

# Steps Toward a Typology for Health Informatics

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## ABSTRACT

In this paper we outline a typology, which will be useful for those engaged in the design and customization of information systems in healthcare. Drawing on ethnographic case studies conducted in six healthcare settings in two countries, the typology outlined here is intended to identify possible sources of local variability of health care work practices, which need to be accommodated in local configurations of generic information systems.

## Author Keywords

Health informatics, ethnography, work practice, computer supported cooperative work.

## ACM Classification Keywords

J3. Life and medical sciences: medical information systems; K4.3. Organizational impacts: computer-supported collaborative work

## INTRODUCTION

Although efforts to computerize healthcare work have been undertaken for nearly five decades, reports abound of health information system (HIS) that have fallen significantly short of expectations. In some situations problematic HISs have warranted significant investigation [2], and have even been withdrawn from use [3, 8]. Often cited reasons for system shortcomings include the complexity of health work [1] and conflicts between the standards embedded within generic systems and the local clinical work practices [33].

Computer supported cooperative work (CSCW) has a strong tradition of investigating and celebrating the complexities in local collaborative work practice [e.g. 16]. At the same time, the CSCW community has for many years struggled with the issue of what ethnographers have to offer to the design of computer systems [e.g. 15]. Ethnographic work in CSCW has tended to reify local variability in work practices. However in recent years implementing technologies tended to be more a process of re-configuring existing generic systems rather than designing new systems from scratch [4]. We find that ethnographic research is essential for configuration activities focused at customizing generic HIS to fit

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particular local health care settings. As we began sharing insights from ethnographic fieldwork carried out in two countries in six healthcare settings patterns of variations emerged. Although the setting for ethnographic work varied a great deal (e.g., oncology clinics, emergency departments and ambulatory clinics), commonalities existed across sites. For example, variation in the spatial layout of a work environment or the patient population had important implications for HIS design. We noticed a certain commonality in possible sources of variation in work practices arising from our empirical material. It is essential for designers who customize HIS to identify differences between the HIS and the current work practices to be able to reconfigure the generic systems in meaningful ways.

The aim of the paper is to develop a typology, which helps systems designers and other stakeholders identify possible sources of local variations of work practices in health care settings. Gärtner and Wagner's [14] framework is used to map these sources of local variations into different contexts, each of which requires different approaches to generating informed design decisions. After presenting prior related work about variations in medical practice, our empirical cases are presented, followed by our research methods. We then outline the typology. First we present the framework of social arenas, followed by concrete examples from our empirical work about the sources of variations we observed through our fieldwork. We define each source of variation and connect it to the arena in which it emerged. Finally, we connect the sources of variation in work practice to arenas in a coherent typology for health care information systems.

## RELATED WORK

It is a well accepted fact that geographical variations in medical procedures exist. By 1973 there was evidence [32] of huge variations in medical practices. A study of variations in terms of beds, manpower, expenditure, and utilization found that there were no substantial clues for why there was a 66% probability that a child living in one part of Vermont got her tonsils removed by age 20, in contrast to the 16-22% probability in five neighboring communities [32]. These observations have been articulated as geographical variations in medical work and procedures.

Variations in health care practices are generally perceived as something we need to reduce through standardization [e.g. 7, 21, 24]. In this view standardization is seen as fruitful and necessary for medical research [23] and to

improve medical practice. Former empirically driven CSCW studies of health care work have recognized that variations of practices at multiple levels exist within hospital work [9, 17, 27, 30]. Pinelle and Gutwin [20] argue that collaboration in health care organizations is often organized in a modular, loosely coupled manner. Each department functions as a separate and autonomous unit with its own organizational logic, which enables continuous change and flexibility within each medical specialty, since each unit can tailor its action and internal structure to meet changing demands. An investigation of coordination activities within a large hospital [30] found that variations in, for example, motivation (to maintain expertise, to avoid blame, and for impression management) influenced coordination processes. A study by Jirotko et al. [17] of the use of new technology for breast cancer screening in different breast cancer units found that while standardization of artifacts may give an impression of uniformity of practice, their use and interpretation would still be tied intimately to local practices. The study suggests that a degree of variation in practice is necessary to support variations in population, resources, and skill between different breast cancer units and to provide space for innovative practice [17, p. 391]. Schneider and Wagner [27] relate the differences in requirements between medical professions to the traditional organizational fragmentation of medical departments within hospitals, and point out that in many cases medical departments are parallel organizations that are loosely coupled with the rest of the hospital. Creating shared representations of information requires shared categories and classifications, however doing this challenges specialists' unique ways of labeling and solving problems [27, p. 233]. Bjørn et al. [9] have introduced the concepts of boundary factors and contextual contingencies to articulate how variations within medical practice might be conceptualized differently. Boundary factors are the variations that are malleable and therefore possible to negotiate. Like boundary objects [28] they are 'plastic, adaptable and meaningful across borders and social worlds' and can be 'represented and displayed within a technology without constraining important flexibility for how actors from different social worlds perform their work' [9]. Variations that are not transferable between settings are contextual contingencies. They are highly interlinked with particular local contexts and embedding them within the model of generic technologies will constrain significant flexibility in work practices of particular contexts [9].

