Leveraging Coordinative Conventions to Promote Collaboration Awareness.

The case of Clinical Records

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Abstract The paper discusses the conventions used by medical practitioners to improve their collaboration mediated by Clinical Records. The case study focuses on the coordinative conventions identified in two wards of an Italian hospital and highlights their role and importance in the definition of the requirements of any system supportive of collaborative work practices. These requirements are expressed in terms of the provision of artifact-mediated information that promotes collaboration awareness. The study identified several kinds of Awareness Promoting Information (API): the paper discusses how they can be conveyed both in the web of documental artifacts constituting a Clinical Record and in its computer-based counterpart, the Electronic Patient Record (EPR). The paper ends with the implications for the design of EPRs and for their integration with Hospital Information Systems in light of the findings.

1 Background and Motivations

The paper illustrates the outcomes of a field study conducted in the hospital documental domain in order to uncover how physicians and nurses coordinate each other through their official documentation, the patient-centered clinical record (CR) and to identify supportive functionalities in view of its digitalization. As documented in the literature (e.g., [6, 26, 36, 37, 47]), the hospital domain and its document systems are characterized by a number of aspects that pose significative challenges to the CSCW research: the

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fragmented and event-driven nature of hospital work; the substantial unpredictability of the illness trajectories managed within recurrent patterns of interventions; the challenging requirements of distributed, mobile and heterogeneous actors such as doctors, nurses and their assistants; along with the multidimensional nature of the CR itself. The clinical record contains at least two partly disjointed sets of documents that are characterized by different colors, stickers and tags: the medical record and the nursing record, where doctors and nurses are supposed to document their interventions and activities. Moreover, the CR reveals a twofold nature: on the one hand, the nature of comprehensive repository for all the information concerning a single patient stay; on the other hand, that of a composite and multiperspective web of documental artifacts. In fact, when the whole clinical record is seen ‘at work’ [29] during the patient’s stay, it can be viewed as a series of heterogeneous and cross-referencing artifacts, which are each very specific for a certain aspect of care and hence are possibly used by different actors at the same time [7].

Because of this twofold nature, the CR is a typical example of “coordinative artifacts” [52]; this is a term that emphasizes the close relationship between artifacts and coordinative practices in the settings where inscribed artifacts are needed to support actors in managing task interdependencies that are too complex to be articulated by ad-hoc interaction and improvisation based on mutual awareness. In these settings, coordinative artifacts can be used by competent actors according to three general use modalities: as (a) templates, when they specify the properties of the result of cooperative work; (b) maps when they specify interdependencies of tasks or resources in a cooperative arrangement; or as (c) scripts when they specify a strict protocol of task articulation and resource interaction [52]. Several examples can be given for each of these categories, drawn from several studies (e.g., [34,38,53,57]): forms, drawings, manuals, lists, spreadsheets, even MS Word documents. Differently from scripts, which offer a limited selection of valid, legal, efficient or otherwise prescribed ‘moves’ [49], both templates and maps support coordination for their ability to let competent actors take heed of what was – or is – going on in their cooperative arrangement and to put this work context in relationship with their goals and expectations, as well as with those of their colleagues.

Our observations showed that the documents which make up the CR play both the roles of templates and maps: in fact, they support articulation work only in close connection with what practitioners find and recognize in them beyond the CR’s primary and most apparent function to represent traces of past work (e.g., in the notes and matrixes of the record) and flexible plans for future work (e.g., in process maps, checklists, and excerpts of clinical guidelines). In other words, the coordinative capability of these documents is fully exploited only insofar as practitioners are able to make sense of the subtle ways these artifacts afford meaningful cues and hints on how to articulate a given activity with respect to the other on-going activities. Moreover, we observed that these ways have a predominantly conventional
nature, i.e., they depend on a progressive – and yet selective – stratification of local agreements on what a particular inscription – or a particular way to refer to an inscription – means with respect to work activities. For these reasons, the main outcomes of our field study is twofold: on the one hand, the identification of conventions acting on and throughout the clinical record; and on the other hand, how these conventions can contribute to making the functionalities of the expected digitized CR more acceptable and profitable.

After the definition of the scope of our study, we articulate the coordinative role of conventions and describe the main ones identified from the field. Then, we show how these conventions are useful to discuss with practitioners on what information they should be aware of and how technology can promote this awareness. We will refer to the literature that we used and shared with our interlocutors to substantiate our discussions and mutual understanding. The paper ends with some implications on design and how our work will proceed in the future.

2 The Scope of Our Field study

We conducted our study in two hospital wards with different specialties and critical needs (an Internal Medicine ward and a NICU - Neonatal Intensive Care Unit) at the Manzoni Hospital of Lecco, a large teaching hospital in Northern Italy. In these settings, we observed and studied the situated practices of making sense of CR through which practitioners articulate their actions across wards and shifts in different clinical cases. From the methodological point of view, we followed a “quick and dirty” approach [39]: we made observations in the wards as unobtrusively as possible, and made informal and semi-structured interviews with key practitioners to discuss the results of our observations and to collaboratively identify problematic situations and technological means that could play a role in alleviating the identified problems. Finally, we mocked-up these supportive means using an original computational framework [18], and we used the mock-ups as a basis for further discussions about the optimal artifact mediated functionalities for effective collaboration.

In agreement with the hospital practitioners, we focused on a set of records of the CR called Single Sheets (SS). Before entering into their specific characteristics, it is important to mention that in light of the expected digitization, the observed departments had previously undertaken the re-design of several components of the CR with the direct involvement of all practitioners [15]. This situation is perhaps unique in the landscape of hospital work analysis: it created a very constructive interaction with representatives of the practitioners, since most of the conflicting points of view had already been included in the current CR. Moreover, these representatives added a point of view that goes beyond their individual perspective since they were very committed to this cooperative elaboration.

Single sheets are denoted as “single” since they integrate in one single sheet sections which, for their own function, could be parts of either the
medical or nursing record. Single sheets are used by physicians to order drugs, prescribe treatments or referrals and establish particular therapies: in short, they are artifacts that “mediate” the process of ordering and prescribing drugs to inpatients, i.e., the so called Physician Order Entry (POE).

The POE is one of the most crucial document-mediated coordinative moments in hospital work. In the POE doctors give nurses orders about either diagnostic or therapeutic interventions; while nurses give doctors clinical accounts on which doctors can take appropriate clinical decisions with a rigidly differentiated assignment of concerns and responsibilities. The artifacts used in the POE then mediate two kinds of coordinative behaviors: a more prescriptive one, in which doctors commit and delegate nurses to accomplish an intervention on the patient, and nurses make themselves accountable for the intervention to be executed as doctors expect; and a more descriptive one, where nurses give doctors feedback on the completion of the related task and corresponding clinical data, thus enabling further activities.

