An Idea Explained: Electronic Decision Making Tools for Physicians Improve Immediate Patient Care and Long-term Research

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An Idea Explained

Louis H. Sullivan's book An Autobiography of an Idea is the inspiration for this story. You can still wander the streets of Boston and see some of the buildings that he saw, mentally dissected, and learned from more than a century ago. From that beginning, as a youth, his idea that "form ever follows function" evolved a new, more honest architecture brought later to full flower by his apprentice Frank Lloyd Wright.

Our idea is a simple idea: Just as architects depend on engineers, physicians depend on information scientists. Informatics tools do not make the physician but broaden horizons of possibility. Our quest is the refinement of decision-making, specifically decisions made by physicians in the care of patients. We wandered medicine's streets, observed processes, dissected them, and learned what tools are applicable at this point in time but remain aware that the great peril is conviction that these are immutable truths.

By training and experience, physicians gather facts then draw conclusions, an inspection process that leads to valid conclusions only if that deductive pathway is well illuminated by current knowledge and the process itself is ruled by logic. Errors can be traced to insufficiency in the gathering of observations, faulty deductive reasoning, and lack of current knowledge. Our hypothesis is straightforward: a practicable physical means of assuring completeness of observations, governing the logic of conclusions, and enriching the decision-maker's knowledge—without penalizing the physician's efficiency--will elevate the quality of the patient care. Careful accumulation and analysis of the resultant data creates new knowledge and buttresses generalizations.

William Osler, the first Physician in Chief at Johns Hopkins Hospital, and a contemporary of Sullivan taught: "Some things can be learned only by statistical comparison. If you have the good fortune to command a large clinic, remember that one of your chief duties is the tabulation and analysis of the carefully recorded experience."

Direct entry of high quality data by the physician serves two important goals: decision support and statistical research. In order for a computer-based decision support tool to embed itself in the physician's workflow, it must pay her back immediately with useful, unobtrusive assistance: relevant medical literature, preventative alerts, standards of practice, even recommendations for further action. With this tool in place, the mechanics of accumulating data for later statistical analysis take place invisibly in the background. Gone is the practice of labor-intensive, error-prone medical abstracting and a new wealth of data is available for research.

Problems with Physician Data Entry

The prepared physician's routine tasks nearly always involve fact gathering, recording and interpretation of data, and consequent action. In this era, assistance by electronic means has become necessary. The variety of information systems spread across institutions and within an institution thwarts this process. For example, while Computerized Physician Order Entry (CPOE) is desirable, its implementation is hazardous and often fails. There is general awareness of the failed attempts to achieve these goals at staggering cost. Among the highest barriers to physician usage are confusing extraneous screen debris, time to train, and time per use. A system will not be adopted if the physician is penalized in either time or convenience. Also, the forced marriage of vendor hardware and software to the institutional information technology department's preferences and policies are often factors in limiting physician participation or adoption of direct entry to the institutional information system. As a result of cultural and technological barriers, most software tools are not designed with either the patient or the physician in mind, but rather by an imposition of techno-administrative hierarchy on the system. It is of utmost importance that we look at the fundamental goals when designing a system for physicians. These include making observations, recording observations, reasoning with logic, consulting reputable knowledge sources, and above all, clear communication.

Making Observations (data gathering)

Osler sometimes summarized his method of teaching by saying "We take as our motto the old maxim: `The whole art of medicine is in observation.' " Collection of facts requires definition of units, timing, and methodology. Users must have these standards at their fingertips, when making observations. Usually, the thoroughness of observations can be measured against medical specialty standards of practice. These standards assume or make explicit the preferred or required methodology and units of measure.

Recording Observations (data entry)

In the practical world, the choice of hardware is fundamental to the ease of data entry. Touch screen, cursive writing, printing, mouse, typewriting, and possibly voice command functionality combined with mobility and wireless connectivity, give the Tablet PC great potential to tempt the reluctant professional user. The software should not limit the appearance of the interface presented to the physician. In other words, the screen presentation must be versatile and content rich. The interface should be institution specific, depending upon local custom and personal preference.

