COHORT: An Integrated Information Approach to Decision Support for Military Subpopulation Health Care

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Abstract

Delayed recognition and response to health syndromes in the past have highlighted the critical need for real-time surveillance of the health status of forces as an enabling capability for decision makers. Real-time surveillance serves to alert health authorities and make possible rapid, appropriate, and effective responses to limit the adverse impact of occupational and operational threats to health.

In support of Force Health Protection, the USAF Surgeon General has recognized a need for early detection of syndromes and epidemics in specific cohorts (subpopulations) over time. Cohort surveillance and monitoring require analytical tools and access to pertinent, timely, and consolidated medical data.

The Composite Occupational Health and Operational Risk Tracking system (COHORT) addresses the USAF Surgeon General's need by providing real-time surveillance of the medical care and treatment of specified groups of military personnel across multiple medical health facilities throughout the world. The medical encounter data aggregated by COHORT provide input for timely detection and monitoring of occupational health concerns and disease trends, syndromes, and outbreaks. The early detection made possible by COHORT avails key decision makers the opportunity to formulate appropriate responses in time to make a difference in the outcome.

1.   Introduction

The health and fitness of military personnel are key concerns of those responsible for ensuring troop readiness and effectiveness. Delayed recognition and response to health syndromes in the past have highlighted the critical need for real-time surveillance of the health status of forces as an enabling capability for decision makers. Real-time surveillance serves as a "canary" to alert health authorities and make possible rapid, appropriate, and effective responses to limit the adverse impact of occupational and operational threats to health.

The acknowledged importance of Force Health Protection has resulted in several legal and administrative initiatives through public law, memorandums, instructions, and directives to provide procedures for conducting health surveillance in support of force health protection. These include.

- **Public Law 105-85, Section 765 (18 November 1997)** – This law mandates medical surveillance of all service members before, during, and after military deployments. As defined by the Centers for Disease Control and Prevention, health surveillance is the ongoing, systematic collection, analysis, and interpretation of health data essential to planning, implementing, and evaluating public health practice.

- **Under Secretary of Defense (P&R) Memo on Enhanced Post-Deployment Health Assessments (22 April 2003)** – This memorandum directs enhancements to post-deployment health assessments, including an expanded questionnaire and

face-to-face assessment with a health provider, blood samples for all returning personnel, placing deployment health information in the permanent medical record, and ensuring appropriate follow-up medical care.

- **Department of Defense Instruction 6490.3 (7 August 1997) –** This instruction implements the policy, prescribes procedures, and assigns responsibility for joint military medical surveillance in support of deployments.

- **Department of Defense Directive 6490.2 (30 August 1997)** – This directive establishes the policy for routine joint medical surveillance of all military members during deployments.

In support of Force Health Protection, the United States Air Force (USAF) Surgeon General is tasked with the care of Air Force personnel and their families and the protection of their health. The USAF Surgeon General has recognized a need for early detection of syndromes and epidemics or significant deviations from expected levels in medical data in specific cohorts (subpopulations) over time. Cohort surveillance and monitoring require analytical tools and access to pertinent, timely, and consolidated medical data.

2.   Vision

The Composite Occupational Health & Operational Risk Tracking system (COHORT) vision is to enable the USAF Surgeon General to consolidate, extract, and make available medical data from various military health care facilities for the analysis and early detection of epidemics, disease trends, and health anomalies and in support of cohort monitoring.

Cohort monitoring falls into two categories: prospective and retrospective.   A prospective cohort study is an epidemiological study in which a group of people is identified who are at risk for experiencing a particular event. A retrospective cohort study is an epidemiological study in which a group of people is identified who have experienced a particular event.

Sample sizes for cohort studies often must be very large, particularly if only a small portion of the overall population will experience a particular event. The entire group must be followed over time to determine the point at which an event occurs, variables associated with the event, and outcomes for those who experienced the event compared with those who did not.

COHORT addresses the USAF Surgeon General's need by providing real-time surveillance of the medical care and treatment of specified groups of military personnel across multiple medical health facilities throughout the world. The medical encounter data aggregated by COHORT provide input for timely detection and monitoring of occupational health concerns and disease trends, syndromes, and outbreaks. The early

detection made possible by COHORT avails key decision makers the opportunity to formulate appropriate responses in time to make a difference in the outcome.

