needs to be available to several clinicians at different places at the same time.

There is a general perception both from most health care professionals and from authorities that information technology could help improve the issues mentioned above and thereby improve the quality of patient treatment (Governmental report no 28 2015, Governmental report no 9, 2015). An EMMS could collect data and present it in a straightforward way, and it could easily show the relationship between different data, such as a fall in CRP due to a change of antibiotics. Several studies also suggest that the use of an EMMS as part of the electronic patient record (EPR) can reduce the incidence of serious errors (Poon et al. 2010, Day et al. 2011, Reckmann et al. 2009, Ammenwerth et al. 2008), due to improved prescription legibility, dose calculation and clinical decision support.

However, the EMMS is not a stand-alone system. An EMMS needs to play along with a great many other systems and technical equipment in hospitals. For instance, data needed in the EMMS is typically harvested from bed monitors and devices that automatically monitor vital signs (e.g. electrocardiography (ECG) leads, automatic blood pressure cuffs, oximeters), which is a routine procedure for patients who have undergone surgery/anesthesia.

Most of the data that is collected in either the EMMS or the EPR could also be useful in the other system. And various patient pathways would normally include processes both in the EMMS and the EPR. So if the aim is systems that provide process and decision support for clinical pathways, there must be integrations between the two systems.

However, EMMSs seem hard to achieve in practice as such systems have not yet become widely available (Meum 2012; Emergis 2006; Aarts et al. 2007; Aarts and Koppel 2009). One reason is that the roles, tasks and responsibilities of different professionals are in practice much less clear than system designers believe. The models the designers use to understand the work processes are often too naïve. For instance, the prescribing of medication is seen as a task performed by physicians, while the work is usually supported by collaborative work practices (Aarts et al., 2007). The boundaries between which tasks and responsibilities the

different professions have in the medication process are often blurred and often include informal delegation from one profession to another (Allen, 1997). The result is mismatches between the EMMS and the workflow processes.

Another issue is that several EMMS do not include information on all patients or on all drugs. For instance, it is common not to include chemotherapy in medication systems and it is common that only some wards at a hospital use the system. This means that users lack the total picture of the patient's medication and the system is not able to follow patients transferred between different wards, implying that users do not get the information needed through the complete patient pathway. Similarly, there may be inadequate integration and communication between the EMMS and other technology systems in the organization. Inadequate integrations lead to lack of needed information in the system and poor clinical decision-making based on incomplete information.

In addition, it has been observed that clinicians may assume that just because the information went into the computer, the right person will see it and act on it. This change in communication patterns could challenge patient safety (Ash et al. 2007).

Another reason is that increased quality of care is often the main reason to introduce an EMMS, but due to the complexity in the work processes and the interdependencies with other systems and collaborative constellations, it is extremely difficult to measure the impact on quality.

These might be some reasons why a successful implementation of an EMMS is hard to achieve.

To summarize, "healthcare is a complex, uncertain environment and there are a great many processes involved in medications management" (Health-e-Nation 2014). To be able to perform those processes in a satisfactory way depends on several different IT systems. And due to the complexity and uncertainty in the processes, the interaction of those systems is challenging. Hence, the establishment of robust integrations between the systems may be hard to achieve. In addition, integration typically implies interconnecting systems developed with different tools that reside on a variety of technological platforms (Tun et al. 2001) and that have been developed for very different purposes.

Healthcare is still a late adopter of integrated systems (Cross 2006). Several studies on integration have suggested that a more organizational and socio-technical approach is necessary for understanding and managing integration in healthcare. Along these lines, Berg (2009) points out that getting such technologies to work in concrete healthcare practices appears to rely on politically textured processes of organizational change. Aarts et al. (2007) focus on how the implementation of a Computerized Physician Order Entry System (CPOE) affects the roles and responsibilities of healthcare workers and that it must fit the workflow in hospitals to enhance quality of care. If socio-technical aspects of the use of such systems are not understood, there is a danger that they may lead to adverse events instead of mitigating them. A key lesson learned from these and other socio-technical studies is that one needs a thorough understanding of the

clinical practices involved when implementing new technology (Silsand and Ellingsen 2014; Aanestad and Jensen 2011; Hanseth and Lundberg 2001).

