The Visualization of Medical Information Design on Personalized Healthcare Services

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ABSTRACT

Medical quality indicator has become an asset in evaluating hospital and patient management. There are some issues with indicator data collection, arrangement, and presentation that are not fully resolved. In particular, one very important area is the medical information visualization that can effectively convey adequate two-way interpretation and communication of complex medical information between patients and health care staffs.

In general, the present health care system is plagued with over or under utilization of services and errors in health care practice. And the system often lacks the full-scaled environment adaptation, integrated processes, and the cross-therapeutic capabilities needed to ensure that services are safe, cost effective, efficient and most of all patient-centered. A health care delivery comprises layers of processes and handoffs. These processes consume resources beyond estimation; leave innumerous gaps from treatment to recovery; result in loss of information or creating redundant data; and fail to build up an expected system that optimizes the strengths of all participating health professionals.

The goal of this research is to establish a new solution of patient based medical information service to improve data delivery routes between patients and medical staff in the hospitals. It will enhance the effectiveness of procedures for individual patient care by

providing personalized information management over the entire treatment course.

Visualized information can significantly contribute to improving the presentation and transmission of medical data. There are five key areas in which medical information could contribute to a better health care delivery system:

1.Access to medical knowledge-based – via Intranet/Internet web server and workstations.

2.computer-aided decision support systems – for use by medical staffs, this system can improve medical practice skills and accumulate hands on experiences, and the integrated application easily explain the medical knowledge to patients.

3.Collection and sharing of clinical information – the automation of collecting patient-specific clinical information is essential for many types of computer-aided decision support system.

4.Visualized medical Information Graphics – dynamic and self-explanatory interactive diagrams and human-computer interface design.

5.Introduce a new visual communication model – Information technology can enhance the way of patients receiving medical care and interacting with their clinicians.

Keyword: medical information design, patient based medical information service, interactive diagrams

1. INTRODUCTION

The medical and professional isolation of health care in contemporary medical organizations often leaves patient's highly anxious and lacking knowledge and understanding about their illness. Most medical information systems are designed for

medical staff to manage patient care. Moreover, the misunderstood information and low quality healthcare are the main reasons lead more medical quarrels than the technical faults did.

With today's technology, humanization is the paramount in order to provide a human centered medical service. The essence of this research, encompassing the design of better methods to reform health care and effective measurement of outcome quality, will provide evolvement force to the relationship between the health care professionals and the patients and most of all, explore solutions to critical aspects of health care and management.

2. PRIMARY CARE

Health-care professionals, patients, families, community leaders, and policy makers all struggle to understand interactions between health and behavior use that knowledge to: improve the health status of individuals and populations.

The nation's current health care system often lacks the environment, the processes, and the capabilities to ensure that the services are safe, effective, patient-centered, timely, efficient, and equitable.

Four key aspects of the current context for health care delivery help explain the problems outlined above:

1. The growing complexity of science and technology.
2. The increase in chronic conditions.
3. A poorly organized delivery system.
4. Constraints on exploiting the revolution in information technology.

"Health care today is characterized by more to know, more to manage, more to watch, more to do, and more people involved in doing it than at any other time. The current methods of organizing and delivering care are unable to meet the expectations of patients and families because the science and technologies involved in health care: the knowledge, skills, devices, and drugs, have advanced more rapidly than our ability to deliver them safely, effectively, and efficiently."[1]

The Pick Institute established the following 8 Dimensions of Care that patients value:

1. Respecting a patient's values, preferences and expressed needs
2. Information, communication, and education
3. Access to care
4. Emotional support–relieving fear and anxiety
5. Involvement of family and friends
6. Continuity and transition
7. Physical comfort
8. Coordination and integration of care

2.1 Physician-patient relationship

Introduction

Individuals coming together in medical dialogue bring with them all of their personal characteristics, including their personalities, social attitudes and values, race, ethnicity, gender, sexual orientation, age, education, and mental health. Furthermore, the endpoints we might wish to measure, such as satisfaction or clinical outcomes, have many determinants.

