

DATA WAREHOUSING AND TELEMEDICINE

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Abstract

The purpose of this paper is to describe the potential impact of data warehousing on the implementation of telemedicine projects in a military healthcare environment. A brief discussion of current data warehousing models in the U.S. Department of Defense (DoD) Health Affairs is presented. Three telemedicine projects that are ongoing at the Center for Total Access (CTA) at Fort Gordon, GA are used as examples of the types of projects that can be enhanced by the use of data warehousing. The CTA focuses on technology to develop new avenues of delivering medical services and it serves as laboratory for healthcare re-engineering through the use of advanced communications. The use of data warehousing at the CTA would establish the backbone for collecting and storing data from all internal and external systems for the primary purpose of in-depth statistical analysis. The integration of data warehousing with the telemedicine applications would result in reliable reports for decision making.

INTRODUCTION

Telemedicine and data warehousing are generally considered to be in their infancy. Gill (1997) forecasts the average data warehouse will grow six to sevenfold every 18 months. Epstein (1997) reports that clinical data warehouses are growing bigger and more complex with data integrity problems rising exponentially. Data warehousing can be defined as using technology to help organizations make decisions about improving and changing processes, rather than just automating them (Sibigroth, 1996). Data warehousing is a powerful data management tool which technology has provided for us to use. Rashid Bashshur (1995) defines telemedicine as a system of care that uses telecommunications and computer technology to substitute for face-to-face interaction between patients, physicians, and/or non-physician providers. As a result, survivability in the next millennium by any healthcare organization may hinge on how new clinical data, accumulated from technology, are turned into valuable information for strategic business decisions.

DATA WAREHOUSING IN THE MILITARY HEALTHCARE SYSTEM

Across the world and penetrating the boundaries among nations and international business corporations, data warehousing is a new part of our every day lexicon.

The field of medicine with its complexity, diversity, and dictionary of medical terminology gave rise to a fragmented military medical information system with over 120 legacy systems (the spider web) and the potential of a medical record to have up to 24,000 pieces of medical information linked to each other. As a result of these legacy systems, the Deputy Secretary of Defense issued a directive to integrate all U.S. Department of Defense information systems (CEIS Manual, 1997). These information systems (IS) 'silos' will no longer be advantageous.

This past June, Timothy Sullivan, Corporate Information Officer (CIO) of Kaiser Permanente, adopted a new information systems strategy. His new strategy was 1) to develop a national information technology architecture that eases the flow of information and 2) to implement a full-fledged computer based patient record system in which records are created and paper is not generated (Goedert and McCormack, 1997). It would seem that the CIO of Kaiser Permanente is following the lead established by our nation's Defense department several years ago.

The military healthcare system was ripe for the logical integration of the components of data warehousing as a decision support tool to integrate all the migration and legacy systems with each service's own functional databases. Subsequently, the Defense department modeled its entire data structure by creating an integrated view of the entire medical data structure and all subsystems. The benefits that undergrid the DoD's data warehousing concept are turning raw data into meaningful information and turning similar and associated medical terms into common definitions. A caveat is that even a well-structured data warehouse may provide easy access to a wealth of data; nevertheless, decisions cannot be made based on data alone. The military healthcare leaders considered it mandatory that the automated information systems (AISs) would support "standardization" of data and provide better access, service, and quality with overall financial savings.

Examples of AISs that are utilized in supporting the Military Health Services System (MHSS) business objectives are described. One example is the consolidation of medical logistics into the Defense Medical Logistics Support System (DMLSS). This data warehouse, which is responsible for the supply of medical equipment and supplies worldwide, initially showed millions of dollars in savings. The warehouse supports 225 Army, Navy, and Air Force hospitals and 400 clinics and multiple outpatient facilities worldwide (Curtis, 97). The MHSS has two primary objectives: 1) to enhance healthcare delivery in peacetime to all uniformed service

personnel, retirees, and dependents and 2) to promote wartime readiness and sustainability.

Another example of a Defense department medical data warehouse is the Corporate Executive Information System-Near Term (CEIS-NT), which serves as a way to bridge legacy and open client/server systems. CEIS is a single system, integrated relational database that uses commercial-off-the-shelf (COTS) applications to migrate the functionality of eight existing legacy systems. CEIS receives data from the Composite Health Care System (CHCS) and the Ambulatory Data System (ADS). The Ambulatory Data System (ADS), collects data from the provider at the diagnosis (ICD-9-CM, 12,500 codes) and procedure (CPT-4, 11,000 codes) levels. The CEIS receives, from the CHCS, the Standard Inpatient Data Record (SIDR) and the Ancillary Record (HL-7 Messages) which contains the basic pharmacy, laboratory, and radiology data. CEIS receives, from the ADS, the Standard Ambulatory Data Record (SADR) which contains the direct outpatient record.

