




# Repetita Iuvant: Exploring and Supporting Redundancy in Hospital Practices

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**Abstract.** This paper discusses the role of redundancy in hospital work, especially in facilitating the cognitive and coordinative tasks of health practitioners in clinical settings. It also investigates the ways in which health information technology can preserve, support and even enhance this role by being grounded in the observations and analyses that two research groups in Italy and Norway carried out in independent studies. In the present study, this previous research is reassessed and shaped into a unified and coherent design-oriented framework. This framework considers four kinds of data redundancy and outlines their peculiarities and the typical conditions in which they occur. In particular, the paper reports how these kinds of redundancies are exploited in both written artifacts and oral communications and how they affect each other. The paper also reports the impact of redundancies on the articulation work of physicians and nurses by playing either a negative or, more often, a positive role depending on the context. A series of lessons learnt are then proposed for the design of suitable coordination mechanisms that could preserve or even utilize this neglected phenomenon, which is strongly related to the interpretative and coordinative practices that are articulated in the patient's record.

**Keywords:** Redundancy, Healthcare work coordination, Artifacts-mediated practices, (Electronic) Patient record

## 1. Introduction

Redundancy is usually identified as a problem in many organizational settings, and hospitals are no exception. Redundancy is typically an effect of repetitive organizational work, such as a resource-demanding nursing oral handover (Sexton et al. 2004; Voutilainen et al. 2004), hazardous copy-and-paste revisions to clinical data (Siegler and Adelman 2009) as well as the presence and use of several fragmented and overlapping information sources (Dixon and Chantler 2011). Moreover, redundancy is considered to cause both ineffective work routines (O'malley et al. 2010) and inconsistent and irrelevant health care data (Wrenn et al. 2010) is usually considered a matter of wasted resources and an economic burden on the organization (Streeter 1992).

Hence, it is no wonder that historically, the management of hospitals (and of many large organizations) has sought ways to reduce or eliminate redundancy (Patel et al. 2000) in both their business processes and information resources. In this regard, information and communication technology (ICT) is considered both an opportunity and a means of solving the problem (Hammer 1990). ICT is expected to streamline the organization's processes (Ashkenas et al. 2015) across departmental and professional boundaries through the formalization of work as well as by standardizing and centralizing existing application portfolios (Kloss 2013; Ulriksen et al. 2016).

However, efforts to eliminate redundancy in hospitals have frequently fallen short of expectations (Ellingsen and Monteiro 2003) or have failed (Munkvold et al. 2006). These outcomes suggest that existing efforts have not paid sufficient attention to the role that redundancy plays in the value chain of these organizations (Porter and Teisberg 2006), particularly in daily clinical work. In addition, very few ICT-related design guidelines address the phenomenon of redundancy properly, if at all, and there is a lack of sound empirical investigations that support innovative solutions that are aimed at preserving, or even leveraging, the redundancy of data. Nevertheless, redundancy is a positive phenomenon that can be supported by ICT (Cabitza and Simone 2008). Consequently, in this paper, we report a comprehensive study of this phenomenon, which is guided by the following three research questions:

RQ1: What is the role of redundancy in clinical work in large hospitals?

RQ2: What forms does it take?

RQ3: And how can ICT support “productive” redundancy?

To address these questions, we take a broad approach to the phenomenon, empirically, methodologically and conceptually. From the empirical point of view, our study summarizes a series of studies that we previously conducted in Italy (Cabitza et al. 2005; Cabitza and Simone 2008) and in Norway in completely independent lines of research. In these field studies, we examined the phenomenon from different angles and according to different aims. This research allows us to reconstruct a more comprehensive view of how redundancy emerges and functions in different work settings and in different cultural milieus.

From the methodological point of view, we aim to integrate the “primarily social” perspective that was adopted in the Norwegian study with the “primarily technical” perspective that was used in the Italian studies. Based on this integrated methodology, we propose concrete and original design-oriented guidelines that are derived from the thorough understanding of the role that redundancy plays in clinical practice. From the conceptual point of view, we draw on the work practice perspective discussed in the CSCW literature (Fitzpatrick and Ellingsen 2013; Blomberg and Karasti 2013). Former studies on redundancy in this field have focused on existing work practices and on the consequences of “obliterating” them (e.g., Dolin et al. 2006; Hutchins 1995; Munkvold et al. 2007; Tjora 2004). In this paper, we go a step further by combining the work practice perspective

with the close engagement and participation of the informants in our field studies, whom we involved in experimental sessions that were focused on the applicability of several technical solutions.

The rest of the paper is organized as follows: the next section outlines our conceptual framework. We start by placing the concept of redundancy in the context, and we outline the managerial goals of eliminating redundancy as well as their success to date. After that, we apply the work practice (social) perspective to examine redundancy in order to highlight crucial issues about its presence in clinical practice. The following sections are structured according to the three research questions. First, the role and forms of redundancy are illustrated through four vignettes taken from the studies of two large teaching hospitals at two geographical and socio-cultural extremes of the European continent, that is, Norway and Italy. These studies examined the ways in which redundancy affects formal and informal practices as well as the interpretation and negotiation of the information shared among doctors and nurses. Moreover, these studies show that redundancy requires the selection of relevant information, how redundancy is generated and how it is considered as an enrichment of the artifacts used in clinical work. Second, the paper discusses ways in which ICT could support positive redundancy based on a classification system that establishes linkages and cross-references to related sections and fields in the electronic patient record (EPR) as well as between different artifacts that contain redundant information. The Clinical Document Architecture (CDA) standard specification (Dolin et al. 2006) was tested in a technical environment to determine whether it could contribute to managing redundancy. The results showed limitations in the efficacy of this standard in relation to the user's expectations. To overcome these limitations, we conducted an initial co-design experiment with the stakeholders involved in order to identify better ways to support redundancy and to establish concrete technical design guidelines that could improve existing EPRs. The last section concludes the paper and draws some final considerations.

## 2. The conceptual framework

In this section, we apply a *managerial/organizational perspective* to present some challenges caused by redundancy, including its consequences and the effects of some ICT approaches to dealing with related problems. We then apply a *work practice perspective* in order to establish the conceptual understanding of the phenomenon from the user's point of view.

### 2.1. Redundancy: causes and consequences

Hospitals are large, complex and dynamic organizational entities. A large number of specialized health professionals belong to various communities of practice, who engage in complicated processes of diagnosing, treating and caring for

patients. The trajectory of the patient during a hospital stay typically includes a comprehensive range of departments, work tasks and technologies. An overarching concern of policy makers and management is to improve the quality and efficiency of dealing with the patients' problems.

In this regard, an identified problem is redundancy (Cabitza et al. 2005; Tang and Carpendale 2007), which may take different forms and may be quite extensive in the organization. Redundancy may be found in the wastefulness or "slack" in organizational routines, such as tasks that are repeated several times, which is frequently referred to as redundancy of effort. The classic (human) resources management considers the redundancy of effort unnecessarily inefficient and costly; therefore, it should be reduced or eliminated (Patel et al. 2000). Another form of redundancy is the redundancy of data (Ellingsen and Monteiro 2003), which occurs when in an organization either the same or similar (i.e., pertaining to the same information) data are repeated, possibly in different places (artifacts, applications, information systems etc.). This latter form of redundancy may lead to inconsistencies, low data quality (Cabitza and Batini 2016), and additional work in aligning different sources and minimizing errors. We illustrate four situations in a hospital context where redundancy is considered a problem.

The first case concerns redundancy in oral communication. In the 24-hour operational context of hospitals, the nursing handover usually takes place three times a day when the off-going nurses provide information about the patients to nurses coming on shift. A typical handover involves the oral exchange of information in nursing handover conferences. However, as part of the efforts to establish EPRs in western hospitals, the nursing handover has been under heavy criticism because it depends on oral information that is often dispersed sources (Bomba and Prakash 2005). Sexton et al. (2004, p. 37–38) claimed the following:

“[The nursing handovers] often lack formal structure, and this is compounded by a lack of guidelines for the nurse giving the report. Consequently, the information presented may be irrelevant, repetitive, speculative or contained”.