There has found that an array of social factors in addition to race – including gender, age, literacy, social class, health status, and the normative expectations that guide the therapeutic relationship–are not only relevant, but also central to an understanding and appreciation of the interpersonal dynamics of healthcare.

Additionally, patient views about healthcare, including satisfaction, have emerged as important outcomes that differ by race, ethnicity, social class, language, and literacy level. Moreover, ethnic minority patients, patients with poor health status, old patients, and patients with less than high school education rate their visits with physicians as less participatory. [2]

The marked differences that often exist between physicians and their patients (for example, patients who are poor, uneducated, and belong to an ethnic or racial minority group) may lead to very basic communication difficulties. Physicians' negative attitudes or the assumptions they make about a patient's personality, motivation, or level of understanding clearly have implications for the care they give.

The Role of Physician Sociodemographic Characteristics on the Medical Dialogue:

1.Physician's race and ethnicity

Few studies have explored the impact of the physician's race and ethnicity on medical communication. Most of these studies have used patient ratings of the quality of the patient-physician relationship and the physician's communication style, rather then actual measures of communication.

2. Physician gender

As compared with women, man have been shown to engage in less smiling and laughing, less interpersonal gazing, greater interpersonal distances and less direct body orientation, less nodding, less hand gesturing, and fewer back-channel responses, and to have more restless lower bodies, more expansive arm movements, and weaker nonverbal communication skills. The male physician's talk included less psychosocial discussion. Male physicians also asked fewer questions of all sorts, engaged in less partnership-building behaviors, produced less positively toned take and less talk with emotional content, use less positive nonverbal behavior, and hold less patient-centered values than female physician. [3]

3.Physician social class

Reviewed by some health care reports, the evidence suggests that there are indeed social class differences in linguistic skills. Most prominent is a tendency for middle-class subjects to be verbally explicit, while working-class subjects tend to communicate more implicitly through nonverbal signals. While most consideration of the consequences of these linguistic differences has been in terms of patients' communication, it is also possible that social-class background relates to differences in physicians' communication. (figure 1)

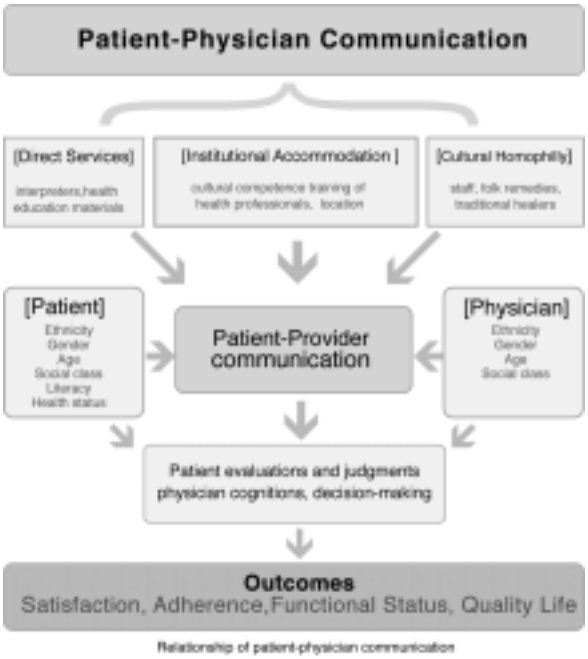

figure 1. Relationship of patient-physician communication

2.2 The role and impact of patient sociodemographics on medical communication

1. Patient race and ethnicity

Ethnic origin and cultural background contribute not only to the definition of what symptoms are noteworthy, but are also responsible for how symptoms will be presented to the physician. Studies have found that physicians deliver less information, less supportive talk, and less proficient clinical performance to color-patient and lower economic class than they do to more advantaged patients. Still another is that due to cultural norms or lack of confidence, such patients do not request or demand a high level of performance from their physicians given the correlation between social class and ethnicity in our society, it is not surprising that doctors' treatment of patients in different ethnic groups tends to parallel that for different social classes.