3 The Nature of Conventions in Cooperative Work

Since the conventional nature of hospital work emerged soon in our investigation, we were forced to clarify the very nature of the common sense term ‘convention’ with our interlocutors and among ourselves in order to avoid the risk of a misleading communication. In our investigation, we use the term coordinative conventions (CCs) to combine the common-sense meaning of ‘shared agreement and related practice that is either established or consolidated by usage’ with the emphasis on the modalities by which practitioners articulate their activities in their mutual cooperative effort. Specifically, we referred to artifact-mediated coordinative conventions, i.e. conventions that regard how and when documental artifacts are used to either articulate or document work activities. Moreover, we agreed to associate to the term coordinative convention the fact that they are usually formed in an ad-hoc manner with respect to the domain and work arrangement. These conventions are fairly flexible agreements that actors share on ‘what should be done if a certain condition recorded in a document occurs’ (i.e., actions), or on ‘what a certain condition related to any document means from the coordination point of view’ (i.e., interpretations).

The term convention has already been used in relation to cooperative work. For example, Lewis [42] defines conventions as solutions to a recurrent coordination problem. They are not habits, but something ranging from rather prescriptive rules (at least in terms of social approval and desirability) to informal codes of appropriate conduct [44]. Clark also reaches this conclusion, when he points out that conventions can solve coordinative problems since actors can “mutually expect each other to do [something] based on the regularity in their recent behavior” [22]. As an example of convention from the clinical work, during surgery, just indicating a certain element in the environment can make it clear to all practitioners involved what to do next, much alike a specific mark at the border of the page.
During the study we made explicit that CCs are regularities in the behavior, which actors of a cooperative arrangement prefer to conform to, relying on the fact that also others do, so that mutual coordination and comprehension is facilitated. The expression “prefer to” hints at two important aspects of CCs: on the one hand, conformance to CCs is a voluntary act, not imposed by an organizational entity (either role or unit) acting as a superior authority. Even when conventions are established intentionally and do not simply emerge from habitual practice, actors follow them since they want or need to, not because some organizational entity has forced them to. On the other hand, conventions are conformed to since they are worth complying with, even irrespective of the number of actors that have agreed upon them. Differently from Lewis, we relax the requirement that “everyone or almost everyone” has to conform to a behavior to make it a convention: the conventional use of documents is any meaningful habit that has been established between actors, even between two single ones. Reciprocity is hence the condition ‘sine qua non’ by which conventions can be applied, since they are built upon and are part and parcel of the common ground that is essential for any ensemble of actors to cooperate and even communicate with [43, 55]. This common ground is by nature cumulative and is developed as actors share experiences and solve coordination problems while on the job.

4 Coordinative Conventions in hospital work

In the study of the practices around the use of the Single Sheets we drew evidence that the conventional ways by which practitioners make sense of their contents and become aware of conditions and events that are useful to coordinate with each other are local, temporary, open-ended and partial: they are neither self-explicating nor fully-specified, but rather become meaningful only in the precise situations that “complete” and activate them. Moreover, they slowly change according to what actors accumulate as experience by acting in conventional ways.

Driven by the interests of our interlocutors, we focused on coordinative conventions that mainly regard either reading or writing data in the clinical record. Our study complements those studies considering coordinative conventions that regard the physical and spatial use of these artifacts, i.e., those conventions that regard the coordinative implications of how documental artifacts look and where they are located. The hospital domain gives several examples of these kinds of conventions by which practitioners can infer either the role, status and location of colleagues from simple cues scattered in the working environment: e.g., in [32] the authors describe the multiple ways practitioners draw inferences about patients and tasks based on the external appearance of records alone; in [5], it is reported how the specific position of a folder within the arrangement provides clinicians with important cues on the clinical status of the patient, the level of priority of the case,
and the progression through the different clinical activities; likewise, in [8], a case where medical records are made clearly visible at the edge of desks in order to make doctors aware that new patients have arrived is reported as an example of artifact-mediated social awareness. While this specialist literature focuses on the coordinative nature of peculiar arrangements, their conventional nature is usually left in the background, notwithstanding the fact that these arrangements work well in virtue of their ad-hocness, locality and informality.

In what follows, some sketchy vignettes describe the role of coordinative conventions when clinicians use the Single Sheets in their daily work at the Manzoni Hospital of Lecco: they are drawn from our field study as the most significative and most extensively treated in the interviews with clinicians for their strong impact on their daily work practices (see Tables in Figure 1 for a tabular summary).

Conventions on proper timing Documental artifacts are used to convey meaning besides what practitioners write on them according to their boilerplate and structure. For instance, when a doctor requires a laboratory test she is supposed to indicate whether the examination is urgent or the blood sample can be taken and sent to the laboratory with all the other routine examinations. Since the indication ‘routine’ conventionally refers to the next day early in the morning, for routine examinations the physician is usually exempted from recording the precise time and even the date of the request. Conversely, for requests marked as ‘urgent’ this indication is necessary because only in this way nurses can correctly prioritize due tasks and realize whether they must quickly take the blood sample. In addition, the locality of the conventional nature of urgency was made clear in both the observed Internal Medicine ward and NICU: at the former ward, checking the ‘urgent’ box on the single sheet for a request, means “please, send me back the lab results in half an hour”, while at the NICU, “urgent” means “right now” with no exception, due to the typical critical conditions of the premature newborns. Right timing on order completion is therefore a clear example in which unwritten CCs are at work, specifically on the notion of urgency that is taken for granted in a given setting with all the coordinative consequences of deeming something urgent: for instance, consider the CC by which nurses make sense of the time elapsed from a request, in order to understand whether they are late or not about an order. Or the CC by which nurses are supposed to explicitly notify doctors that lab reports have just been sent back from the lab and are ready to be reviewed (as in the case when they are urgent) instead of letting doctors look the reports up in the clinical record on their own. The point on the proper timing CC is not whether ward practitioners need to be supported in realizing what an urgent order means every time, but rather it is how a (digital) documental system could remind them of urgent orders timely.

Conventions on proper redundancy In a previous analysis of cooperative work in the Internal Medicine ward [15], we pointed out the manifold
ways the phenomenon of data redundancy occurs in the daily documental work of nurses and doctors. We denoted with the expressions redundancy by duplicated and replicated data those cases in which the same data are reported either in two or more documents of the clinical record or in different points of the same artifact, respectively. Also at NICU, redundancy can at times play an important role in supporting both coordination among practitioners and their decision making. For instance, it is only on a conventional basis that members of a specific NICU team want to have data on the weight, age and height of newborns reported in every single sheet of drug prescription: in fact, they want them only when a newborn is in life-threatening conditions, i.e., when it could be useful to have these data immediately available in the current sheet to calculate precise drug or nutrient dosage on the fly. Conversely, the fixed and good-for-the-whole hospital organizational rule on data replication that is irrespective of patients’ condition would likely neglect this local and team-based conventional requirement. In doing so, it would also expose practitioners to the risk of both being provided with irrelevant and overloading information and losing the unobtrusive reminder on critical conditions that the presence or absence of this data could play at the very point of order entering.