Second, redundancy also occurs in numerous informal information sources that have survived the introduction of information systems that manage the illness trajectories of patients, the caring activities of the practitioners, and the administrative, financial and organizational aspects of the entire hospital: these goals intersect and possibly conflict because they respond to different objectives and granularities of interests (Nilsson et al. 2002; Heath and Luff 1996; Pratt et al. 2004). Many informal information sources need to be examined to derive an overview of the patient and to use in writing formal documentation. Some examples of informal information sources are blackboards, notebooks, locally designed forms and personal yellow notes, which are used directly in the process of caring for patients. In such settings, there is no single point of entry that a clinician or a nurse can access to gain an overview of the situation. These disparate sources

of information are considered a major cause of the reduced quality and low efficiency of hospitals in patient care (Baldwin and McGinnis 1994).

Third, redundancy may also be the results of an excessive number of formal information systems. Examples are EPRs, electronic medication management systems (EMMS) nursing documentation, laboratory systems, radiology systems etc. Many systems (even if they are formal) are frequently considered problematic because they promote the overlapping of information. Duplication may lead to different representations of the same information, especially if this information is represented not only in different artifacts but also in different mediums, such as, paper and electronic forms. Because the same information is documented in different places, there is a risk of unsynchronized or inconsistent information and hence misconceptions or other human errors. Both informal and formal information sources sometimes co-exist without correspondence, which may cause trouble. Houben et al. (2015) observed this phenomenon in cases when clinicians kept two parallel records, paper-based and electronic. This “hybrid documentation environment” caused a “number of configuration and coordination problems related to finding, using, updating, communicating and managing both records”. Hence, much work was required to synthesize the different sources to obtain a coherent picture of the patient’s condition.

Fourth, redundancy is also caused by the repetitive characteristics of the clinical documentation process. In writing formal reports, both physicians and nurses spend a great deal of time reading previous reports. Consequently, they tend to repeat part of what was written earlier by drawing on the same artifacts (i.e., different versions of physicians’ running notes and nurses’ handover reports) as well as other artifacts.

## 2.2. Ambitions and experiences with ICT for eliminating redundancy

ICT is expected to play a crucial role in eliminating or reducing redundancy. For instance, in response to oral narratives in nursing handover, electronic nursing care plans are supposed to play a key role in documenting and planning care for patients, facilitating the transition from oral to written handover (Sexton et al. 2004, p. 42), and be the “primary focus for patient care delivery” (Wallum 1995; Kennedy 1999; Solvang 2005). In this regard, Voutilainen et al. (2004, P. 72) note: “When documentation is accurate, individual, pertinent and up-to-date, it promotes consistency and effective communication between nurses and the other team members involved in care.” In addition to other formal documentation tools, such as an EPRs and an EMMS, a nursing care plan may ensure that many existing informal information sources are made superfluous. Furthermore, in hospitals and health regions, an all-encompassing EPR is expected to replace many existing information sources. This argument supports standardization, in which hospitals aim to implement a few centralized and standardized technologies, such as EPRs, as their core systems.

However, surprisingly, the effort to use ICT to eliminate and reduce redundancy has frequently caused difficulties or outright failures. Efforts to replace oral communication, particularly related to nursing handovers, have frequently failed in the attempt to replace oral handovers by written handovers (Munkvold et al. 2006) and to replace informal information sources by formal ones (Ellingsen and Munkvold 2007). One reason is of course that these sources are not “visible” to the same extent as formal information sources are, but they are nonetheless essential in tuning, adjusting and monitoring their use among groups. Hence, informal information sources are part of what Star and Strauss (1999) referred to as articulation work that is invisible in rationalized models of work (ibid.).

Similarly, the implementation of hospital-wide EPRs to eliminate many redundant smaller and local systems has not met expectations. A key problem is that large-scale systems generally focus on administrative, financial and organizational aspects of the hospital at the expense of the functionality of smaller systems that are tailored to various local practices. In such cases, technology often imposes constraints, impediments and rules that interfere with consolidated and effective practices (Heath and Luff 1996; Ellingsen et al. 2007).

### 2.3. Towards a new approach: understanding the essence of clinical work

The many failed attempts to replace redundancy suggest that we need a better understanding on the role that redundancy plays in clinical work. This understanding may then provide a basis for determining where, when and how either to reduce it or to support it in cases where redundancy has a positive role to play. In this regard, Meum (2013) appraised the importance of the distinction between negative and positive redundancy for its potential to increase “the understanding of how the correlation of supplementary information has a role in the integration between work processes and computer systems”. Recently, Tang et al. (2015) suggested considering the redundancies at play in a hospital setting as part of a comprehensive analysis of the socio-technical requirements for effective communication and collaboration. Moreover, Zhang et al. (2014) suggested that data redundancy in hospital records could have the potential to function positively. However, “further study is needed to determine the extent to which these communication patterns improve teamwork as opposed to simply producing an overhead”.

A nuanced view of redundancy may be found in the classical resource management literature where redundancy has a positive connotation. In this regard, one type of redundancy is the redundancy of functions, which the management may obtain either by employing more people than are needed or increasing the capacity of individuals by creating an overlap of functions or skills (Emery et al. 1978). The redundancy of functions allows different people in an organization to complete the same task so that it is flexibly substituted or exchanged as seamlessly as possible according to the current needs. In classic organizational theory the combination of

skill duplication and overlap is associated with “the ability of an organization to suppress error and generate alternative action strategies”. In a healthcare setting, an example may be found in emergency centres, which rely heavily on shared rules and protocols so that practitioners know what to expect at any point in time. Here redundancy facilitates the availability of functional alternatives when dealing with emergency cases (Tjora 2004). Thus, in order to function efficiently, everyone also needs to know something about the other person’s job in order to interpret the situation.

In contrast, the redundancy of effort is considered harmful because tasks are repeated several times or more resources than necessary are invested in accomplishing the task. For this reason, the redundancy of effort has frequently been the focus of elimination. However, redundant effort could also be viewed as a clear strategy for improving effectiveness and safety. For example, someone repeats a word to increase the possibility that it is heard by the other person; similarly the latter could repeat a message to make sure that what was said by the former has been understood thoroughly, such as directions give in naval processing (Hutchins 1995) where the expression “Do you copy me?” is intended to determine whether the message is understood so clearly that it could be repeated word for word. In the same vein, the work in coordination centres is characterized by a certain amount of redundancy of effort because information is checked repeatedly, possibly through the use of a conventional jargon (Normark 2002).

Furthermore, the redundancy of effort can be stipulated in an official or conventional protocol or it can be a spontaneous practice that is introduced and accepted by the target community for some benefit. In the first case, the redundancy of effort is the result of a precise choice of the management to achieve different goals, such as reliability and accountability. In the second case, the spontaneous redundancy of effort has to be observed from an evolutionary perspective to understand why spontaneous redundant practices have appeared in the field of work and especially why they have survived efforts to optimize them. Similarly, with regard to the redundancy of data or the technological components through which data are digitalized, the use of multiple representations of data and components may increase the fault tolerance of the system (Gorman et al. 2000; Perrow 2011). Accordingly, studies in the CSCW field have pointed out that overlapping information sources and redundancies indeed have a role to play because they are a potential source of reliability in collaborative work (Ellingsen and Monteiro 2003; Tjora 2004). The redundant nature of artifacts and information contributes to making components robust because if “one component fails for the lack of knowledge, the whole system does not grind to halt” (Hutchins 1995, p. 223). In addition, the data in different information sources may be compared in order to ensure the quality of the information that is disseminated.

However, our discussion so far mainly reflects the organizational perspective on redundancy, and therefore represents a bird’s eye view of this phenomenon. In comparison, clinical work is extremely complex because of its richness and

messy character (Berg 1998; Strauss et al. 1985) and its continuous uncertainty (Atkinson 1995, p. 111; Hunter 1991, p. 28) in which “[informal] comes into being with formal” (Berg and Timmermans 2000). Berg (1996) relates this to an ongoing process of making problems manageable within the hospital’s work routines:

“Through activities of reading and writing (. . .) [the physician’s] narrows down the plethora of potential tasks and divergent data into a clear notion of ‘what to do next’.”

