

Metaphor and medical decision-support-tools

The paper medical chart that has become so familiar to clinicians over the past few decades has often been used as a metaphor to guide design and implementation of electronic decision-support tools for medical practice. We believe the chart is the wrong metaphor for this purpose, and that its use inevitably leads to an ill-formed system that will fail to meet the needs of clinicians and managers alike.

Metaphor is a powerful tool to help us understand unfamiliar processes and objects, and to help us teach and explain unfamiliar things. Metaphor can also help guide the design of new objects and new technologies. A metaphor provides a framework and a world view within which certain design choices are more natural than others. The right metaphor may promote creative design by suggesting design solutions that might not otherwise have been considered. Unfortunately, a pervasive metaphor can also be limiting, keeping us tied to outdated processes and traditional forms that are less than optimal. The effects of old metaphors on new technology can be striking. Early automobiles, for example, were designed with "steering reins" that mimicked the reins used to drive a horse and buggy.

Design metaphors may be conscious or unconscious. Some of the most powerful metaphors are those of which we are not fully aware, and even the most sophisticated designers can be trapped by these unrecognized metaphors. Although the power of old metaphors diminishes over time, outdated metaphors can have an astonishing ability to persist for a long time and to exert unwanted effects in an unrecognized way.

Consider the typewriter. The most widely-used types of manual typewriters used a moving "carriage" to transport the paper. With each keystroke, a spring-operated mechanism pulled the carriage and paper to the left by one character-width. When the edge of the paper had been reached, a lever at the upper left side of the carriage was used to push the carriage all the way back to the right. A further push on the lever caused the paper to roll forward in a "line feed" so that a new line could be started. If a second "line feed" was desired, the lever was pushed a second time. To perform these necessary functions, the typist was forced to remove his or her left hand from the keyboard at the end of every line.

Figure 1.

The left hand was used to operate the "carriage return" lever at the end of every line.



The designers of early electric typewriters created a special "line feed" key to roll the paper forward, but --trapped by the metaphor of the manual typewriter -- also equipped their machines with an electrically operated "carriage return" lever in the traditional location. Later electric typewriters replaced the electric lever with a keyboard key labeled "carriage return." Although there is no carriage on a computer terminal, the label "carriage return" was ubiquitous on computer keyboards until 1983, and continues to appear on some keyboards to this day. The designers of modern computer software continue to be trapped, in a subtle way, by the same metaphor: under the MSDOS™ and Windows™ operating systems, the end of each line of characters must be terminated by two separate end-of-line characters: a "carriage return" (ascii 13) and a "line feed" (ascii 10).

Only when the prevailing metaphor underling an old design can be identified and challenged can the designer recognize and explore potentially better design paradigms. It has been said that the single most important contribution of the Unix™ operating system was the adoption of a single newline character in place of the carriage return + linefeed combination still used by other popular operating systems.

The Paper Chart

The visit of a patient to the emergency department is made up of a very large number of inter-related encounters, events, observations, actions, and results. The paper chart is one view of the path a patient takes through the department, but it is an extraordinarily incomplete view. The paper chart documents only a small fraction of all the interactions that have made up that visit, and contains only a small part of all the existing information associated with the visit.

What is more, the emergency department is a place in which a complex process involves many different patients and many different caregivers and support personnel, all involved in interconnected processes that together make up the overall reality of the emergency department. The path of a single patient through the emergency department is the intersection of that one patient with the entire ongoing process of emergency care. Out of the entire universe of data elements reflecting the overall emergency department process as it evolves over time, the paper chart contains a small amount of selected information related to a single patient and organized into arbitrary sections bearing on a single visit. We describe this as a "patient-centric, visit-centric" record.

The patient-centric, visit-centric record serves a useful purpose for patient-centered care, but is less useful for other purposes. For example, often it is necessary to consider the emergency department process from a viewpoint other than that of a single patient. Staffing, materials management, quality assurance, epidemiological research, and financial management are all examples of processes that require consideration of data pertaining to many patients all at one time.

