The Problem-Oriented Medical Synopsis: A Patient-Centered Clinical Information System

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A clinical information system consists of four major components: the clinical database, decision support, data analysis (including outcomes), and the development system. We have created such a system using generally available database methodology. The clinical database, for record-keeping, is called the Problem-Oriented Medical Synopsis, and is quite an old system, originating in 1966. We describe the suitability of a problem-oriented model of clinical records management to the relational model of database design, and describe our experience with the database as a departmental information system for patient care and outcomes research. Hybrid, or partially problem-oriented, databases represent an acceptable approach to clinical record-keeping.

1. INTRODUCTION

Health care information systems can be separated into the "hotel" component, including accounting, and the patient-care component. Most hospitals now are probably fully computerized on the hotel side. On the other hand, the patient-care side is only 1% computerized, compared to around 7-10% capital investment in automation in comparable industries. Total costs of health care account for about 10% of the entire world's GDP (up to 13% in the USA). Of these extraordinary costs, about 70% are spent on personnel costs, mostly nursing. Thus there is a very compelling need to automate this process. Hospital computerization is characterized by islands of automation, with little or no transfer of information from one system to the next. There has been a desire for more than 25 years to provide more patient-centered information systems, but for many reasons this need is still largely unmet, in part due to previously unsolved data management problems. Some data management problems include:

1. Lack of standards for **structure** of information storage. Many existing data management systems were derived from hospital information systems, which used hierarchical or network data models. The combination of the relational data model and problem-orientation of data derived from medical records seem to hold promise as a standard. Furthermore, the relational model, where data records are stored in flat files, independent of the order of rows or columns, identified by keys, fits well with the "data matrix" approach to storing data in statistical packages, spreadsheet, and other reporting tools. The relational model has been found to have many useful features for clinical information systems [1].

2. Lack of standards for **content:** meaning that free-text (or "medical narrative"), on its own, is unsuitable for storage and retrieval. Event data must be translated into a collection of terms that has a hierarchical structure and terminological control.

3. Lack of **integration:** between different software modules (such as database management systems and statistical software), and between sources of data, such as primary medical records and forms designed for data collection.

2. BACKGROUND AND DESIGN

The Problem-Oriented Medical Synopsis (POMS) was designed to store and retrieve event data derived primarily from medical records (or similar sources). The POMS was developed originally at the Walter and Eliza Hall Institute for Medical Research at the Royal Melbourne Hospital, Australia [2] in 1966. This project was designed to study all patients admitted to a clinical research unit, to assist in recognition of coexistence of autoimmune manifestations in various systems of the body [3]. Earlier versions of the POMS owed more to the original work of Korein [4] on variable-length text processing than to the Weed problem-oriented medical record (POMR), despite the similarities in the name. Korein's work was intended to automate the creation of a structured discharge summary.

A POMR organizes medical record information under specific patient problems, rather than by the source of this information (such as laboratory or X-ray reports, or nurse's notes). There were many articles about the Weed POMR system in the 1970's. A common thread running through many of these articles was the assertion that failure to achieve success in implementing a POMR might be due to lack of strict adherence to the Weed approach [5]. Weed himself implemented the PROMIS (Problem-oriented Medical Information System) [6, 7] at the University of Vermont in the 1970's, but this system no longer exists. The Karolinska Hospital in Stockholm also implemented a computerized POMR (called the Computerized Problem-oriented Record, or CPOR) which has been used successfully for some years [8]. Neither the Royal Melbourne Hospital nor the Karolinska Hospital implemented a strict Weed system. Both considered that the **data** about the patient should be recorded in the traditional source-oriented way, and that the interpretation of the data, i.e. **information,** should be recorded in a problem-oriented way. Thus administrative data, full medical history and physical, and laboratory test results are recognized as data, and are presented with reference to the source. Problem lists, problem descriptions with progress notes, specialist consultant's notes, and discharge summaries are recognized as information and are presented in problem-oriented format. Both these systems were therefore hybrid systems, or partially problem-oriented. More recently, Carey and workers [9] have asserted that a partially computerized record is ideal for support of medical care in the outpatient setting. Neither system used the structured (SOAP) Weed approach to progress notes. Both systems placed great emphasis on a timely, problem-oriented discharge summary (or assessment). Some users of problem-oriented records complain that the approach is too rigid, and is cumbersome to use. Others find it hard to fit the problem-oriented method into the "working diagnosis" approach. Weed himself never clearly defined what a "problem" was in his book or papers [10-12], merely stating that problems were "aspects of the patient's condition which need attention". The major advantage of the computerized POMR for patient care is the speed with which items can be found, and the ease of finding out why something was done to the patient (such as an order or procedure). A computerized POMR is also easier to audit because of the structured content and lack of repetition [5, 13].

