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A Problem-Oriented, Knowledge-Based Patient Record System

Elisabeth BAYEGAN and Øystein NYTRØ

Norwegian University of Science and Technology,
Department of Computer and Information Science and
Department of Community Medicine and General Practice,
NO-7491 Trondheim, Norway

Abstract. The concept of a problem-oriented patient record was presented in the late 1960s but has yet to gain wide acceptance. In this paper we suggest a distinction between the idea of problem orientation and the implementation of the idea. We argue that the problem-oriented patient record offers an intuitive and useful way to work with patient information. We show that the concept of problem-oriented patient records facilitates better care of patients by supporting continuity of care, removing redundant and confusing information, and enabling easy overview of and access to its content. We further propose a two-layer framework that has knowledge of its content and use and is able to better utilize information in the record by presenting relevant information to the user at a time when needed. Conceptually, this is done by adding a layer of knowledge to the patient record system: 1) Knowledge about physicians' way of thinking and working, 2) Their corresponding information use and need during patient care, and 3) Tools to determine information relevance in a given situation; such a knowledge-based system is able to reason with its content and use.

1. Introduction

Lawrence L. Weed introduced the Problem-Oriented Medical Record (POMR) in the late 1960s with intentions of improving the structure of medical records [1]. Current patient record systems make it difficult, if not impossible, to obtain history of illness from its earliest stages because of their episodic orientation (i.e. on a per-encounter basis). Without a complete record of a patient's problems, clinicians cannot track course of development and systematically learn from own experience. For efficient and high-quality patient care the patient record should provide a foundation for linking patient-specific data with medical knowledge, learning, and improving skills of medical practice. A problem-oriented patient record proposes a change from a reductionistic view to a holistic view – to see problems in connection with prior and possible future events.

Previous implementations of POMR such as the Problem-Oriented Medical Information System (PROMIS[1]) have yet to gain widespread acceptance. The early PROMIS system imposed constraints on user's input data - system design directed clinicians to become more complete, rigorous, and systematic in documenting clinical information - one of the most persistent complaints against the system. Moreover, PROMIS required change in all levels of health care delivery and forced replacement of existing practice rather than functioning as an alternative or supplement [2].

[1] Medical Center Hospital in New England, USA.

However, POMR as an idea offers an intuitive and useful way to work with the patient record by structuring information related to a patient's medical problem into a unit, providing a context for dealing with medical problems, improving efficiency, and supporting continuity of care. Despite less successful experience with computerized POMR [3], we believe it possible to overcome some of the known deficiencies - such as enforcing strict and thorough data entry - with a knowledge-based approach to implementation.

2. Traditional Patient Records versus Problem-Oriented Patient Records

Many patient record systems that exist today contain mostly unstructured text – the text valuable in different circumstances of patient care (Table 1). To extract information from the record relevant for decisions that appear consumes time and because physicians work under severe time constraints [4], they have little time left to search for this information. Although, clinicians benefit from efficiency gains of the computerized patient record system, efficiency gains are not enough. A record system should also support physicians in geting overview of and access to information in the record.

Table 1: A record entry form a time-oriented patient record. Information in the record is not easily reusable because of the unstructured text.

131291JTA Hypertension treatment for several years, tried without medication for a period this spring, but was suffering from headaches and started again with TERNORMIN. BP 160/90 puls regular 62. Indicates a little dizziness, particularly when dark. Ophthalmoscope - no papilledema, bleeding or exudates, some minor blood vessel alterations. ---HYPERTENSION ESSENTIAL NOS ---HYPOTHYROIDISM RP: THYROXIN NA TBL 0.05 mg No:100 Pck.6 Reit:3 Pain left side abdominal-thorax evenings after going to bed, increasing last half year, particularly after meals. Pressure. Variable dyspepsia for years. Clin.ex.: Cor-pulm NA. Abd: BZ feces NA ---STOMACH ACHE UNSPECIFIED Lab.test sent to hospital STOMACH ACHE UNSPECIFIED

2.1. Potential for Improving Existing Patient Record System

Below, we look at some limitations of an existing patient record system in order to come up with some requirements for improving a future patient record system. Table 1 is an excerpt from a Norwegian text-based patient record system[2]:

1. The text can be characterized as rich and extensive in words. Usually, the record contains several pages of text. Many implementations of patient record systems have time orientation [5] - recording events in order of appearance. Information is, more or less, only accessible to the author, or information owner, who knows where to search.
2. The patient record is built around a principal free-text area to document patients' complaints, symptoms, signs, clinical findings, diagnoses, prescriptions of medication, laboratory tests, and other information pertinent to the specific medical

[2] We base most of our references to record systems on experience from Norwegian primary care patient record systems. Typically, physicians themselves enter information into the patient record system during patient care. Therefore, we consider physicians as both information owner and information user, thus, simplifying issues related to security and privacy of information. In general, clinicians in primary care have read access to all patient-specific data from the patient record.

problem at hand. The free-text area contains a lot of information, but with very limited possibilities to extract parts of it.

