

Integration of heterogeneous medical supplies and computerized medical maintenance management (CMMS) databases and decision support systems

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I. INTRODUCTION

This paper discusses an ongoing medical informatics and business process reengineering research project. The Joint Medical Asset Repository (JMAR) is a relational database system created to integrate very diverse medical supply and medical maintenance management information from the US military services existing heterogeneous database systems. JMAR was originally envisioned to correct medical supply and drug distribution problems that occurred during Operation Desert Storm, and it received additional strong impetus and urgency from the September 11th terrorist attacks (TechMaui, 2002). JMAR also is a critical component of the Joint Vision 2010 and 2020 concepts, plans to provide seamless clinical and medical supply information from the front lines to the home-based forces and their families (Stratton and Dick, 2002). The Joint Vision 2020 plan is an aggressive and all encompassing one, and it seems well ahead of civilian efforts found in the literature to date.

II. BACKGROUND

The basic logistics and supply chain management issues are not dissimilar to published efforts in other industries (Clark and Crosson, 1997); simply stated, the Surgeon Generals of all three military branches would like to ensure access to any required drug, supply, or medical device regardless of which branch owns or inventories it. For example, an early JMAR module is one that integrates the information on available blood supplies from the three services existing information systems. By updating the JMAR knowledge base daily, the military's medical supply teams can locate needed plasma and blood types, deploy it where and when necessary, and coordinate replenishment activities to minimize overall waste.

JMAR is based on a centralized Oracle engine, with a growing interface library to allow integrating information from the hundreds of heterogeneous systems in use by the medical services. This not only facilitates medical care to save lives, but it also eliminates the hours and hours of staff time to make phone calls around the world that such searches required. Most drugs, supplies, and eventually most medical devices information will be integrated into the JMAR system, allowing it to serve as a global metadatabase for the military's medical leaders. Realization of the full scope of JMAR will take many more years, as it must eventually integrate complex information models like those used for medical equipment maintenance, updates, recalls,

and repairs. As each phase is implemented, the system architecture can be instructive for civilian applications. For example, JMAR's military project leaders would like to explore ways that the system might help the Red Cross improve its own blood management programs.

The general medical procurement process is being integrated in JMAR, too. This allows visibility of purchases from Prime Vendors and/or alternate sources. This offers an excellent opportunity to improve efficiency and reduce costs by allowing centralized oversight and intervention when higher cost suppliers are used instead of pre-negotiated, discounted Prime Vendors. No instant remedy is expected, however, as such purchases may have valid reasons, such as product shortages or unexpected emergent requirements that cannot be fulfilled within the discount terms. Centralized information will allow Pareto charting and other statistical tools to identify and rectify the most significant problems as they occur.

III. TECHNICAL DISCUSSION

Technically, the JMAR system requires many levels relational database metastructures to allow mapping items from each source because every military service has adopted unique product and supplier coding, and each existing system stores different details about each item. Drugs, biologics, blood, and many supplies, for instance, often have expiration dates, lot/serial codes, and other important details that may be diffused throughout databases and/or paper records. As each new category of medical resources are integrated, the data structures must be enhanced to facilitate the unique needs and environments that are being embraced. Further, each level of expansion offers new security and privacy issues that are often similar or identical to the HIPAA laws.

For example, the military, and the VA, has had to create their own coding system for drugs because no industry standard existed. The FDA's March 2003 requirement for industry-wide drug coding will eventually make its way into the JMAR universe.

An Oracle database server environment has been established to store the information. Each of the tables in this star database design has to have the flexibility to store the disparate data in tables that share relatively common fields, though the fields may not be precisely matched to every application. For example, every location exists in a Facility table that provides many more fields than most facilities require. For example, most inventorying facilities may not have patient beds. Another example is that most inventoried items may not bear a serial number or have an

expiration date, but the Inventory table includes those fields so that they are available when needed. Though this format “wastes” some storage and may not strictly be a formal third normal form design, it offers substantial simplicity for users and access speed advantages. A further operational complexity tradeoff exists in this design, too: the use of various fields creates hidden data-related meanings. For example, an item that bears an individual serial number must be inventoried in single unit quantity.

Further complexities of medical supply information have been incorporated into the design, including the following:

1. Assemblies (pre-packed sets of items) are themselves inventoried items, with recursive numbering that uses other the existing inventory numbers of each subcomponent and the appropriate quantities to specify the assembly composition.
2. Substitution of non-prime-vendor alternatives is supported, along with quantity multipliers to accommodate situations in which the substitute item is issues in different packaging (e.g., batteries that are single items instead being in a six-pack.)
3. Reservation of specific quantities of items for specific purposes (e.g., emergency rooms supplies) is supported, along with purpose-specific reorder levels

Synchronizing the information from each source requires careful analysis and programming with each service’s medical logistics and IS teams. The synchronization must, by necessity, be robust enough to tolerate unavoidable lapses caused by urgent situations like natural disasters or military operations. If blood or other supplies are transferred from one service to another and the records are not updated simultaneously or contemporaneously, the system might show episodic shortages or double-counting until all updates are posted. As bar code, IR, and other automatic, real-time data acquisition is implemented by the military bases, however, these problems will be reduced. These are the exact same trends recommended by the Institute of Medicine report in 1999 to help reduce drug errors, and they are also the trends that helped retailers like Wal-Mart create efficient, leading-edge supply chains.

Future planned JMAR enhancements include medical equipment, repair parts, and specialized repair tool tables and reporting and management programs. These information decision support will facilitate implementing more effective, uniform computerized medical maintenance management system (CMMS) programs throughout all of the services, and may significantly reduce MTTR (mean time to repair) and increase MTBF (mean time between failure) by locating necessary parts and tools quickly and/or ensuring timely preventive maintenance respectively. When the size and complexity of the global medical technology infrastructure

that the US military services must support, the savings may be very substantial.

IV. CONCLUSIONS

The emerging consensus seems to be that the JMAR metadatabase is becoming an invaluable and efficient tool for managing the heterogeneous information systems and databases. It allows strategic and tactical decision making without the cost, complexity, risk, and delay of forcing each military service to convert to a standard platform. It has allowed the military services to synthesize a “single view” from their disparate systems now, not a decade from now.

From an operations research perspective, this effort resembles “lean manufacturing practices” that are being developed for healthcare (Lewis, 2001). This is a new area of Health Systems Engineering research, because systems that serve a manufacturer like Dell may, or may not, be adequate or appropriate when considering the life-and-death consequences of potential supply shortfalls following catastrophic events. It is one thing to run out of keyboards or disk drives for a week, but it is quite another story if plasma or critical antibiotics are unavailable. The military’s logistics supply expertise is quite extensive, however, and lessons learned should be instructive to the civilian healthcare community.

Although many aspects of the JMAR system design must remain secret, the overall JMAR design and implementation represents a valuable opportunity to explore the challenges and constraints of integrating a large number of heterogenous databases to facilitate executive decision making and to effect administrative efficiencies. Its successful development and evolution offers encouragement for civilian medical supply logistics at a time when healthcare’s economic losses and clinical errors continue to be headline news.

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