2.1 Structure of the database

Tho original version of the POMS was written in FORTRAN for the IBM 360. The system was completely redesigned and implemented in a relational database management system in 1982-3 [14]. The database entities and relationships are surprisingly simple to understand if the problem-oriented approach to medical records is accepted. The POMS database can be represented as a **four-level hierarchy,** with a combination of data and text files; also some of the fields in the data files contain mostly text. The database schema is depicted in Figure 1.

1. The **Patient Master Index:** a unique patient number is assigned by the database, and the hospital number is a field used to cross-reference the manual record (this number can also be used as the primary identifier). The file contains binary (BLOB) fields for text about the patient (such as the social history) or images (the patient's photograph).

2. The **Treatment Episode:** where the date of admission and discharge (or purge), and reason for the episode are recorded. An "episode" is an epoch of patient care under a particular physician and location [15]: a patient can have multiple serial or concurrent episodes—for an in-patient hospitalization this is the same as an admission. For out-patient episodes this could span the patients entire life-time. Each episode is documented with an overall assessment which is a binary text file created by the physician in charge of the case. At discharge, this is the discharge opinion. Each episode record contains the referring and treating doctor identification numbers. The doctor name, address, and telephone number are obtained from the doctor master file. For each treatment episode a set of forms, "panels", or management indices can be created from files already in the system, or from new files created by the user. Panels typically include groups of investigations, such as hematology, blood chemistry, urinalysis, immunological tests, or any other findings. Management indices include any combination of symptoms, signs, or findings that the physician wishes to track day-by-day in flow-sheets. These findings can be displayed, sorted by date and time, or can be displayed graphically using statistical or graphical software.

3. The **Problem List:** the problem file includes the ICD-9-CM code, problem rank, problem onset date, and date of resolution. All problems are coded from the Problem Glossary, labeled with start and end dates, and qualified according to status, time course, acuity, and diagnostic weight ("ruled out" to "confirmed"). Linkage to the coding dictionaries occurs through the problem or management tables.

4. **Events:** related to problem management describing the problem, its assessment, management, and course. Element codes identify the history and physical examination; investigations