Looking more closely at the information that is transported across different information infrastructures, we imagine the information as relatively standardized and stable or as an immutable mobile (Latour 1987). For instance, what is sent as a laboratory requisition remains the same when it is received and processed in the laboratory. However, we challenge the apprehension of stable information objects in interconnected large-scale infrastructures. Information is shared across many contexts, and needs to be adapted to particular settings. By applying the notion of translation rather than transmission, Winthereik and Vikkelsø (2005) underscore how the recipient of a discharge letter plays several roles and how different users adapt the letter to their own context. They provide an example of how a general practitioner (GP) modified the discharge letter by highlighting different sections to emphasize important points. Green was used to mark the reason for hospitalization and red was used to mark medications prescribed for the patient (*ibid*, p. 56).

Furthermore, given that there are several stakeholders involved, the strategies toward integration may vary depending on whether these strategies serve the interests of each of the stakeholders (Latour 2005). Existing systems (for instance legacy systems) and practices may also come into play and shape what is possible to achieve (Edwards 2009). Many of these systems have different vendors and users, who potentially have varied agendas that may diverge from the overall goal in new projects. In total, this may influence the extent to which integration is possible (Johannessen and Ellingsen 2012).

The theoretical framework of information infrastructure has been used to study the design, implementation, and use of large-scale information systems (Aanestad and Jensen, 2011; Hanseth and Lyytinen, 2010; Star and Ruhleder, 1996). These systems are never seen as stand-alone entities, but are integrated with other information systems and communication technologies, and with non-technical elements (Aanestad and Jensen, 2011. p. 162). Therefore, analyses of information infrastructures need to consider a broad range of socio-technical issues shaping the implementation process.

A basic principle of an information infrastructure is that it is never built from scratch; rather, it evolves from the installed base, the existing information system (IS) portfolio in specific contextual practices. As a part of this, the infrastructure shapes and is shaped by the work practice in an ongoing co-construction process between technical and social elements (Monteiro et al. 2012; Star and Ruhleder, 1996). During the progression of an information infrastructure in any given context, the installed base may become very large and will shape its environment to an increasing degree. Similarly, the size and complexity of the installed base means that it becomes difficult to replace or change. Therefore, newer versions are adjusted or changed carefully in order to maintain backward compatibility with previous versions (Bowker and Star, 1999). This is a process of ongoing negotiation and compromises for achieving stability or alignment (Latour, 1987).

A crucial part of such negotiation is to establish and maintain the boundary between the new system (the EMMS) and the installed base (the EPR). These

boundaries are not fixed, but may be renegotiated and redefined (Hernes 2004; Barrett et al. 2007) as the implementation process emerges. The task of establishing and maintaining these boundaries resembles what many researchers in the STS field refer to as boundary work (Gieryn 1999; Barrett et al. 2007). The concept is widely used in organizational settings to describe the strategic behavior and the circumstances related to engaging in work to sustain boundaries between different communities of practice. “Generally, when privileged groups engage in boundary work it would mean (...) constructing and maintaining distinctions between themselves and others” (Barrett et al. 2007, p.8). In implementation of a new system, this might include negotiating the boundaries with the larger IS portfolio or clarifying the scope of the system in relation to the users. However, what is particularly interesting in developing new systems is how these boundaries may be expanded (Barrett et al. 2007; Gieryn 1999) due to added functionality, integrations, increasing numbers of users and new requirements. In this sense, we may observe an increasingly influential role of the system, which is in accordance with Lee’s (2007) argument that “artefacts can be used to push boundaries” (2007, p.308).

Method

The study is based on an interpretative research tradition (Klein and Myers 1999; Walsham 1995), where reality is socially constructed among the participants. The epistemological position in interpretive research emphasizes the understanding of social processes by getting involved inside the world of those generating them, and not by hypothetical deductions or predefined variables. The approach also assumes that social realities are not discovered, but interpreted, meaning that a phenomenon is looked at from different viewpoints. In line with an interpretive approach, the authors have collected the empirical data in the EMMS project and in the users’ practice by participant observation, document studies, participation in workshops and project meetings and formal semi-structured interviews.

The purpose of the data collection was to learn about the medication process, to be able to understand how new technology could influence the work practices. Furthermore, we wanted to gain insight into the process of deciding, developing and implementing integrations between the EMMS and other systems used in the hospital.

In total the authors have conducted 14 interviews with nurses, physicians and project members. The duration of the interviews varied from 30 minutes to 1 hour. We used an interview guide, but let the informants choose the direction of the conversation. The interview guide served as a checklist to ensure that the questions of interest were covered. A digital voice recorder was used to record the interviews. Afterwards, the interviews were transcribed. The data collection started in January 2015 and is still ongoing. Table I is an overview of the data collection.