Accordingly, in order to suggest design guidelines (both social and technical) for dealing with redundancy, we need a detailed empirical understanding of the nature of clinical work that may both contribute to and cause redundancy in several specific ways. Some aspect of clinical work are investigated in the literature. An important part of problem solving in hospitals is related to determining the diagnoses of patients. In simple cases, a disease will be easily recognizable when its major symptom is readily apparent, but in many other cases the diagnosis is far more complex (Hunter 1991, p. 70). One way of dealing with this uncertainty is to use a narrative approach, as every event in medicine, at least potentially, consists of both oral and written narratives (Hunter 1991, p. 69). There is no way to solve a difficult problem without telling its story because stories make sense of ambiguous situations (Orr 1990), which applies to communication in nursing handovers as well as the progress notes written by clinicians. There is a close relationship between written and oral accounts in the everyday organization of medical work (Atkinson 1995, p. 90; Hunter 1991, pp. 5–6). Based on narratives, work is obviously communal and thereby collaborative, such as nursing handover conferences and interdisciplinary meetings, morning meetings etc.

In such socio-technical ensembles, the handover conference plays informational, social and educational roles (Kerr 2002). In a busy hospital environment, the oral handover is an important meeting place where the entire team is assembled, and it provides a basis for social affiliation and coordination of tasks and work. The handover represents the transfer of responsibilities from the outgoing nurses to the incoming nurses. The handover conference allows for a discussion of particular patient cases, as well the processes involved in reaching a consensus about what to take (Kane and Luz 2006). Accordingly, decision making is a collective activity in which decisions may be subject to debate, negotiation and revision based on the talk within and between groups or teams of practitioners (Atkinson 1995). In addition, oral handovers include an educational aspect, which challenges the implementation of written reports. Both verbal and non-verbal communication in oral handover conferences allows for dynamic interaction in which inexperienced nurses may learn from experienced ones. Hence, we need to consider how the knowledge that is distributed among individuals and embedded in their work practices could be integrated and shared with others, not by dividing the situation into elemental parts but by focusing on the entire situation



and providing intensive feedback about the accuracy of clinical judgements (Benner 2004). Consequently, the redundancy and overlap in the work practice may increase the robustness of the system, which potentially could be lost in a written handover.

A related area is the identified repetitions found in progress notes and discharge letters. A key insight is the way in which repetitions carry weight; they are anything but redundant. Repetitions selectively enact certain elements by omitting others. The generation of discharge letters that are intended to summarize and “repeat”, provides an opportunity to analyse this historical reconstruction of working knowledge. Garfinkel (1967, pp.204–205), in his study of medical work, makes a similar point in emphasizing the productive roles of repetitions and omissions:

“A subsequent entry may be played off against a former one in such a way that what was known then, now changes complexion. The contents of the folder may jostle each other in bidding to play part in a pending argument. It is an open question whether things said twice are repetitions, or whether the latter has significance, say, of confirming the former. The same hold true of omissions. Indeed, both come to view only in the context of some elected scheme of interpretation”

### **3. The role and forms of redundancy: the field studies**

In order to answer the first two research questions regarding the possible role and forms of redundancy, we report the design and the outcomes of the field studies that the authors conducted in Italy and Norway in previous years. After the research settings and the methodology are described, four vignettes are examined to support the final considerations of the multifaceted aspects of the observed redundancy.

#### **3.1. Research setting**

The clinical settings of our field studies were two hospital departments in an Italian Hospital and two clinical settings in a Norwegian hospital (see Table 1). The Italian studies were accomplished in two different periods and departments in the “Alessandro Manzoni” Hospital (AMH) in Lecco (Italy), which is a large teaching hospital (approximately 1,000 beds and 2,700 employees) that serves a provincial territory (whose catchment area is approximately 300,000 inhabitants, an average of 20,000 hospital stays yearly) in the Northern area of the most populated region of Italy, Lombardy, where one sixth of Italy’s population lives (10 million inhabitants) and whose gross domestic product is the highest in the European Union. The second study was conducted in the neonatal intensive care unit (NICU) at the same hospital. These two settings were chosen because

*Table 1.* Data collection methods about the four field studies reported in the paper.

Study sites	What	When	Interviews	Observations
Rheumatology ward (UNN, Norway)	Field observations of: Interdisciplinary meetings where discharge reports were produced	Feb 2000 Jan 2001	10 interviews (avg length: 1 hour)	40 hours
Psychogeriatric ward (UNN, Norway)	Field observations of: Nursing handovers, interdisciplinary meetings, and the process of writing nursing plans reports.	May– Dec 2005	15 interviews (avg length: 1.5 hour)	80 hours
Internal Medicine Department (AMH, Italy)	Field observations of: Nursing handovers, interdisciplinary meetings, ward rounds, and the daily tasks of record-keeping. Artifact analysis (see Table 4)	Dec 2004 – Mar 2005	7 interviews (avg length: 1.5 hour)	65 hours (including artifact analysis)
Neonatal Intensive Care Unit (NICU) (AMH, Italy)	Field observations of: Nursing handovers, interdisciplinary meetings, ward rounds, and the daily tasks of record-keeping. Artifact analysis (see Table 4)	Jan– May 2006	4 interviews (avg length: 1.5 hour)	25 hours (including artifact analysis)

of their apparent diversities. The patients admitted to the IM ward were long-term and acutely ill. They were attended by practitioners who specialized in the diagnosis and nonsurgical treatment of a very wide range of adult diseases. Conversely, the NICU shelters premature new-borns with severe deficits and high criticality needs that are addressed by highly specialized practitioners who often work in a frantic environment that is similar to that of a typical emergency unit.

The two Norwegian studies were conducted at the University Hospital of North Norway (UNN), which has approximately 5,000 employees, including 450 physicians and 1,000 nurses. The hospital has 600 beds, of which 150 are psychiatric. Precisely, the first study was conducted in the rheumatology ward, which is a medium-sized ward at the university hospital consisting of 23 beds served by cross-functional personnel: physicians, nurses, physiotherapists, occupational therapists and social workers. The second study took place in the psychogeriatric ward at UNN. The patients in this ward were 65 years or older and were usually diagnosed with a psychiatric disorder such as dementia or anxiety. The average length of a patient's stay was six to eight weeks. There are 45 permanent staff, including nurses, unskilled workers, substitutes, social workers, occupational therapists and physiotherapists.

### 3.2. Research method

The analysis of these four studies is based on an interpretative research tradition (Walsham 1995; Klein and Myers 1999), in which reality is socially constructed by the participants. Our study largely followed the ethnographic tradition, which is useful for obtaining an in-depth understanding of the people, the organization and the broader context of their work (Klein and Myers 1999; Forsythe 1999; Harper 2000). The interpretative approach assumes no predetermined relationship between information technologies and social contexts. As researchers, we thus “[seek] an understanding of the context of the information system, and the process whereby the information system influences and is influenced by the context” (Walsham 1995, pp. 4-5). The methodological strategy of this study is based on the qualitative research paradigm. We were inspired by ethnography in particular, and we relied to a large extent on participant observations as the primary method. A key aim of an interpretive inquiry is to identify the perspectives of the different stakeholders in order to gain a thorough understanding of the phenomenon in question. The data collection methods consisted of semi-structured interviews, participant observations, informal discussions, document analyses and participation in internal project meetings. The form and extent of the data collection methods are shown in Table 1.

All interviews were taped and subsequently transcribed. Hand-written field notes were taken during the observations and transcribed immediately after the interviews. The analysis of the data was based on a hermeneutic approach (Klein and Myers 1999). In this approach, all sources of field data are included in the interpretation process. The methodology included relatively detailed case reports, followed by the examination of the data to identify potential analytical themes (Seidman 2013). During the fieldwork, the data were regularly validated through discussions with key informants, and the transcripts were read by the informants to obtain their approval and verification of the content.

### 3.3. Redundancy at work

The following four vignettes are examples of the investigations that were performed to deepen the understanding of the role of redundancy in some critical steps of clinical work and how some technological solutions did or might “disorganize an organized state” (Landau 1969). They serve as a direct empirical basis for the technological considerations that will be developed in the next sections.