2.Patient gender

Among patients with chronic disease, females are more likely to prefer an active role in medical decision-making than males. In some studies, patient participation in decision-making was particularly low when male patients interacted with male physicians, and female patients were given more information than male patients, and that the information was given in a more comprehensible manner. The same dataset also revealed that the greater amount of

information directed toward women was largely in response to women's tendency to ask more questions in general and to ask more questions following the doctor's explanation. Investigators have also found that female patients receive more positive talk and more attempts to include them in discussion than males.

3.Patient age

Patient age is associated with both the frequency of medical contacts and the communication dynamic of these visits. Older patients are plagued by multiple and complicated medical problems are often required to make difficult decisions regarding the management of debilitating conditions. Particularly relevant to these decision-making demands is the fact that older patients appear to experience medical visits during which they are more passive and less actively engaged in the treatment decision-making process.

4.Patient social class

The effect of social class on patients' presentation of themselves and their problem also has relevance for the medical treatment patients receive. Doctors talk more with patients who are higher in social class and give more information. Physicians were much more likely to give high-class patients information regarding problem resolution and to engage in social talk with them than with lower-class patients. The better educated patients and patients of higher socioeconomic backgrounds received more physician time, more total explanations, and more explanations in comprehensible non-technical language than other patients. Thus, the educational aspect of social class determination is a particularly strong factor in doctor-patient communication.

2.3 The challenge of present care delivery system

The health care system does not have well-organized programs to provide the full complement of services, nor do we have mechanisms to coordinate the full range of services needed by those with multiple serious illnesses. And our current health system has only a rudimentary ability to collect and share patient information. The application of engineering concepts to the design of care processes is a critical first step in improving patient safety. These lessons include organized approaches to collecting data on errors and analyzing their causes, minimizing reliance on human memory, and standardizing routine aspects of care processes. [4] Patient safety emerges from systems that are skill-fully designed to prevent harm. [5]

For the most part, health care organizations are only beginning to apply information technology to manage and improve patient care. A great deal of medical information is stored on paper.

Communication among clinicians and with patients does not generally make use of the internet or other contemporary information technology. Hospitals and physician groups operate independently of one another, often providing care without the benefit of complete information on patient's condition or medical history, services provided in other settings, or medications prescribed by other providers.

If the current delivery system is unable to utilize today's technologies effectively, it will be even less able to carry the weight of tomorrow's technologies and an aging population, raising the specter of even more variability in quality, more errors, less responsiveness, and greater costs associated with waste and poor quality.

The challenge before us is to move from today’s highly decentralized, cottage industry to one that is capable of providing primary and preventive care, caring for the chronically ill, and coping with acute and catastrophic events. To meet this challenge, there must be a commitment to organizing services around common patient needs and applying information technology and engineering concepts in the design of care processes.

3. ACCESS TO MEDICAL KNOWLEDGE-BASED (TRANSLATION VIA INTRANET/INTERNET WEB SERVER)

The advent of the Internet and the World Wide Web has placed us on the threshold of a change that is reshaping virtually all aspects of society, including health care delivery. The Internet supports a rising tide of consumerism, with greater demands for information and convenience in all areas of commerce. And Internet services are becoming cheaper and easier to access.

It is estimated that there are 10,000 or more health-related Web sites, allowing consumers to search for information on specific diseases and treatments, evaluate health plans and clinicians, pose questions to care providers, manage chronic conditions, participate in discussion groups, assess existing health risks. [6]

The effect of these trends on health care will be a fundamental transformation in the ways services are organized and delivered and clinicians and patients interact. Individuals are making many of their own decisions about diagnosis and treatment. Increasingly, they are also bringing information to their physicians to obtain help in interpreting or judging its value.

To better understand how information technology can contribute to improving quality, the Committee on the Quality of health Care in America held a workshop in September 1999 at

which participants identified five key areas in which information technology could contribute to an improved health care delivery system:

1. Access to the medical knowledge base.
Through used of the Web, it should be possible to help both providers and consumers gain better access to clinical evidence.

2. Computer-aided decision support system.
Embedding knowledge in tools and training clinicians to use those tools to augment their own skills and experience can facilitate the consistent application of the expanding science base to patient care.

3. Collection and sharing of clinical information.
The automation of patient-specific clinical information is essential for many types of computer-aided decision support systems. Automation of clinical data offers the potential to improve coordination of care across clinicians and settings, which is critical to the effective management of chronic conditions.