Conventions on proper compilation of records A similar case regards the infusional therapy sheet and the conventions we observed pertaining to whether a compiled sheet is considered complete/accurate or not within some practitioners’ community. At the NICU, nurses are conventionally used to not reporting liquid intake values -or to reporting them only by a rough estimate- whenever these values are within normal range; this is done for two main reasons. They adopt this convention for the sake of conciseness and to convey an implicit reminder that “all is well” to the colleagues of the next workshifts. We then observed how traditional dimensions of data quality like accuracy, completeness and timeliness [10], which are usually taken as intrinsic to a document or data set, assume a more conventional and context-dependent nature in a highly dynamic and frantic domain as clinical work is. We also observed that actors perceive how well work is documented depending on local conventions, which determine what fields are really mandatory or what could be the most convenient order of their compilation on the basis of the current workload and kind of work (e.g., whether critical or stable patients). This is also a case in which CCs and the business logic of a Hospital Information System (HIS) could be discordant with each other: the risk is that administrative managers and biostatistical researchers could have designers embed their own quality requirements (e.g., for accurate and complete clinical data) irreversibly into the EPR forms and workflow in terms of corresponding constraints that straight-jacket the coordinative and informational needs of clinicians at the point of care [17].
Conventions on content When practitioners document and make their daily work accountable, they jot down in the CR contents that can be produced and consumed in light of conventions that affect the very meaning they convey. For instance, we observed in almost any ward that the long and continuous working together of the staff generates a very complex but still yet unofficial jargon by which medical terms and habitual examinations and treatments are abbreviated in shorthand. As the novices and frequent job-hoppers that we interviewed confirmed to us, besides very ordinary ways to shorten medical expressions that are common to a certain discipline or scientific community, also other much less common naming conventions are employed, especially in spoken language. For example, in the very same hospital, practitioners referred to their ward as either ‘reparto’ or ‘divisione’, or with abbreviations such as U.O. (for Unità Operativa) or S.C. (for Struttura Complessa) according to their length of service: corresponding “ward-wide” conventions became then consolidated according to the average age of ward staffs. These and similar conventions, once introduced within a certain group of practitioners even by chance, can become more and more consolidated over time, either by sheer habit or even for the often implicit intention of fencing off outsiders or ward patrons for whom it is better that they can not catch everything said in the ward (e.g., patients or their relatives). Drop-down menus that are employed in EPR pages and forms usually disregard these local abbreviating conventions, or even worse, tend to impose their own “standard” acronyms: that notwithstanding, doctors usually fill in free-text fields with ward-wide abbreviations that make sense only on a conventional basis. Forgetting these conventions in the process of the EPR design could seriously undermine the effectiveness of any computer-based support for the mutual articulation of ward activities.

Conventions on record-based practices Other times, naming conventions come from the clash between precise marketing strategies of pharmaceutical companies and regional-wide or hospital-specific drug supplying policies: practitioners make sense of what is written on clinical records from these conventions: e.g., when they prescribe name-brand drugs, while, in doing so, they mean any drug with the same active principle; or when viceversa, nurses administer specific branded drugs instead of tantamount others once that doctors have prescribed a generic drug. The point here is that doctors and nurses cooperate about pharmaceutical treatment more on the basis of ward- or even doctor-specific conventions, rather than on what it is actually written on the single sheets. Again, forgetting these ordering conventions undermines the effectiveness of automatic drug dispensers [4] and can hinder their actual inclusion in clinical practice. We also observed a set of even more articulated conventions that –consolidating across, rather than within single wards– “regulates” how nurses should prepare patients for certain treatments or tests, especially when the latter are accomplished in an exter-
nal facility or another ward [16]. EPRs and request forms are usually intended to mediate the booking of a time slot at the external facility and they limit themselves to supporting just the “scheduling” dimension of articulation work between multiple wards: instead, the pragmatic dimension of articulation, i.e., handing over patients so that their care trajectories result in no seams or discomforts, is left to the ad-hoc externalization and combination of CCs across different communities of practice. The fact that a patient must fast a predefined number of hours before undertaking a test, or that she must be provided with either a local or systemic sedative; and even how and to which extent she should be informed about the sequence of treatments she will undergo, is a matter of more or less externalized conventions between nurses of the referring and of the accepting wards. We discussed with practitioners how it can be frustrating and unrealistic to embed these conventions into any global logic. Global organizational rules usually do not take into account practitioners’ idiosyncrasies, particular testing modalities and other local practices.

Conventions on underspecification The above mentioned conventions not only involve record keeping practices but also how clinicians make sense of what is written on these records. For instance, blank fields in the liquid intake sheet are interpreted as either ‘good news’ or ‘missing values’ according to the general condition of the newborn. In this case the intended meaning of a blank structure for whoever conceived and designed the form (i.e., ‘no value here’) differs from the context-situated meaning that that same structure acquires for whoever fills in it during her work (i.e., ‘no significant value to report’). These misalignments are inevitable but they are not bad per se. Traditional paper-based artifacts, with their silent but still present structure allow for these minor misalignments to be integrated into the usual daily work. This is because the constraints associated with structure and its intended function are left purposely underspecified, and hence they do not have the capability to overwrite the doers’ actions. The opposite would happen in the case of an EPR page that forced practitioners to fill in its form completely in order to give them access to other forms to use in the next activities. Another example of conventions thriving between the folds of underspecification concerns another sheet from the CR, the ‘First Care Planning’ (FCP) sheet. At the Lecco hospital the physician admitting a new inpatient is supposed to formulate at least three, but not more than five, diagnostic hypotheses since this is considered to be the optimal ‘medical framing’ of a given symptomatology irrespectively of its clarity or uncertainty. The hypotheses must be filled in in order of reliability and likelihood and must all be pertinent to the signs collected in the preliminary objective examination. Correspondingly, the FCP sheet has five blank rows and no space for further comments, which the physician should report on a specific section of either the Problem List or the Clinical Notes sheets, if necessary. Notwithstanding these hospital-
wide rules, the convention among admitting physicians is to only report the hypothesis of the most probable diagnosis, possibly adding related comments if other hypothesis should be considered.

