A Generic Model of Clinical Practice
A Common View of Individual and Collaborative Care

H. J. Tange¹, J. L. G. Dietz², A. Hasman¹, P. F. de Vries Robbé³
¹Department of Medical Informatics, Maastricht University
²Department of Information Systems, Delft University of Technology
³Department of Medical Informatics, University Medical Centre Nijmegen

Summary
Objective: Many shared-care projects feel the need for electronic patient-record (EPR) systems. In absence of practical experiences from paper record keeping, a theoretical model is the only reference for the design of these systems. In this article, we review existing models of individual clinical practice and integrate their useful elements. We then present a generic model of clinical practice that is applicable to both individual and collaborative clinical practice.

Methods: We followed the principles of the conversation-for-action theory and the DEMO method. According to these principles, information can only be generated by a conversation between two actors. An actor is a role that can be played by one or more human subjects, so the model does not distinguish between inter-individual and intra-individual conversations.

Results: Clinical practice has been divided into four actors: service provider, problem solver, coordinator, and worker. Each actor represents a level of clinical responsibility. Any information in the patient record is the result of a conversation between two of these actors. Connecting different conversations to one another can create a process view with meta-information about the rationale of clinical practice. Such process view can be implemented as an extension to the EPR.

Conclusions: The model has the potential to cover all professional activities, but needs to be further validated. The model can serve as a theoretical basis for the design of EPR-systems for shared care, but a successful EPR-system needs more than just a theoretical model.

Keywords
Electronic-medical-record, shared-medical-care, clinical reasoning, communication, process-model

1. Introduction

Electronic patient-record (EPR) systems based on a theoretical model of clinical practice have never been successful. The dogmatic nature of these models is often an obstacle (1). Practical approaches that build upon the well-accepted tradition of paper record keeping prevail. Shared medical care, however, is a relatively new phenomenon characterized by multi-disciplinary collaboration across institutes and shared responsibility for key decisions. In such a setting adequate communication is an important issue, but many shared-care projects have experienced that paper clinical records are poor communication tools (2, 3). EPR-systems hold the promise to support communication much better (4).

However, operational EPR-systems that successfully support shared medical care are scarce.

Shared medical care involves different professionals from different organizations who need to communicate their findings and decisions effectively. To support this communication, an EPR-system must be more than just a technical integration of the systems of the different parties involved. It has to support different professions with different information needs and connect different organizations with different information systems. It must allow an adequate representation of clinical decisions, be useful for physicians, nurses, and other disciplines, be applicable to different organizations, and be robust against redistribution of responsibilities.

It is obvious that an EPR-system for shared care has to meet many requirements. In the absence of a pragmatic reference, a theoretical framework is the only thing to hold on. For shared care one needs a shared model of clinical practice, describing generic patterns of activities, decisions, and communication, which are recognized by any discipline in any setting. This model should be equally applicable to individual care and to collaborative care. Moreover, the consequences for medical-record keeping should not be dogmatic.

In this article we demonstrate that such a model does not exist, but that most ingredients have already been described in the literature. They must only be integrated in a way that is useful for the design of a patient record. We review these ingredients and integrate them into one generic model of clinical practice. We explain the implications of this model for the design of EPR-systems for shared care. The most prominent implication is the construction of a process view of clinical practice, which gives insight into how medical care proceeds: not only what happens, but also why.

2. Approach

The development of the model took place in two steps. In the analysis phase we determined the ingredients of the model. We started with two well-known models of individual clinical practice: the problem-oriented model of medical record keeping (5) and the hypothetico-deductive model of medical reasoning (6). These models appeared to be complementary, not competitive, so we integrated them to a single model of individual clinical practice. The only ingredient we missed in these models was the patient perspective. We also found a useful concept of communication: the clin-
ical dialogue of the faithful medical record (7).

In the design phase we put these ingredients together into a new model of clinical practice. This model was constructed using the principles of the DEMO method for business-process modeling (8), which is based on the conversations-for-actions theory (9).