COHORT leverages existing normalized clinical data available from operational decentralized Integrated Clinical Database (ICDB) sites. Locally deployed ICDB systems support the Military Health System (MHS) health care providers who deliver clinical services to all enrolled members of the military health care community. As entries and updates are made on the local ICDB system, a software agent transmits the new or updated medical data to the centralized COHORT database. In effect, the data are made available to COHORT at the same time the data is made available to the local health care provider.

COHORT can monitor the incoming ICDB data traffic continually, processing the data against user-defined business rules to detect deviations from user-specified thresholds. COHORT provides the ability to send automated alerts to appropriate staff notifying them of events (cases, clusters, or signals) that warrant investigation. In addition, COHORT maintains a repository of the data in a reporting database to support analysis through state-of-the-art online analytical processing (OLAP) software.

COHORT will enable the USAF Surgeon General to consolidate, monitor, extract, and make available medical data from various military health care facilities for the analysis and early detection of epidemics, disease trends, and health anomalies. In support of Force Health Protection, COHORT will achieve the following objectives:

- Consolidates ICDB Data – COHORT extracts pertinent medical data sets from decentralized ICDB locations and consolidates the data on a centralized database. These data include laboratory results, prescriptions, radiology results, procedures, diagnoses, and immunizations.

- Avails ICDB Data to Analytical Engines – COHORT provides access to the consolidated medical data to facilitate cohort monitoring, real-time detection and surveillance, and long-term analysis.

- Monitors, Alerts, and Disseminates – COHORT issues alerts and disseminates monitoring results based on defined alert criteria and signal thresholds.

- Supports Online Reporting and Analysis – COHORT will provide a web interface for the viewing of reports and ad-hoc analysis of data.

3. **Approach**

In support of force health protection, the USAF Surgeon General has identified a potential capability to effectively extract, aggregate, and synthesize medical data from the various decentralized Integrated Clinical Database (ICDB) sites for the early identification and analysis of infectious disease trends and anomalies. Early recognition of these medical events will provide critical information for timely and appropriate

response.

The ICDB system supports local Military Health System (MHS) health care providers who deliver and track appropriate and timely clinical services on all enrolled members of the military health care community. ICDB provides operational users the capabilities to retrieve, maintain, analyze, display, and print timely and accurate clinical services data. ICDB is either currently deployed or scheduled to be deployed in support of over 80 military health care facilities throughout the world.

USAF has a unique opportunity and ability to leverage the investment made in the existing ICDB systems to support force health protection via real time alerts and cohort monitoring. The COHORT Oracle application server provides the ability to send automated alerts to appropriate staff notifying them of events (cases, clusters, or signals) that warrant investigation. A subset of the interactive channels used for sending the alert messages are: PDA, Web, email, and Telephony. When integrated with commercial off-the-shelf (COTS) or custom analytical tools, epidemiologists can use the aggregated data for long-term research, monitoring, surveillance and analysis. For example:

- The magnitude and distribution of the outbreak

- Time, location, and mode of exposure

- Demographics of affected persons

- Vehicle(s) of exposure

- Persons at risk for disease (from either initial exposure or secondarily through contact with a case) who will need treatment, prophylaxis, and medical follow-up.

4.   Objectives

COHORT will leverage existing capabilities of ICDB to support the following objectives:

Consolidate ICDB Data – COHORT will extract pertinent medical data sets from decentralized ICDB locations and consolidate the data on a centralized database. These data may include laboratory results, prescriptions, radiology results, procedures, diagnoses, and immunizations.

Avail ICDB Data to Analytical Engines – COHORT will provide access to the consolidated medical data to facilitate cohort monitoring, real-time detection and surveillance, and long-term analysis.

Monitoring, Alerting, and Dissemination – COHORT will provide alerts and dissemination of monitoring results based on defined alert criteria and thresholds.

Support Online Reporting and Analysis – COHORT will provide a web interface for the viewing of reports and ad-hoc analysis of data.