Table I. Data collection

Data collection	
Observations	2 nurses doing reconciliation 2 physicians admitting patients
Documents studied	Plans for the EMMS project Plans for the EPR project
Workshops and meetings	8 workshops in the EMMS project Several meetings in the EMMS project
Interviews	6 physicians from three different wards at the University Hospital of North Norway (UNN) 6 nurses from three different wards at UNN 4 project members (project leader, leader for integrations, representative from the vendor, physician (clinical member)) 1 representative from the EPR vendor

The EMMS project

In January 2012, the Northern Norway Regional Health Authority decided to start a bid for tender process for a common EMMS for the health region. There were several reasons for this: a) A fundamental problem was the prevalence of paper-based medication charts as well as a risk of medication errors, b) the lack of efficiency in the overall medication cycle and c) a lack of functionality for decision support and medication management in patient pathways. The cost of the procurement, the implementation and 15 years of use is estimated at EUR 114 million. It has been decided that the EMMS will cover emergency units, intensive care and anesthesia departments, operating rooms, outpatient clinics and clinical wards. To support the needs of health personnel at every step in the patient's pathway, the EMMS is intended for use wherever the patient is located. The aims were: 1) A standardized and integrated system that supports complete patient pathways. 2) Automatic data acquisition from medical technical equipment and devices. 3) Overview of drug interactions, dosages, adverse effects, mixing, administration. 4) Access to the patient list of medications through the whole patient pathway. 5) Clinical decision support.

Like EMMS projects internationally, this project is recognized as having an extremely high degree of complexity. This complexity in turn requires a very flexible technology, as the EMMS project group recognizes: "The system must possess a high degree of flexibility to be able to collect data from different sources and digital resources (...) [this includes] development of modules, configuration, adjustments, integrations and interconnecting medical instruments". Likewise, the system is intended to have a large inter-departmental scope (intensive/anesthesia wards, ordinary bed wards and outpatient clinics). In 2014, the Norwegian ICT vendor Evry won the contract for the delivery of the EMMS MetaVision. The project continued working together with the vendor Evry on configuring the software to adapt to the Northern Norway Health Authority. The work is ongoing, and the implementation is planned to start in 2018.

As stated above, the EMMS needs to be tightly integrated with other key systems in clinical practice, most notably the EPR from the vendor DIPS ASA. The DIPS EPR has been running in the northern healthcare region since 2004. In 2015, the management in the EMMS project ordered several integrations between the EMMS MetaVision and the DIPS EPR from the vendors. These are as follows:

From DIPS EPR to MetaVision:

1. Patient information (demographic)
2. Contact and localization information including the patient's bed
3. CAVE (list of allergies) and critical information
4. Reconciled Medication list on admission to the hospital

From MetaVision to DIPS EPR:

1. Active medication
2. Context synchronization between DIPS EPR and MetaVision (to ensure that the same user and the same patient are activated in both systems at the same time)

The integrations were contracted to be delivered before December 31, 2016. After that the integrations will go through a verification test with clinicians in May 2017. Other planned integrations were put on hold, such as integrations related to surgery planning and patient pathways. However, in the integration efforts, it became increasingly clear that the EMMS project was facing serious socio-technical integration challenges. In the following sections, we offer a few vignettes that highlight these challenges in detail.

Case

Admitting the patient – using the EPR for medication reconciliation

When the patient is admitted to the hospital, the content in the medication list should be quality assured. Medication reconciliation is the process of creating the most accurate list possible of all medications a patient is taking — including drug name, dosage, frequency, and route — and comparing that list against the physician's admission, transfer, and/or discharge report, with the goal of providing correct medications to the patient at all transition points within the hospital. This includes asking the patient about his/her medication and checking different information sources. This process results in a medication list that represents documentation of what the patient actually used when admitted to the hospital.

Because the hospital has a paper-based medication chart today, the checking against other information sources must be done manually. The goal in the future is that this could be done partly automatically by comparing the drug list at admission to information from other electronic sources such as the national core record, the e-prescription database or the medication list from the general practitioner, home care service or nursing home. The one with the easiest electronic access and most updated information today is the e-prescription

database, and the plan for the Northern Norway Regional Health Authority was to develop functionality where the drug list in the e-prescription database is compared to the medication list at admission.