We conclude this section by emphasizing that CCs like the ones illustrated above are seldom supported by document and record systems in a native way: rather, coordinative conventions involved in paper-based practices usually only survive in the grey zones of systems that have the potential to almost completely thwart and block them (see Figure 2). This fact is mainly due to the little attention to conventional practices that analysts and designers pay when they are committed to the elicitation of functional requirements, since their attention is more directed toward activities and operations that generate value from a management perspective. Our point is that full-fledged functional requirements can not come (nor should they come) from the externalization of coordinative conventions. The latter are local, informal and can pertain to extemporaneous groups of actors that develop across institutional communities of users: in our case, these groups encompassed doctors and nurses, clinical and administrative practitioners, and nurses of different facilities. For this reason, after discussing with practitioners about how CCs should be supported in their EPR, we agreed that freezing these conventions in ad-hoc and narrow-scoped functionalities would have resulted in giving these informal habits more “visibility” and formality than necessary; and that this could also backfire on the effectiveness of their practices. Therefore, we agreed that CCs should inform mechanisms which are able to evoke these conventions without constraining or imposing them within their daily practice. This agreement stimulated the active participation of practitioners in the further elaboration that we describe in the next sections.
5 Local Conventions as Basis for Awareness Promotion

From the cases illustrated above it is clear that any (computer-based) support for cooperative practices should recognize the value of coordinative conventions and preserve them by avoiding undue constraints on work practices. This conservative view of coordinative conventions, though not trivial, neglects the possibility of leveraging conventions to provide practitioners with a support which is more aligned with how they really work. The fact that a) conventions are more informal than the rules and policies of an organization; b) their scope is more local, i.e. specific to small groups of users rather than to the whole hospital; and c) their life-cycle is bound to the contingent and transitory needs of communities that are much more fuzzy-delimited than institutional units and departments of the organization; all these facts suggest that conventions can not be the basis of functionalities that prescribe well-cut flows of work, establish preconstituted orders in the work arrangement or mediate formal communication. Rather, conventions can be leveraged to indicate opportunities to practitioners for informal but correct interpretations, suggest for them behaviors which could meet the local and informal expectations of their colleagues and help them make sense of highly context dependent situations.

The idea of considering the convention-based provision of suitable information and indications as a way of supporting cooperative work was first semiinally introduced by Mark [43]. Mark suggested conceiving the requirement of establishing and maintaining appropriate conventions within a distributed group of cooperating actors akin to the requirement of building and maintaining “an active learning device” aimed at improving what in the CSCW literature is called collaboration awareness. This regards the capability of the actors involved in a collaborative setting of being constantly aware of the conditions that are relevant for performing their work and coordinating each other. We were influenced by Mark’s suggestion of relating conventions and collaboration awareness with some differences. First, while Mark’s investigations focused on loosely distributed groups, our field studies focused on relatively closed communities of practitioners that share strong common interest (the care of patients), hold and develop a common ground of knowledge and experience (the clinical cases), cooperate by means of offi-
cial inscriptions on a web of documental artifacts (records and reports), and develop and maintain local conventions and agreements for making sense of these inscriptions. Second, during our study we progressively interpreted such a learning device as a proactive way of improving coordination and promoting collaboration awareness by making actors aware of contextual conditions only when they are relevant to a specific convention. To support memory, judgment, communication and coordination clinicians agreed that records and reports should be augmented by functionalities that go beyond mere annotating capabilities [12]: e.g., adding informal notes, extemporaneous links, marks, colored strips and the like to the “data layer” [13] of records and official documents. In addition, the computer-based system should provide practitioners with contextual indications conveyed as graphical clues through the artifacts used in a seamless and unobtrusive way with respect to clinical practices of data accumulation and task coordination [11]. The contextual indications would be meaningful, and hence pragmatically useful, only in virtue of specific conventions that the clues evoke, leaving to practitioners the task of recognizing the relevance of the conventions evoked and exploiting them if needed.

The study was then oriented towards the identification of suitable information to promote awareness – called Awareness-Promoting Information (API) – according to the precise requirements that clinicians expressed for a suitable support of their convention-based articulation work. Novices advocated API provision as a support for their ‘practice learning’ and inclusion in the ward habits. On the contrary, seniors and experts appreciated the possibility to be reminded about relevant information when hectic action and frequent interruptions could hamper the proper compliance to conventions, local agreements and evidence-based recommendations.

Within the CSCW community, recent surveys have ended up by listing and describing up to nineteen different types of awareness information (e.g., [33, 40])\(^1\). Generalizing the situated phenomenon of collaboration awareness can be useful to detect common features and recurrent patterns of provision of this kind of information, and hence to extract similar requirements for a supportive technology. Nevertheless, one should never overlook the domain specificity of awareness promotion [51]. Much of what an actor needs to know about others and of the work context heavily depends on the application domain and on the means actors use to get this information: in our case, through the direct reading and writing interactions with documental artifacts and records, like SSs.

\(^1\) In a private communication with one of the authors, K. Schmidt pointed to the misleading nature of this expression, since awareness relates more to a state of mind, rather than to the provision of data in a specific context and for a specific purpose.
6 What Actors Need to be Aware of

The notion of *Awareness-Promoting Information* helped us address the question “what should practitioners be made aware of, while they skim, consult and inscribe official records?”. Since the problem of information overload, which Mark’s work highlighted, was also raised by the practitioners we interviewed, in trying to respond to the above mentioned question we agreed not to consider further information besides what records store and show in virtue of their institutional role: the main idea here was to avoid any additional effort by practitioners in their daily work.

In what follows, we specify the different types of APIs that we detected from the interactional and functional needs that clinicians expressed when invited to think about the actual use of their documental artifacts and of prospective digitized counterparts. We collected requirements about API provisions mainly by (a) direct observations of the use of CRs; b) interpretation of what clinicians did and said about their use of CRs, in light of relevant contributions from the specialist literature; and (c) explicitly challenging these interpretations during scheduled interviews by means of “key questions” which were inspired from those proposed in [50] and [33]. The answers we collected show that API provisions regard paper-based and electronic artifacts, both their structure and content, as well as the work practices which closely relate to the basic activities of reading, writing and annotating. The analysis we undertook allowed us to distinguish 13 typologies of API\(^2\). This set of API types is far from being comprehensive of all the possible nuances, and due to the bottom-up nature of their elicitation, some API types are partially overlapping in aim and scope. No particular effort was made to cut any clear boundary between API types since these boundaries would not reflect actual clinical practices and their needs. Even worse, fictitious boundaries between API types could affect the design of any support that would not cover the several grey zones from which most of the significative examples came from. For each API we provide an informal definition and some examples taken from our observations of the field of work and the interviews we had with the clinicians’ representatives. Moreover, it is important to note that API conveyance can regard both paper-based and electronic patient records: in the former case API is usually conveyed by marks and inscriptions that had been previously annotated by the clinician; in the latter case, API can be conveyed by means of the context-driven change in the affordance and look of the pages of an EPR, as discussed with clinicians by considering the interfaces of the most common applications. In what follows we do not explicitly consider “how actors can be made aware of something”, nor how API can be conveyed and displayed through the pages of an electronic CR. General requirements on interface design will be proposed in Section 7.