Figure 1: Micro COHORT Collection Overview
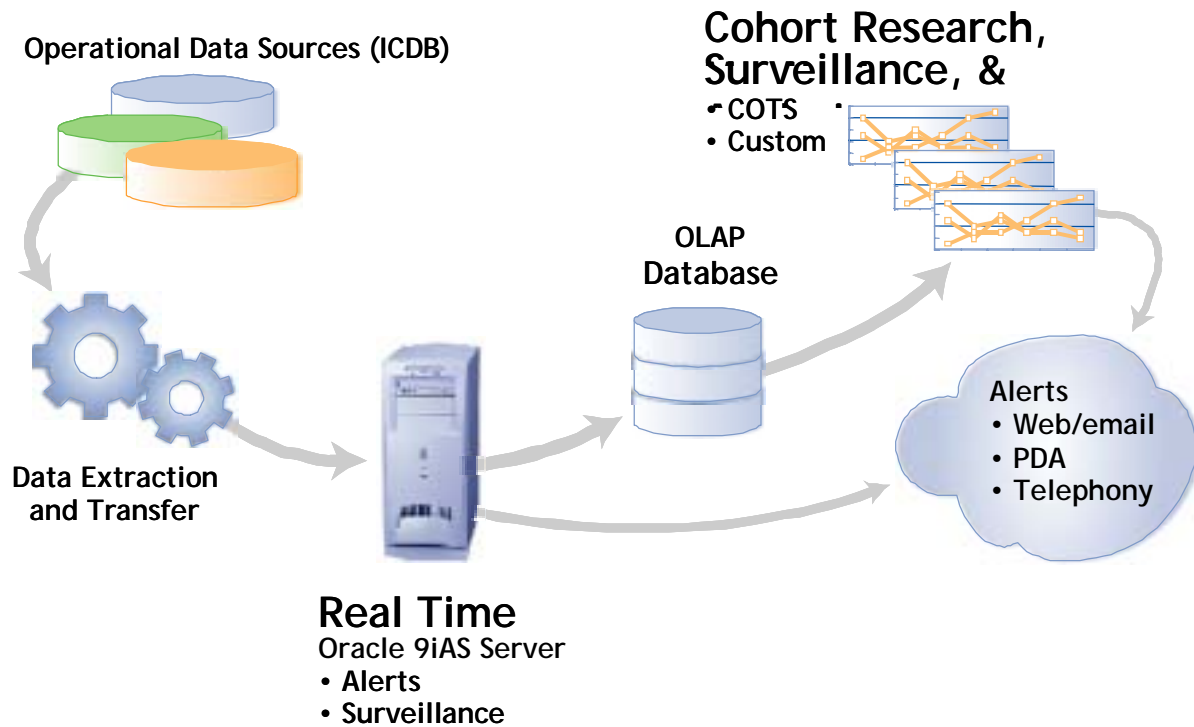
COHORT will provide the following capabilities when integrated with analytical tools and algorithms:

- Cohort monitoring and analysis

- Detection of reportable diseases and syndromes

- Process control charts to detect clusters and changes in trends

- Alerts to staff

- Fully accessible, cumulative data set for research or special studies

5. Industry Benchmark

COHORT will leverage software systems and solutions that have been built for industries that face similar challenges and needs. Analogous systems include financial trading and

analysis systems and healthcare decision support systems. These system types support monitoring, alerting, and dissemination and research of trends, incidences, and patterns for decision support.

6. Technology Solution

COHORT will be built using standard technologies with a proven history of solving complex problems in a scalable, flexible, maintainable, and architecturally sound way.

Java/J2EE

Java 2 Enterprise Edition (J2EE) is the programming architecture of choice for server-side development of enterprise-class applications. Developers can take advantage of the many third-party offerings of Java packages, database drivers, and vendor-specific application adapters, as well as develop their own custom applications.

Oracle 9i Database Server

Oracle 9i provides a robust database platform for scalable, flexible, data-intensive application development. Oracle has many important features that make it not only an exceptional database management system, but also an excellent database server choice for enterprise computing.