### 3. Analysis: Review of Ingredients

In the past decades, several models of systematic medical practice have been presented and discussed. Although these models focus on individual rather than collaborative medical practice, they hold many useful ingredients for shared care.

#### 3.1 Weed’s Problem-Driven Model

In the late sixties, Lawrence L. Weed introduced the problem-oriented medical record (5, 10). It was received as a revolutionary approach to medical-record keeping, because it was the first medical record based on a model of systematic clinical practice. Weed’s ideas were normative and emphasized the education of students and physicians. The problem-oriented medical record structure is based on three principles:

- **Collection of a complete initial database** – A comprehensive record of chief complaint, patient profile, past history, present illness and systems review, physical examination and a set of base-line procedures (laboratory, X-ray) should be collected for each case. These base-line diagnostic procedures should be routine rather than case-specific.

- **Indexing progress notes to problems** – Weed criticized physicians who think and work diagnosis-directed, reducing the patient to an object of care. In his opinion, each patient has a complex of physical, psychic and social characteristics (problems) that must be recognized and documented in a problem list. Clinical practice should be problem-driven.

Therefore, follow-up information in the medical record should be indexed to problems in the problem list.

- **Reflecting the process of medical practice in progress notes** – New findings (observations) lead to new insights, which in turn will lead to new plans, followed by new findings, etc. This iterative work-up should be expressed in the SOAP structure of progress reports (Subjective findings, Objective findings, Assessment, and Plan).

Weed claimed that the problem-oriented medical record results in a better understanding of clinical practice (11). Whether the use of the problem-oriented medical record will also lead to better quality of care, has been subject of discussion. The creation of a complete initial database would be an illusion, and the separation between initial and follow-up observations would be undesirable (12). Indexing progress notes to problems would obscure rather than elucidate the physician’s insight, because problems are often badly defined, and lead to compartmentalization of medical data with the potential of impeding ‘synthetic thinking’ (i.e., searching a common cause for several problems) (13). The distinction between “subjective” and “objective” observations would be highly artificial and should be replaced by a distinction between “history” and “observations” (HOAP instead of SOAP) (14).

More generally, Weed’s emphasis on the format of medical documentation would divert the physician’s attention from the real problem: the accuracy of medical data (15).

Many have partially adopted the problem-oriented medical record. Most popular is the element of problem partitioning. The SOAP-structure is used among computerized general practitioners in The Netherlands (16), but there is little evidence of its use among specialists.

#### 3.2 Elstein’s Diagnosis-Directed Model

Elstein developed a model of medical reasoning based on the traditional diagnosis-directed approach of medical practice. In this ‘hypothetico-deductive’ model, medical reasoning is an iterative process of hypothesis generation, cues acquisition, cues interpretation, and hypothesis evaluation, directed to a medical diagnosis. Elstein shaped this model in line with the well-known empirical cycle that is used to describe scientific practice, and used it to study how accurate physicians interpret cues when testing their hypotheses (6).

What Elstein’s and Weed’s models have in common is the idea of clinical practice as an iterative process. There are also some differences, however. Weed proposes the routine generation of a complete initial database before a first assessment should be made. Elstein, on the other hand, is satisfied with an initial database containing sufficient cues for a first hypothesis. Another difference is that Elstein’s model is restricted to the diagnostic process, while Weed’s model – as he does not make a distinction between diagnostic and therapeutic problems – covers the whole care process. The most essential difference is, that Weed emphasizes inductive reasoning (problem driven), while Elstein describes deductive reasoning (diagnosis directed).

As a consequence, Weed’s model underexposes the significance of diagnoses, while Elstein’s model ignores the role of medical problems. It is this last difference that pleads for an integration of both models.

#### 3.3 Integration of Both Models

One of us has integrated the ideas of Weed and Elstein to one model of systematic clinical practice (17). This model describes the care process as follows:

The first patient encounter is usually a medical intake, consisting of medical history and physical examination. At the end of the intake, the physician reviews the relevant findings (cues) and makes up a list of medical problems. After completion of the problem list the physician generates, for each medical problem, one or more hypotheses about cause, consequences, and possible associations with other problems. Each hypothesis leads to a plan for testing or treatment. These actions generate new
clinical data, which again are reviewed for cues, now to confirm or reject the hypothesis. With this new insight, the physician is able to reformulate the initial medical problem into a new constellation, which may give rise to new hypotheses, which again will be verified, and so on, until finally a diagnosis can be established.