\(^2\) In what follows, we adopt the naming convention that each API is characterized by an attributive noun indicating what information actors need to become aware of.
Inquiry API
This kind of API is conveyed to make actors aware of the opportunity of further or more in-depth inquiry related to a certain item (e.g., a content entry, a whole passage of the record). Clinicians assimilated this opportunity to the imaginary situation where the record itself could “speak” and suggest to a reader that she could “have knowledge of something else related to this”. The provision of this kind of API regards three main requirements: support data interpretation; support double checking of the consistency of mutually correlated data; and support knowledge retrieval and retention on a specific clinical case, e.g., by binding fields, terms or entries with a corresponding legend, medical glossary or clinical guideline. Inquiry API can be annotated directly by clinicians when they record an item that is related to another one, possibly stored in a different document, to make this link and relationship more explicit. In doing so, clinicians can imply a relationship between entries of the CR that can be as precise or ambiguous as the case needs [19]. Moreover, Inquiry API can be generated automatically, whenever the system displays a record entry that has been correlated to others resources, e.g., by means of an explicit hyperlink, or that is related to a medical handbook or local glossary, as in the case of abbreviations and acronyms. In this case, Inquiry API can help avoid and limit medication and transcription errors [28], as well as increase practitioners’ access to educational materials [48] and improve learning and knowledge retention [41]. Irrespectively of who or what creates it, Inquiry API is conceived to make practitioners aware of additional data that could help them interpret a specific inscription, in order to leverage what has been called redundancy by supplementary data [15].

Criticality API
This kind of API is conveyed to make actors aware that either what is currently happening or what has been stored in the record represents/represented a critical and serious situation (e.g. in newborn intensive care, an APGAR score less than 4 after five minutes). Therefore, this API regards the need to check something since the related condition is considered critical and beyond an acceptability threshold that has been fixed on the basis of specific conventions and domain rules. Clinicians assimilated the situation where this API could be aptly conveyed to warn colleagues that: “beware, this is serious!”. The clinical practices provides plenty of examples, related to either absolute or relative conditions of criticality. In regards to the former category, consider the frequent case in which a convention states that, whenever the body temperature of a patient is higher than forty degrees, the accountable nurse should be alerted and intervene. In regards to the relative conditions of criticality, a doctor expressed the following more complex convention: for operated inpatients low blood pressure is normal unless and until also signs of an anaemia show up, when that could be an indication of internal hemorrhage. Similar conventions can be applied to all those cases where data become significant only after their insertion into the CR, i.e., outside the context in which they were originally recorded. In those cases,
an alert should be raised as soon as a vital sign becomes serious under some other condition, although when it was reported into the documental system it did not raise a particular warning since negligible at that time.

**Change API**

This kind of API is conveyed to make actors aware of either i) significative *updates* in the documentation; or ii) significative *shiftings* in the illness trajectory as is reported in the clinical record. Therefore, this API is conveyed according to conventions of significance to unobtrusively notify: i) what data/values have been inserted more recently and what section of the CR has been modified/updated last; this is useful, e.g., during the daily round, when physicians skim the whole CR quickly to see whether tasks ordered have been completed and if any relevant event has occurred in the previous shifts; ii) what data represent a significative change with respect to either the latest illness trend (e.g., in the vital signs, blood levels) or the last prescriptions (e.g., when a drug regimen is suspended in favor of a different regimen). Clinicians assimilated the provision of this information to the provision of warnings like these: “beware, this is new!”, “beware, this has changed!”. This kind of API responds to two intertwined requirements: on the one hand, it responds to the need for feedback channels so that clinicians can know whether and when a conventionally relevant event has occurred or not; on the other hand, it responds to the typical complaint [3] that practitioners are often left unaware of events like the insertion of new orders, the arrival of new results and the accomplishment of placed orders. Lacking computer-based support, these events and explicit feedbacks are usually notified either by direct communication – both co-located (conversations) and distributed (telephoning, coded paging systems) [25] — or by ingenious ways of exploiting resource location and arrangement (see Section 4). Clinicians consider Change API a means to either surrogate or stimulate extemporaneous communication on relevant changes in the clinical context of each patient. This API can also contribute to helping clinicians manage the frequent interruptions they have to put up with during their work [1,45], by reminding them about what they were doing when last using the clinical record.

**Deviation API**

This kind of API is conveyed to make actors aware of what data either regard or represent a variation with respect to an expected outcome, trend or indication by the physician. This API must not be confused with Change API, that regards changes (either clinical in nature or not) that occur over time; on the contrary, Deviation API regards changes of some expected therapeutic practice, physiological value range or conventional prognostic frame and that have not yet been associated to any Criticality API. In fact, clinicians assimilated the provision of Deviation API to the provision of messages like: “beware, this is something unusual!”, “beware, this is not expected!”. In this case, “expectations” (i.e., expected values reported in the CR) are based on specific diagnostic/therapeutic patterns defined in terms of local and evidence-based conventions. As in the case of Inquiry API, clin-
icians can generate this API on their own initiative: for instance, to justify a prescription that involves dosages that are significantly different from those normally computed by formulas taking into account clinical data (as body surface in chemotherapy, or age of newborns in neonatology). A clinician can create Deviation API also to point out to her colleagues that she deems a certain clinical trend (e.g., in the vital signs or blood levels) as unusual, unexpected or just different from the hoped reaction to the treatment. On the other hand, Deviation API can be automatically generated by the system, as it is already by modern electronic monitoring systems on the basis of well-known patterns of regularity. In these cases, this API is the output of rules that match the values reported in the CR (e.g., current vital signs) with upper and lower thresholds that are set according to clinical studies and well agreed practices: the convention involved is that values either below or above these limits indicate a significative deviation of the patient’s illness trajectory from the expected course and that such deviations must be managed as soon as they occur.

**Provisionality API**

This kind of API is conveyed to make actors aware of the need to consider a specific part of the CR as provisional. “Attention, this is not confirmed!” was the catchphrase clinicians assimilated to this API when we discussed its characteristics with them. They illustrated the important role of this API referring to the number of paper-based practices in which they prefer or have to convey specific items and entries as still provisional. This can be the case of items pertaining to an unfinished job that had to be interrupted. In this case, Provisionality API can support interruption management [45] in a manner complementary to Change API. We observed specific conventions on whose basis clinicians create and consider provisional data: for instance, they write notes down on the CR in pencil or on post-its attached to the official documentation before having them copied at the end of the task. In these cases, clinicians are aware that what has been inserted in the CR may be incomplete, inaccurate or still unconfirmed and unofficial, as in the case of some test results and medical reports anticipated by phone. Yet, they still need to use provisional data for a number of situated reasons even breaking institutional rules and laws: e.g., because they know that their colleagues may need those data available to activate or prepare the next tasks (cf. Articulation API); or because clinicians consider that in some particular and conventional context some data is better than no data at all. The need for actors to be aware of what is still provisional with respect to what conversely constitutes an unmodifiable and legal account of accomplished clinical deeds is essential for safe cooperative decision and judgment making. This distinction is usually not supported by the digitized counterparts of paper-based artifacts since it is often difficult to realize [35]. At the NICU we observed the case of an electronic parenteral nutrition calculator, where actors relied on the convention that values inserted long before the scheduled feeding time were not to be considered as definitive, but only as prospective formula in order to prevent unnecessary preparations. Since the calculator
was unable to make this distinction, the proper usage of the data was totally dependent on the clinicians.