Tables 2 and 4 describe the main artifacts that were observed to be used by the practitioners and that were referred to in the Norwegian and Italian vignettes. As the tables show, the artifacts encompassed two parallel records, the (patient) clinical record, compiled by medical doctors, and the nurse documentation or care record, which is completed by nurses. These two artifacts support task planning and execution and their recording in equal and complementary ways. The (patient) clinical record includes the physicians’ order entry, drug prescriptions and examinations. This record is the physician’s primary source of information. In contrast, the nurse documentation or care record is primarily used by nurses to articulate and document their activities in caring for the inpatients.

#### 3.3.1. *Vignette 1: Physicians and nurses in a discharge meeting*

The Department of Rheumatology is a medium-sized ward at the university hospital. It consists of 23 beds that are served by cross-functional personnel: physicians, nurses, physiotherapists, occupational therapists and social workers. There are a vast number of different rheumatologic diseases, the various symptoms of which often prohibit an exact diagnosis at an early stage. Accordingly, the ward has many chronic patients. On this Friday morning, 10 physicians are present at the previsit meeting. The physicians have brought written notes, and they take additional notes as they discuss the latest information about the patients. On the table, there are stacks of patient records and the patients’ medication charts. Some of the records are very thick, up to 15 cm each, as the ward has many chronic patients. Some physicians skim through the patients’ records. A book containing nurse documentation is also on the table. A nurse brings in a booklet that contains laboratory results.

After working through the documentation on all the inpatients, it is time to discharge some patients. Another nurse joins the group, bringing the nursing documentation about the patients. The group then discusses the cases thoroughly. In one instance, they discuss what to do about a specific patient who regularly forgets to take her medicine. Based on their different information sources about this patient (the nurses’ documentation and the physicians’ notes), they discuss how to cope with the situation. One of the physicians underscores the importance of taking the prescribed medication while the nurse argues that pushing medication now is of no value because the patient forgets to take the medication, and they would not be able to follow her up after she left the hospital.

*Table 2.* The main artifacts involved in the clinical settings care and coordination activities that had been objects of our study in Norway.

Main folder	Single Component	Brief Description
Patient Record/ Clinical Record	Physicians' Running/ Progress Notes	Contains chronologically narrative on the patient's progress, any significant events, and specific actions that have been taken from the perspective of the doctors
	Medication Chart	Contains pulse, temperature, blood pressure, medications prescribed and given
	Laboratory Results Abstract Sheet	Results of requested lab examinations The informal Abstract sheet is an outline for a stay of a patient
	Discharge Letter	Reports to the patients' general practitioner
	Discharge Form	A hand-written preliminary discharge letter containing brief information to the patient, the general practitioner and the secretary at the Rheumatology ward.
	Specialist Reports	Examinations by specialists from other wards.
	ECG Printouts	Electrocardiography
	Informal notes for each professional Nurse documentation	Paper Notes, Personal Notebooks
A book containing nurse documentation		The nurses regularly used personal notebooks in interdisciplinary meetings to remind them of recent, and important, observations
Electronic Nurse Module (report section)		Corresponds to physicians' running notes
Electronic Nurse Module (progress notes)		A nursing care plan containing highly structured international codes for diagnoses and interventions.

Table 2. (continued)

Main folder	Single Component	Brief Description
	Predesigned schemas	The codes are based on the NANDA and NIC classification systems. Different types of schemes for recording information where we document anxiousness, sleep, worries, shouting, anger, eating and drinking
Whiteboards	Whiteboards	Contained entries for all admitted patients, indicating the status for each of them.

Nurse: She forgets to take her medicines.  
 Physician: But it's important that she takes them!  
 Nurse: Why bother? She forgets it anyway when she returns home.  
 Physician: She has all the signs of depression and has been suicidal.

The group studies the patient's chart, which contains important information, such as pulse, temperature, blood pressure, medications prescribed and given. They discuss the current medication. One physician writes something on the patient chart. The nurse writes notes on her own paper, which she will later transfer to the nursing documentation. After a while, the table is covered with papers from the patient records, specifically the chart book, which contains information about all the patients associated with this working group. For each patient, essential information is extracted from his or her paper record. The chart book also contains the patient's medication chart, laboratory results and abstract sheet. The abstract sheet is the outline of the stay of a patient. Physician A explained:

"It is a tool for us... It contains information about the history of the case, reason for referral, patient diagnoses, internal referrals, test results, problems etc".

The abstract sheet is also an important tool in the communication with the other professionals in the hospital, such as nurses, physiotherapists, occupational therapists and social workers. The abstract sheet is used in interdisciplinary meetings both as a summarized version of the case and as a place where to write short notes.

The chart book contains copies of the physician's running notes that were previously entered in the EPR. When a patient is discharged, a letter is produced and sent to the general practitioner. However, because of incomplete information and the lack of personnel resources, it often takes a week or more before the discharge letter can be produced. To compensate, a preliminary discharge letter, a so-called discharge form, is produced before the patient leaves. The discharge form is on A4 paper to which several carbon copies are attached. It contains brief handwritten information about the patient, the general practitioner and the secretary at the rheumatology ward. One copy is placed in the patient's record until the formal discharge letter is written.

Discharge letters produced by the Department of Rheumatology tend to be long because of the chronic character of the patients' illnesses. However, the detailed discharge letter seems to be only partially useful to the general practitioners, who usually prefer to have their questions answered as quickly as possible prior to receiving the complete discharge letter. General practitioners include only the most important parts of the discharge letter in their own EPR system. Let us return to Friday's round of discharging patients. Physician A has three patients to be discharged. To support the writing of the discharge form, she uses information in the chart book (e.g., the laboratory results), consultations written by other specialists, EKG printouts and physicians' text notes. She frequently examines the patient's chart and the abstract sheet to obtain the information for the discharge form.

### *3.3.2. Vignette 2: Nurses producing the nursing plan*

In the psychogeriatric ward at UNN, the patients are 65 years or older, and they typically have been diagnosed with a psychiatric disorder, such as dementia or anxiety. Some are extremely psychotic and constitute a danger to themselves and others. In addition to the physicians and psychologists who visit several times a week, there is a staff of roughly 45 environmental workers in the ward, many of whom are nurses.

The electronic nursing module introduced in 2005 includes guidelines for writing daily reports and for creating nursing care plans for each patient. The module includes replacing oral shift handovers by written handovers—the so-called “silent handover”. The screen is divided into two parts. The upper screen shows the report section where users write reports about a patient several (usually three) times a day. In this section, the users have the option of writing a free text, that is, constructing a narrative about the patients' problems. The lower screen shows the actual nursing plan. Unlike the report, it is highly structured and contains international codes for diagnoses and interventions. The codes are based on the NANDA (NANDA 2005) and NIC (Butcher et al. 2013) classification systems. Several NIC interventions might be prescribed for one NANDA diagnosis. Each NIC intervention might include several instructions) (see Figure 1).

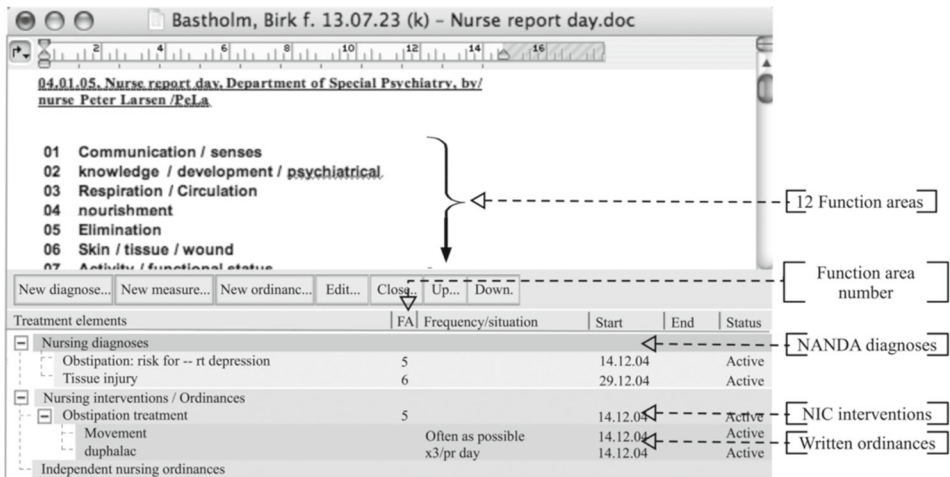


Figure 1. From Ellingsen et al. 2007.