The power of this model is the combination of hypothetico-deductive reasoning with a problem-oriented approach, which makes it a valuable reference for educational purposes. This model has been used successfully for several years, to teach medical students, residents, and house officers at the University Medical Centre Nijmegen (17). This integrated model contains two important definitions: A cue is defined as a clinical finding that explicitly contributes to the formulation or reformulation of a medical problem. A medical problem is defined as the initial constellation (i.e., meaningful arrangement) of relevant findings that is certainly part of one single disease process, according to the physician. Managing a medical problem is a converging process of iteratively reformulating more accurate constellations until finally a diagnosis has been reached. This definition is compliant with another definition of a medical problem as a problem that is manageable for the physician and that serves as a starting point for further medical actions (18). In both these definitions, a medical problem must not be confused with a problem presented by the patient, a definition often used in primary care.

3.4 The Patient’s Perspective

It is good clinical practice to involve the patient in decisions with significant clinical implications. The patient must know what (s)he can expect from the care process. The patient explicates his care request, the doctor suggests his intention, and both have to agree about the purpose of care. We already mentioned the difference between a medical problem and a patient problem. To avoid confusion, we further use the term ‘patient demand’ instead of ‘patient problem’. We define a patient demand as a complaint or other health-care request that forms a reason to consult a doctor. The patient wants his demand fulfilled, which is more than just receiving a medical diagnosis. It is up to the doctor to find an acceptable answer to this demand. We call this answer the outcome of patient care.

The doctor, in turn, needs a cooperative patient who follows his advice and takes medication on time. Otherwise, the necessary observations and interventions cannot be carried out successfully. We define a patient instruction as any directive meant to get cooperation with a clinical observation or intervention. Patient compliance then is the actual cooperation of the patient with this observation or intervention.

3.5 Clinical Communication

The models described above reflect individual clinical practice. In collaborative care different persons are involved, so clinical communication must also be taken into account. This aspect is not visible in any of these models. In 1991, Rector introduced the idea of a faithful medical record. “A faithful medical record should necessarily consist of what clinicians have stated about what they have heard, seen, thought, and done. (...) Information in the medical record is not about what is true about the patient, but what has been observed and believed by clinicians. (...) It should be faithful to the observations, to the decision-making process, and to the clinical dialogue.” (7). Clinical dialogue is any kind of communication between health-care professionals about patient care. It includes order and result notes, referral and discharge notes, but also opinions that are discussed. Clinical dialogue is important, because it is the only activity by which observations and decisions are exchanged. Hence, clinical dialogue should have a place in any model of collaborative clinical practice.

4. Modeling Principles

To put all these ingredients together in a systematic model, we followed the principles of the ‘conversations-for-actions’ theory, and worked it out with an experimental method called ‘DEMO’.

4.1 The Conversations-for-Actions Theory

In the ‘conversations-for-action’ theory, described by Winograd and Flores, information is defined from a language-philosophical point of view (9). According to these authors, information is always the result of a conversation between two human beings. There are two types of conversations: order conversations and result conversations. In an order conversation, one subject (A1) sends a request for action to another subject (A2). After successful negotiation, A2 accepts the order and promises A1 to take action. Later, in a result conversation, A2 sends A1 a statement about the result of this action. After successful negotiation, A1 accepts this result and the action has completed successfully. If negotiation is not successful, the prior phase will be repeated, or otherwise the conversation will end without the desired result.

4.2 The DEMO-Method

Dynamic Essential Modeling of Organizations (DEMO) is an experimental method with associated terminology for the description of business processes and the development of information systems (19). The method is based on the conversations-for-action theory. DEMO describes each organization as a social system consisting of a network of actors with specific tasks and responsibilities. An actor is an individual or collective subject that performs essential actions. An essential action causes changes in the object of business, either now (by making a new observation or intervention) or in the future (by taking a decision). In medical practice, the object of business is the patient’s health.

