Technology Opportunities: Implementation of Deployment Health Policy in Operational Theaters

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ABSTRACT

It is U.S. policy that medical and personnel information systems be designed, integrated, and utilized with military medical surveillance to protect the physical and mental health of Service members throughout their military service. Within the last several years, new applications of information technology have vastly expanded our capabilities for surveillance, and these technologies are now starting to move out of hospitals and other fixed facilities into forward deployed settings. Surveillance technology must evolve toward an integrated system of systems that can comprehensively address future needs to identify acute and chronic exposures of military personnel to health threats over the course of their entire military career. Many of the necessary component technologies are available now or will be soon - the key will be to integrate them.

1.0 INTRODUCTION

In accordance with Department of Defense Directive dated August 30, 1997, it is the policy of the United States Armed Forces that medical and personnel information systems be designed, integrated, and utilized with military medical surveillance to protect the physical and mental health of Service members throughout their military service. These systems will be continuously in effect and be specifically configured to assess the effects of deployment on the health of Service members by encompassing the periods before, during, and after deployment.

Medical surveillance is the routine, systematic collection, analysis, interpretation, and reporting of standardized, population-based data for characterization of and countering medical threats to population health, well-being, and performance. It consists of active, passive, and sentinel procedures. Deployment health surveillance includes identifying the population at risk through personnel unit databases as well as pre-deployment and post-deployment health assessments, recognizing and assessing potentially hazardous occupational and environmental health exposures and conditions, employing specific preventive countermeasures, monitoring real-time health outcomes, and reporting disease and non-battle injury (DNBI) data to higher headquarters in a timely manner.

Medical surveillance requires an understanding of the complex inter-relationship of the environment, threat agent, and at-risk host. The types of threats include those from both environmental sources and intentional attack, and the consequences from either may result in acute illness, chronic illness, or both. A successful

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surveillance program requires aggressive data collection including environmental monitoring (vectors, water, soil, climate, air, noise, food, and other environmental sources), data analysis, feedback, and countermeasure actions including the required modifications to data collection. Together these actions comprise the Surveillance Cycle.

The incentive for developing a comprehensive surveillance program is substantial. DNBIs represent the largest proportion of morbidity and mortality in deployed forces. A successful program will assist commanders in assessing the impact that diseases and injuries are having on the availability for duty of individuals and entire units. In addition, early detection of diseases, risks, and hazards will allow commanders to complete an operational risk assessment matrix and employ appropriate countermeasures, thus multiplying the force and conserving health care resources.

Within the last several years, new applications of information technology have vastly expanded our capabilities for surveillance, and these technologies are now starting to move out of hospitals and other fixed facilities into forward deployed settings. We are rapidly approaching the time when we can truly say that we have a fully integrated and comprehensive system for conducting effective surveillance in operational theaters.

2.0 SURVEILLANCE PROGRAMS AND SYSTEMS

A successful surveillance program requires a "system of systems" that makes full use of available technologies. A key factor is that systems need to be connected in "real-time" to support every aspect of the Surveillance Cycle and provide for force health protection. Several technology applications have been developed that are already, or could become, components of this system of systems. Some of these applications have already been integrated, while others are simply prototypes or early concepts. The following discussion highlights the capabilities of current surveillance programs and the technology applications that are included within them.

2.1 Department of Defense Global Emerging Infections Surveillance and Response System (GEIS)

The GEIS brings together laboratory partners from 58 countries and several agencies and organizations including the World Health Organization and the Centers for Disease Control and Prevention (CDC) to identify new disease events. The surveillance priorities include respiratory illness (especially influenza), febrile illnesses, enteric illnesses, and antimicrobial resistance. In addition to global surveillance, GEIS assists the global response to a new disease event by providing uniquely capable, permanent, multidisciplinary platforms for staging and supporting a wide range of field, laboratory, human, and veterinary health investigations. GEIS also assists in building global capacity, thus creating focal points for leveraging local capacity through training and infrastructure strengthening. The GEIS has over 30 influenza surveillance sentinel sites located worldwide (Figure 1). A key part of the GEIS is the Early Warning Outbreak Recognition System (EWORS) that was developed by the U.S. Navy and the Indonesian Ministry of Health. EWORS is a computerized hospital-based surveillance network for early detection of outbreaks. EWORS monitors trends to differentiate an epidemic from endemic disease events.