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The paper chart is optimized to help guide the clinical care and the billing process for a single patient visit. This is a reasonable goal, given that a paper record can have only one organization and can be optimized for only a small number of compatible purposes, but the chart also contains a great deal of information that might be useful for other purposes, if it could only be re-organized.

The paper chart for a single emergency department patient visit is in effect an atomic unit of retrievable patient care information containing clinical, demographic, and operational data specific to a given patient and a given ED visit. It is an atomic unit because it is not divisible any further (except in rare instances in which different pages of the paper chart are sorted and stored in different venues). The hospital's medical

records department typically stores patient records using patient name or medical record number as the index key in which all of a patient's records are stored together (a patient-centric system) and then organized chronologically within each patient.

Multiple uses for the paper chart

Despite the fact that it has been optimized for just two key functions, the paper chart from an Emergency Department visit actually serves many different purposes. Any new or different conceptualization of the ED chart will need to be at least as useful for these purposes as the existing paper chart. Some of these purposes are served while the patient is being cared for in the ED; others are post-facto functions.

Organization of clinical information that enables better clinical decision-making.

By presenting clinical data elements in an organized fashion, the ED chart can support and enhance the clinician's ability to do what is right for the patient, whether that be avoiding administration of a medication to which the patient is allergic or displaying diagnostic test results in a way that enhances clinical decision-making

Presentation of demographic information that affects patient's follow-up care

The chart may contain information about the managed care plan to which the patient belongs and the name of the patient's personal care physician, both of which the clinician needs to know to ensure proper follow-up care.

Recording of therapeutic interventions that avoids duplicative actions

An ED patient typically has more than one care-giver which can lead to problems resulting from breakdowns in communication. An on-going record of the care that has been rendered can help prevent too few or too many therapies administered to a patient.

Transmission of information among members of the ED provider team (MD, RN, clerk)

Orders are written by one member of the patient care team for another member to act on. The chart serves as the vehicle for communication of that information.

Conveyance of the essentials of a clinical case to someone who has not participated in the primary evaluation of the patient.

This can be culled from the whole ED record or there may be a pithy case summary that would formulate the case and summarize the thinking of the emergency physician.

Timed recording of relevant aspects of what happened to the patient to enable a temporal reconstruction of the patient's course at a later time.

Such a temporal reconstruction is useful when an untoward outcome occurs or when a complaint is registered about the care the patient received.

Protection against malpractice claims

“If you didn’t write it down, you didn’t do it.” Certain pieces of information need to be documented not because they serve any useful purpose either in clinical decision-making or in information-conveyance, but because they may help to defend malpractice claims.

Compliance with billing requirements

HCFA has extensive guidelines delineating which data fields are required to be obtained and documented to support the billing of a given CPT billing code. The chart is the vehicle which determines if the care that is rendered meets the requirements for billing at a given level.

Compliance with regulatory agencies

HCFA, JCAHO, and state regulatory agencies have rules and guidelines which prescribe and proscribe certain actions on the part of an ED or its providers (eg. all patients must receive a medical screening evaluation to determine if an emergency medical condition exists [HCFA], no patient can be refused evaluation or needed care for financial or insurance reasons [HCFA], transfers and conscious sedation cases must meet certain specified standards [JCAHO])

Information for performance improvement

The chart is the source of data about a given patient care process that are retrospectively collected in order to monitor for adherence to quality standards or to identify opportunities for improvement.

Information for research

The chart is the source of data for clinical researchers to collect the information needed in chart review designed clinical studies.

Why the paper chart is a poor metaphor in the electronic age

It is a fundamental mistake to take the incomplete, single-viewpoint thing we call a paper chart and try to re-create it in an electronic format. This misguided approach is a classic example of "paving the cowpaths." There are many attributes of the paper chart that make it a poor metaphor to guide the design of an electronic decision-support-system.