Actors coordinate their activities by seeking commitments. To reach a commitment they have to engage in conversation, which is a communicative action instead.
of an essential action. By a conversation, actors commit themselves to an essential action. The combination of order conversation, essential action, and result conversation is called a transaction. A transaction is the elementary business process in the organization, in which two actors reach one commitment (Fig. 1). All transactions of a business system together can be presented in an interaction diagram.

4.3 Main Consequences
This theory and method contain some valuable principles that enable us to bridge the gap between individual care and collaborative care. We used these principles to build a model that is applicable to both individual and collaborative care.

Information is always the result of a conversation – Changes in the object of business (the patient’s health) are “published” by conversations. Without a successful conversation there will be no commitment about these changes, and without commitment there will be no valid information.

5. Design: Construction of the Model
As said by DEMO, information comes from either an order conversation or a result conversation. Along with this principle, we have classified the ingredients described above into order conversations and result conversations (Table 1). In each row, both conversations are part of the same elementary transaction (business process). The sequence of transactions represents the hierarchical sequence of elementary processes that form together the process of clinical practice.

This process can better be visualized by an interaction diagram (Figure 2). In this diagram clinical practice of the health-care professional is divided into four actor-roles A1...A4. Each actor represents a level of responsibility, associated with stereotypical tasks.

1. The Service Provider is the highest level of responsibility. He is responsible for the outcome of clinical practice. He is the patient’s advocate for the different kinds of care that may be needed. He keeps track of the whole process and keeps the customer satisfied along the way. He deals with questions of the kind “What is...?” He identifies new demands and translates them into manageable problems: medical, nursing, or other problems. He has to keep an open mind to the patient and a holistic view of the care process.

Table 1 | Organisation of ingredients for the generic model of clinical practice.

<table>
<thead>
<tr>
<th>Order conversations</th>
<th>Result conversations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>generic name</strong></td>
<td><strong>examples</strong></td>
</tr>
<tr>
<td>Patient demand</td>
<td>complaint, request</td>
</tr>
<tr>
<td>Problem</td>
<td>medical problem</td>
</tr>
<tr>
<td>Goal</td>
<td>hypothesis, differential diagnosis, nursing goal</td>
</tr>
<tr>
<td>Plan</td>
<td>test order, intervention plan</td>
</tr>
<tr>
<td>Instruction</td>
<td>advice</td>
</tr>
</tbody>
</table>

Fig. 2 Interaction diagram of the generic model of clinical practice. Rectangles represent actors. A1...A4 are different actor-roles of the health-care professional. T1...T5 are transactions between the actors. An arrow points to the executor of a transaction. P1 and P2 are different actor-roles of the patient.
2. The Problem Solver strives for the best-fitting solution for a medical problem or other problem and seeks specific goals that bring this solution nearby. For example: to reach a diagnosis, a doctor formulates a differential diagnosis, which is a set of alternative solutions that must be tested. He deals with questions of the kind “What if...?”, so he needs a hypothetico-deductive attitude.

3. The Coordinator works as a project manager. He receives clearly defined goals and seeks the means to reach these goals. He makes a breakdown of procedures (tests, observations, interventions), plans them in time, allocates the resources, and controls their proceeding. He deals with questions of the kind “How to...?”.

4. The Worker is the lowest level of responsibility, but not the least important. He applies his skills when performing a clinical procedure. This is the surgeon who operates, theendoscopist who observes, or the nurse who sticks the needle or washes the patient. This actor represents the old idea of a doctor as a handicraftsman. In Figure 2 the patient is represented in two actor-roles, which are the two stereotypical sides of the patient-professional relationship.

1. The Customer of Care actor represents the patient in an assertive role. He negotiates with the Service Provider about the demands he want to be answered, and eventually, he must agree with the outcome of clinical practice. Results may vary from a complete fulfillment of a demand to an acceptable way to cope with a demand.

