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Testing and Evaluation of a Military Medical Decision Support System

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EXECUTIVE SUMMARY

The Military Medical Decision Support System (MMDSS) is a promising medical informatics technology approaching maturity. Given the present military climate, automated medical surveillance capabilities are valuable tools for medical support of the armed forces. MDSS promises to enhance medical support for the military. The development of MDSS is consistent with the following Department of Defense (DoD) directives, which identified medical surveillance as important for maintaining force readiness:

ORGANIZATION BACKGROUND

In addition, MMDSS addresses the military goals of Information Superiority and Full Spectrum dominance. The recent and continuing emphasis on detection and prevention of chemical and biological attacks has made research and development of medical informatics technologies a pressing need for deployed forces. Such technologies offer medical command the ability to integrate and analyze patient data from widely dispersed forces, permitting early detection and rapid response to disease outbreaks.

Previous demonstrations and discussions among product developers and medical users at sites have done much to advance the product. However, no independent test and evaluation work has been conducted emphasizing military applications of MMDSS during extended deployments. Based on the performance of the product during previous demonstrations, the military command believed that MMDSS would benefit from systematic evaluation by a Test and Evaluation team independent of the product developer. Such an evaluation would also allow the Military Command a base from which to make decisions on the suitability of the product for future deployment.

SETTING THE STAGE

System Description

MMDSS is a Web-based information system that allows access to real-time medical threat assessment for deployed forces. The software facilitates response to medical threats by providing the preventive health officer, epidemiologist, or Surgeon with automated tools to assist in the process of investigating, identifying and reporting significant medical events. MMDSS automatically searches patient data for trends based on epidemiological clues identified by the Centers for Disease Control (CDC). The system is intended to provide epidemiologists with tools for early detection of disease outbreaks and chemical attacks. It also promises to give medical command and control the ability to integrate patient data from widely dispersed forces for mission planning.

The key feature of MMDSS is advanced dynamic change point detection analysis, which is designed to allow early detection of illness trends and disease outbreaks. MMDSS uses a set of dynamic change point algorithms to identify the start and end points of medical events, trends, and shifts within routinely collected data. The system is able to identify incidence spikes using relatively small data sets.

MMDSS enables epidemiologists to set and adjust baseline and threshold values, detect shifts and trends within data, and reconstruct the signal to show the form of the underlying event. MMDSS automatically alerts medical users of abnormalities and provides tools so that users can investigate the nature and source of medical events. The system can calculate baselines based on a week's worth of data or less from a Medical Treatment Facility, and provides early warning of trends to alert medical command of possible disease outbreaks before they become epidemic. MMDSS can serve as an effective early warning system to enhance both war fighter readiness and homeland defense. MMDSS supports the tenets of the three interrelated pillars of the DOD's Force Health Protection:

- Promoting and sustaining a healthy and fit force
- Preventing illness and injury casualties
- Sustaining a world-class casualty care and management system.

As mentioned above, MMDSS has undergone substantial development in recent years, including testing and evaluation for military utility and this application received the highest marks for military utility.

CASE DESCRIPTION

The testing process for MMDSS is iterative and ongoing. The MMDSS application, as well as the associated procedure manuals, hardware, and system interfaces must be thoroughly tested. Testing is done throughout the application development, and must also be tested as an integrated working component of the overall system. The original programming developers have already accomplished some of the MMDSS testing. They have verified that the application will work properly under certain conditions.

After the MMDSS application passes these desk and data tests, it must be link tested with test data. Programmers must also test the application with both valid and invalid test data, to test base routines and to catch errors. Normal data is first created and analyzed and then variations to the data are added. The MMDSS application will be tested for variations in the data above two standard deviations that will provide a "burst" that appears as a color change on the screen. In addition, documentation of Type I and Type II errors in the epidemiological trending will be documented. This portion of the testing will be performed in the laboratory, in order to provide internal validity for the testing and evaluation of MMDSS.

After link testing is satisfactorily completed, full systems testing with random test data is utilized, in order to validate system objectives. This testing will involve inputs to the database from various sources. At this stage, operators and evaluators become actively involved in testing, and the focus of the testing revolves around the generalizability of the MDSS application to other sites and situations paralleling those conditions that may be found under actual field conditions. The link testing provides external validity to the process, and considers the following factors:

- Determine if operators have adequate documentation available to them in the MMDSS procedure manuals
- Check whether procedure manuals are clear enough in communi cating how data should be prepared for input
- Ascertain if work flows necessitated by MMDSS actually function

- Determine if output is correct and whether users understand that this is how output will look in its final form
- The system will be tested to determine if it is "doing what it is supposed to do", by measuring the following:
  - Errors
  - Timeliness
  - Ease of use
  - Proper transaction order
  - Acceptable down time
  - Understandable procedure manuals

Final use and maintenance practices will be performed to test the MMDSS application under actual field conditions. Through this full systems testing with live data the MMDSS application will be continuously improved and adapted to changing environmental needs and compared to legacy systems and their outputs.

Research Methodology

The team's task was to Test and Evaluate the MDSS. The team functioned as "active participants" in the project. According to Creswell (1998), a qualitative approach is necessary when research must be undertaken in a natural setting where the researcher is an instrument of data collection, data is analyzed inductively, the focus is on the meaning of participants, and a process needs to be described. Qualitative researchers want to interpret phenomena in terms of the meanings people bring to them (Lincoln, 1995). Selection of a qualitative approach should flow from research questions that attempt to answer why or how questions (Yin, 1994), so that initial forays into the topic describe what is going on (Creswell, 1994).