The user writing the report is expected to use the plan, including the diagnosis, interventions and instructions as a basis for the reports:

“The goal is to write as little as possible in the report, we shall only write what deviates from the nursing plan.” (Project group nurse)

However, redundancy was (re)introduced to increase the robustness of the plan. For instance, although certain information was already contained in the plan, the daily report sometimes repeated the content of the plan. Consider this extract from the daily report that a nurse wrote for a diabetic patient:

“Be aware of the restrictions concerning fruits, cakes, etc. The patient is not capable of regulating the amount of these things. See the nursing plan” (extract from the report)

This information was already captured in the plan, so why repeat it here? The nurse explained:

“Sometimes things are registered twice, that is, what is in the report you may also find in the nursing plan. This has to do with experience (. . .) I know that the report is read aloud at the change of shift meeting while the nursing plan is not”

In response to the inability to decide how to classify interventions, a common strategy is to duplicate the information by entering it in both possible places, but slightly rephrased to “cover up” the duplication. Another example is a patient with neglect on her left side after a stroke. The nurse was not quite sure where to write the instructions “talk to” and “inform”. She finally decided to place them under the NIC intervention, “reducing anxiety.”. However, after further consideration, she decided that this instruction might be as equally well placed in the NIC



intervention category, “neglect–left side”. Therefore, she rephrased the instructions “talk to” and “inform” to “explain what is going on” and added it to the “neglect–left side” category. She admitted that this meant that similar instructions were entered in several categories, but she said, “It has to be like this in order to be visible in both places” (see Table 3).

A major aim of the nursing plan was to replace many of the existing heterogeneous, redundant and informal information sources in the psychogeriatric ward. However, the nursing plan was used to a lesser degree in practice, such as during nursing handover conferences and in interdisciplinary meetings. Instead, the old heterogeneous information sources were used. For instance, in treatment meetings, the observations made by the nurses were crucial:

“In our ward, medical treatment has little effect on the patients. Therefore, environmental therapy (. . .) and nurses’ observations [of patients] and [subsequently their] interpretations become especially important.” (Physician)

“Discussing the observations in the meetings involves a lot of participants and takes most of the time (. . .) the physicians contribute with advice in this process, although they have the formal responsibility for the treatment.” (Nurse)

The nurses regularly consulted personal notebooks in interdisciplinary meetings to remind them of recent important observations. In addition, they regularly drew on schemes for recording information, which had been used when they observed and worked with patients:

“We have different types of schemes for recording information where we document anxiousness, sleep, worries, shouting, anger, eating and drinking, etc.” (Nurse)

The physicians, in contrast, would use the paper-based medical cardex, which contains information about prescriptions, medications and associated dosages. Another information source that was frequently used in interdisciplinary meetings was the large whiteboard in the common meeting room. The whiteboard contained entries on all the admitted patients and indicated the status of each. Consider the following fieldnote extract from the cardex meeting:

“A nurse is reporting on a patient who is suffering from anxiety. The patient is extremely agitated, almost hypomanic (. . .) While the nurse is talking, the

Table 3. Redundancy in the nursing plan.

<b>Intervention</b>	Reducing anxiety
<i>Instruction</i>	Talk to
<i>Instruction</i>	Inform
<b>Intervention</b>	neglect - left side
<i>Instruction</i>	explain what is going on

rest of the staff is preoccupied with making notes in their private notebooks. However, one of the physicians has moved to the whiteboard. He updates the field called going-out-status and writes “go with”, which means that the patient is not allowed to leave the ward without being accompanied by a nurse”

Typically, the nurses made notes in their private notebooks or on slips of paper during such sessions. Later the actual updating of the nursing plan usually occurred during the writing of the nursing reports, which typically occurred some minutes before the nursing handover conferences. The nurses then used their personal notebooks, data recording schemes, whiteboard information and other information sources as input to the nursing plan.

Although it was considered important to have a complete plan, it also became evident that without any boundaries, the plans for patients with complex conditions would increase substantially, which would make it difficult to keep track of the content. While writing a report and updating the plan for a patient with stroke, anxiety and other complicated conditions, one nurse said:

“We could for sure have written 15 pages on this patient because there are so many things that are important.” (Nurse)

Hence, the users had to decide carefully what to include and what to omit in the plan. Because the documentation must reflect the context of the psychiatric ward, somatic conditions were included and repeated in the plan to a lesser degree. Hence, for psychiatric patients with stroke, many of the measures and instructions related to the general care and management of stroke were omitted.

### *3.3.3. Vignette 3: The order entry by the physician in the ward*

In the Italian ward, the process of medication delivery was still paper-based: the official documentation (i.e., laboratory examinations forms and medication records) was compiled by a practitioner (usually a physician or an accountable nurse). The head nurse then checked whether the request matched availability by consulting the current medication records in the ward’s drug storeroom. The head nurse also checked orders in the general therapy context and detected possible deviations. The drug orders were written again on the internal forms of the hospital, which were read by a clerk in the pharmacy or by the laboratory staff. Then the hospital introduced the measure of checking and double checking in critical situations in order to rely on the institutionalized form of redundancy of effort.

Because medication delivery might be inconsistent, there is an obvious and urgent need to avoid mistakes or drug misuse, which raises serious concerns about various safety measures (Donaldson et al. 2000; Korpman 1990). For this reason, we discussed with the physicians and the nurses the implications of the adoption of the computerized physician order entry system (CPOE), a technology that requires the physician to enter orders for patient care directly into a computer-based system, thus eliminating transcription mistakes. An automatic CPOE would

not only relieve health practitioners from the effort of recopying the order but also eliminate the direct involvement of the pharmacy or third-party services staff—at least at the level of single order entry—thus resulting in the elimination of redundant effort. Our discussions with the practitioners and our direct observations of their practices showed that a CPOE would be beneficial only in part. In fact, automated order processing requires that information, which is supplied only once to the computers by the practitioners, is as precise and complete as possible at the time of insertion, which could result in unexpected and novel kinds of mistakes (Berger and Kichak 2004; Koppel et al. 2005).

However, eliminating the redundant access to information would require that the information be precise and complete, whereas redundancy – in terms of double checking for possible unclear or absent information – allows practitioners to be flexible in managing incomplete and unprecise information. The practitioners agreed that a clear balance between technologies oriented to the complete or partial elimination of negative redundancy of effort and technologies that tend to preserve the positive redundancy of both effort and data were to be sought and found. Hence, while guaranteeing sufficient safety, a technology such as CPOE would relieve nurses of mere secretarial work and at the same time preserve and support the collaborative nature of the overall medication process by improving the mutual awareness among all the health practitioners involved.

#### 3.3.4. *Vignette 4: Progress notes in the nursing handover*

Let us now move to the NICU of the AMH and focus on the nursing handover and related supporting artifacts (see Table 4). To improve the handing over conference, three main management strategies were adopted by each nurse, which could be substituted by any other in any given shift. The first two were two forms of the redundancy of functions (e.g., sharing the same competencies and language conventions and frequent and close work shifts) because the nurses on duty in several shifts in the same week come to sharing “gist knowledge” about all the aspects of the ward’s status. However, a comprehensive knowledge of the details concerning the ward patients’ trajectories was obtained mainly by means a third factor: the thorough handing over conference, which we observed in the process of recording the progress notes.

The progress notes are an impressive example of the advantages of redundancy, which supports coordination in terms of context sharing. In fact, the nurses’ progress notes are written in a narrative manner particularly when they summarize their work shift a few minutes before the handing over conference begins. This narrative style also may be found in artifacts comprising the clinical record although at different levels of abstraction. An example is considering information regarding a particular apparatus and disease rather than an idiosyncratic inpatient as a whole person. During our interviews and observation of the ward activities, it emerged that although the progress notes could be compiled succinctly as in any formal document, every nurse was used to writing long narrative accounts of what

*Table 4.* The main artifacts involved in the clinical settings care and coordination activities that had been objects of our study in Italy.