Past research pointed to the variations in health care practices as a factor that is essential to explaining and understanding the challenges in designing and configuring electronic CSCW systems, yet has not tried to conceptualize the essential variations across different contexts. In this paper we suggest a conceptualization of crucial variations in practices that can be used to determine and explain variations across health care contexts. There is a need for a coherent framework for understanding the nature and relations between existing variable work

practices. By applying the framework of social arenas to our conceptualization we suggest a coherent framework as a typology of health informatics.

## OVERVIEW OF CASES

The empirical work presented here comprises three cases: the ACC-case of two ambulatory clinics; the ED-case of two emergency departments; and the ONC-case of two oncology clinics. Each case has two settings, and cases span two countries and three geographical locations. The empirical material comprises investigations of six health care settings and their transformation to electronic HIS. The ACC-case and ED-case are Canadian and the ONC-case is Austrian. Each case is based on an in-depth ethnographic study of work practices over the course of several months to two years, which included observation, informal and formal interviews, and participation in relevant meetings.

The ACC-case is an ethnographic study of the work practices within two ambulatory clinics: a Gastroenterology clinic (GI) and a Neurosurgery clinic (NS). Digestion disorders are addressed in the GI clinic, and NS focuses on treating central, peripheral nervous system and spinal column diseases through mechanical intervention (brain surgery). The ACCs are both located at a pediatric hospital, which is in the early stages of introducing a computerized patient record system. The hospital has a mandate to serve the entire province; which means that many patients travel significant distances to visit the hospital. Depending upon the patients' health condition, they may visit an ACC just once (as is a frequent pattern for many patients attending the GI clinic), or they may have an ongoing relationship (e.g., to manage inflammatory bowel disease over time). Patients attending the NS clinic typically have a time-limited engagement in order to determine a surgical treatment path, perform surgery, and follow up care. The ACC-case was undertaken to investigate the use of paper-based patient records, and the use of duplicate records, which have implications for the computerization of work.

The ED-case is an action research study [6] conducted in the emergency department of the same Canadian pediatric hospital as the ACC-case, which treats patients younger than 17. All severe cases of pediatric emergencies (burns, assaults, fractures, and poisonings) from the whole province are diagnosed and treated at the ED. The ED-study has been going on for almost two years and has included observations of the complex coordinative work practices between various ED staff managing the patients entering the ED. Observations have focused on how nurses assess the urgency of patients entering the ED, and on this basis sort the patients (this process is referred to as triaging patients), and on how the in-charge nurse manages and coordinates the treatment of patients in the back end of the ED. Engagement with the ED has included participation at design workshops related to the introduction of a new HIS, from which we gained insights into the work practices at a regional ED, which treats adults and children. Variations between the two EDs are not limited to the populations they

serve, but include differences in spatial layout and work organization, which have implications for HIS design.

The ONC-case draws on empirical work from two oncology clinics, ONC1 and ONC3. Both clinics are located within a large community hospital in Austria. Oncology work treats tumors. It roughly consists of the administration of chemotherapy, in multiple cycles, and the taking and testing of blood for the purpose of monitoring the state of the patient. Chemotherapies are based on hundreds of clinical protocols, with specifications of combinations of drugs and cycles. Chemotherapies often need to be supported by complementary interventions, such as surgery or radiation treatment, which, in the settings at hand, are delivered by other clinical departments at the same hospitals; hence the need to cooperate with a series of other clinical specialties. In the clinical settings we studied oncology work takes place at three levels of intervention: patients arrive at the outpatient clinic for the purposes of planning and monitoring therapy (or if they have acute problems); they are admitted to the day clinic for chemotherapy and other infusion therapies that last a few hours; and for treatments which last a few days they will be hospitalized in one of the wards. Both clinics have a computerized patient information system that dates back to the 1970s and only contains basic administrative data. The main source of information about patients at ONC1 is the paper-based patient record. In contrast, ONC3 has a homemade oncology information system, which supports documenting, appointment scheduling, ordering chemotherapies and lab tests, and writing discharge letters.