2. The Recipient of Care represents the patient in a submissive role. The Recipient of Care accommodates to the Worker as to make a medical procedure succeed, e.g. by answering questions, undressing when asked, taking drugs, and following advice.

6. Abstractions in the Model

The generic model of clinical practice has a high level of abstraction. This makes the model universally applicable, but difficult to apply to concrete situations. For proper understanding, one should notice the following abstractions.

6.1 Abstraction from Persons and Professions

The model does not distinguish between individual and collective tasks. In primary care, one doctor usually performs all actor roles. In hospital care, each actor role may belong to a different profession. For example, if an internist encounters a patient with shortness of breath, he may call in a cardiologist to exclude any pathology of the heart. This cardiologist, in turn, may call in the clinical laboratory to perform some tests. On the other hand, one single decision may even be made by a team of experts. The determination of treatment goals for the rehabilitation of a stroke patient, for example, may be the responsibility of a complete rehabilitation team. Also the actor roles of patients are abstractions. In medical-historical taking, an infant may be represented by one of his parents. To avoid premature personification of actor roles, it is better to think of actors as decision-making units, and of transactions as commitments that have to be reached with oneself or with others.

6.2 Abstraction from Treatment Phase

The model does not distinguish between the diagnostic and therapeutic phase of clinical practice. It is applicable to both phases. This puts some restrictions to the terms used. Originally, problem and diagnosis could be associated with any of both phases (πρόβλημα = ‘what requires a solution’; διάγνωσις = ‘distinction’). Problem still does, but diagnosis has been redefined in medicine as ‘determination of the nature of a disease’ (20). This makes the term inadequate for a generic model of clinical practice. Likewise, hypothesis is often associated with a differential diagnosis, which gives also this term a diagnostic taste. To avoid misunderstanding, we use the terms solution and goal instead of diagnosis and hypothesis. We illustrate this with a simplified example.

Diagnostic phase – A patient with abdominal pain and diarrhea visits the doctor. The doctor defines the problem ‘acute gastro-enteritis, cause unknown’ and sets his first goal: a differential diagnosis (a list of hypotheses about potential causes of this problem). To verify or eliminate these hypotheses, the doctor plans some bacteriological testing. Eventually, the doctor is able to solve the diagnostic problem: he determines the diagnosis ‘acute gastro-enteritis, caused by campylobacter infection’.

Therapeutic phase – Now, the doctor will define the next problem ‘treating campylobacter infection’. The doctor sets his second goal: a prognosis about the effect of a possible therapy, for example ‘tetracycline may be effective’. If this prognosis turns out, the goal is realized with the conclusion ‘tetracycline is effective’, and a solution to the problem ‘campylobacter infection successfully treated’ is close by.

Thus, the solution to a therapeutic problem is comparable with a diagnosis and can be defined in a similar way, as ‘determination of the outcome of a treatment’. Differential diagnosis and prognosis have both the character of a hypothesis, with the implicit goal to be verified.

6.3 Abstraction from Time

In Figure 2 clinical practice may seem to be a linear process, but this suggestion is wrong. The interaction diagram does not represent time at all. In reality, clinical practice is a chain of iterating cycles.

- Each actor has a decision cycle. He picks out a task, delegates subtasks to other actors, collects the results of these subtasks, and then decides whether he has enough information to complete his current task. If not, he will start another iteration of subtasks. For example, if a test result does not provide enough information to eliminate a possible cause, another test must be ordered. If the completion of a differential diagnosis
does not provide enough information for a medical diagnosis, alternative hypotheses must be formulated. This kind of iteration is represented in the interaction model as a nested pair of transactions. The upper transaction delimits the start and completion of the entire process, while the lower transaction can be iterated as often as needed.

- Each conversation has a negotiation cycle. The initiator must persuade the executor to accept an order, and the executor must persuade the initiator to accept his result. If negotiation fails, both parties may start again or the process may be canceled altogether.