Main folder	Single Component	Brief Description
Clinical Record	Medication Record	Contains the diagnoses and the current status of prescribed therapies.
	Lab Examination Form and Referral Sheet	contain the requests of lab examinations and their results, respectively
	Physician Order Entry	The set including the Medication Record and the Lab Examination form
	Problem List	Contains the whole set of either concomitant or sequential problems affecting the patient
	Physician Notes (or Clinical Diary)	Contains narrative notes to chronologically chart the patient's progress, any significant events, and the specific actions that have been taken, from the perspective of the doctors
Care Record	Progress Notes	Contains narrative notes to chronologically chart the patient's progress, any significant events, and the specific actions that have been taken, from the perspective of the nurses
	Patient List	An unofficial document containing clinical data, examination requests form, remarks/observations from activities during the concluding shift and notes taken by oncoming shift nurses during handover meetings

had happened in the ward during her shift. More importantly, the nurses included information that would be useful only in the next shift. According to the description of ward activities, each shift ends with the alignment of legal documents with the activities accomplished in the ward and with the corresponding synchronization of the various documents with the nurses' progress notes, which precede the handing over conference.

The accuracy required in the progress notes may seem redundant because it requires additional efforts by the nurses. However, as observed in (Kovalainen et al. 1998), this additional effort is not superfluous. In fact, the amount of time the nurse spends in producing this supplementary information is not intended to produce a report to be used only by others. On the contrary, her effort helps her to organize past events in her mind; consequently, the nurse becomes aware of

the most crucial events that happened in the ward and their context. Her progress notes enable her to be focused during the hand over meeting because she can refer to what she has written in these notes. Hence, the most coordinative moment of ward work happens quickly but precisely when the nurses share “the same context” of the ward. The nurse coming on duty usually jots down some notes on the patient list to support her work and facilitate the next handing over conference, which is also a form of redundancy because several pieces of information are reported in other documents although sometimes in a different context.

In other words, the repeated writing supports coordination by improving context sharing. Specific and conventional signs are sometimes used to augment the efficiency and effectiveness of record keeping. The same phenomenon applies to health assistants. However, because no official counterpart of the patient list exists for them, they write notes on paper carried in their pockets, which are artifacts that support their memory. This description of all the activities related to the shift change, provides a clear example of the redundancy of data and effort, which is spontaneously managed by all the actors involved, regardless of their specific role, competencies and skills.

### 3.4. The multifaceted aspects of redundancy

This section summarizes and discusses some characteristics of the observed redundancy. First, the relationship between informal and formal information sources and how these constitute each other is discussed. Second, the purposes of redundant information from different sources are discussed, particularly how they intertwine in complex negotiation and interpretation activities. Third, the section considers the ways in which repetitions—paradoxical as it may seem—are both a burden of additional effort in their production and use and but they also *carry weight* in medical and caring processes. This section concludes by proposing and discussing the classification of various kinds of redundancy from a technical perspective.

#### 3.4.1. *The informal and formal relationship (making sense over time)*

The four vignettes illustrate the inherent relationship between formal (written) and informal (oral) practices related to information sharing, in which redundant information exists across formal and informal practices. On one hand, efforts to establish formality require comprehensive documentation routines. On the other hand, the same formality may induce reluctance to document among the personnel involved until they have made sense of the patient and know the facts. Consider the following excerpt from the interview with a physician:

“The admittance report produced in the emergency department is a mix of previous case history and reasons for admittance and what the physician believes is the patient’s problem. But if this turns out to be wrong, the admittance

report becomes completely useless. What the admitting physician assumed initially becomes irrelevant both in professional terms and for the receiver of the discharge letter.”

The uncertainty in reporting a patient’s case may be also still valid in the long run. The rheumatology ward is a vivid illustration. At the morning meetings, the group is faced with patient records each of which contains 20 cm of written documentation of chronic conditions. Therefore, the narrative encapsulation is vital. One physician explained:

“We are a kind of oral and assessing profession (...) it is important to have meetings, to discuss which treatment that is most important or correct and whether it should change or not (...) [for chronic patients] we have medications that will not be effective within 3 months or 6 months’ time.”

This excerpt suggests that many informal information sources are used as part of the process of making sense of the patient and thus constitute an emergent formalization process. This potential is underscored by the fact that clinical data are often entered some time after they have been gathered (Berg 1998). In our study, the actual updating of the nursing plan usually occurred during the writing of the nursing reports, typically some minutes before the nursing handover conferences. The nurses then used their personal notebooks, data recording schemes, whiteboard information and other information sources as input to the nursing plan.

Instead, the existing heterogeneous (informal/formal and oral/written) documentation and communication practice prevailed. This heterogeneity contributed to the interdisciplinary work in situ and finally served as the basis of a good nursing plan. Hence, informal information sources led to and were a condition for the success of the formal documentation. Accordingly, “[t]he most promising route towards understanding medical (or other) work practices lies not in opposing the “formal” or the “informal” or the complexity of medical work to the record’s impoverished representation of it, but in seeing how the two merge and interlock” (Berg 1996, p. 515).

#### 3.4.2. *Interpreting and negotiating (spanning out the perspectives)*

Obtaining a complete picture of a patient’s condition presupposes that the nurses make proper sense of the clinical signs and events, and they are able to understand and interpret the implications. Generally, such tasks are not performed by one nurse but are a collective achievement (Atkinson 1995; Kane and Luz 2006). The nurses in the team need to understand the patient’s condition and agree upon a care strategy. The best way to achieve these requirements is making sense of and discussing a patient’s case during face-to-face meetings:

“Observations, opinions and worries are difficult to write in the report. What I write in the report has to be concrete. Gradation and subjective observation may

be missing in the written documentation. When you are sitting around a table, it is easier to tell what you have observed and tell a story about the patient. Others may have observed different things and together it will be a collective understanding.” (Nurse)

The achievement of a collective understanding was based on several different information sources. Some sources had complementary functions and others had overlapping functions. The sources existed in different media, such as paper, whiteboards and IT systems. Moreover, they had slightly different purposes, such as the sleep/disorder list. This list provided a schematic overview of the sleep and disorder pattern in a 24-hour timeline where different markings indicated that the patient had been asleep, awake or restless. The list provided a quick and detailed overview, and the mobility of the paper made it easy to use in different contexts, such as at bedsides, while nursing etc. The list is not part of the formal documentation required by the ward, but nonetheless it is part of the overall landscape of the heterogeneous information sources at play.

The rheumatology ward provided a similar example. The episode with the forgetful patient illustrates the role of related but different information (i.e., the nurses’ documentation and the physicians’ notes). This example shows an important characteristic of the work in the department, namely how decisions are negotiated among (and within) the professional groups based on their related but different written accounts. One physician pointed out:

“Rheumatology is a kind of oral and assessing profession (. . .) it is important to have meetings, discuss which treatment that is most important or correct [and] whether it should change or not”

### *3.4.3. How data redundancy is generated?*

Ward work is heavily based on documental artifacts: therefore, the redundancy of data plays a primary role in supporting both coordinated activities and patient safety. During the interviews, the clinicians often referred to their ability to make explicit linkages and references within and across fields, in sections and entire sheets, and in their paper-based patient records. They said that this feature was necessary in clinical practice and especially in emergency situations. This finding confirmed our observations of the paper-based practice of record keeping, where clinicians frequently jotted down brief annotations beside the fields or inscriptions to make cross-references. Some clinicians drew lines connecting the related pieces of information, especially when these were in the same sheet. Finally, other clinicians used signs, asterisks and other symbols to relate fields and inscriptions, and others attached post-it notes.

These work practices illustrate the several ways in which data redundancy is generated. These practices are described in Table 5 and shown in Figure 2. When the same data were reported at several points of the same artifact, we called it replicated data (Figure 2, a.) because they resembled carbon copies made by

Table 5. Kinds of redundancy of data in documental artifacts.