**Inconsistency API**

This kind of API is conveyed to make actors aware of the need to verify the correctness and consistency of some data reported in the CR. “Attention, this sounds wrong!” was the catchphrase clinicians associated to this API. Inconsistency API regarding specific items can be provided on the basis of either their intended type (e.g., a dosage in milligrams, instead of milliliters) or their conventional meaning (e.g., body temperatures cannot be higher than 44 degrees; dates for examinations due cannot be scheduled in the past). We also discussed more local and articulated conventions by which clinicians may consider data as inconsistent. In these cases, inconsistency is usually verified with respect to either other data recorded previously in the CR, or to domain knowledge deemed as reliable: e.g., drug administrations can be considered inconsistent with respect to some particular disease, or to allergies of the patient. The former inconsistency would be detected by matching the drug uses reported in the drug handbook with the patient’s primary diagnosis reported in the specific section of the CR. Allergy-related inconsistencies would be detected by simple rules that match ancillary documents to the record, such as the manual reporting of drug facts and contraindications, with data reported in the CR, such as patient’s anamnesis and lab tests. Furthermore, drug dosages can be considered inconsistent with respect to the lab tests’ results for liver and kidney functionality (reported in the CR), as well as with respect to acceptability limits set by the hospital pharmacy on the basis of professional consensus and local conventions (whereas no one has generated Change API to justify over- and under-dosing). Exam prescriptions can be considered inconsistent with respect to particular patient-centered and work-related conditions, as in the case of pregnant women scheduled for a C.T. examination, or when meat-based meals are ordered for vegetarian inpatients. From these examples, it is clear that Inconsistency API regards conditions and data that can, at least potentially, jeopardize the patient’s safety and lead to (or be the direct consequence of) medical errors. Yet, the practitioners stressed that these conditions and data do not necessarily require an amendment: this API is aimed at prompting the verification, not the correction, of its data sources (see Revision API). In fact, actors may find a reason to want to deal with a partial inconsistent state of the world, or even to supersede the conventions by which a situation is fallaciously considered inconsistent, as in the case when a pregnant woman must undertake a C.T. for life-threatening complications or a vegetarian who suffers from serious anemia which is resistant to dietary supplements.

**Revision API**

This kind of API is conveyed to make actors aware of the need to correct (or better yet, revise\(^3\)) some values in the CR. “Beware, you are supposed

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\(^3\) Nothing reported in the CR can be deleted but only amended by addition.
to correct this!” was the catchphrase clinicians associated to Revision API. This kind of API can be provided according to either some formal data model or more local conventions by which data are considered mistakes with respect to their type or data representation. This case is slightly different from the Inconsistency API, in that it regards data affected by syntactic mistakes, like a date where a name is supposed to be filled in or an e-mail address that is filled in without the ‘@’ sign. The need for this API derives from the fact that doctors and nurses deemed any automatic correction in their records as unsuitable and even potentially harmful: they preferred to speak about proper warnings to be raised according to specific data constraints. These constraints respond to specific data quality requirements defined in light of conventional practices as those mentioned in Section 4.

Quality API
This kind of API is conveyed to make actors aware of the current level of data quality of either specific sections of the CR or of the whole of it. The need for this API emerged after observing the initiative taken by the pharmacy and radiology supervisors to sporadically return order forms to the ward in case of inadequate information: they attached a rough indication of the intrinsic quality of the request to the forms to raise practitioners’ awareness of the importance of filling forms completely and accurately, or else their departments could not process requests efficiently and safely. For instance, requests lacking the indication of the patient’s gender, weight, as well as reporting inaccurate identification details and incomplete reasons why a certain exam has been requested usually lead the referred unit to contact the referring unit or the hospital admission by phone in order to complete this information with consequent delays, rework and responsibility bouncing back. Speaking with the supervisor of the pharmacy, we envisioned a request form that could promote awareness of necessary levels of data quality, similarly to how electronic forms usually indicate what fields are mandatory or how robust a password is when the user is filling it in. Likewise, we conceived a system that could automatically associate an entry of the CR with a ‘poor’ value of data quality (e.g., completeness 93%) if it detects a too large a variance from the data quality targets (e.g., completeness 97%) that are necessary for, e.g., statistical procedures in clinical trials; conversely on the basis of other conventions and quality requirements, the system could associate the same set of data to different data quality values (e.g., ‘discreet’ or ‘good’) for legal accounting or billing (where data quality requirements are lower, e.g., 90%). The basic idea was to help clinicians become aware of the secondary requirements pertaining to the post-care part of the hospital process, leaving them free to improve the quality of the document either on the spot or later in the work shift [17]. Data quality of CRs is a topic of increasing importance for the central role that data produced by clinicians play in risk management and in a number of heterogeneous activities that use these data to reach their organizational objectives [56]: e.g., epidemiological and pharmacological research centers, hospital and regional administrations, national policy makers and interna-
tional committees. Since the level of accuracy and completeness for medical records is approximately 95% [2], relatively small improvements in their data quality can yield significative improvements in process quality and safety. However, this is a terrain where the conflicting needs of different stakeholders ask for solutions to increase the culture of quality without hampering the contingent healthcare practices that necessarily risk to reduce it.

**Safety API**

This kind of API is conveyed to make actors aware that either the activity they are performing or that they are about to perform can have a strong impact on the patient’s safety and is correlated with a significative occurrence of adverse events (i.e., events implying a damage for the patient, e.g., adverse drug reactions [58]). Recent cases of adverse events that aroused a great deal of attention (e.g., the Jowett case [58]) led some of the clinicians we interviewed to create specific conventions by which certain situations were deemed safety-critical, like drug administrations performed outside their regular schedule; administrations at close time intervals of drugs that differ in their administration way or with strong and known interactions; or, more generally, any unexpected situation where administration time, drug type or anything else has changed in the end without planning. Clinicians assimilated this information to the requirement that the record itself could detect critical interventions by its own and warn readers: “attention with what you are doing, be careful!”. The need of this API was associated to a number of cases determined both ‘a priori’ and at run time, both by clinicians at need and automatically driven by the context. For instance, Safety API can be associated to the prescription and administration of specific treatments (e.g., cytotoxic and chemotherapeutic drugs); to the use of any abbreviation and acronym (which are frequently misunderstood and associated with errors [24]); to the prescription of dangerously invasive procedures (e.g., angiography, rachiocentesis); to the prescription of drugs with names similar to those of dangerous drugs (called look-alike and sound-alike drugs [54]) or close to dangerous drugs in a list. This condition often leads to juxtaposition errors, i.e., those errors resulting when an entry in a list, either on the screen or on paper, is close to other entries, and wrong options are too easily selected by mistake [3].

**Schedule API**

This kind of API is conveyed to make actors aware of the need to perform tasks that have been previously scheduled or expected on the basis of a timing convention, as in the case of urgently due lab examinations reported in the single sheets. For instance, blood samples at NICU are to be sent to the lab within twelve hours after prescription: only actors that consult the lab exam sheet during this time span can be reminded of an outstanding prescription; instead, after the time limit has passed, the system can warn any actor of the due task, no matter her current documental activity. Clinicians assimilated the provision of Schedule API to the provision of a message like this: “beware, this has to be done”.