6.4 Abstraction from Documentation

In DEMO, a conversation represents the content of information, not its format (19). The interaction model does not specify how the information has to be documented. Information can be stored in any fashion: on paper or electronically, as free text or in coded format. Information may not even be recorded at all, which is the case for many instantaneous hypotheses generated during history taking, and for many conversations with the actor Recipient of Care. The fact that the patient gave blood for testing is recorded, but the fact that he raised his right arm for examination is not.

7. Implications for the Patient Record

One of our aims with this model is to demonstrate to designers of EPR-systems, that there are generic patterns of activities across different disciplines and along different phases of clinical practice. The adoption of the generic model of clinical practice has several consequences for the design of an EPR-system. The most important consequences are for the information model.

7.1 Clinical Information

Some commitments are important to remember, others are not. The obvious place to capture important commitments about clinical practice is the patient record. The vast majority of these commitments encompass results from observations and interventions. In most patient records, this information is subdivided in a source-oriented way (21). However, Figure 3 shows that there are more types of information than only these T4-results. Also commitments at other levels of clinical practice may be important to remember, like problems, diagnoses, and treatment goals. These types of information must also have a place in the patient record. Together, this information about commitments reveals what happened to the patient.

7.2 Process Information

Figure 3 also shows how different commitments can be related to one another. These relations give insight in the making of clinical care in general and in the reason of medical decisions in particular. This insight is needed for reasons of quality control, in case the process of clinical practice must be reconstructed. This insight is also vital in situations where many people are involved, which is the case in collaborative care. In these and other situations where this insight is important to remember, these relations can be stored in the patient record as links. There are three types of links.

1. An indication link gives the reason (indication) for an order conversation. Why was an X-ray request made? Based on which hypothesis?
2. A motivation link gives the arguments for a result conversation. How was the diagnosis renal failure established? Based on which arguments?
3. A transaction link gives the straightforward relation between a specific order conversation and a specific result conversation. To which diagnosis did this problem lead? Who ordered this laboratory test?

These links provide meta-information about the process of clinical practice. They indicate why these things happened the way they did. Together, these links provide a process view of clinical practice and demonstrate the relevance of clinical information. Figure 3 shows the data model for this process view.
7.3 Other Implications

There are two other implications worth mentioning.

- Each transaction follows the same pattern. As a consequence, each commitment can be described with the same attributes, whether it concerns an observation, an intervention or a decision.
- The tasks of an actor are more persistent than the tasks of a person or even a discipline. As a consequence, the authorizations of an EPR-system should be linked to actors rather than to concrete persons or disciplines. This will make an EPR-system more flexible and robust against organizational change.

8. Discussion

Past experiences have learned that attempts to base an EPR-system on an explicit model of clinical practice eventually failed (PROMIS (1)) or never surpassed the experimental phase (22-26). Pragmatic approaches were often more successful. So what inspired us to construct again another model, and to expect that EPR-systems based on this model will be successful? We had three reasons for this. First, we think the need for a common reference framework in shared care is more widespread than elsewhere. Shared care is far more complex than traditional care from the point of view of information processing. Individual decisions have become team decisions. Tasks and responsibilities are being re-divided time and again. An EPR-systems based on a pragmatic approach cannot anticipate these organizational changes, so system designers will feel some need for abstraction from current work practice. Second, we expect less resistance against change, because shared care does not yet have a long tradition of paper record keeping. Third, we believe that our model is more acceptable as a reference for an EPR-system than the previous models, because it is the first with a complete coverage of clinical practice.

8.1 Is this Model New?

The generic model of clinical practice is neither a new view of medical reasoning nor a breaking approach of medical-record keeping. As was explained before, the model has been constructed from existing ingredients. Only the inclusion of a patient’s perspective is new. Also communication as the leading concept of medical-record keeping is not a new idea. Already in 1994, Frisse et al. suggested the use of conversations as the central metaphor for handling future patient records (27). Several authors promoted a process view as an extension of an EPR-system, explicitly or implicitly. Van der Lei missed the rationale of medical decisions in many EPR-systems (28). Wyatt stated that the significance of clinical data can only be measured along with their relevance to medical decisions (29). Kluge explicitly advocated the extension of the medical record with a meta-level containing links between medical data that represent the clinical process (30). In fact, the world’s leading standards for EPR-architectures already provide the option to interconnect clinical data. These are called associations in HL7-RIM, link items in CEN TC251 ENV 13606, and observation references in COAS (OMG Health Task Force, the former OMG CorbaMED) (31-33).