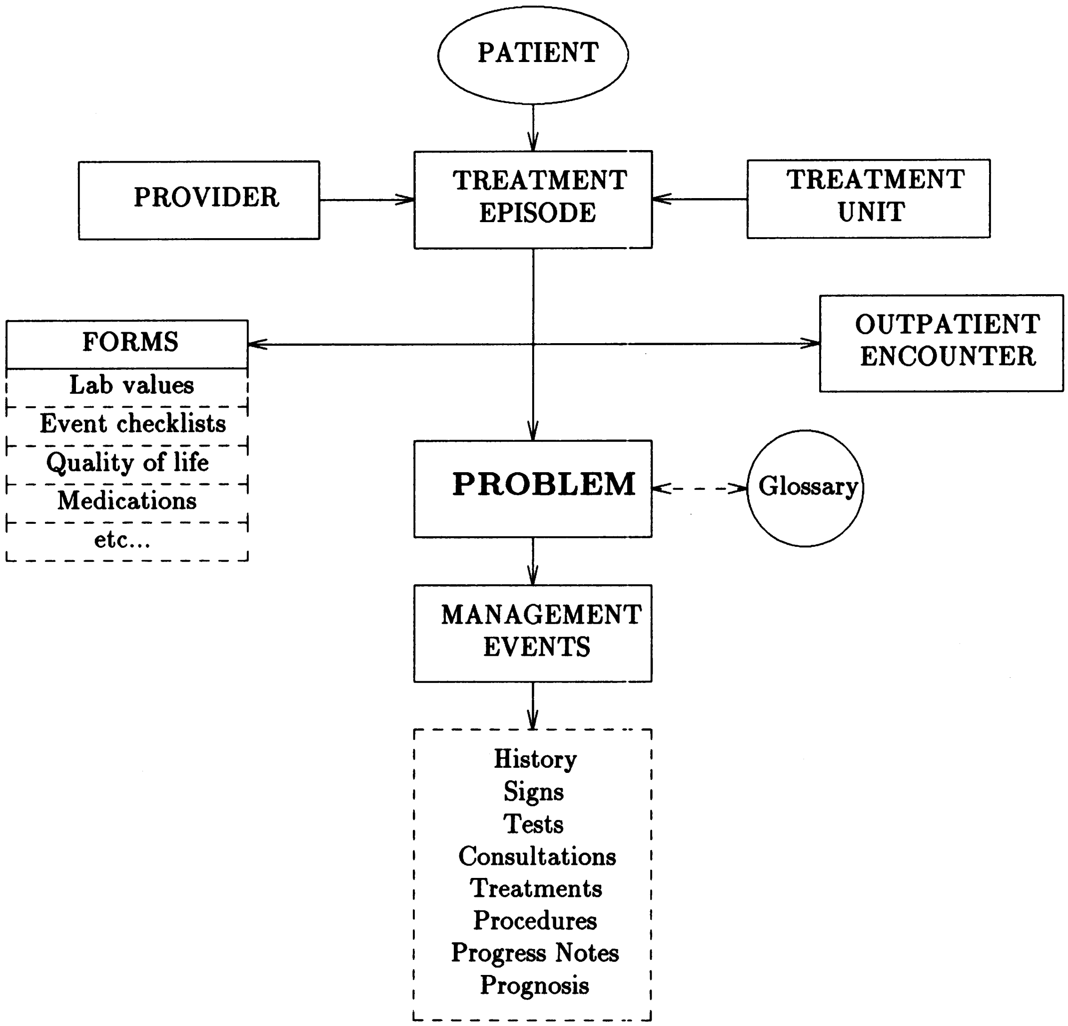

Figure 1 - Database schematic for the Problem-oriented Medical Synopsis

and the results; consultants, and details of the consultation; treatments and details of the treatment (*signa* information); procedures, which can be automatically looked up from the glossary (CPT-4 codes and titles are used); and, progress notes, with details on major events such as discharge and follow-up notes that do not fit in elsewhere. This element can be used for the recording of overall treatment plans. A binary field is used to store image BLOBS for diagnostic images. Each of these files also contains a date and time stamp.

There is an important difference between the structure of the POMS and that of the Weed POMR or PROMIS: the components of the progress notes that Weed calls SOAP—an acronym for Subjective (symptoms), Objective (signs), Assessment, and Plans—are presented as directly related to the problem in the POMS, and the progress notes are rarely needed. There have been some controversies about the structure of relational databases for POMR's. Most critics agree that the POMR structure is much more amenable to coding and storage in computerized medical information systems than the text of traditional medical charting systems, when properly used. The strengths of the POMR are the result of imposing order on an otherwise amorphous medical decision making process. Some weaknesses of the POMR are the lack of time orientation, and the problems of defining and recording inter-relationships among the problems. We have addressed these in several ways: all records are associated with a time and date stamp, and reports generally display the data in reverse sort order (most recent first); the episode record provides a reasonable approach to clustering by time, location, and provider; and the database uses "views" extensively to describe relationships among records. These views are stored in the database catalogs.