## RESEARCH METHOD

Our data comprises in-depth empirical descriptions of work practices within three cases involving six different health care settings. Although the three cases differ somewhat and include both action research [6] and interpretative case studies [13], all cases are workplace studies of health care settings [18]. Our analysis here is grounded in existing analyses of the internal relations within each case. Prior to our work undertaken for this paper, each case was analyzed as one entity (a within-case analysis). Within-case analysis involves detailed write-ups of each case as a coherent entity to cope with enormous quantities of data collected from each case [13]. This process included writing papers and reports addressing only one case [8, 26]. We wanted to compare our empirical material in order to address HIS in a more general manner. Hence we conducted cross-case analysis searching for patterns, which occurred across the cases. The tactic for performing cross-case analysis was to select categories or dimensions based upon literature (the social arena framework [14]), and combine these with the themes emerging from the three cases [13]. We used this 'grid' of concepts as a means for constructing the typology, which brings together important conceptual issues identified in the empirical material concerning HIS.

## ELEMENTS OF THE TYPOLOGY

HIS in hospitals are typically collaborative systems, since hospital work in general is highly collaborative and interdisciplinary in nature. An essential activity for designers of HIS is to configure collaborative systems so they enable rather than constrain a local context. Identifying local variations is important because such variations need to be explicitly addressed by designers during their configuration of the system. Hence the question, which our typology seeks to answer, is: what are the possible sources of variations within healthcare work practices in hospitals?

We have identified eight sources of variations within our empirical material: political/policy issues; patient population; spatial layout; internal and external organization of work; existing technology support; organization of information; temporal ordering; managing patient flows. These elements are all possible sources of contextual contingencies, which we have grouped into three main social arenas:

*Arena A: The political and policy-making context.* Here the political decisions affecting the design of health care systems are taken and policy measures are designed. For example, the politics of systems acquisition or specific health care policies occur in this arena. These are decisions that influence the organization of health care work, resource allocation and also the local work, by determining for example which kind of technology will be implemented.

*Arena B: The institutional/organizational context for action.* Here the wider organizational issues that directly frame the space for systems design and that in turn are responses to policy and administrative measures taken by municipal and state agencies are negotiated and implemented. The most relevant constituents of this context are *patient population*, the allocation of space to the different care activities and *spatial layout*, as well the overall organization of work: how care is organized, how relationships with external actors/services are managed, staffing, and the general organization of workflows.

*Arena C: The context of systems and workplace design.* Here specific HIS are configured and implemented responding to the political and organizational arenas. Here *existing technologies* come into play (which can be considered outcomes of, e.g. a state agency's politics of system acquisition), as well as manifold social and organizational details, such as: the *organization of information* (e.g. differences in how different professions organize information, using a collective artifact or a range of artifacts); *temporal ordering* (that there are different temporal flows in different local settings), including how *patient flows* are managed.

Earlier work defined a social arena 'as a place in which different communities of actors meet to discuss shared or overlapping projects and concerns' [14, p. 191]. Strauss defined social arenas as a field of interaction between different collective entities [29]. He described how each

arena is framed by its salient structural and processual conditions. Actors in a specific arena typically engage in the definition of issues requiring attention, which compete with other arenas for resources. An arena may extend far beyond the boundaries of an organization or any of its subunits and the debates held in this arena ‘will reflect more than (intra) organizational dynamics, since the debaters will be representative of professional, occupational, ethnic, gender, and other social worlds’ [29, p. 158].

The notion of arena is particularly well suited to analyze HIS, where global actors, such as international standards bodies, large technology vendors, and national health agencies almost entirely disconnected from local policy-making influence HIS implementations. As a consequence debates occurring in the systems design arena reflect issues arising in contexts where designers and users often may have no influence (e.g. health care policies) or which are hard to change within a design project but which nevertheless have to be taken into account.

#### **Arena A: The political and policy-making context**

Gärtner and Wagner [14] suggest that the political and policy context (termed ‘industrial relations’) constitute an important social arena which exerts an extra local force or pressure on software design decisions. Constituents of this arena include the perspectives of external stakeholders (such as health care authorities), the politics of systems acquisition, the mechanisms for budget allocation or the documentation purposes defined by different actors (research, care, local accounting and quality, access [3]) but also regulations concerning matters such as working time.

In the ED-case we encountered how distant social arenas impacted decisions about design and implementation of HIS. The ED management applied for provincial government funding to design and implement a HIS in the pediatric ED. Funding was granted, but with constraints. The ED was required to use a particular HIS already in use at other hospitals in the province and the HIS had to be implemented under strict time constraints (within nine months) prior to the end of a fiscal year. The province is the main funder of both regional and provincial hospitals, and thus is interested in negotiating collective contracts for technical support and software licenses. Hence the politics of system acquisition were heavily influenced by provincial budget allocation – a social arena far away from the actual settings in which the HIS would be implemented and used.