Kind	Same artifact	Different artifacts	Same data	Related data
Redundancy by replicated data (see Figure 2, b)	x		x	
Redundancy by complementary data (see Figure 2, c)	x			x
Redundancy by duplicated data (see Figure 2, a)		x	x	
Redundancy by supplementary data (see Figure 2, d)		x		x

folding back one sheet on another<sup>1</sup> in order to have the information at hand and close to other relevant data, especially when the artifact was big and has to be scrolled. Alternatively, when the same data were reported in two (or more) different artifacts, we called it duplicated data<sup>2</sup> (Figure 2, b.). In addition to the previous motivation, this case was typical of administrative entries that were needed to construct a case related to a specific patient, which was possibly a particular step in the caring process. Our term related data (Figure 2, c. and d.) refers to (usually two) different entities or concepts or to the same concept, which is expressed in slightly different forms in relation to the context in which they are produced. They can be in strict correspondence, because of either a causal or a functional relationship between them. When this relation is functional, we termed it derivative data (e.g., in Figure 2 c. and d., the expression B stands for 2A, i.e., the functional notation  $B = 2A$ ).

When related data belonged to the same artefact, we drew on the concept of complementary data to account for their common generative and interpretative context. We drew on the concept of supplementary data when they occurred in different artifacts to account for their different contexts of reporting and reading. Therefore, derivative data are a subset of complementary and supplementary data. The above distinctions are important because they point to practices of increasing complexity, and they can be used to determine how the technology could support redundancy.

This issue is considered in Section 4 to answer our third research question.

<sup>1</sup> “Re-plicare” means “to fold back” in Latin.

<sup>2</sup> “Duplicate” means “to double” in Latin.



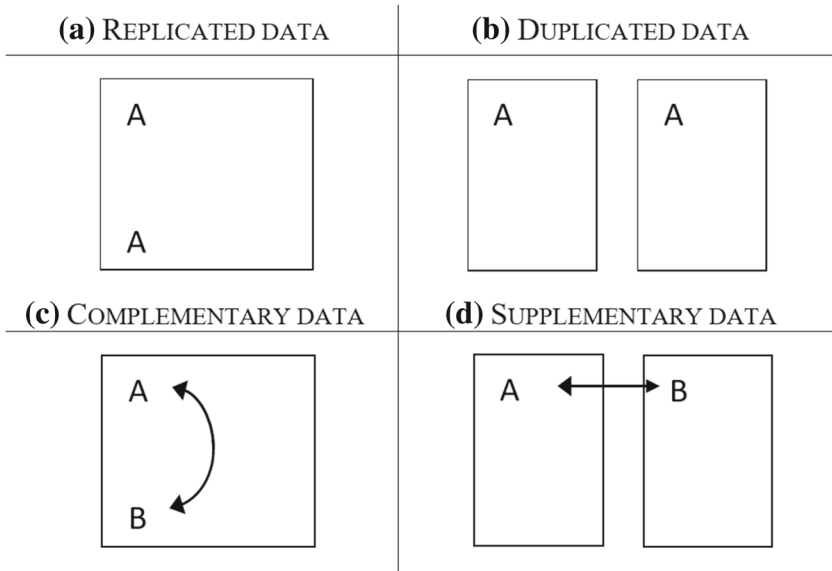


Figure 2. Kinds of redundancy of data in documental artifacts, in visual form.

3.4.4. *What to repeat and what to omit*

A key insight is the way in which repetitions carry weight; they are not void. Repetitions selectively enact certain elements by omitting others. The generation of discharge letters that are intended to summarize and “repeat”, provides an opportunity to analyse this historical reconstruction of working knowledge. Garfinkel (1967, pp. 204–205), in his study of medical work, makes a similar point in emphasizing the productive roles of repetitions and omissions:

“A subsequent entry may be played off against a former one in such a way that what was known then, now changes complexion. The contents of the folder may jostle each other in bidding to play part in a pending argument. It is an open question whether things said twice are repetitions, or whether the latter has significance, say, of confirming the former. The same hold true of omissions. Indeed, both come to view only in the context of some elected scheme of interpretation”.

This phenomenon is clearly illustrated in the Norwegian vignette when the nurses produce the nursing plan. Information and cues are added to several place in order to emphasize the importance of information and to illustrate relationships in the information. Similarly, in one of the Italian vignettes, repetitions are part of the CPOE process when it is crucial to perform quality checks on medication.

Over time, the workers become acquainted with the patients’ cases through meetings, discussions and assessments of further treatment and informal discussions in the on-duty room. The on-duty rooms are arenas for collective learning as physicians and nurses regularly come and go, pose questions, discuss cases, share

stories and talk on the phone with patients (Brown and Duguid 1991, p. 46). This collective sharing transforms individual knowledge into a sort of distributed cognition or a stream of collective self-knowledge, which is recognized as a “constant humming with itself about itself” (Cetina 2009, p. 173). Included are an ongoing enactment, refinement and omitting of earlier, historical knowledge representations. For example, the admittance report, which is the first report filled out during a patient’s trajectory, frequently needs refinement and revisions in later reports as the patient’s case become clearer to the health personnel.

The process of repeating and omitting information is a way of expressing what is most important in a patient’s case and keeping the process on track. The nurses who produce the nursing plan have to select carefully the information to include and omit in the nursing plan in order to ensure and maintain a reasonable overview. Repetition also occurs in different formats, such as whiteboards and accumulated sheets. For example, in the Department of Rheumatology, the staff used the abstract sheet in their daily operations. It provided supplementary, abbreviated and condensed information. Because of the vast volume of documentation associated with chronic patients in the ward, summaries are essential supplementary information, particularly across different communities of practice (or professions).

#### **4. How ICT can support positive redundancy**

In order to answer the third research question about the role of ICT in dealing with redundancy, we refer to the classification of redundancy types provided in Table 5. These types have different levels of complexity, which require specific considerations and functionalities to preserve the positive aspects of redundancy and limit the inefficiency and risks that might be generated by them.

##### **4.1. Supporting replicated and duplicated data**

Technology can increase the amount of redundant data among different artifacts while relieving practitioners of the redundant effort of writing. This capability is highly relevant in cases where nurses have to copy data from artifacts without achieving any real benefits (redundancy of duplicated or replicated data) (cf. Figure 2, b). For example, the replication of inpatients’ names and dates on each sheet of the patient lists falls in this category. The automatic generation of redundant data would be aimed at promoting awareness of the work status in the ward to facilitate nurses in coordinating with each other, such as by supplying the same and related data in different places simultaneously either on personal devices (e.g., pagers and tablets) or on shared public formats (e.g., whiteboards). A further example is the management of the diagnostic tests that are prescribed by physicians in forms similar to the laboratory examination form. This information is transcribed in internal hospital forms. In this case, problems and conflicts

may arise in the paper-based practice, such as when two examinations that are requested by the physician are either scheduled in overlapping hours or require incompatible preparations of the inpatient (e.g., an examination that requires the patient to fast occur on the same day as an examination with contrast media).

ICT could also be helpful in managing the redundancy of function. For instance, it is difficult to track how the learning process of novices progresses during their apprenticeship and what the novice has actually performed during her training course. A technology could be fruitfully employed to let each novice track the tasks that she is able to perform by recording them autonomously on an “activity form”. In this way, the novice could gain a deeper awareness of her levels of competencies. In addition, her superiors and coordinators would obtain an overview of the gaps that need to be filled in the novice’s training.

In these scenarios, duplicated and replicated data could be supported by an interface that specifies where the same data have to be redounded. This approach was used in a prototypical application that we developed as the proof-of-concept in a document-oriented environment where each document was built by composing smaller components and by linking them with either explicit cross-document hyperlinks or simple data-processing rules (Cabitza and Mattozzi 2017).

#### 4.2. Supporting complementary and supplementary data

The findings of the field studies presented in Section 3 showed that clinicians and nurses are proficient in managing and making sense of multiple complementary sources of information, such as the problem list and the physicians’ notes, which were observed during the physicians’ ward rounds on one Italian ward as well as the different information sources used in the Norwegian wards, such as the closely related nursing plan and the daily nursing reports used during the nurses’ handover conferences. However, the case of related data is more complex because it involves the intended meaning of the involved relations.