Special features of the CEIS are the report generating functions: Quantum and Trendpath. Quantum and Trendpath use hierarchically nested menus and point-and-click interaction style, accomplishing the goal of easy navigation for the users on reporting medical data. Trendstar has ad hoc report capability that can be mapped into Trendpath reports.

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Garber (1997) states that in almost any other industry, technological innovation is a good thing. In the managed care field, he adds, no reasonable person can defend using technology that has not shown any health benefit, or can criticize technology that both saves lives and saves money (Garber, 1997). Here telemedicine technologies may offer the capability to provide timely health care services across distances and be cost effective in a managed care network. For example, radiological images are captured, stored, and forwarded to the point of care, a desktop computer. The physician reads the transmitted images sent by telecommunications technology. Recent literature suggests that this technology reduces costs and saves time for both physicians and patients. Telemedical projects at the CTA are aimed at evaluating technology costs and the accumulated data.

MEDICAL READINESS

Medical readiness is the central focus of the Theater Medical Information Program (TMIP). The TMIP's primary mission is to provide seamless integrated automation of the theater medical environment. Furthermore, the TMIP goal is to provide a global medical information system linking information databases and integration centers (warehouses) that are accessible to the warfighter anywhere, anytime, in any mission. The

battle-focused responses include a variety of responses from evaluating the Advanced Warfighting Experiment (AWE) to utilizing advanced telemedicine (T-MED) technologies. For example, T-MED technology consists of voice, store and forward or real-time video, and data over a suitable communication network. (1994, Force Development Evaluation Report). In addition, medical information and images may be transmitted to a distant site for a specialist's consultation. This is especially true for teleradiology.

Appropriate training and performance of the medics is essential. The hands-on training and skill performance objectives must be quantitatively measured. Measurable usability attributes (ease of learning, efficiency of use, memorability, error rate, and subjective satisfaction), espoused by Jacob Nielsen, will be measured also. The SAS System with FRAME technology has a proven track record with usability engineering. Scenarios, employing valid measurable techniques, are the key to training and accurately testing the medical personnel in the skills necessary for employment of advanced technology in the battlefield of the future. The major objectives of the tactical T-MED are to deliver expeditious combat medical care and to lessen the footprint of the medic on the battlefield. A successful U.S. Marine Corps operation, Sea Dragon, illustrated the integration of emerging high-tech weaponry, communications and data processing onto the battlefield (Yost, 1997).

The data gathered from the simulated combat medical missions will be housed in such a way that responsible command and control decision-makers will have ready access. Data Warehousing will play a critical role because of the many databases that will be spawned by the large volume of data. This testing involves mountains of tabulated results regarding soldiers who are stressed by severe training conditions as well as the testing of the equipment.

BREAST CANCER EDUCATION

The World Wide Web (WWW) will soon change the face of decision support systems (DSS). Medical technology hopes to capitalize on this communications media as a cost-efficient means to reduce military health care expenditures. At the Center for Total Access the Breast Cancer Prevention, Education, and Diagnosis Initiative has been implemented. This Web-based project, a Regional Breast Cancer Awareness and Solutions Network, is intended to provide increased access and education on breast cancer to all eligible beneficiaries. This is a state-of-the-art multimedia effort with audio/video engineers and medical illustrators supporting it. This comprehensive breast cancer detection, prevention, training, and educational program will integrate audio-visual material, including 2D and 3D animations with structured learning, on the correct techniques for women to perform breast self-exams. This

awareness network will be available on the WWW and on kiosks (full screen and full video) at the 17 medical treatment facilities in TRICARE Region 3.

In the civilian hospitals, these touch screen kiosks usually record patient survey data at the point of service. In this case, the kiosks are used as an interactive tool for patient education on routine care, breast self-exam, mammography, biopsy, and cancer treatment options while waiting in a clinic area. Two major objectives in the planning stage of data collection were to obtain a database that allows statistical analysis on a real time basis and serve as a 'within the organization' web database for future projects. A complex statistical analysis, caused by site visitors leaving the page before completing the entire program, is anticipated. Examples of the Breast Cancer Education web site are shown in Figure A and Figure B.