Figure 2: Macro COHORT Collection Overview
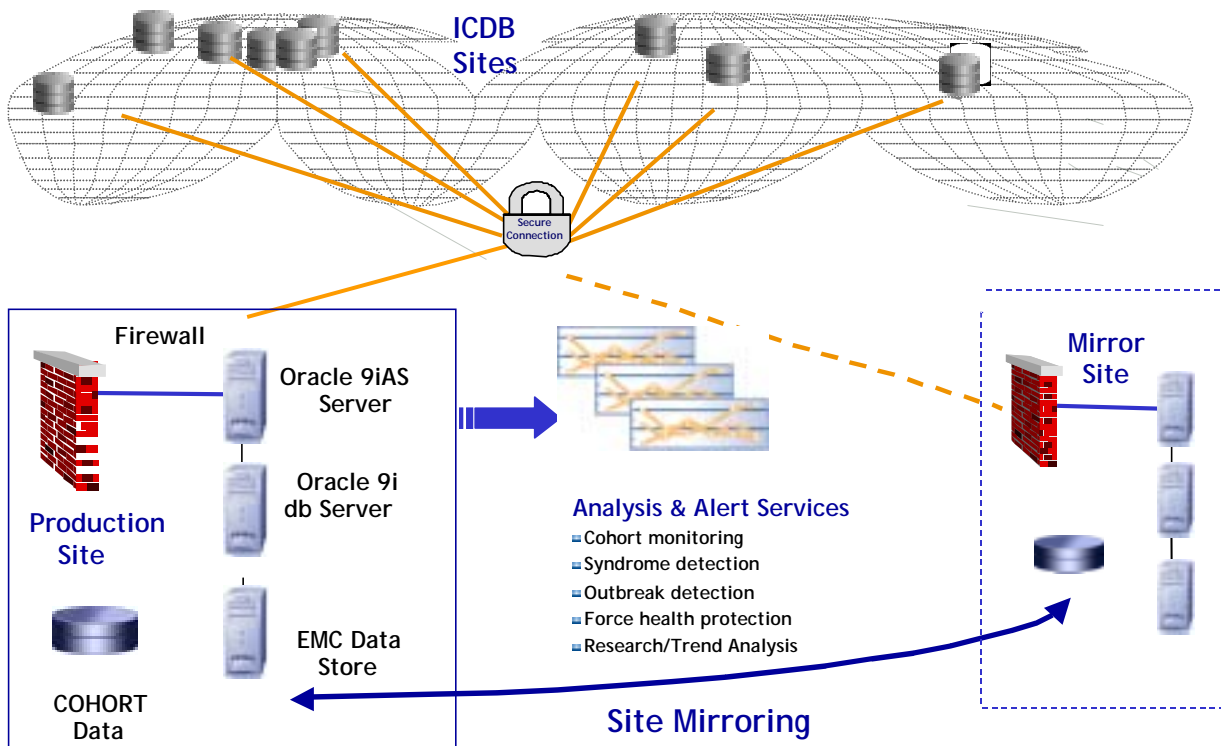
Oracle 9i Application Server

Oracle 9i AS is a fully-featured, standards-based J2EE application server providing the core application development environment. With its comprehensive set of features, compliance with open standards, multi-tiered architecture, and support for component-based development, businesses are choosing Oracle 9i AS to develop and deploy best-of-breed applications.

COHORT will use Oracle 9i AS to provide:

- Secure Data Transfer Interface

- Real Time Data Monitoring and Alerts

- Web Interface for Reporting and Analysis

- The Oracle application server will be deployed on Windows 2000 Advanced Server.

Secure Data Transfer Interface

To facilitate the use of data from multiple sources, the application will use an adapter-based architecture. This will allow data transfer agents to communicate to the application via a standard set of encrypted XML formats and protocols. Additional data feeds can be added by creating data agents for that particular source without requiring changes to application code.

XML Data Transfer Formats:

- Real Time Data Sets

- Aggregated Data Sets

- Historical Data

Transfer from data agents will use the XML-RPC web services protocol over certificate-based secure socket layer (SSL). The Oracle server provides all the required web services protocols and security mechanisms to accomplish these transfers.