The EMMS project group (including representatives from the vendor Evry) and DIPS ASA discussed whether reconciliation should run in the EPR or in the EMMS. In one way, the EMM was preferred because it is a task closely related to medication management. However, the EMMS project decided that this process should run in the EPR because the EPR, unlike the EMMS, had good functionality for the task and because a reconciled medication list represented a historical document that had to be time stamped, signed and stored in the patient's EPR. Based on this, the project decided that the EPR was better suited for this process. Figure 1 shows what the reconciliation looks like in the EPR.

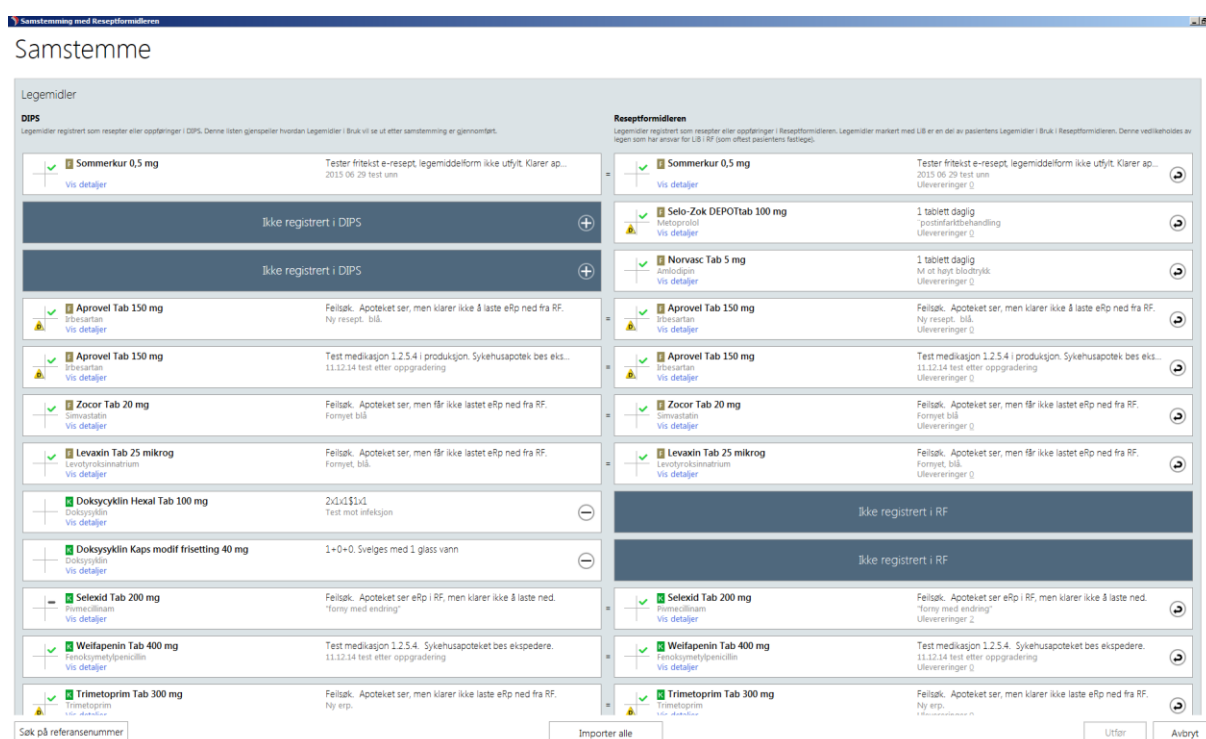


Figure 1. Reconciliation in the EPR. The list to the left is from admission. The list to the right is from the e-prescription database. The dark blue areas show deviations between the two sources. It is easy to indicate discontinuation or addition of drugs by clicking on the plus or minus sign.

Hospital stay - the EMMS takes over responsibility for medications from the EPR

In the EMMS, the clinician can request the medication list for the specific patient from the EPR. This list represents the starting point for any medication management during the patient stay in hospital.

In the EPR the drugs are denoted by their brand name while the EMMS uses the international non-proprietary name of the active substance(s). For the latter, it means that each international non-proprietary name (active substance) could match more than one brand name.

This is a problem when a medication list is transferred between the EPR and the EMMS because there is no one-to-one relationship between the brand name and the international non-proprietary name (see the example in table II). This came as a surprise to the EMMS project members. One of the members said:

I was surprised that the relationship between international non-proprietary name and brand name lacked uniqueness, i.e. when patient had been admitted to the hospital and had a medication list that contained some brand products, the lists could not be translated uniquely to international non-proprietary name without a human touch. Everybody was very disappointed by this.