Interestingly, the ACC-case was located in the same hospital as the ED-case and some of the decisions taken to design and implement the HIS in the pediatric ED highly influenced the local context of the ACC-case. In the pediatric ED, an electronic patient registration system (Affinity) was used prior to implementing the new HIS. However the new HIS required that Affinity be removed and replaced by a patient registration module (PtReg), which was a part of the whole software package from the vendor of the ED HIS. PtReg was designed to register,

schedule, admit and discharge patients within a hospital. Replacing Affinity with PtReg was not a decision local to the ED, since Affinity was used all over the hospital including in the ambulatory clinics. Replacing Affinity with PtReg in the ED required that Affinity be replaced throughout the hospital. So decisions related to the HIS taken in the political social arena mainly aimed at influencing the ED heavily influenced the local work context of the ambulatory clinics by forcing them to replace one of their vital HIS with PtReg. The clinics in the ACC-case did not have any influence over how the PtReg was reconfigured and designed. In this way the social arena of the ED-case highly influenced the local work context of the ACC-case from a distance.

#### **Arena B: Institutional/organizational context for action**

The institutional/organizational context comprises yet another set of contextual constraints referring to the political context however at a lower level. It is at this level that differences in how work is organized, framed by organizational structures, emerges. Differences exist between departments even in highly standardized care contexts such as oncology, and can be explained in part by differences in institutional and organizational contexts.

#### *Patient population*

In healthcare, considerable local variation flows from differences in patient populations. For example, in EDs, children tend to present with different ailments than adults, and even when children and adults present with the same ailments, the symptoms they present with may differ, and the appropriate action required to care for children and adults with the same symptoms may vary (e.g., diarrhea is much more serious in children than adults, and high temperatures are much more serious in adults than children). Our work in the EDs [8] has shown differences in patient population that are not recognized as an important issue for configuration of HIS may risk failure [3].

Patient population was also a source of variation in the ACC-case. In the GI clinic, lab reports and a particular type of diagnostic imaging (endoscopy) reports are commonly part of the patient’s record. In the NS clinic, surgical reports and a different type of images are more prevalent (e.g., MRIs). Thus, the patient population stipulates which types of imaging are relevant to include in the patient chart. Another difference related to the patient population is the requirement for documentation. The medical specialty reflects a particular patient population, which may create demands for particular kinds of documentation. In the GI clinic they require nursing notes because nurses engage in teaching patients about their condition which includes a variety of tasks, such as fielding phone calls from patients, and writing letters to schools about the implications of a child’s disease. There is a need for timely access to certain types of information in the GI clinic and GI nurses may need to look at a patient’s file in order to provide appropriate information when the patient calls. In the NS

clinic there are no nurses fielding calls which reduces the need for readily accessible patient records.

Other factors—such as whether or not a patient has co-morbidities (other ailments), and which co-morbidities they have (e.g., a GI patient who is also a kidney transplant patient) may also come to bear on the local variability in information organization needs. For example, when children in British Columbia need kidney transplants, they travel to another province to get the transplant. In such cases their record is placed in a special binder, which accompanies the patient to the hospital where they receive the transplant. Future computerization of records must somehow account for the fact that pediatric kidney transplant patients' files need to be accessible to doctors in another province, which may not be an issue for other GI patients, or NS patients. This example illustrates how decisions taken in the political arena (to have a regional centre for transplantation) influence local HIT needs, and points to the need for IT systems to exchange information with other IT systems, a process we call coupling which is a component of the organization of work, discussed below.

#### *Allocation of space and spatial layout*

Architectural form provides a particular register for social and professional discourses. Earlier CSCW research investigated work practices surrounding digital radiology systems (PACS), and examined how spatial arrangements construct, sustain, constrain, and, occasionally, transform the production of radiology images and reports [31]. Bardram and Bossen [5] introduced the concept of mobility work highlighting the need of 'the achievement of the right configuration of people, resources, knowledge and *place* [italics added]' [5, p. 137]. These and other studies point to the fact that local features, such as the spatial layout can be important sources for work practice variability, if for example health care work is carried out in a single or in multiple locations, if there are provisions for the spatial ad-hoc accessibility of services (such as for a quick lab test in the case of oncology) or other geographic factors (such as the spatial proximity of patients and services) differ.

The spatial structures in which the two oncology clinics are located offer quite different spatial constraints. In ONC1, the outpatient clinic and the day clinic are located separately and function largely independently of each other: they have their own staff and admission procedures, with separate reception counters, but they share a small laboratory for blood tests. In ONC3, the outpatient and day clinics are in the same space with a shared reception counter for admissions, and they also share personnel. On the other hand, ONC3 does not have its own lab, and patients therefore have to wait from one to two hours for their lab results. For this reason, doctors at ONC3 often recommend that patients have blood tests done the day before at an external laboratory. On the other hand, ONC3 has less storage space available and hence has resorted to transferring the content of patient folders of inactive

patients to microfiche. These constraints are trivial but can nonetheless have significant impact on actual work.