A back-end technology could support the redundancy of the derived data (Table 5) by means of a sound model of correlations between clinical data. The case of derived data is straightforward because the correlation type could be made explicit in a sufficiently formal way to be conceived algorithmically. A straightforward example is the computation of the partial and total balance of fluids in graphs included in the medication record. In other situations, the relations could not be formalized easily unless there were an explicit representation of recurrent rules or shared practices. For example, the relationship between the temperature of “38.5°” and an account in the progress notes of “pyrexia” (high fever). Here the role of the technology would not be to substitute or constrain human action, such as by suggesting medical deductions, (e.g., pyrexia) inferred by some vital parameters (e.g., the probed temperature) but to help the caregivers by notifying them of possible deviations, oversights and omissions. According to the rules and shared practices, these recommendations would be integrated in all the accounts

of the responsible nurse. Adding the requirement for relational “hyperlinks” to the obvious requirement of having access to the data stored in the EPR would then enrich the entries in the document by providing explicit graphical cues that would suggest to the reviewing clinician that an opportunity to access related data was available. ICT could facilitate the interpretation of this “skein” of redundant entries by not only tracing the linkages between different information across different artifacts (as suggested in Table 1) but also making explicit the nature of such linkages. To this aim, we further investigated how to characterize and typify the relations in order to make sense of and use positive redundancy. We therefore developed a series of co-design sessions with the clinicians. This series was planned to elicit from the clinicians functionalities that, based on the presence of a particular kind of correlation, could promote collaborative awareness, by helping people be mutually aware of their work with others with the aim of coordination. In the following, we report the main outcomes of this investigation, which are illustrated in detail in (Cabitza and Simone 2008).

A natural starting point of the characterization of the relations occurring between different artifacts was the Clinical Document Architecture (CDA) specification, which is a consensus-based standard developed by Health Level Seven Inc. (HL7) (Dolin et al. 2006). The CDA specification proposes built-in relations to relate any act reported in a compliant document to any other act in a semantically unambiguous way. The formal meaning of CDA relationships appeared to be “easily” grasped by the clinicians regardless of their experience and roles. However, applying the CDA’s system to their work contexts proved to be a less than straightforward task, especially the following relations: CAUS (whose semantics is “is aetiology for”), GEVL (“evaluates”), MFST (“is the manifestation of”), RSON (“has reason”) and SPRT (“has support”). The clinicians requested more than the CDA relationships could provide. They found it more natural to consider relationships occurring between data entries, either already existing or awaiting report in the clinical record. For instance, the clinicians agreed that an examination could be seen as motivating a particular drug prescription. However, using metonymy, they preferred to relate the results of the examination reported in the referral sheet to the marks that would be jotted on the medication record to denote the order of prescriptions. This preference had a strong impact on how they tended to interpret CDA relationships and on how their unambiguous semantics related to their actual needs.

Unfortunately, the technology was not able to afford the same flexibility in the interpretation of the same label in different contexts. Therefore, it could not play a proactive role in the clinicians’ articulation and decision-making processes. In order to find a suitable compromise between unambiguous indication and necessary under specification (Cabitza et al. 2013), we scheduled short experimental sessions in which the respondents were asked to relate the most relevant notes and entries that they recorded during their activities to other entries pertaining to other sections of the same clinical record both previous and expected. To achieve

this aim, we provided the clinicians with a mock interface where relationships from the CDA specification could be selected from a scroll-down menu and used to make explicit the interconnections among all clinical entries. Moreover, we encouraged the clinicians to assign an idiosyncratic meaning to these relationships according to the content to which they had applied the relationships. We then observed that the subtle differences between the CDA relationships tended to fall into three main categories of correlations: causal, temporal and intentional. Those relations can be seen as the specifications of relations between supplementary and complementary data because each source and the target information can be seen as mutually supportive, that is, as adding a semantic nuance that in a particular context mutually completes, reinforces, or generalizes (or specifies) the meanings of the related data. In general, during their interviews, the clinicians told us that by being enabled to make explicit relations with an agreed and conventional “flavour” (i.e., causal, temporal and intentional relations), they also felt both enabled and invited to write common reflections and remarks that otherwise would be difficult to reconstruct or even discover in hindsight in a less “explicit” record. This capability was then recognized as a crucial requirement for both physicians and nurses with regard to the EPR that they would welcome in their daily work.

In summary, the above narrative highlights three main requirements for a functionality to support the correlations between redundant data: i) to preserve their informality, that is, not to force clinicians to correlate data beyond their voluntary initiative; ii) to leave relations unrestricted by any rigid page structure, that is, take them as producing an information layer just above the actual data attached to them for exclusively coordinative and informal reasons; iii) to use them to provide clinicians with an unobtrusive and “light” support by graphical hints and indications as information that promotes their collaborative awareness (which we called awareness promoting information (API) mechanisms in Cabitza et al. 2007).

## 5. Conclusions and implications for design

In this paper, we discussed the crucial role that redundancy plays in clinical work. By reporting field studies accomplished in a heterogeneous range of hospital settings across two countries, we showed how formal and informal information sources are sides of the same coin. These information sources are used as the basis of a continuous process of negotiation and interpretation of patients’ cases. Grounded in our observations of the phenomenon of information redundancy in clinical records, we have given concrete suggestions about how to manage and support positive redundancy from a technical perspective. This technology, far from being detached from the organizational elements of the settings that we studied, actually emerges from and is intertwined with the social perspective. In particular, we pointed to the cross-document linkages that clinicians create and maintain, the relations that they conceive and share with their colleagues to support both collaborative decision making and articulation work, and the document

standards (namely, the CDA) that support these relationships and enable the partial automation of the repetitive tasks that relate to positive redundancy.

Although we recognize the role that technology can play in supporting the emergence of this phenomenon (instead of hindering it for the sake of ideals of hyper-efficiency), we have also noted the pivotal role that top and middle management have to play in this process. The phenomenon includes the recognition of hidden documentation practices by health practitioners in even supporting them. All the actors involved have to accept that some type and some degree of redundancy is necessary and even desirable for the seamless coordination and effective decision making *at the ward*, which is the field of work and the “shop floor” of hospital care. The acceptance of redundancy also requires that the organizational level is constantly informed about the social phenomena that constitute clinical practice, especially in settings where ICT strategies are executed, in order to prevent their “obliteration” (Hammer 1990) and to promote their “infomating” (Taylor 1995). In the traditional CSCW approach, ICT strategies must gain a firm foothold in (clinical) practice. The phenomenon of redundancy reveals that even repeated practices (e.g., writing the same data several times) must be taken into consideration, understood in the context, and supported organizationally (policies and procedures) and technologically (with specific affordances, as in the case of the API mechanisms mentioned above, and functionalities).

We therefore draw the conclusion that further qualitative-oriented studies (such as the present one) are needed to address the use of ICT systems in clinical practice. The findings of such studies may serve as a relevant alternative for managers and policy makers when they take strategic ICT decisions. Such findings would counterbalance empirically derived “hard” facts, such as statistics, surveys and economic analyses. If we are to share Deming’s famous observation, “the most important things cannot be measured” (Deming 1989, p. 27), efficiency cannot be reduced to task execution times, and outwardly superfluous activities must be considered in the design of technological support. In so doing, a truly socio-technical approach must be pursued. Focusing on particular areas for analysis is problematic to say the least. It is illusory to focus on either the technical or the social dimensions of cooperative work as if they were geometrically and ontologically different. Similarly, focusing on either formal information sources or informal ones is based in a naive attitude to system design and organizational management. (Hardstone et al. 2004; Chen et al. 2013), as if formality were an essential characteristic of artifacts.

In fact, artifacts are relational nodes that bind stories, narratives and accounts together and indeed constitute them *materially*, where “facts” (i.e., what would abhor redundancy as unnecessary elements and indeed harmful ones) emerge from “interpreted data”, which conversely need the multiple viewpoints, voices and layers of progressive writing. In the processes of sense-making and cooperation where written data document cases and represent phenomena, it would be a mistake to separate those data from the processes, as they are one and the same. In

these recording processes, which we observed and reported in this contribution to the literature, *repetita iuvant* “repeating does good” and the “repeated things help”.

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