2.2 The Problem Glossary—Coding Dictionaries

The problem glossary forms the heart of the family of coding dictionaries. It is a collection of primary or preferred terms used in internal medicine and its specialties—synonyms are also included, to some extent. The list is known to be at least 99.8% complete in this domain. The remaining terms are added as needed. The problem codes are compatible with the AMA's CPT-4, used for medical and surgical procedures. The procedure codes have been augmented with additional codes for sub-tests, for example a code for SMAC-12 *(multi-channel blood chemistry)* is linked to single tests or results for sodium, potassium, and others that are included in the test. Each term is coded with ICD-9-CM, also augmented to include codes that are not currently included in ICD-9-CM (such as diarrhea). At present 5,400 of the problem terms are cross-indexed with SNOMed—the Systematized Nomenclature of Medicine, which provides indexing and retrieval at the medical concept level. Each problem and procedure term is classified, using a biaxial classification system: the axes are organ system (based on anatomy and physiology), and a "process" classification, based on procedures and other events that happen to patients in the clinical setting, such as medical history, physical exam, diagnostic investigations, diagnoses, prognosis, and outcome. Drugs are coded using the WHO International Drug Information System, noteworthy for its combined anatomic-therapeutic-chemical classification of drug action.

2.3 Other Components

The clinical database also includes data acquisition from notes, physiologic monitors, and laboratory or pharmacy systems; a generic forms library, with routines to create new forms and add them to the database (forms include severity of illness and nursing acuity assessments).
Decision modules include: statistical and graphical analysis (P-STAT), with gateways to other popular statistical packages; outcome assessment and the creation of data-derived prediction rules; interfaces to medical knowledge, including the Problem-Oriented "Aide-Memoire", a set of decision-support rules using the checklist as its metaphor; and, clinical alerts based on action-oriented rules build with an extension of the database programming language, such as "triggers" and stored procedures.

2.4 Development Environment

The application runs on UNIX-based super-microcomputers or workstations, and is based on the INFORMIX-ONLINE relational database management system. INFORMIX-4GL and INFORMIX-4GL/GX are used for for front-end programming. The development system includes the Metadatabase (META), an on-line database dictionary (written in INFORMIX itself) used to describe entities, attributes, and relationships, domain support, and a database code generator for new applications; and, integrated office automation software (UNIPLEX), which provides a uniform character (menu-driven) or graphical (icon-driven) user interface (GUI). The GUI uses MIT's X-windows, MOTIF, X.desktop.3 as a window manager, and Uniplex Windows for application development.

3. EXPERIENCE AND EVALUATION

As mentioned in "Background", POMS had its genesis in 1966 as a tool for improved data management in a clinical research unit, for record keeping, improved patient care, teaching, and administration. The 1972-77 experience, involving 3,569 admissions, was summarized by Proudfoot and Mackay in 1980 [16], showing the utility of the POMS in studying unit activity, disease correlations, stability of diagnostic criteria, completeness of diagnosis lists, and accuracy of coding. The database version of the POMS is intended as a clinical department information system (as an adjunct to a hospital information system), and has been used for HIV/AIDS, infectious disease, cancer, vascular surgery, and neurosurgery. In a typical implementation, at the Miami Veteran's Affairs Medical Center Special Immunology Unit, 1736 patients have been included in the database since 1988, with 5,416 treatment episodes, and 30,702 problems (by July 1993). A major benefit of the POMS is the presentation of a clinical synopsis in a standardized format. A large number (over 50) of reports are also available to describe the contents of the database. These are either written using the database report-writer, often to summarize a single case, or group of cases; or using the P-STAT statistical package. As a rule these statistical reports summarize the entire patient experience in the database, organized by body system, disease category, and intervention type. These reports are being used for natural history studies of disease, [17], and outcomes research (including cost studies), using severity-of-illness disease staging [18]. "Hot links" to a spreadsheet are also used for real-time summarization and reporting.

We conclude that a synopsis of patient data, represented using a problem-oriented format for storage and display, can be successfully implemented with a relational database, and used for patient care and outcomes research.

4. Reference

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