The four-level structure of clinical decision-making may be new in medicine, but not in business science. In 1960, Simon introduced a model in which business decisions are divided into the following phases: intelligence, design, choice, and execution (34). In the intelligence phase problems are defined (cf. Service Provider); in the design phase the goals are determined to solve these problems (cf. Problem Solver); in the choice phase the means are determined to reach these goals (cf. Coordinator); in the execution phase these means are applied (cf. Worker). Our generic model only demonstrates that professionals take strategic, tactical, and operational decisions within one and the same case, and even perform the operations themselves.

What makes the generic model of clinical practice really unique is that it integrates all these perspectives into one consistent and flexible model. The model is consistent, because it has been constructed using an approved theory and method. The model is flexible, because it can be applied to different domains, professions, and settings.

8.2 Is this Model Generic?

In this article we explained that the interaction diagram of clinical practice is generic and can be used as a reference for EPR-design. However, claiming generality is dangerous, since every exception encountered will dispute this claim. We tested the generic character of the model in two different clinical domains: radiotherapy in a specialized institute for radiotherapy and rehabilitation of stroke patients in a cross-institutional setting. To this end, we performed a brief information analysis in which we tried to map domain-specific clinical information to the generic conversation types in the interaction diagram. This mapping was successful, in the sense that we found domain-specific equivalents for all conversation types, and that we were able to map all domain-specific terms to any of these conversation types. For example, in radiotherapy every patient is treated according to the following procedure: first it has to be motivated why radiotherapy is indicated, then a treatment specification is formulated, which then will be worked out into a radiation protocol and accompanying monitoring protocol that have to be executed. Treatment motivation can be mapped to problem (T2), treatment specification can be mapped to goal (T3), and radiation protocol and monitoring protocol can be mapped to plan (T4).

But plausibility is no proof yet. In this stage, it is still a theoretical exercise, but step-by-step we hope to make the idea more tangible. First, the generic character of the model has to be evaluated on a broader scale. Second, the added value of the model for the design of EPR-systems has to be demonstrated. Third, the effect of the use of such EPR-systems on clinical practice has to be evaluated.
8.3 How can this Model Effectively be Used?

The interaction model can be used for business (re)design and business analysis and may serve as a starting point for functional requirements analysis and information modeling.

Business (re)design – The DEMO method has already demonstrated its use for business-process redesign projects in non-medical (8) and in medical organizations (35). The interaction model of clinical practice, specifically, can be used as a reference for redividing responsibilities for pieces of care from one setting to another, e.g., when introducing a multi-disciplinary approach, or when substituting routine interventions from doctors to nurses.

It works as follows. First, the characteristics of the old situation will be mapped to the interaction model. The interaction model keeps the essential processes and leaves away the documentation and information processes. Second, a new situation is designed, based on the essential characteristics of the old situation and equipped with the new possibilities of the new setting. The advantage of using the interaction model is that the new situation will not be biased by trivial practices from the old situation.

Business analysis – As the interaction model represents a chain of iterating cycles, each actor is urged to work on a systematic planning-and-control base. The model can be used to check the systematic character of existing practices. For example, during the validation of the model in a cross-institutional stroke-rehabilitation project, we observed two kinds of meetings. There was a stroke meeting in which for each patient the problems were determined that should be treated (T2) and discipline-specific goals were set (T3). There were also weekly reviews to evaluate the realization of these goals and to define new goals if needed (T3). But it was never evaluated whether the underlying problems were solved or not. Hence, mapping these meetings to the interaction model revealed that at T2 the planning-and-control cycle was not closed and had to be repaired.