The effect of this is that there has to be a translation between the brand name in the EPR and the international non-proprietary name in the EMMS. Therefore, the physician must carefully examine each translation of medication between the systems. The integration will suggest a mapping, but the physician using the EMMS must check whether this mapping looks correct and potentially make changes before the process is considered complete. When this is done, the medication list is ready for use in the EMMS.

Table II. Example of a non-proprietary name and its brand names

International non-proprietary name	Ibuprofen
Brand names (Non-complementary)	<ul style="list-style-type: none"> • Advil • Ibux • Bufen • Motrin

The patient stay – the user juggling between the EMMS and the EPR

While it was obvious that medication data should be transferred from the EPR to the EMMS, it was not so when it came to CAVE information. CAVE specifies what kind of treatment a patient should avoid. The concept may include drugs, drug excipients and food preparations. CAVE is normally registered through the Anatomical Therapeutic Chemical (ATC) code, which refers to the international non-proprietary name of the medicine. Based on the ATC code, it is then possible for the EMMS to provide decision support to the physician in form of warnings if (s)he tries to prescribe medication that the patient is allergic to. Along these lines, in the acquisition phase of the EMMS, the project took for granted (and decided) that the EMMS should serve as the main database for CAVE because it is so closely connected to medication. In this regard, the EMMS would store the master data for CAVE. Other systems that needed CAVE information should then access the EMMS database to get it.

This was easier said than done. For several years, the EPR had served as the master storage for CAVE. And over the years, several other systems had been integrated with the EPR and could get CAVE information through these integrations. These systems included Imatis, which delivered electronic boards to the emergency rooms in the hospitals, and Sectra, the radiology picture system. These systems used the EPR as the master system for CAVE. If the EPR in turn was to use the EMMS as its master system for CAVE, things started to become complicated. As a project member put it:

Automatically, it becomes more risky if the EMMS should be master for DIPS EPR and DIPS EPR should be master for the other systems. Then you increase the potential for complex risk scenarios.

Another point was that the EMMS project had several integration options in the newly established framework contract with the vendor, but not corresponding options with the EPR vendor. This limited the possibilities, especially because the EPR vendor was reluctant to let the EMMS store the master data for CAVE.

Based on this, the project members changed their plans and decided that the EPR should continue to store the master data for CAVE. In this process, integration 3 (see above) was ordered, where CAVE could be imported from the EPR into the EMMS. At the same time, it was considered crucial that the physicians working in the EMMS should be able to update CAVE information when needed. A two-way integration was considered, implying that the physician could both read and update CAVE information in the EPR from within the EMMS software. However, because the EPR and the EMMS organized their structures for medication substances differently, there was a risk of errors. Consequently, the physicians had to do any update to CAVE directly in the EPR because this was the master system for CAVE.

The patient stay – the EPR needs EMMS data

The Northern Norway Regional Health Authority has decided that the EMMS should be the master for medication data during the patient hospital stay. An overview and information about the medication – including drug name, dosage, frequency, route, and missed doses – will only exist in the EMMS during the stay. Currently the EPR has no access to this data prior to the discharge. The reason for this has been to clarify roles and responsibilities between the systems. However, this is problematic as there are several instances where EMMS data may be very useful to have in the EPR during the patient stay.

First, the EMMS will integrate with medical technology. Such equipment includes bedside monitors and devices (e.g. ECG leads, automatic blood pressure cuffs, oximeters) that automatically monitor, store and feed vital signs continuously into the EMMS. Connecting patients to such devices is a routine procedure for patients who have undergone surgery/anesthesia, intensive care patients, and unstable patients. This data could be useful in several instances in the EPR. An example would be that if the blood pressure increases, one could see any correlation with an increase in the dosage of a particular drug, or if the patient

is vomiting, whether this might be caused by the medication. Another example would be that data from bedside monitors and devices (data collected in the EMMS) compiled with additional data in the EPR could help the clinicians to interpret symptoms.

Second, an important functionality that was asked for in acquisition for the EPR was process support for clinical pathways. Specifically, this would be the possibility of setting up a pathway template according to a clinical protocol and from this preparing a treatment plan for the patient. This plan will display all the activities that are planned for the stay. Documentation will be much faster for clinical personnel, as they can easily tick off for actions performed. Updated status is hence more easily achieved, and other involved personnel can see when their contribution is needed. The transparency of patient status that such functionality would provide is among the features that the clinicians want most:

A good visualization of the patients' trajectory - his status, what is done and what is to be done – would help us to optimize in-house resources and plan for discharge early on, hence reduce length of stay. Actually, the visualization in itself would be a kind of decision support (physician in workshop)

This plan in the EPR represents the overall plan for the patient. Data on vital parameters coming from bedside devices and the EMMS is needed in the treatment plan, because it provides information critical to deciding on actions, for instance deviations from the plan, but also in documenting actions and effects of actions. For instance, if a rising temperature indicates that an infection is progressing, steps need to be taken.