4. Reduction in errors.
Information technology can contribute to a reduction in errors by standardizing and automating certain decisions and by aiding in the identification of possible errors, such as potential adverse drug interactions, before they occur.

5. Enhanced patient and clinician communication.
Information technology can change the way individuals receive care and interact with their clinicians. Similarly, patients would be able to go online and obtain test results, inform their clinicians about how they are doing, send pictures and data, participate in interactive care management services, receive after-care instructions, and participate in support groups. Appropriately structured e-mail communication between patient and provider could also permit continuous of clinical conditions, especially for patients with chronic conditions that require self-management. (figure 2)

A recent report by the National Research Council of The National Academies, Networking Health, also concludes that "the Internet has great potential to improve health by enhancing communications and improving access to information for care providers, patients, health plan administrators, public health officials, biomedical researchers, and other health professionals." [6] In recent years, some applications have become commonplace, such as online searching for health information by patients and providers. Others, such as remote and virtual surgery and

simulations of surgical procedures.

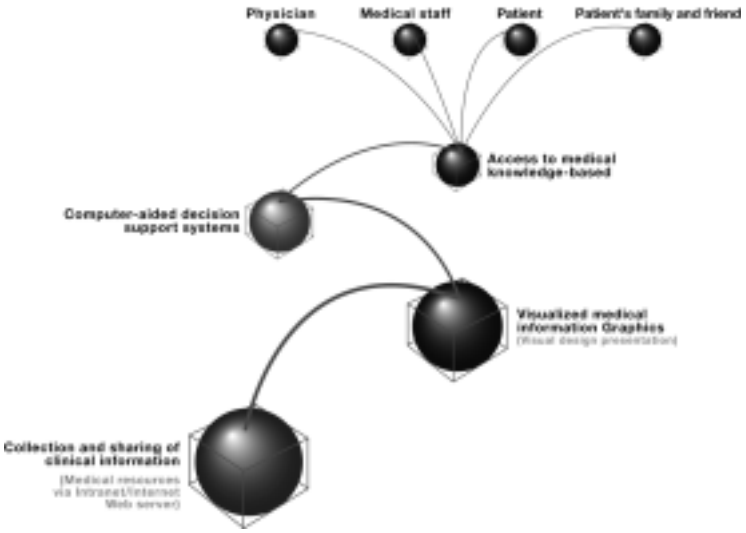

Figure 2. The process of medical information transmission

4. COLLECTING AND SHARING OF CLINICAL INFORMATION

The automation of collecting patient-specific clinical information is essential for many types of computer-aided decision support system. However, regionalization leads to simple image maps: digitized drawings, broken down into regions, each region being hyperlinked using HTML (Hyper Text Markup Language, used for writing “Web" pages) to a specific document, such as a patient's medical records. In general, web-based image maps were constructed either by using a GIF image (broken down into regions using Macromedia's Fireworks package) in conjunction with HTML, or by using Scaleable Vector Graphics (SVG), a new technology which allows zoomable and panable image maps to be designed. Both types of image maps can be used together with Active Server pages (ASP) to dynamically update and present data. The study has also used Geographical Information Systems (GIS) a specialist analyst tool, which inherently works on image maps.

4.1 Scaleable vector graphics

Scaleable Vector Graphics (SVG) is a new markup-based vector graphics format, which the World Wide Web consortium (W3C) has made into an open Web standard. SVG is an XML

styled tag language, which allows a text file to store the way that a vector graphic should be displayed. This has advantages over raster-based formats such as GIF and JPEG, which store data about each of the pixels in the image, resulting in large files. Another problem associated with raster images is that zooming tends to turn the image blocky. Vector graphics on the other hand, just store the end coordinate points that define lines, thus allowing the creation of polygons which not only can be colour filled, but which may have their own attributes. Because only data about the end points of a line are stored zooming and panning of the image are possible at any size. Moreover, this type of image requires less storage than a raster image. [7] Lastly, the fact that SVG is XML-based, and is therefore a text-based graphics language with semantic markup, enhances the ability of search engines to hunt through the format and extract meaningful information for the end-user.