Spatial layout also has an impact on the work practices within the ACC-case. The NS clinic comprises a central space, where the clerk is located and has access to all the clinic's patient files. Preparing for clinic days the NS clerk uses her list of patients to pull the charts from shelves. All relevant charts are put on a counter close to the shelves. On the morning on the actual clinic day the clerk will move the pile of charts to her desk, and as each patient arrives and patient information is confirmed, the patient's chart is placed on corner of her own desk next to the door to the waiting room, where the surgeons will pick up the chart and browse through it before calling patients into the examination room. The whole clinic day is managed around the central space of the NS clinic. The whole NS clinic (offices, waiting room, storage, administration and examination rooms) is located on the same floor in the ambulatory building. The spatial layout of the GI clinic is quite different. While all office and clinic administration are located on one floor, the examination rooms are located on a different floor in the same building, and examination rooms are shared with another specialty. This means that on clinic days the clerks in the GI clinic must pack up all the patient charts, place them on a wheeled cart, and prior to the clinics, the clerk takes the cart on the elevator to the clinic space, where all the charts are spread out on a large conference table in a room. The physicians go to this table to get the patient charts before examining the patients. This physical division of the GI clinic necessitates that time be spent preparing for transporting charts, and also created a need for development of different coordination mechanism than those in use in the NS clinic.

#### *Internal and external organization of work*

Variations in organization of work refer to how different healthcare settings choose to organize the flow of work. Internal organization of work refers to allocating particular assignments to particular staff within a particular context. External organization of work refers to how interlinked collaborative processes between the department and other external actors are managed, such as how the ED manages their relation to the radiology department each time they order an x-ray. Organization of work is about managing the coupling between collaborative actors shaped by other factors such as spatial constraints and availability of tools.

The ONC-case illustrates distinct differences in how work is organized in the two clinics. The outpatient clinic of ONC1 is staffed by three to four nurses, and one or two doctors. There is a division of labor between the nurses but it is not fixed; in fact, they take turns at the different tasks ('rotate'). One is responsible for the counter, receiving patients, checking what has to be done and arranging whatever is necessary. Another nurse takes care of preparing blood tests. A third nurse is 'at the back', in the next room where the folders with all the patient documents are stored. What the nurses do at the outpatient clinic of

ONC1 is not primarily care giving, but rather administrative tasks. Also, in ONC1, the doctor alone sees the patient. The outpatient clinic at ONC3 is staffed by a secretary at the reception counter and three to four teams consisting of a doctor and a nurse who work closely together in the consultation rooms. Sometimes a nurse is responsible for assisting two doctors and she must then constantly move between two rooms. In contrast to ONC1, in ONC3 all of the nurses request blood tests and check for lab results.

In the ED-case designing and re-configuring the electronic HIS for the pediatric ED included configuration of an electronic whiteboard. In re-configuring the whiteboard various differences between how the work was organized in the adult and the pediatric ED became evident. For example when the nurses were assigned to particular patients in both ED settings, being assigned had different meanings. In the pediatric ED the nurse was assigned to particular rooms and when patients were directed into these rooms, the nurses took responsibility for the room's inhabitants. However in general the nurses at the pediatric ED collaborated a lot and helped each other out with all patients during each shift. In contrast, being assigned to a patient in the adult ED meant that the nurse would focus on a particular patient. This variation in organizing work collaboratively (the pediatric ED) versus individually (the adult ED) influenced the configuration of the electronic whiteboard. Because nursing hand-over (during shift change and/or breaks) was a collaborative process at the pediatric ED, it included the use of a whiteboard with additional detailed information about each patient. In contrast, in the adult ED, nursing hand-over was a one-to-one activity, which required the nursing chart, but not the detailed information captured on the pediatric whiteboard. Adult ED nurses required less information on the electronic whiteboard than the pediatric nurses.

### **Arena C: The context of systems and workplace design**

This is the arena where specific HIS are designed to be implemented and used. This context is a local response to the two higher-level arenas comprising the politics, organization of work, patient population, and spatial layout.

#### *Existing technologies*

The information technology landscape into which a HIS is introduced is often a source of variations. In the ACC-case in the pediatric hospital, a few enterprise-wide HIS exist, serving primarily administrative (as opposed to care) needs (e.g., the Affinity system, which has just been replaced by the PtReg system). In cases where enterprise wide solutions do not exist (e.g., to bill the province for the work performed by the doctors), local solutions may be in place, and vary between clinics. In the ACC-case an electronic document repository was introduced in all ACCs. This HIS allowed staff to view doctors' dictations and some lab and diagnostic image results. It did not allow users to perform queries, and hence was limited in terms of performing analysis. Before and after the introduction of the electronic document repository various local databases were implemented to support informational needs of clinical

specialties, often related to research. Each of these locally used systems leads to variations in work practice.