Responsibility API
This kind of API is conveyed to make actors aware of the opportunity to know who was, is and will be accountable and responsible for reporting (and hence performing) a specific activity. Clinicians assimilated Responsibility API to messages like these: “consider that she did/is doing/will do this”, “consider that she was/is/will be supposed to do this”. The provision of such an API was advocated for those situations when practitioners consult the history or log of updates of a certain section to have a quick glance of who did what in order to ask for a consultation or clarification on a clinical case or to assess the reliability of the entry [23, 46], especially in case of disagreement between colleagues. For this reason Responsibility API can be assimilated to social awareness (see [8] and Section 7).

According to the degree of granularity of the work context representation, this API can be characterized also in terms of other contextual information besides merely accountability (who did it) and time (when she did it): e.g., which was the activity that enabled or triggered the record; where was it done; whether it is traceable back to a routine task or to the handling of an exception, etc. For instance, a convention collected in the field study states that if a certain item has been recorded by a nurse long after the scheduled end of her work-shift, this could mean two things: on the one hand, that it refers to a serious emergency handling and, on the other, that recorded items should be considered with some caution.

Articulation API
This kind of API is conveyed to make actors aware of mainly two aspects of their cooperative work: i) how they contribute with their work to the performing (and performance) of the whole process; ii) how their activities are interdependent with the others’ work. Clinicians assimilated the provision of Articulation API to situations where there is a need to tell a reader “what others are doing for her” and “what she is doing for others”.

Nurses especially expressed a strong interest for Articulation API and proposed that it could be conveyed in all those cases where actors involved in blocking activities should be supported in understanding the needs of colleagues involved in blocked activities. This would contribute to avoiding underutilization of resources and limiting the occurrence of situations where practitioners are kept idle and their time is wasted. We also observed the occurrence of these conflicts and schedule clashes and found them quite frequent and time consuming, besides being a source for resentment and frustration [15].

From our analysis, it is clear that Articulation API is one of the most difficult APIs to convey effectively. In fact, it requires a model of the process correlated with the completion of the data structures of the CR as well as proper representations of both one’s own and others’ work progress [14,21]. Since in the observed hospital there is specific experience and interest in

4 Only seldom who reports a clinical intervention is not the same person who has performed it (e.g., chemotherapeutic drug preparation, rachiocentesis).
the definition of Clinical Pathways (CP) [20], the provision of this API was considered worthwhile to be taken into account during the analysis phase and as feasible only in the long run.

**Appropriateness API**

This kind of API is conveyed to make actors aware of whether they should or should not perform a certain activity in the present context. This context pertains to either the current content of the CR or another contextual condition, such as absolute time (e.g., it’s noon) or time relative to a past event (e.g., it’s the second day of the chemotherapeutical cycle). While advocating its existence as “mild” and unobtrusive suggestions, clinicians agreed that this API would be extremely difficult to achieve since it requires a substantial modeling effort that can be justified only in the case of some specific critical situations. Clinicians, or more often the system itself, can indicate rough levels of appropriateness on the basis of either a specific care program or contextual conditions, e.g., ordering a specific set of ancillary tests according to the drug prescribed; or prescribing a specific therapy protocol according to the latest results of lab exams. As in the case of the previous API, Appropriateness API was perceived as a good category for the analysis phase and as a realistic requirement only in the presence of a sound integration of CRs and CPs.

We make a brief point to conclude the presentation of the list of APIs. Clinicians generally expressed appreciation for the focus on awareness promotion and actively contributed to identifying illuminating cases by retrieving their experiences. In fact, they related this perspective to the general capability of documental and recording systems to provide information that could make them aware of things that they could miss while they consult, skim, inscribe and annotate the CR [9]. Clinicians preferred to see this capability in terms of awareness promotion rather than information retrieval and knowledge retention. We were told that the adopted approach seemed to pay careful attention to the actual role of clinicians – who are the only ones responsible for clinical work – and relegate the digital support to the background. This is coherent with the requirement of full autonomy and authority expressed in several occasions by clinicians for the fulfillment of their duties.

### 7 Supporting awareness in clinical records

In order to experiment the mechanisms to convey the identified kinds of API with some key actors of the medical staff, the NICU management put a web-based Electronic Patient Record at our disposal. This had been commissioned to a small local IT firm by the head physician approximately one year earlier. Although this application was developed with the intense involvement of the NICU practitioners, it was never deployed at the ward for interoperability issues with the hospital information system and red-tape hindrances. Nevertheless, the NICU EPR constituted an ideal reference platform for discussing the API providing mechanisms with practitioners. We
set up three “mock up” sessions to identify the general interactional requirements that clinicians expressed as necessary in order to exploit API provision effectively and, above all, unobtrusively. In these sessions the graphical interface was instrumental and not a primary concern since our aim was to detect general functionalities to facilitate the provision of API and the coexistence of the archival and articulative dimensions of records and documents [17,30].

These requirements refer to four main functionalities that are summarized in the following enumeration:

1. **Message displaying**; the system must be able to display text messages on top of the electronic document. The trigger of this functionality must be driven either by the insertion of particular data (data-driven message displaying); or by contextual and interactional events. For instance, this functionality is triggered whenever a task reported in the Planning Sheet is accomplished in order not to create delays (cf. Schedule API); or whenever the user moves the pointer over a specific and specialist term to indicate the availability of a glossary or of any guideline related to the term (cf. Inquiry API). Messages can display their content either as notes, remarks and comments that practitioners previously annotated on the CR. Or alternatively, messages can display texts that are set at design time and are associated to specific conditions (e.g., in order to refer to something that the reader is supposed to check or to do, cf. Inconsistency, Schedule and Revision API). In regards to the examples described in Section 4, the mock up sessions have shown that clinicians appreciated having messages displayed to convey specific typologies of APIs: e.g., the message “Attention, an urgent PCR test for patient R. requested half an hour ago” would be displayed to convey Schedule API to the nurse accountable for R. at the Internal Medicine ward according to what urgent conventionally means in this specific ward. The message “Attention, different brand names could refer to the same active principle” would be displayed close to the pertinent field to convey Safety API whenever nurses access the Single Sheet before preparing the drugs in a ward where this convention holds. Finally, the message “Attention, Mrs. B. received an extra dose of sedative for gastroscopy” could be displayed on the terminal of the head nurse in order to convey her Deviation API e.g. to remind her not to serve Mrs. B. any meal until the sedative effects fade away.

2. **Highlighting data values**. The system must be able to highlight specific data values to make them more evident or just different from the others reported nearby. Colors and their intensity were selected during the mock up sessions to convey several APIs. The practitioners agreed to consider red coloring as a suitable means to express critical situations at a glance. For instance, Criticality API would be conveyed by coloring clinical data in red, such as weight and height to the clinician responsible for a patient whenever she is in life-threatening conditions. Provisionality API instead would be conveyed regarding any inscription not yet confirmed (i.e.,
before saving the page or committing the order) by coloring inscriptions in grey in order to resemble pencil-made writings.