To enhance patient security, Health Care Governments has initiated a “patient safety campaign”. Part of this campaign involves using scorecards to assess patients' conditions in a structured manner, so the data can be used to produce reports and quality assessments. Patients who are evaluated to be at risk of malnutrition, falling, developing bedsores, or declining should be scored. One of these tools is the Modified Early Warning Score (MEWS). The scorecard makes use of the heart rate, systolic blood pressure, conscious level, temperature and hourly urine output (for previous 2 hours) in a calculation that results in a numeric score as shown in figure 2. The score indicates how soon a new assessment is recommended, to enable early intervention in patient deterioration. For instance, if the score is 4, a new assessment should be performed in 30 minutes.

Modified Early Warning Score

Score	3	2	1	0	1	2	3
Respiratory rate (min^{-1})	≤ 8			9–14	15–20	21–29	> 29
Heart rate (min^{-1})	≤ 40	41–50	51–100		101–110	111–129	> 129
Systolic BP (mmHg)	≤ 70	71–80	81–100	101–199		≥ 200	
Urine output (ml/kg/h)	Nil	< 0.5					
Temperature ($^{\circ}\text{C}$)	≤ 35	35.1–36	36.1–38	38.1–38.5		≥ 38.6	
Neurological				Alert	Reacting to voice	Reacting to pain	Unresponsive

Figure 2. Modified Early Warning Score

All the vital parameters that go into the scorecard will be entered and stored in the EMMS, as this will be the main system for monitoring patients. However, this system has no functionality for the calculation, so if the score is to be displayed in the EMMS, a manual calculation and entry of the score is needed. The risk of error caused by manual procedures in calculation and data entry is evident as well, as it represents duplication of registration since the score is also needed in the EPR. If the data on vital parameters is transferred to the EPR system, the score can be calculated automatically.

Third, operating theaters are among the most costly resources in hospitals. Hence, well-functioning routines for planning and performing surgical procedures are important to utilize the theaters maximally. In the surgery planning module, the EPR has functionality for estimating the time for the surgical procedures, based on previously accomplished procedures. Based on the nurse's recording of "start incision" and "stop incision" in the EPR during surgery as part of documenting the actions, the EPR calculates and estimates the time for procedures with the same code. This is an important feature because it helps the coordinating nurse to make the most of the very costly resource "operating theater". Being able to estimate how long an intervention will take might make it possible to schedule three patients for surgery instead of two in a day.

However, in configuring the EMMS, personnel working in the theater want to register procedures in the EMMS instead of the EPR, so that procedures can be connected to the recorded actions during the continual monitoring of the patient during surgery. To be able to combine and aggregate data of this kind is important to them for quality assurance, and for documenting effects. For instance, if a patient has a fall in blood pressure during a procedure, the connection between these incidents can be indicated, whereas if blood pressure and procedure are recorded in different systems, the data must be linked manually, or must be entered into an analytical tool. Additionally, since the monitoring of the patient makes the EMMS the primary user interface during the operation, theater personnel see this as the most convenient system to do all the recording during surgery. This means there must be several integrations for both the EMMS and the EPR to work: for procedures, for actions during surgery such as time start, time stop, but also patients' position on the table, what tool was prepared for the intervention, and how the intervention proceeded (complications or as planned). The data is needed in the EPR as this is the main tool for documentation of treatment, and because it is the system that communicates to the patient and to caregivers outside hospital, such as homecare nursing and general practitioners.

Discharging the patient - Medication reconciliation once more

Similarly, when the patient is in the process of being discharged, the project team considered it most suitable to do the reconciliation work in the EPR due to the closeness of the discharge documents that were produced in the EPR, i.e. the discharge report and e-prescriptions. The medication list is then transferred from the EMMS to the EPR. Drugs that are not supposed to be used after discharge should be discontinued in the EMMS prior to the transfer. Then the EPR software

maps the two lists: the reconciled medication list from admission and the medication in use during the stay, and automatically brands each drug in the list as “as before”, “new”, “changed” or “discontinued”. However, the whole process is not straightforward, as the lists are sorted in accordance with the international non-proprietary name and brand name respectively.