There is some overlap in HIS between the NS clinic, the GI clinic, and the pediatric ED (e.g., all uses the same admitting, discharge, and scheduling HIS). However, some components of the HIS are used differently in the two ambulatory clinics. In the NS clinic a scheduling module of the billing program is used to print out the daily roster of appointments, while in the GI clinic, the enterprise wide IT is used to accomplish the same task. In the NS clinic, the enterprise wide document repository system is used regularly, while in the GI clinic only the nursing staff and administrative staff use it and rarely the physicians. The integration of the locally available patient databases into clinical practice also varies. In the NS clinic the local patient database is used to generate a page which is attached to each patient chart, which helps the specialists develop a quick overview of the patient, based on their diagnostic and surgical history in that clinical area.

These examples suggest that existing technology systems, which often fill gaps not met by enterprise wide HIS, may meet needs particular to a unit. Existing technologies may be both a source of and a reflection of work practice variation, which designers need to accommodate when configuring generic HIS. Moreover, designers should be aware that even though the same technology is in place in different settings, it does not necessarily mean that the technology is used in the same manner in different settings.

#### *Organization of information*

This element relates to a much broader topic of how information is organized, the artifacts used for its organization, the notation systems used, etc. In [26] we pointed to the fact that clinical staff uses a variety of representational techniques in creating different types of documents. Among these techniques are specific spatial arrangements of information on the surface of an artifact, the use of notations or the physical arrangement of documents with the clinic space (in the form of folders, stacks of folders, etc.). These techniques enable health care providers to flexibly organize information for different purposes and needs. Conversely these needs are reflected in the material design of each document.

Accidental circumstances have provided ONC3 with the ability to use a computer-generated appointment sheet that serves a central coordinative role in ONC3. An appointment sheet is printed at the end of a consultation. It records the date and purpose of the appointment, and what the patient will have to provide (e.g., results from a blood test). It is central for the doctors in a consultation and often they look at it first. It lists current measures and also provides an overview of the diagnoses and the therapy so far, and current medications. During the consultation doctors might turn to the appointment sheet to get a quick overview of the current state and course of treatment. Having the specialized oncology system also allows ONC3 to integrate

information such as an explicit therapy plan into one document, i.e., the order form for chemotherapy, thereby providing an overview where and when it may be of use. At ONC1, the same information is distributed over several documents (patient diary, care sheet, progress notes, etc.) that have to be aligned and viewed together.

We can also see how different types of work organization create the need for different kinds of overview. In ONC1, where nurses distribute patients (and the information connected with them) to different rooms and workplaces and are not present when doctors see the patients, they have created a special document -- the 'care sheet', in support of their own overview and control. In ONC3, where doctor and nurse work closely together exchanging information, both have an overview of what is happening and also reporting is done cooperatively and concurrently. Different clinical areas also 'view' patients differently: in the GI clinic, the patient overview consists of a drawing of the GI system the doctors make notes on, while in the NS clinic the doctors establish an overview of the patients through a list of surgical interventions each has had.

#### *Temporal Ordering*

Variations of practices occur in relation to the temporal ordering of providing care. Different health care settings have different temporal patterns. In the ED, there are few appointments (e.g., to re-check patients) and patients mostly just show up. This means that the timeline for the day is continuously reevaluated and redefined in the ED. In the ambulatory care clinics work is usually managed around a pre-defined timeline planned for the day, since most patients only come when they have appointments and unscheduled visits are rare. Oncology is a mix of scheduled and unscheduled appointments. Other temporal factors are the need to link appointments across provider areas (e.g., so a patient can see two specialists in one visit), and dealing with the urgency of a patient's status, which may change.

Temporal issues contribute to the local variability of healthcare work in different ways. For example, the extent to which timeliness is a factor in the provision of care influences work organization and work practices, such as whether an appointment can be booked in advance or not. Temporal issues may come to bear on information co-dependencies related to the external organization of work. Although the majority of lab tests required prior to patient visits in the GI clinic can be performed routinely at any medical labs and most patients can easily obtain such tests; the diagnostic imaging used in the NS clinic is highly specialized and must be done in an operating room at a hospital. If patients live near the hospital, the imaging can be at a different time from the subsequent surgery. However, if a patient comes from out of town, the imaging appointment must be scheduled the day before the surgery, to reduce patient travel. If a case is more urgent, it will need to be scheduled more quickly than less urgent cases, which may result in a need to move less urgent patients to later appointment or surgery times. Temporal issues take varied

forms reflecting patient acuity, distance to clinic, special requirements for medical labs, and available resources in terms of staff and spatial layout. Hence temporal ordering comprises a possible source of variation in health work, that needs to be addressed in configurations of generic HIS.