Recording of observations in an electronic system include entry by forced choice (selection from lists), free text, and a combination of the two. To achieve maximum efficiency, selection from pick lists with a stylus is emphasized. By studying patterns and idioms that emerge from repetitious free text, the designer can create pick lists to replace narrative, saving time and improving the usefulness of the data.

Reasoning

Using their observations, physicians use logic to arrive at the right diagnosis, treatment, or other conclusion. Practical artificial intelligence techniques can assist in this process when used judiciously. Simple checks for contradictory errors or unlikely conclusions are very useful in preventing the human error that will inevitably seep into even the most meticulous practitioner's work. The infamous Institute of Medicine report has documented the magnitude of the problem. Fortunately, the barrage of media attention brings this to the forefront.

Allowing the computer to infer the context and goal of the user's task is useful for a number of reasons, as long as the action is unobtrusive. Examples include winnowing visual chaff by removing extraneous material, clutter, and noise. As a simple example, if the gender of the patient is male, do not present data sections for females. Similarly, a flood of information as opposed to knowledge delays the arrival at a conclusion.

Learning

How does knowledge from Olympians in a medical specialty become part of the decision making process? Standard texts and other electronic sources of knowledge are accessed in real time. Similarly, the astonishing resources of the National Library of Medicine can be used in real time to access current and classical literature. An application that anticipates the user's behavior enables access to these sources not only in real time but also in context with respect to the specific data element under scrutiny. Search results tailored to the user's preferences search results are available in seconds.

Although the above features are important, another approach is likely to entice a busy practitioner to interrupt his routine. The most useful knowledge for practitioners is the distillation of static or stale textbook knowledge and the evaluation of current literature as reflected by the current practices in major academic institutions or specialty organizations. This goal can be achieved only when the product has proven its worth in most other aspects. Corollary advantages include the creation of a mechanism for Continuing Medical Education of the most highly prized kind, direct application to patient care.

The establishment of patterns of use between distant practitioners and an academic department will become, in turn, a pathway for direct consultation. The incorporation of digital imaging technology to incorporate images into patient reports, storage, or transmission is a state of the art requirement for a modern user platform.

Communication

This may be a better term than data output. Communication may imply a specific destination of data to a file (document) used by many or to a single person for a very limited purpose. The latter, for example, could be an "off duty" physician's messages for the "covering" physician that may differ in kind and detail from the information needed for the official medical record.

The output should have universal applicability and be independent from the HIS vendor's requirements. Often, data will have multiple destinations in addition to the official medical record (laboratory, radiology, billing, physician offices, tumor registries et. al.) Often, the Hospital Information System vendor's product may limit secondary transmittal to additional databases, therefore, the need for versatile structured data output.

Above all else, including electronic archival, the communication must present the patient or practitioner who receives it with as many relevant observations as possible, but with a clear message regarding the action to be taken.

Although most informatics professionals are aware of the importance of user-centered design, most informatics departments are not equipped with the talent or resources to apply it, even if the cultural barriers are overcome. In order to build a useful, usable tool for physicians, a complete change in the approach to software development is necessary. At the center is the population of users, who not only accept or reject the system but *play a hands-on, central role in its development*.

User as Central

User-centered design enlightened by human factors science requires a deep understanding of the users and their environment through direct observation and interviews, to determine what their work tasks are, what their goals are, with what other people and systems they interact, what task constraints exist like time pressure, what physical constraints exist like environmental noise or restricted size of their work area to name a few. mTuitive's Chief Technology Officer Mark B. Law, Ph.D. is an expert in Human Factors Research and is the Software Architect and as Chief Technology Officer has assembled extraordinarily talented and diverse staff. Two physicians have been participants, nearly full time, in this project since its inception. mTuitive's usability teams have performed on-site task analysis and have observed members of target user groups in different hospital environments. An iterative process of redesign and retest for usability ensures that the product meets the needs of the physician.