Functional requirements analysis – The interaction model may also serve as a preparatory step to the analysis of functional requirements for an EPR-system. DEMO does not support this phase, but others have demonstrated that a DEMO conversation is a suitable starting point for the definition of use cases (35). A use case is a description of how a user interacts with an information system (e.g., an EPR-system) when using a specific function of this system (e.g., defining a medical problem). A use case is one of the diagrams of Unified Modeling Language (UML), which is, since several years, the de facto standard for reporting the analysis and design of information systems (36).

The advantage of using DEMO is that it helps the analyst focus on one conversation at a time. In the case of the stroke meeting, the model will help to separate between the analysis of problem determination (T2) and the analysis of goal setting (T3).

Information modeling – The third use of the interaction model is as a reference for information modeling. How it works was already explained in section 7.2. It provides the possibility to extend an EPR-system with process information: the process view. However, the implementation of a process view is not as easy as it may seem. It will be difficult to design an acceptable user interface for the entry of indication links and motivation links. It will be a new phenomenon for doctors and other health-care professionals to work with links between clinical data. Each decision gives rise to many links, so it may be laborious and time consuming to create a process view. This data-entry problem may be alleviated when clinicians follow the principle of clinical pathways, where only deviations from the pathway have to be motivated (recording-by-exception) (37, 38). Notwithstanding, it will still be a huge challenge to researchers of human-computer interaction to find an acceptable way to create process links.

8.4 What are the Implications for Health Care?

Suppose that it will be possible to develop a user-friendly process view into an EPR-system, and suppose that the users are willing to express their reasoning in this view. What effect will this have on clinical practice? It is obvious that it will make clinical reasoning more transparent than it is now. Appropriate use of this transparency will open the way to Rector’s faithful medical record (7). It will also meet the central challenge in each shared-care project: better communication, better commitments and better collaboration. DEMO is based on the idea that communication is the thread from which an organization is woven and along which organizations can be interwoven. According to this idea, the kernel of health care is not the health-care institutes but the people that make commitments and take responsibilities. Essential decisions are per definition not computable. They have a creative dimension, which makes them reserved for human beings (8). In our interaction diagram, these humans are professionals and patients. Humans take the responsibility for the tasks they carry out, not the machines that may support them. For example, a clinical chemist can never deny responsibility for an incorrect test result by referring to a failing blood analyzer. Why else does he have to authorize each test result, even if it is computer generated? A human as an actor can only be replaced by another human, but never by a computer. So if in the future the patient would first turn to the computer to seek help, it is not the computer that plays the doctor, but the patient himself.

8.5 Other Possible Uses of the Interaction Diagram

The immediate reason for us to develop this interaction model was to obtain a basis for the generic design of an EPR-system that provides a process view of clinical practice. We ended up with a model of stereotypical tasks that may also be used for other purposes. Some of the following examples are speculative, but may be worth trying out.

1. In medical education it can be used to illustrate which kinds of decisions physicians take to solve a problem or reach a diagnosis, and which information they need (17). It could also contribute to the
dispute among nurses, to which extent their cognitive strategies differ from clinical reasoning (39).

2. In medical audit it can be used to determine the underlying rationale of a treatment strategy by tracing back a series of medical decisions.

3. In medico-ethical and medico-legal studies, the bipartition of the patient into a customer and a recipient actor role may serve as an interesting perspective for problem analysis. At least, in this ambivalent role of the patient in our model one can recognize some of the uneasiness in the patient-doctor relation.

8.6 Conclusion

Although a theoretical framework is just one of the prerequisites for EPR systems design, we believe that without a generic model of clinical practice, EPR-systems for shared care will never be a success. We found a method that considers communication as an intrinsic part of information. With that method we bridged the gap between individual and collaborative clinical practice and integrated the existing models of clinical practice into one generic model. This generic model of clinical practice has the potential to cover all professional activities and can serve as a theoretical basis for the design of EPR-systems. However, both the model and its implications are still very abstract. Further study is needed to validate the generic character of the model and to try out the implications for EPR-systems.

References


Correspondence to:
H.J. Tange
Department of Medical Informatics
Maastricht University
P.O.Box 616
NL-6200 MD Maastricht
Fax: +31 43 388 2230
E-mail: h.tange@mi.unimaas.nl