#### *Managing patient flow*

Most literature focuses on simulation of patient flow through a whole hospital. In our use of patient flow we refer to the local management of patients within a facility at a given time. Few studies have investigated patient flows as interwoven with other working activities [e.g., 12]. For example, in a study of work in a surgical intensive care unit, Reddy and Dourish [22] report on some of the techniques staff uses in anticipating patterns of patient flow, depending on the recent progress of current patients. While they stress the role that working rhythms play as a resource to interpret and manage work, we also look at spatial arrangements, organizational issues, and the availability of tools as determinants of how staff order patient flows and how this results in variability between health care settings.

The fact that in the outpatient clinic of ONC1 patients do not have to make appointments but can decide for themselves when they want to come creates a particular patient flow embedding continuous reevaluation of the time and space. This way of managing patient flow is quite similar to the patient flow within the ED, where the main job of the nurse located at the ED entrance is to continuously evaluate the urgency of new patients to the available time and space of the ED [10]. Patient flow is organized differently in the ONC3 clinic. Here patients arrive by appointment only (except in cases of emergency), and handling patient flow includes the use of a specialized computer system. We can also see that these different ways of handling patient flow are supported by and result in different sets of coordinative artifacts. At ONC1 patients arrive to be received by a nurse who fetches the patient folder from the archive, checks to see if all relevant information is available, takes care of administration (by means of the administrative information system), enters services on the 'care sheet', sends the patient along to have blood taken or directly to one of the consultation rooms, and places the patient folder wherever it is needed next. At ONC3, a list of appointments is generated the day before, on the basis of which the head doctor manually constructs the work plan for the teams of doctors and nurses in the outpatient clinic, trying to ensure that patients are seen by a doctor with whom they are familiar. It lists all patients with appointments, planned activities, and responsible doctors. The list is photocopied and distributed. The person responsible for blood tests uses the list the day before for preparations (tubes for blood tests with stickers, printing out of orders, etc.). The nurse in the consultation room uses the list for preparing printouts of lab results; she annotates the list with remarks and stickers, highlighting special needs. In ONC1 a nurse is needed at the reception to assess the patient's situation and needs (similar to the triage nurse

in the ED). Admission at ONC3 can be done by a secretary as preparation for incoming patients is done in advance.

### CONNECTING THE ELEMENTS OF THE TYPOLOGY

Our typology could be seen as merely a list of elements to consider in designing HIS. However, the work practices we describe as illustrative of different sources of work practice variations reflect—as our typology suggests—several interconnected and interdependent variables or elements, and allows us to see how each arena is highly interlinked with the others in a nested pattern.



**Figure 1: Typology of Health Information Systems**

The inner *system and workplace design context* is closely related to the actual work practices within the department where new HIS are supposed to be used. Successfully configuring a generic system to a particular context requires designers to develop an understanding of work practices, which includes determining elements within the design that might conflict with the existing embedded structures of the system. Although a HIS may have been designed to support a particular area (e.g. oncology work and therefore, in theory, should be supportive of oncology in general), there are variations between oncology clinics that must be addressed during reconfiguration of the electronic HIS. An example is how a clinic decides to manage the patient flow (scheduled versus unscheduled appointments), which has implications for how information is retrieved, what the supporting artifacts look like and how they are used.

However it is not enough to only examine the elements of possible variation embedded within the context of design, since this context is nested within the second level of analysis *the institutional/organizational context*. This means that elements of possible sources of variations embedded within the institutional and organizational context also influence and affect the concrete work setting directly. Thus, designers should investigate whether these possible sources of variations conflict with models embedded within the technology. Elements of the institutional context we have identified are the patient

population, the spatial layout, and the external and internal organization of work. This means that when designers determine which aspects of e.g. a generic HIS designed to support triage in emergency departments should be re-configured for a particular setting, they must investigate whether the concrete setting is a good fit with or conflicts with the generic HIS. The designers must examine, for example, whether the spatial layout or patient population of a particular department conflicts with the model embedded in the technology, or creates a need for a software change.

The outer context of our typology, *the political and policy-making context*, provides additional possible sources of variations that can influence the design and re-configuration of generic HIS. Policy differences (e.g., between how triage activities are performed in one ED and another, especially between countries), or high level political interventions (e.g., as we saw when comparing the ED and the ACC cases, where a political decision resulted in replacement of one patient registration system with another in the ED, which affected the ACC since the ACC also then had to replace the system) can also result in a need for further configuration of generic HIS, as well as lead to changes in the system and workplace design context and in relation to the institutional or organizational context. In this way, the political and policy making context can have an extra-local impact on the other contexts.