4.2 Active server pages

ASP (Active Server Pages) allows for dynamic content to be used on the Web. The text document that is used to build the Web page contains either Visual Basic or Java scripting and requests the server to carry out some functions, such as database data retrieval or updates, before the HTML page is built dynamically, at run-time. Once the server has carried out its operation, the instructions for laying out the Web page are sent to the client. One of the main uses of this technology is to allow Web pages to interface with, and get results from, a database. In order to make use of this technology, the ASP queries and the database have to be stored on either an IIS (Microsoft Information Interchange Server) or a PWS (Personal Web Server), thereby allowing the server to carry out the queries on the database and return the information requested.

4.3 Geographical information systems

With the advent of computing and information systems, the analysis of complex geographical datasets and their related databases and flat files has been greatly enhanced by Geographical lnformation Systems technology. [8] Geographical lnformation Systems (GIS) tools such as ArcView allow the user to visualize data that may have gone unseen in spreadsheets, charts and other types of reports . [9] However, GIS does not need to be a single system, as it can be made up of a number of different hardware and software components, each performing a role in the storing and integration of digital images and related geographical data, thereby allowing for fast information retrieval. [10] Using GIS, several methods of analysis can be carried out on the data, such as selection by geographic criteria for the spatial dataset, or using standard

database functions such as sum, maximum, minimum, average, frequency distribution, and standard deviation on the no spatial data held in the database. As most GISs are built using relational databases, SQL (Standard Query Language) statements can also be used in such systems. [10] As the system is visual, it removes the complexity of paper files or large spreadsheets and allows users to point and click in logical ways through the datasets. [9] For instance, if an area of the visual image is selected, the selected area will be highlighted and all corresponding data in the related tables will also be highlighted and vice versa. In order to build a GIS, a base map is used, where every point, line and area are given a unique identification code. These codes can then be linked to the database by inserting a new linking attribute into the database. The GIS software then automatically builds all the links that are needed for the system to work.

5. MEDICAL INFORMATION DESIGN

The discipline of medical information design addresses the organization and presentation of data and its transformation into valuable, meaningful, and useful information to communicate between patients and medical staffs. Medical information design doesn't banish aesthetic concerns, but it doesn't focus on them either. However, there is no reason why elegantly structured or well-architected data can't also be beautiful. Medical information design isn't meant to replace graphic design and other visual disciplines but to provide the framework for expressing these capabilities.

Medical information design as a discipline has the efficient communication of information as its primary task, and this implies a responsibility that the content be both accurate and unbiased in its presentation. Unlike much of advertising and marketing design, in which the object is to persuade the user into a course of action, medical information design tries to present the entire objective data required to enable the user to make some kind of decision. The information designer has been described as a "transformer" of information – whether of raw data, a set of actions or a process – into a visual model capable of revealing its essence in terms that a particular audience can grasp easily.

5.1 Historical depictions of the human body used for medical purposes

According to historical depictions from medical documentary materials, there are some differences of medical representations between East and West cultures. In ancient China, most of medical graphics and sculptures are represented the meridian of body to indicate the main

points for acupuncture and herbal medicine. In the West, medical researches are more contributed to explanations of the anatomy, pathological concept, diagnostic method, and treatment strategy. (figure 3)

Figure 3. The comparison of ancient medical representations

5.2 Realistic graphic depictions of the human body

Advanced imaging diagnostics (the use of technical imagining equipment for medical diagnosis) is an interesting research field for the study of medical information design. It can also help us to appreciate the crucial importance information design plays in assuring the quality of a medical diagnosis which is based on advanced technological equipment. The realistic graphic style represents the accurate structure of human body, supplying the value of precision, readability, and quick comprehensible medical information for physicians to analyze the symptoms.

5.3 Scientific medical imaging

The Visible Human Project ®is an outgrowth of the NLM's 1986 Long-Range Plan. It is the creation of complete, anatomically detailed, three-dimensional representations of the normal male and female human bodies.