3. The record system offers separate windows to document patients' family and social history but to record this information requires extra effort in moving away from the main record. Physicians tend to integrate family and social history into the free-text area relevant for the medical problem being treated at the time of writing. The record system structure appears as rigid and seems to force physicians to work in non-optimal ways.
4. Interleaving medical problems impede overview and, thereby, also continuity of care. A chronological record mixes descriptions of different medical problems. The process of getting an overview of previous history of a medical problem or to view simultaneously documents related to a specific problem either consumes time or does not exist. Due to lack of overview and continuity of care, the record contains both redundant and confusing information, complicating work with the patient record unnecessarily. Evidence from a study we made of several patient records indicate that[3]:
   a. Many of the diagnoses used in the record relate to different manifestations of the same medical problem. The variety of diagnoses creates confusion and difficulties in getting an overview of a patient's major medical problems
   b. Much of the text documented is redundant, making the record lengthy. We consider the overhead a result of not having the possibility to view medical problems as a unit (e.g. as an Episode of Care (EoC)).
5. When activating the patient record, it highlights text from previous encounter, which implies that the clinician has to scroll backwards to recapitulate previous documents if treating a problem not related to the previous encounter.

Table 2: Example of a problem list and variations in diagnoses given to a patient. The problem orientation provides a structure for layering information; the problem name function as a high-level concept, while the set of diagnoses represent a lower-level description of the patient's condition.

Problem	Variations in diagnose
Myalgia neck/shoulder	Stiff neck
	Tension headache
	Headache
	Shoulder syndrome
	Tendinitis shoulder
	Myalgia neck
	Myalgia shoulder

2.2. Requirements for a Future Patient Record System

We relate requirements for a problem-oriented patient record to some of the limitations listed in previous section:

1. A problem-oriented patient record should present levels of relevant information. For lengthy records, not all information is useful at all times, information have degrees of relevance. Information in patient record should be ranked according to its relevance in a given situation, but at the same time leave other information easily accessible to the user if needed or wanted.

[3] At the time of writing, preparation of results from study are in progress.

2. A problem-oriented patient record should also provide physicians flexibility when working with record information. Table 2 is an example of how information can be structured and divided into layers of relevant information; the ``problem" is a high-level concept, while the set of diagnoses represent a lower-level description of the patient's condition.
3. A problem-oriented patient record system should not force physicians to work in formal ways.
4. EoC represents a core concept in general practice, initiated by the first encounter with a health care provider and completed with the last encounter. Immediate follow up from previous encounter of a problem secures continuity of care. In contrast to chronological records, an EoC-supported record system enables easy access to and overview of information for medical problems.
5. A system should adapt to clinician's situation (i.e. process awareness) by incorporating knowledge of clinicians' work processes into the record system.

3. Toward a Problem-Oriented Patient Record

One key to a successful implementation of a problem-oriented patient record is a system with knowledge of processes and abilities to rank information as relevant or irrelevant to a situation. We propose a two-layer framework for a problem-oriented patient record that aims to minimize the transition between how physicians work and how the record system forces the user to work:

1. A knowledge model: A record system with knowledge of its content and use empowers the record system to recognize where in the process physicians are and determine corresponding information use and need.
2. A relevance model: Information is ranked according to its relevance in a given situation (i.e. a medical problem), enabling the system to present levels of relevant information.

3.1. Ontologies for Building Knowledge Base

As one of our goals has been to design an architecture that enables the record systems to extract information that is more relevant than other from the complete patient record, our approach has been to identify and classify clinicians' interaction with the patient record.

We use the Protégé-2000 system to develop an ontology for a patient record system that link clinicians' work processes and activities with the use and need for actual clinical data in the patient record. Protégé-2000 comprise a set of knowledge-acquisition tools for developing ontologies, it supports a graphical tool, and has query abilities to assist in discovering the relationships between concepts and participating components [6].

Ontologies define a framework for organizing concepts in a knowledge base [5]. The purpose of our ontology has been to identify *informationsources* that can be ranked according to some criteria of relevance and comprises three sub ontologies.

1. **A process ontology** that identifies the primary care workflow; i.e. the way physicians work and their corresponding information need related to each activity
2. **A patient record ontology** that captures the content of the patient record; i.e. clinical terms
3. **An information ontology** that functions as a bridge between the process ontology and the patient record ontology. The information ontology implements the concepts of problem orientation.

Merging the three ontologies enable us to recognize the intersection between the workflow ontology, the information ontology, and the patient record ontology.

Informationsources distinguish activities in the primary care process and clinicians' information need within that activity with corresponding clinical terms in the patient record (Table3). *Informationsources* is a nametag for the set of patient-specific data that relates to an activity. The selection of relevant *informationsources* for each activity is in itself a ranking of the record content. Yet, a remaining challenge is to develop measures for ranking these sources.

Table 3: *Informationsources* for two activities. *Informationsources* comprise a set of information considered as relevant for an activity.

Action	Information Source
Determine assessment actions	Problem list
	Problem history
	Related problem list
Clinical examination	Clinical examination history
	Clinical examination history for related problems

4. Conclusion and Future Work

Among the most useful contributions of patient record systems is, in particular, the ability to support physicians in their decision-making process. The information in the patient record serves many purposes, but one of the most important ones is the linking of patient data and medical knowledge. We aim to assist physicians in their decision-making process by presenting relevant information and better utilization of information in the record system. We believe that the idea of problem-oriented patient records is still an intuitive and useful way to organize the patient record – despite previous less successful implementations of it. A problem-oriented patient record system provide a foundation for a well-structured patient record that 1) supports physicians' way of thinking and working, 2) removes redundant and confusing information, and 3) enables easier access to and overview of information in the record.

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