We argue that re-configuring generic HIS is thus a process of first determining if the possible sources of variation exist within the setting where a generic HIS is to be introduced, and then determining whether the existing variations comprise contextual contingencies or boundary factors [9]: whether the sources of variation are malleable and negotiable (boundary factors) or are given conditions (contextual contingency) which will require essential HIS re-configuration. The degree of malleability of sources of variability also depends on the social arena in which system design projects are negotiated. The argument here is that the distinction between boundary factors and contextual contingencies cannot be made without considering the context of action—something that cannot be changed in one setting (e.g., a patient population) may be easily altered in another, where the context of action differs. From the perspective of the arena of systems design in a specific health care setting factors such as patient population, spatial layout of the clinic, and general organization of care may be largely ‘given’ and are often specific to a particular setting. However, when for example the task is to define common formats of data reporting across settings or to design a ‘generic’ workflow for oncology, access to and activation of actors in other social arenas is necessary (and certainly not always within the power and competence of systems designers themselves), to determine which factors affecting these design issues are negotiable. It is precisely for this reason that designing collaborative HIS for use in health care should include in-depth analyses of the surrounding

'arena issues' and ethnographic studies of work practices requiring essential software re-configurations.

### **WORKING WITH THE TYPOLOGY / THE WORK OF THE TYPOLOGY**

The typology of health information systems we propose is intended as a descriptive tool, rather than a causal model. It can be used as a tool to open discussions about the challenges and issues associated with planning HIS implementations, and to facilitate discussions about issues, which may not otherwise be addressed by those responsible for system design, procurement, configuration or implementation. It can also be used to examine implementations which have not gone as hoped or planned.

The typology provides a mechanism through which concepts that are normally outside of the domain of systems designers and project managers can be addressed within design and project management activities. Whether used by designers and project managers, CSCW researchers or health decision makers, the typology offers the possibility of surfacing political and social issues yet it remains compatible with domain specific views (e.g., that of a designer, that of a health practitioner), and, as such can be used as a boundary object to bridge the often differing views of varied groups required for successful design, configuration and implementation of HIS.

### **CONCLUSIONS**

CSCW workplace studies are concerned with revealing the nature of particular work practices within particular settings, and constructing and developing theoretical concepts and frameworks which are helpful in explaining collaboration and technology support in general [25]. We may find widespread support for the claim that re-configuring generic HIS for particular hospital settings requires that designers pay attention to 'the delicate balance between shared 'core'' values and beliefs' in how medical work is enacted within a particular medical profession such as oncology, while taking into account the 'fluctuating zone' of varied styles and practices' [27, p. 233]. Moreover, the fact that medical departments often are organized in a loosely coupled manner requires different design and deployment strategies for HIS, as has been argued for example in [20]. However, exactly how to identify essential sources of variation is still an open issue within CSCW.

The typology we propose here can help designers identify these sources of variations by prompting and grouping where these sources of variation may be located, and alerting designers to explore which factors may be negotiable and which will not be. Although providing important attention points, the typology as such is no substitute for ethnographic fieldwork and cross-case analyses. It can, however, help focus this research. The typology also highlights the interconnectedness of design and use and, together with our examples, demonstrates that social arenas continue to shape IT systems after customization and implementation have officially ended. An emphasis on this reach beyond the point when a system

has been 'delivered' distinguishes our typology from some of the implementation methodologies used in industry, such as Accenture's ADM or IBM's RUP.

Orlikowski and Barley have argued that technologies that become 'embedded in complex, interdependent social, economic, and political networks' ask for hybrid explanations 'that weave together human action and choice, the functions and features of specific technologies, and the contexts of a technology's use in a way that attends to the micro-dynamics of situated practice [19, p. 11]. Although directed to the IT research and organizational studies (OS) communities, their view can be extended to CSCW as well. Our typology includes elements that have been identified by studying the larger organizational and institutional issues surrounding HIS, including the political and policy-making context. This research reaches beyond workplace studies but is complementary to them in important ways, as it helps identify some of the 'forces' that shape and constrain work practices. We want to suggest an approach that Clarke [11] terms 'arena analysis', as complementary to work practice research, arguing: 'The real power of arena analysis is that very different types of worlds can be studied simultaneously' [11, p. 138]. Arena analysis involves identifying the participants in the relevant social arenas, their distinctive perspectives and the nature of their interactions, but also how agendas are set and power is exercised, as well as the boundary objects [28] that cross social arenas, helping systems designers better understand and define their own space for action.

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