The intention of the research was to test and evaluate an MMDSS that streamlines and automates the discovery disclosure process. The team was also responsible for the education and training of end-users to assist them in using the system to develop their own processes based on their own needs. From a problem solution perspective the team wanted to better understand how new technology is implemented in support of a complex process or discovery disclosure in an environment unaccustomed to change. With this knowledge, we could then derive better solutions for improving information flow related to discovery disclosure. The MMDSS system not only required dramatic changes to the existing technology infrastructure, it required a paradigm shift in the way end-users interact with technology. The MDSS system allows end-users direct control over the design of their processes without the need for computer programming. As a result, both the end-users and management had to rethink the way they operated. Change is difficult in any setting, but radical change is even more difficult to manage. In pursuing the answers to the research question we wanted to record the people, political, technical, and managerial dynamics involved in the case. We entered into the project with an understanding that the MDSS testing and evaluation needed to be completed on schedule and that what was learned from our participation would be used to facilitate process change.

The team adopted the qualitative tradition of action research. Action research is a "deliberate, group or personally owned and conducted, solution oriented investigation" (Boomer, 1987). Anderson, Herr, and Nihlen (1994) define it as "insider research done by practitioners using their own site as the focus of their study ... [it] is oriented to some action or cycle of actions that practitioners wish to take to address a particular situation" (p.2). Action research is problem focused, context specific, and future oriented and aims at improvement and involvement (Hart and Bond, 1995). It is continual disciplined inquiry conducted to inform and improve practice (Calhoun, 2002). According to Kember and Kelly, 1993), action research is a practical research methodology that requires three conditions to be met. First, its subject matter normally is situated in a social practice that needs to be changed. Second, it's a participatory activity where the researchers work in equitable collaboration. Third, the project proceeds through a spiral of planning, acting, observing, and reflecting in a systematic and documented style.

Our study adheres to the principles of action research. Our research was conducted on site where the project was taking place. We focused on a specific problem that was context specific with the goal of improving information flow related to disclosure. Our goal was to inform those involved and improve practice. We worked equitably in collaboration with all parties. We approached the project and research in a systematic manner in accordance to the "spiral" approach touted by Kember and Kelly. Consistent with Swan (2002), we adopted an iterative approach to the testing and evaluation of our MMDSS system during our action research activities. We adhered to a constant process of revisiting the problem(s), re-analyzing processes, and synthesizing revised solutions. Nigel (1989) suggests that scientists, architects, and engineers problem-solve by analysis, whereas designers problem-solve by synthesis. That is, scientists use "problem-focused" strategies and designers use "solution-focused" strategies. The Team found this to be the case as we began designing the discovery disclosure process into our system.

For testing purposes, end-users are defined as Test and Evaluation personnel acting as evaluators of the system software. The evaluators will check the functionality of the software as determined by the Users manual. No training of end-users will take place during this testing and evaluation of the MMDSS application. The evaluator will refer to the MMDSS User Manual to perform the associated tasks in evaluating the MMDSS application.

Program Testing

The testing process for MMDSS is iterative and ongoing. The MMDSS application, as well as the associated procedure manuals, hardware, and system interfaces must be thoroughly tested. Testing is done throughout the application development, and must also be tested as an integrated working component of the overall system. The original programming developers, have already accomplished some of the MMDSS testing. They have verified that the application will work properly under certain conditions.

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After link testing is satisfactorily completed, full systems testing with random test data is utilized, in order to validate system objectives. This testing will be conducted utilizing inputs to the database from various sources. At this stage, operators and end-users become actively involved in testing, and the focus of the testing revolves around the generalizability of the MMDSS application to other sites and situations paralleling those conditions that may be found under actual field conditions. The link testing provides external validity to the process, and considers the following factors:

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Final use and maintenance practices will be performed to test the MDSS application under actual field conditions, in exercises conducted in the Middle East. Through this full systems testing with live data the MMDSS application will be continuously improved and adapted to changing environmental needs and compared to legacy systems and their outputs.

CURRENT CHALLENGES/PROBLEMS FACING THE ORGANIZATION

Trend Analysis Process

The Testing and Evaluation Team will monitor MMDSS information, perform epidemiological research, and conduct trend analysis and report significant medical trends for each identified site. This Trend Analysis data will be then utilized to generate an Alert Report, which is transferred to the MTF. The Trend Analysis can then be utilized to provide epidemiological consultation to assist in making appropriate medical decisions.

Epidemiological Reach-back Process

The Team will develop Epidemiological reach back cells (one-on-one consultation of episodic situations) to view data and work collaboratively through a message capability, receiving requests from MTFs regarding concerns and Epidemiological support.

Generate Alert Reports Process

The Team will conduct reviews and analyze patient data, per MMDSS, to determine medical threat assessment/identification and provide feedback to MTFs as identified. The report format will be as determined by the collaborating MTF and forwarded to the MTF directly for their purposes.

Medical Modeling and Simulation

Provide management and functional support responsibilities for Medical Modeling & Simulation (M&S), in operations and exercises in support of military Commands as identified. Currently this support is being provided, but not limited to, exercise, planning and coordinating conferences for this and other operations and exercises as directed.

Help Desk/Engineering Support/System Administration

The Team will provide help desk support and system administration services to all deployed sites. The Technical /Engineering Team will administer the database to compliment MMDSS and other technologies and systems as identified. Network requirements to satisfy connectivity and compatibility will be provided by the Technical Engineering Team.

Data Collection and Storage

The Technical/ Engineering Team will ensure connectivity between all selected sites and conduct oversight of the data collected from the various sources feeding the database. Dominion over the database involves detailed planning and collaboration with the staff of selected deployment sites.

Training

The Training Team shall design and administer functional training programs (instructor lead curriculum, user manual development, quick reference guides, Online Assistance, etc.) through distributed learning for personnel at MMDSS installation and utilizations sites as required for MMDSS software builds released to deployed sites.

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