Data entry and data display are identical

The paper chart displays information in the same place where it was entered, surrounded by a static context of other information. Only one view of the data can be presented. An electronic record built according to this metaphor presents the user with a screen full of labeled data entry sites to fill out, either by using a pick list or by entering data freeform through a keyboard or voice-to-text program. The way the information is displayed for subsequent viewing is simply by having those data entry sites filled in with data. There may well be very different needs driving data entry and data display, and a format that does not distinguish the two is not properly using the power of the computer medium.

There is a low data ink / non data ink ratio

An 8 1/2 x 11 inch sheet of paper is a very high-bandwidth visual display, capable of compressing a tremendous amount of information into a very small space. The style, format, and content of material that is hand-written onto a paper page can vary tremendously to meet the needs of the moment. In contrast, a 1024 x 768 pixel computer screen is a much lower-bandwidth visual display, capable of presenting only a fraction of what can be presented clearly on a sheet of paper. The style, format, and content of hand-entered material is rigidly prescribed by the program used to enter it. Data labels that are fine on paper are intrusive on a computer screen, where they consume precious real estate in a way that must be visually pleasing, but that does not add to the content. To display the contents of a single page of paper often requires several computer screens.

The display format is rigidly fixed

Because a paper chart can only display things in one way, data is organized in different areas of the chart within rigid categories of demographic, clinical, and financial information. Data elements are further rigidly organized into many sub-categories such as the traditional clinical subcategories of nursing triage note, physician history, physician physical examination, orders, laboratory and radiology results, therapeutic interventions, serial observations (by nurse and by physician) diagnosis, disposition, and discharge instructions.

This sort of rigid organization makes less sense in an electronic record, where a more useful approach allows each user to interact with any desired data elements at any time, grouped together in any useful way.

Because the two principal users of patient visit information are clinical users and financial users, a division has grown up between "clinical" data and "non-clinical" data. This false dichotomy is a relic of our paper chart roots, perpetuated into the information age only because early decision-support systems were designed as electronic versions of the paper records they augmented or replaced. When we abandon the paper document metaphor, the scales fall from our eyes and we see that in reality, data is data.

Data is entered into the system predominantly by the end user.

The paradigm for data entry in the paper chart model is for the registration clerk, physician, or nurse to enter it directly. The medium of entry is only secondary -- pen, keyboard, voice. There is little impetus to collect key patient data automatically and in the background.

Conflicting versions of the data may exist

In a paper-based world, many groups of information users have developed their own parallel charting systems, each one containing additional copies of the same information, organized and optimized to meet specific needs. In a best-case scenario, the information is merely redundant. In many cases, the information stored in one place actually conflicts with the same information stored in another place. The information in each of these paper-based systems is manually entered, ...

It is extremely difficult to consider data related to multiple patients

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The Data-Centric Database Metaphor

A single type of paper record can never fully meet all the conflicting needs of clinicians, teachers, researchers, managers, billing personnel, and enterprise-level planners, yet it is the same underlying data that is needed to support each constituency.

The chart contains date, time, and location information not only for the patient, but also for many members of the staff, indicating who was where, doing what, at what time. The chart also contains information about the use of materials and supplies that relates to inventories. Clinical data that might initially appear to be purely patient-specific has epidemiological value when properly aggregated with similar clinical data on many other patients. Billing information related to a single visit is the raw material of which reports are built to guide financial decision-making at the enterprise level.

A decade ago, we, too, developed electronic systems based upon the organization and displays of the existing chart, but in retrospect, the answer seems obvious: instead of a patient-centric, visit-centric chart for the clinician, a separate billing-centric visit-centric chart for the billing service, and an inventory-centric calendar-centric record for materials management, we must develop a data storage and retrieval system that is not organized along any one axis, but merely reflects the breadth and diversity of all the data that is available.

We call such a medical record a "data-centric" record, as it is optimized to receive, store, and deliver any data element that may be captured as a result of encounters between a patient and any part of an institution.

In a data-centric record, the atomic unit of information is a data item that may relate to any individual patient, or to a staff member, or to the emergency department or hospital as a whole .