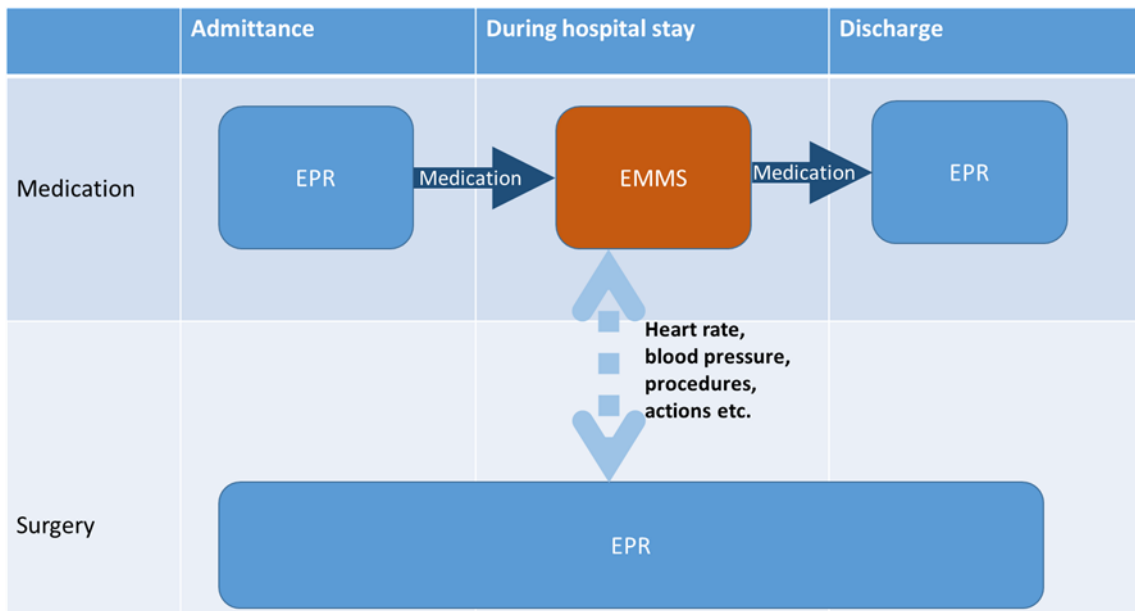


Fig. 3. The figure shows two patient trajectories: the medication pathway and a surgical pathway. The medication pathway is documented both in the EPR and in the EMMS. The drug list will be transferred via two integrations between the two systems. The surgery pathway is documented in the EPR. Both pathways need information from both the EPR and the EMMS during the patient’s hospital stay. Integrations that ensure sharing of data during the stay are not planned in the near future in the EMMS project in the Northern Norway region. Illustrated by the dotted arrow in the figure.

Discussion

We frame our discussion around three conceptual themes, namely the existing installed base (Bowker and Star, 1999; Hanseth and Lundberg, 2001; Pipek and Wulf, 2009), boundary work (Barrett et al. 2007, Pollock and Williams 2008) involved in integration efforts and translation of data (Carlile 2004; Latour 1987) from one context to the next.

First, a key point from the information infrastructure literature is that new technology is never built from scratch; it always builds on and extends the installed base. In that way, it is possible to keep the original user base relatively intact while new users are attracted to the installed base by adding new functionality to it (Hanseth and Lyytinen, 2010). In this regard, our case illustrates that the existing practices and systems play a crucial role in the decisions that are

taken in a project (Silsand and Ellingsen 2014; Hanseth and Lundberg 2001). That is, decisions are not taken freely, but depend on the existing context and what is feasible when designing a new EMMS. In our case, the existing EPR had been running for many years and therefore it made sense to exploit some of the functionality that worked smoothly with it, particularly the functionalities that in turn were integrated with other existing systems and work practices, such as e-prescriptions and discharge routines. You may also consider how the project decided to keep the master data for CAVE in the EPR even if it was closely connected to medication information and therefore should have been placed in the EMMS instead (as the project also considered). In this situation, there existed good functionality in the EPR that was useful in relationship to CAVE. Also, the CAVE served as master data for several other systems that were integrated with the EPR. Through this, we may conclude that the portfolio of existing systems with the associated work tasks both enable and hamper action for new implementation and integration efforts. Hence a large-scale component becomes a stakeholder in its own right (Latour 2005).