This research is a feasibility study of developing a semi-automatic (with a minimum human intervention) data segmentation system to facilitate segmentation of anatomical entities in visible human data set, quantitative analysis of human body parts, and visualization of human anatomy. The ultimate objective is to extend the above results to living human data and to

facilitate a feasibility study of virtual surgery. (figure 4)

Visualization of Visible Human
(www.nlm.nih.gov/research/visible/visible_human.html)

Figure 4. The Visible Human Project

5.4 Methods of medical information visualization

The fundamental issues in medical information visualization can be understood in terms of representation: the visualization is a representation of some aspects of the underlying information; and the main questions are what to represent, and how to represent it. Medical information visualization needs a theory of representation that can take account not just of the capabilities of current display technology, but also of the structure of complex information, such as scientific data, the capabilities and limitations of human perception and cognition, and the social context of work.

There are several principles that may be useful in assessing a range of medical information visualization design:

1.micro/macro design

Micro/macro designs enforce both local and global comparisons and at the same time, avoid the disruption of context switching. Vacant, low-density displays, the dreaded posterization of data spread over pages and pages, require viewers to rely on visual memory that will be a weak skill to make contrast, a comparison, a choice. The power of micro/macro designs holds for every type of data display and panoramas. Such design can report immense detail, organizing complexity

through multiple and hierarchical layers of contextual reading.

2. Layering and separation

Confusion and clutter are failures of design and lacking attributes of information. Also the focus is to find design strategies rather than to fault the data for an excess of complication or worse to fault viewers for a lack of understanding. Among the most powerful devices for reducing noise and enriching the content of displays is the technique of layering and separation, visually stratifying various aspects of the data. Effective layering of information is an excellent technique, where various elements are collected together and represent range of visual relationships. Thus, a structural hierarchy is developed for the new system, with information organized according to immediate importance. Effectively using the layering and separation to construct the system of information will help the user to make an accurate informed decision.

3. Space and time

An especially effective device for enhancing the explanatory power of time-series displays is to add spatial dimensions to the design of the graphic, so that the data are moving over space (in two or three dimensions) as well as over time. This space-time-story graphic illustrates how multivariate complexity can be subtly integrated into graphical architecture so that viewers are inconsequently looking into a world of four or five dimensions.

4. Dynamic interactive diagram

Sometimes, text and diagrams are not enough to accurately inform the user of the mechanisms of a procedure. Interactive system diagram can enable a user navigate to call up text, photographs and significantly, animated diagrammatic sequences help explain complex procedures. The interactive document is an

overview diagram, which acts as a kind of graphical index to a range of visual information resources. Digital diagrammatics are going to play an increasingly important role by providing valuable resources for learners and experts alike.

5. The usage of pictogram

The usage of pictograms – pictorial graphic equivalents of a function or action – is widely seen as a more satisfactory alternative to using words because pictograms do not require translation into other languages. Pictograms are most successful when they are used to represent an easily recognized object and this meaning can be extended to convey a larger idea, depending on the context. Pictograms can be used instead of words, animations, and sound can be used to enhance communication further.

6. Multiple windows and multiple functions display

By sorting through immense stockpiles of text and images, computers can quickly assemble and display information designed to serve immediate or unique purposes. In architecture of content, the information becomes the interface, sequentially stacking up little bits of data to be unveiled gradually. The interface shows the scope of information made available for users. The hierarchical structures, with facile navigation apparatus helps visitors navigate complex medical information. Multiple windows can describe multi-functions of particular subjects. Interactive pop-up windows explain specific areas to extend the depth of the user's knowledge and experience.

6. CONCLUSIONS

Most of the hospital Information systems were designed based on the purpose of patient registration and physician's orders management. Medical staffs and patients need an access that can effectively convey adequate two-way interpretation and communication of complex

medical information to avoid over or under utilization of services and errors in health care practice. A visual communication-based system that utilized those visualization design components would clearly enhance the quality of healthcare in the hospitals and would help ease what is often a traumatic and stressful experience for hospital patients. The visualization of medical information would easily explain what, how, and why things are happening to the patients and would help them understand and deal with their condition, and to ensure that services are safe, efficient and most of all patient-centered.

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