3. **Highlighting data structures.** The system must be able to highlight specific data structures such as fields, sections, sheets, to convey APIs that are more related to the document structure than to the data they contain. The liquid intake fields described in Section 4 were taken as paradigmatic cases of this need. Practitioners proposed to have these fields colored in yellow when the newborn is well until they are filled in. In this way, clinicians would be reminded that “Everything is ok but fields should be filled in for secondary purposes” (Quality API). Conversely, when the newborn is in poor conditions and liquid intake fields are empty, they would be colored in red.

Practitioners discussed whether the interface should use few colors or not to convey all the APIs. On the one hand, this could limit the risk of information overload; on the other hand, it would end by associating the same color to different meanings: e.g., criticality and safety APIs. The conclusion was that what is either critical, a mistake or inaccurate should be highlighted in red. To distinguish what APIs are involved when an item is displayed in red, an appreciated way was to display textual cues evoking the involved API on demand, when users right-click on the red item.

4. **Displaying icons, pictures or other graphical items.** The system must be able to flank either data values or data structures with graphical cues (marks, signs, lines, icons and pictures) conventionally associated to a number of meanings, like alerts, reminders, warnings, helps and anything which is concerned with API and related conditions. During the the mock up sessions clinicians considered it useful to have explicit lines connecting data fields and to use their color and thickness to convey their meaning and strength. This need emerged in order to have these connections cross the various artifacts constituting the clinical record: e.g., practitioners proposed to have Inquiry API conveyed by links associated to specific sections of the Problem List and Clinical Notes sheets, where the hypotheses should be reported and commented, respectively. As another example, a bar dynamically filled and colored from yellow to green was selected to indicate the quality of the sheet at hand: e.g., to the First Care Planning sheet in order to evidence whether the required number of hypotheses has been formulated or not. Discussions arose among practitioners on how to convey the choice of the physician to formulate only the most probable hypothesis. In the end, they agreed that this choice can be properly supported by letting doctors check a specific box next to the first hypothesis field so as to convey Deviation API with respect to the related hospital policy: in doing so, the clinician makes it evident that only the most probable hypothesis should be considered in order not to dissipate the staff’s effort on dead ends.

More generally, the possibility to enrich the information presented by the usual EPRs was considered a viable way of preserving and sometimes
promoting some of the habits developed in the use of the paper-based CR. Practitioners agreed that none of the above mentioned solutions can be considered as definitive and that a more systematic, incremental and participatory way to implement and validate them is necessary. This preliminary study was only intended to open a space for future cooperation.

8 Implication on design and future work

The members of the research team raised different although coherent considerations about the results of the field study. For the practitioners, the requirements collected should be the basis for the design of any computer-based technology that supports cooperation in the two wards considered. Obviously, the envisaged interactional functionalities should be experimented and tuned accordingly. For the technicians, one basic concern is how this technology can be integrated with the legacy systems of the hospital, typically the HIS, in order to avoid introducing additional functionalities that would remain uncorrelated with the usual practices.

Of course one possible solution would be to conceive HISs more in the light of supporting collaboration than in the one oriented to the management of information supporting managerial and administrative tasks or clinical research. This approach seems unrealistic for at least two reasons. The first one is related to a contingent situation (at least in Italy): the design of HIS is in the hands of companies that own the market and are resistant to change their design strategies; second, the two above mentioned orientations are very difficult to be reconciled into a single design effort because their aims are contrasting especially in regards to policies and organizational requirements on document use and work reporting [17]. Information systems, and in particular HISs, aim to make organizational rules more stable and widely applied. These rules are intrinsically normative and are set by the management, in order to “mold” document-based business practices. The logic that enacts these rules into an electronic document application is usually hard-wired in the data schema and its manipulation methods: the consequent rigidity is deemed by management more as an opportunity for compliance and efficiency, than as a hindrance to smooth “practice flowing”, as often reported in the CSCW literature (e.g., [31]). Conversely, CCs are the expression of the users’ needs and spring out from practice, which is not necessarily “best practice” (besides for those who prefer to conform to the convention) nor an institutional praxis. Conventions on document use thrive for their local and possibly temporary ability to solve and even prevent coordination problems on an ad-hoc basis. In this regard, one of the main findings of our study is that conventions should not be embedded in technology in terms of hard-wired functionalities, as those resulting from precise organizational requirements are. Otherwise they would loose the informal, local and fluid nature by which they effectively help actors coordinate each other. Instead, conventions have to inform the design of
functionalities which are able to evoke them during the use of artifacts and to provoke (i.e., call forth) apt interpretations for the sake of more effective collaboration and smoother articulation work.

For these reasons - the difficulty in changing the design and the temporary, voluntary and local nature of conventions - our point is that artifact-mediated CCs can be profitably addressed by a dedicated and logically different layer “on top of” the hard-wired application logic of electronic document systems. We agree with the suggestion that systems that support “finding and presenting the planned ‘order of work’ rather than enforcing it” [27] can significantly limit the risk of frustrating practitioners with the need to maintain both computer- and paper-based systems [37], getting bad results from both. Our approach is that technology should provide practitioners with the identified kinds of awareness promoting information. As illustrated in Figure 3, archived data are retrieved and conveyed through the HIS (below in Figure 3). Instead, API is conveyed as the output of the coordinative layer, shown above in Figure 3, that would act as a “reactive presentation device” able to make conventions present-at-hand (in the sense taken up in [59]) when needed. The provision of this additional information is aimed to (a) mildly and unobtrusively remind actors of how-and-when their colleagues rely on actions made on the clinical record content; (b) facilitate the adoption of and compliance to work habits on proper documentation, especially in the case of apprenticeship and frequent collaborator turnover; and (c) foster fruitful and on-the-point-of-work discussions about the conventions used in the given cooperative setting. These opportunities for discussion would be focused on what is usually “taken for granted” and can hence lead to unexpected breakdowns if they are not actually internalized by all the stakeholders involved.

![Figure 3](image)

**Figure 3** The two-tier architecture to enhance closed electronic document systems, like the EPR, with the provision of Awareness Promoting Information (API).

Regarding API provision, an interesting research project would focus on the best ways to have different types of API “cohabit” over a lower common data layer without running the risk of information overload [3,43]. To avoid this risk, API could be conveyed according to a most-recent-on-top policy and fade away according to time and presets of the specific user. This, in
turn, could switch an API either on or off in order to filter it according to her needs and the current context. Since coordinative conventions become relevant (in the sense that they are selectively applied) according to contextual conditions, in our mock-ups we adopted a declarative and context-aware approach to make API provision computational and decoupled from any specific implementation platform. For this we experimented the constructs of the WOAD rule-based framework [14] and [18] to express the relationship between coordinative conventions and the functions to convey the kinds of APIs described in Section 6. Since the outcomes were satisfactory in terms of clear requirement identification and fruitful discussions about useful interactional functionalities, the research path is now focused on the full implementation of the awareness promoting prototype and will continue with its evaluation with the clinicians who were involved in the preliminary study.

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