The data items are stored in some "natural" organization that makes it easy to add new data elements to the system, and both input and output functions are divorced from the structure of the data as it is stored. In this way, both input and output can be handled in the most flexible way possible, independent of each other and independent of the underlying storage system.

In a data-centric system, "views" are made out of data items that can be selected and organized in any fashion whatsoever, filtered and sorted by criteria related to any existing data item, and displayed in whatever format meets the viewing need. A new view can be created in seconds to meet any unanticipated need, and views can be saved for re-use. This flexibility helps data-centric systems meet the needs of many different constituencies that are under-served by currently available paper-based systems. More importantly, turning away from the paper chart metaphor allows us to perceive for the first time exactly how inadequate the paper chart really is to meet the needs of even one constituency.

Clinicians, for example, have become comfortable working with the paper chart. In a data-centric system, if a traditional "patient-centric, visit-centric" view is desired, an output screen can be designed to call up all the data elements related to a single patient ED visit, grouped and sub-grouped the same way we now record them on a paper chart. Experience shows that when given the option, clinicians rarely elect to work with such a view, because other views can provide much more understanding and insight in a much more natural fashion.

If given the opportunity, a clinician would like to see different parts of the information organized and presented in different ways at different times.

Implications of a database metaphor for the medical record

Data can be presented or sorted along different dimensions as needed

One can create a patient-centric view of the data that would in essence be the typical chart, day-centric views of the data that would constitute the typical ED locator board, or doctor-centric views or nurse-centric views to aid in managing a cohort of patients. For performance improvement or research purposes, any combination of fields on any specifiable groups of patients can be displayed.

Any data element can be displayed juxtaposed next to any other data element, depending on the need

It is remarkable what can be learned by juxtaposing data fields that would not ordinarily seem to be natural, because they are not typically juxtaposed in the standard ED chart. eg. juxtaposing the data fields “age” and “insurance” status can help detect whether there are many over 65 year old patients who are not being registered with Medicare; juxtaposing the data fields disposition with presenting complaint can identify how many of those patients who died in the Emergency Department entered with other than “CPR in progress.”

Data can be searched on any condition; ad hoc queries of any type can be supported

Data can be displayed in a multitude of formats, including the data-rich relational database display of nothing but rows and columns

Data can be aggregated along any dimension so that trends can be spotted and performance monitored

Markers of quality of care can be disaggregated back into their component parts in a search for cause and insight.

If the percentage of patients who leave the ED prior to receiving care exceeds a certain threshold, then a detailed analysis of those patients can be made to see if it is a volume-staffing mismatch issue, an individual staff member issue, or is occurring more in a specifiable group of patients.

Data can be gathered from any source and “plugged into” the appropriate data field.

Input is decoupled from output. Data need not be entered by the end user. When data can be gathered automatically, the physician is freed to spend his or her time talking with the patient or thinking about the patient’s case.

In an emergency department, interesting views might include:

Empty beds in the ED
Empty beds in the hospital
All abnormal labs for my patients today
All patients who have been in the department more than 4 hours

All patients for whom all ordered tests are done and the results are back
All patients who have not yet been seen
All patients who are waiting for a room

Etc
Etc

For a researcher, interesting questions can be asked on a moment's notice, and results can be obtained within a few seconds. Questions we've addressed in 30 seconds or less have included:

All patients who died in the department during the previous year
All patients who returned within 72 hours and were admitted
All patients who had a diagnosis of deep vein thrombosis during the past year
All patients who sustained a foot injury at work, sorted by occupation

For a clinical manager, interesting views might include:

Number of patients in the department, by hour and by day of the week
Number of patients cared for by each clinician
Delays between admission and the time a patient leaves the department
Number of labs ordered by clinician

For a financial analyst:

EOB denials of payment because of incorrect insurance information, sorted by clerk
Medicare level of service documentation compliance by physician and by diagnosis
Patients over age 65, registered as self-pay

A fundamental insight: yet another reason why systems designed for hospital inpatients will never work well when adapted for emergency departments:

Hospital medical records are stored by medical record number.

Within the ED, patient records are always stored by date of visit, then by name.