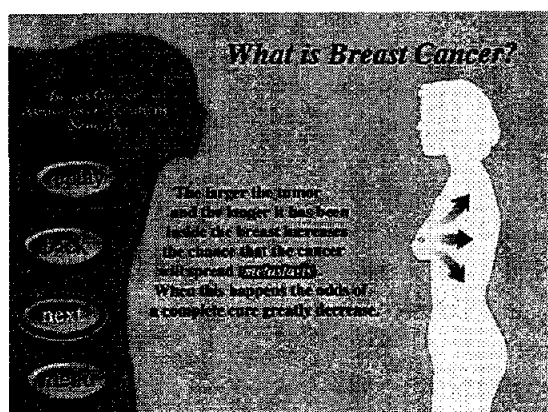


Figure A

MEDNET-SE and ISOETHERNET

Telemedicine has unique technical requirements that differentiate it from what might be acceptable in a usual service oriented environment. For example, a radiology department requires a 2K by 2K image resolution in order to meet the American College of Radiology requirements (DICOM III) for diagnostic quality over a PC workstation on their radiology reports. Consequently, the integration of any information/communication architecture (data-text, video, audio, spatial, Web, and structured-in scalable, accessible systems) would require technology that is suited to pass the required standards prescribed by the hospital and the clinical community. An architecture system was needed in order to avoid 'total breakdown' and be receptive to change (Simon, 1981). The CTA, in conjunction with other agencies, was instrumental in the implementation of a Medical Network-SouthEast (MEDNET-SE), which promulgates the DoD's open systems environment (OSE). This network allows communications between the command group and the military treatment facilities while providing medical services and support to their patients.

Ancillary with this implementation was the Isoethernet protocol at Eisenhower Army Medical Center

(EAMC). Isoethernet is a standards-based technology that can best be described as the "marriage" of Ethernet (an asynchronous packet technology) and ISDN (a synchronous circuit technology). It is a technology that extends the ubiquitous PSTN (Public Switched Telephone Network) to the physician's desktop. This frame relay technology fulfills three requirements: 1) high-quality video conferencing, 2) high bandwidth data (for file transfers of large pictures including x-rays), and 3) ubiquitous coverage (any PC accessing the Local Area Network equipped with Isoethernet interface IEEE 802.9). This technology is attainable at Ethernet costs. 'Statistical communications' has been coined to describe several of the various types of data communication modalities which lend themselves to statistical analysis generated from the telemedicine protocols at EAMC.

TECHNOLOGY 2000 and SAS

In summary, having the right tools is a start in the right direction. The integration of a comprehensive data warehouse into the objectives of the CTA's goal of applying technology in the medical environment was examined. The data generated from the new interactive telemedicine technologies, demonstrated in the above examples, will need heuristic analytical design, interoperability, and sophisticated statistical analysis. For example, data collected on the battlefield soldiers as well as on the Web site visits will be going into the next century. The time analysis (longitudinal) of multiple independent and dependent variables, with missing values on the subjects, can be easily handled by the GLM (Generalized Linear Model) MIXED procedure of the SAS System or the Generalized Estimating Equations (GEE) of the SAS System (Stokes, 1995).

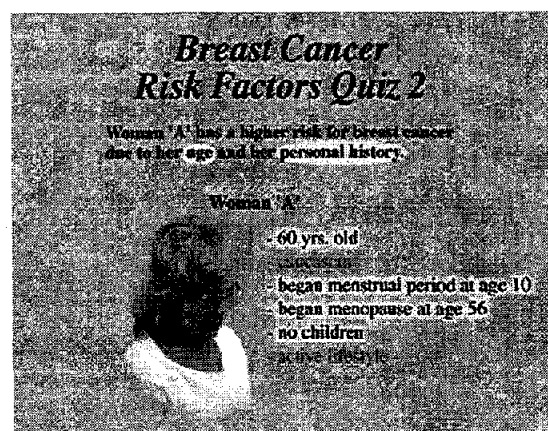


Figure B

Brown (1997) states, in a nutshell, that a data warehouse system is an extremely complex process, requiring significant planning, patience, and persistence. The SAS Data Warehouse Model does provide an end-to-end solution for managing, organizing, and exploiting

data. Once the data is in the data warehouse, one can choose from a full range of capabilities for exploiting the medical data for effective decision making, hypothesis testing, and data mining. Everything needed for data query and reporting, interactive reporting systems with the executive information systems (EIS), on-line analytic processing (OLAP)/multidimensional analysis, database marketing, data visualization, and presentation graphics, are instantly accessible without ever leaving the SAS Data Warehouse. The integration of data warehousing with the detail and in-depth statistical analysis of telemedical applications on large and small data sets makes common and monetary sense. If a logical integration of all the legacy systems in the medical environment can be accomplished, then data warehousing will be a major force in achieving the military healthcare goal of integrating all existing medical data systems.

Disclaimer: The opinions and assertions in this article are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

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