Real Time Data Monitoring and Alerts

Real time data monitoring can be accomplished using many tools available in Java for the Oracle platform. These tools include:

- Statistical analysis and modeling

- Ilog – Jrules Rules Engine Financial modeling and alerting

- Scientific analysis packages

- Online Analysis and Processing

Algorithms and tools developed in other programming languages are easily integrated into the J2EE platform via standard connection protocols and services (JNI, SOAP, XML-RPC).

Alerts will utilize a standard Java Messaging Service (JMS) protocol to hook into any number of available alert providers. By using JMS adapters for alerting services any number of services can be used with no change to the application code.

Web Interface for Reporting and Analysis

Oracle is ideally suited for developing and deploying web applications for reporting and data analysis. Several COTS products are available for online analysis, expert systems reporting, and query capability:

- FormulaOne - e.Report

- Visual Mining inc. – Net Charts

- Custom designed web interfaces

ICDB Data Agent

The ICDB Data Agent will leverage existing ICDB infrastructure by running as a Java service on the ICDB Interface server. This agent will periodically check for data that needs to be extracted from the operational data store, transform that data into a standard XML packet, and transmit it via SSL to the main COHORT application server over XML-RPC. This data transfer can be done as often as required to ensure timely data for processing on the Oracle server.

OLAP Interface and Tools

The Oracle 9i provides standard interfaces for OLAP and other analysis tools to work directly on the data. These interfaces allow complex queries to be run directly against the data for research and analysis.

Oracle Data Mining (ODM) incorporates supervised and unsupervised learning models. Supervised learning models, sometimes called directed models, are used to predict a value, or probability. These techniques are appropriate for scenarios where you identify a dependent variable and want to model how a group of independent variables influence it.

Data Storage, Mirroring and Replication

EMC DAS/SAN solutions provide an ideal environment for the intense demands of today's networked storage environments, offering industry-leading performance, high availability, simple management, and unparalleled consolidation for Windows and UNIX. EMC provides expandable storage for the growing dataset needed to facilitate surveillance and detection.

The EMC storage arrays can be used for several purposes. The most basic use for the array is to provide the multi-terabyte database storage required by the application. In addition, EMC MirrorView and SnapView software can be used for:

- Site Mirroring for Disaster Recovery and Fault Tolerance

- Data Replication to other database instances for Research and Reporting to other locations or for performance reasons.

7.   Summary

Currently, the United States Air Force (USAF) Surgeon General (SG) has a mission to provide Force Health Protection for active duty Air Force personnel and their dependents. Past successes indicate that cohort analysis – the analysis of small linked sub-populations - is a timely and cost effective mechanism for early detection and warning of possible health risks to a larger population. Cohort surveillance and monitoring requires analytical tools and access to pertinent, timely, and consolidated medical data. However, The USAF SG does not have a viable integrated medical surveillance system to adequately execute that mission. This shortfall limits health care administrators the ability to issue timely and effective direction and guidance. There are a number of reasons for that shortfall – but many of the reasons have solutions that can be found through the integration of existing and emerging information technology (IT) programs.

The technologies required to address this shortfall are a combination of commercial-off-the-shelf and government-off–the-shelf (COTS/GOTS) solutions. By integrating these tools and in some cases adding specific enhancements/extensions, COHORT can provide USAF decision makers with real-time data and analysis on the medical health of the military population.   COHORT addresses the USAF Surgeon General's need by providing real-time surveillance of the medical care and treatment of specific groups of military personnel across multiple medical health facilities throughout the United States as well as those deployed overseas.

COHORT will enable the USAF Surgeon General to consolidate, monitor, extract, and make available medical data from various military health care facilities for the analysis and early detection of epidemics, disease trends, and health anomalies.   Medical surveillance and monitoring provide decision makers necessary and paramount information needed for the appropriate deployment of personnel and assets.   Through such an analytical tool as COHORT, Command and Control (C2) leaders are empowered

to; accurately ensure the safety of a specific location, determine appropriate resources required to combat specific disease trends and adverse health care outcomes and provide an accurate assessment of the health of target populations. The result for C2 management is fewer casualties – civilian and military, decreased recurrence of diseases, less waste in treatment options and an overall healthier and fit fighting force.

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