User as Expert Author

Decision-making experts should create and edit the application but usually lack computer programming expertise. Since the chasm between those who understand technology and those who understand medicine is difficult to bridge, it makes sense to give the experts a tool that they can use to codify their knowledge. In no way should the tool attempt to turn the expert into a programmer, but rather enable natural flow of human knowledge and ingrained process into an electronic tool.

Our belief is that competence with e-mail software should be sufficient computer skill for expert who will author the decision-making processes used in the tool. It is far more valuable to let the expert define rules-based logic and standards of observation than to turn the expert into a programmer.

Putting the power of accurate definitions of observations and reasoning by rules-based logic in the power of the expert is far more valuable than turning the expert into a programmer.

User as Individual

User is author and data is structured. Given that the control of information system components must reside with institutional IT staff, there is a realm that is more reasonably under the control of the domain expert user, in our model the physician. How may the conflicting agendas be reconciled?

The expert user of our software creates structured data that can be transformed to conform to the norms of the Information Technology staff within an institution as well as the constraints of extramural database administrators. By gathering the majority of observations in a consistent (i.e.: forced choice) manner, it is possible to compare apples to apples, and even the colors, juiciness, and ripeness of apples. In other words, by consistently gathering structured, discrete units of data, it is possible to perform useful analysis to discover correlations between observations, treatment selections, and patient outcomes. Current narrative text-based hospital systems are little better than glorified word processors and rely on grossly inaccurate technologies like search and natural language processing to perform data analysis. In conjunction with structured data, the use of standard coding systems and languages enables the value of automated analysis to cross systems, institutions, and even nations. When systems can analyze the attributes of a tumor across thousands of cases, and compare the results of specific treatment protocols on similar groups of tumor patients, the resulting analysis has solid scientific underpinning.

User as Tester

Although our efforts have been toward a system with wide applicability, this presentation has been directed to field of medicine. Therefore, a proof of concept within the field has been tested. We tested our assumptions by applying mTuitive's expert system software to accommodate a specific need: generate reports by surgical pathologists on malignant tumors. Lists of data elements formulated by experts selected by the American College of Pathologists constitute the standard of care for practicing pathologists. To complicate the task there is a subset of these data elements that are required by the American College of Surgeons to fulfill the needs of Tumor Registries at the local, regional, and national levels. The inclusion of the various data elements in the checklists for each anatomic site of tumor origin is based upon literature evidence that each element is justified or recommended because uncertainty about a promising data element requires more data for resolution.

User as a Success

So far, a testable version of the mTuitive software application for Surgical Pathology has been distributed to individuals at several leading hospitals. Several more sites are now scheduled for installation. We do not speak for them but have interpreted verbal comments as very favorable. Most encouraging is their enthusiasm to apply the same principles to other areas in medicine.

William Sydney Thayer paraphrased bedside aphorisms gleaned from his long association with Osler at Johns Hopkins: Observe, record, tabulate, communicate. Use your five senses." Osler's discipline produced about two thousand publications and the most influential Textbook of Medicine by a single author. He changed the direction of Medicine.

Similarly, Louis Sullivan's careful observations and thoughtful innovations led to that pinnacle of architecture we now take for granted: the skyscraper.

A contemporary example of change in conventional wisdom -- in a field where we are all experts -- is demonstrated convincingly in a recent book, Moneyball by Michael Lewis. It is a delight to read. You will become a believer in the magic of 3. And it's great fun. Why didn't I think of it?

With new tools, attitudes, and defined alliances between medical experts and software gurus, perhaps we are ready change today's practice.

About the Authors

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A graduate of Johns Hopkins Medical School, Dr. O'Toole practiced surgical pathology for over thirty years at various institutions. He adopted one of the first laboratory information systems and continues to work toward better informatics tools for physicians.

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