Second, traditionally, integration of information systems is considered to be a task to identify the data elements that need to be integrated across two or several systems and then develop the implementation. This approach is too simplistic, reflecting a view that integrations are a clear-cut technical task where the boundaries between the work tasks can be easily identified and structured (Ellingsen et al. 2012, Singletary 2004, Giuse 2003, Berg 2001). This was illustrated in our study where six different integrations were ordered from the vendor of the EMMS and the vendor of the EPR. And where a clear-cut boundary (and thus responsibility) between the systems was established: The EPR should take care of medication management at admittance and discharge, and the EMMS should take care of medication management during the patient stay. Clearly, this does not take into account the implicated organizational work that is associated with the integrations.

Several studies underscore how boundaries are intrinsic to organizations (see Barrett et al. 2007; Pollock and Williams 2008) and integrations are used as a means to overcome the boundaries. However, a key point in this literature is how boundaries are continuously produced and reproduced, countering claims in the management literature related to boundaryless organizations (Ashkenas et al. 1995) or clear-cut boundaries to support a seamless information and process flow (Davenport 1993).

Along these lines, the boundary between the EMMS and the EPR had to be negotiated for various use situations, for where to store master data for CAVE and for which system should deal with the work task of conducting reconciliation. For delimited use scenarios such as admission and discharge of patients, this could be done after some negotiation through the assignment of the responsibility to the EPR. The EMMS should then take care of all medication management during the patient stay.

Still, this strategy seems to fail when taking into account that integrated data needs to be continuously shared between several systems. For the full support of decision support and other planning activities in the EPR when patients are

hospitalized, the EPR would need some data from the EMMS. According to the traditional way of developing integrations, several new ones need to be ordered to accomplish the ambitions. This is enormously complicated, requiring identification of every possible use situation, and thus, these issues are not resolved. The lack of strategies for these problems has spawned suggestions that the EMMS should take some responsibility for planning and decision support from the EPR, thus illustrating a shifting boundary for responsibilities between the systems.

Third, echoing Latour (1987), Winthereik and Vikkelsø (2005) suggest that data is translated between different contexts, not transmitted. In our case, this was reflected in how the integration needed to be manually maintained on a routine level by the users. It was the responsibility of the physician working with the EMMS or the EPR to check whether the integrated data is correct, to make the necessary modifications and then sign off that everything is in order. This has to be done both when the patient is admitted to the hospital and as part of the discharge process. This requires a lot of work for the physicians in their daily routines, which was difficult to foresee in the project start-up phase. Accordingly, the integration is not purely technical or the transmission of data from A to B; it rather implies a socio-technical engagement and effort to keep things running (Ellingsen et al 2012). This suggests that many integration projects actually create more work for the users than what they save and may therefore be a cause of failures of many integration projects.

Conclusion

Integrations are not solely a technical task. An organizational and socio-technical approach is necessary for managing integrations in health care. The process in developing integrations depends on the installed base, the stakeholders' interest and the work practice, and it involves a great deal of negotiations. To reach decisions and achieve good integrations requires effort and resources, and is not something that can be done in haste.

New IT systems like the EMMS always build on the existing systems and work practices in the hospital. This installed base and the existing work processes shape the process and outcomes of the integrations. For instance, existing functionality in the installed base affected the originally planned work practices and thus also the integrations.

In addition, the different stakeholders' interests influenced the integration work. Content in the different contracts with the vendors affected their willingness to adapt to particular integrations. This shows that the portfolio of existing systems with the associated work tasks both enable and hamper action for new implementation and integration efforts. Moreover, large-scale components become a stakeholder in their own right.

Data from one system to another is not always easily transmitted, but must be translated between the different contexts. This may lead to additional manual

work, as in our case where clinicians have to approve the translation. This shows that integrations are not purely technical, but depend on a socio-technical commitment.

Patient pathways in hospitals would normally include processes in more than one IT system. Sometimes the systems have overlapping functionality, and the boundary between them is not clear. The same data and information may be needed in several systems, and to reach full process and decision support integrated data needs to be continuously shared between them. To complicate the issue further, the boundaries are not fixed, but constantly produced and reproduced. When planning the patient pathways, the trajectories are often seen as straightforward processes that follow a determined timeline. In reality, the pathways are not always chronological; they take detours and the direction changes.

This shows that integrations include crossing boundaries, which implies translation and negotiation. These concepts thus need to be considered to achieve successful integrations in health care.

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