Figure 1: DoD GEIS 2003–2004 influenza surveillance sentinel sites

2.2 Electronic Surveillance System for the Early Notification of Community-Based Epidemics (ESSENCE)

ESSENCE is a technology application that is an outgrowth of the GEIS. ESSENCE is designed to facilitate syndromic surveillance as an adjunct to traditional reportable disease surveillance and sentinel systems. It gathers information regarding outpatient medical visits for detection of potential infectious disease outbreaks and monitoring of disease trends. The system was developed and is run by the Walter Reed Army Institute of Research in collaboration with the Johns Hopkins University Applied Physics Laboratory. ESSENCE can identify increased visits for broad infectious disease categories (Figure 2), which may herald release of a biological agent. Most fixed military treatment facilities (there are only a few exceptions) are included in the surveillance system. The system is available on a secure password-protected website, and no patient identifying information is presented. ESSENCE monitors conditions using International Classification of Diseases, 9th Revision (ICD-9) codes entered into the Ambulatory Data Module and Standard Ambulatory Data Record as follows:

- Respiratory (cough, pneumonia, and upper respiratory illness)
- Gastrointestinal (vomiting and diarrhea)
- Neurologic (meningitis and botulism-like)
- Dermatologic – hemorrhagic (petechaie and bruising)
- Dermatologic – infectious (vesicular rashes and smallpox-like)
- Fever/Malaise/Sepsis (unspecific fever and sepsis)
- Coma/Sudden Death (coma and sudden death)

In addition, ESSENCE monitors the percentage of influenza-like illness (ILI) seen at primary care clinics, similar to the CDC sentinel influenza surveillance. An advanced version of this system (ESSENCE IV), which includes pharmacy data and runs more advanced statistical algorithms and geographic analysis, is in development.

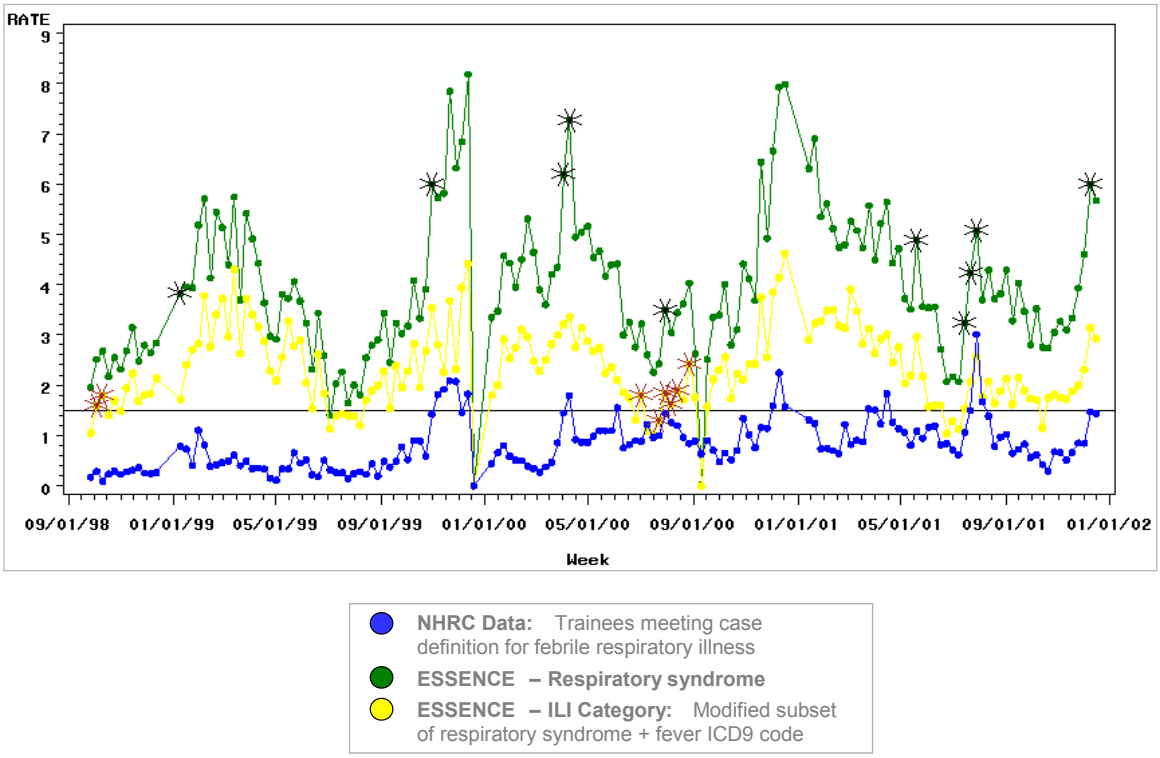

Figure 2: Monitoring of respiratory illnesses, comparing ESSENCE respiratory and ILI groups to a traditional surveillance system, the Naval Health Research Center (NHRC) febrile respiratory illness surveillance, which monitors the number of basic trainees who fit a clinical case definition per week

2.3 Defense Medical Surveillance System (DMSS)

DMSS is a database system for routine and systematic collection of longitudinal data and thus provides medical surveillance decision support. The DMSS is maintained by the Army Medical Surveillance Activity at the Center for Health Promotion and Preventive Medicine (CHPPM) and stores data on active duty service members from pre-induction through post-discharge. The DMSS serves as the central repository of medical surveillance data for the U.S. Armed Forces and includes personnel data, medical data from ambulatory care and in-patient care records, immunization records, deployment records, and data from pre- and post-deployment health assessments (Figure 3). The DMSS includes the Reportable Medical Events System (RMES). RMES uses dedicated reporting software to track and report 70 specified medical conditions. It automatically transmits the data to the main database of the DMSS and issues summary reports as feedback. RMES data support the investigation of unusual events.

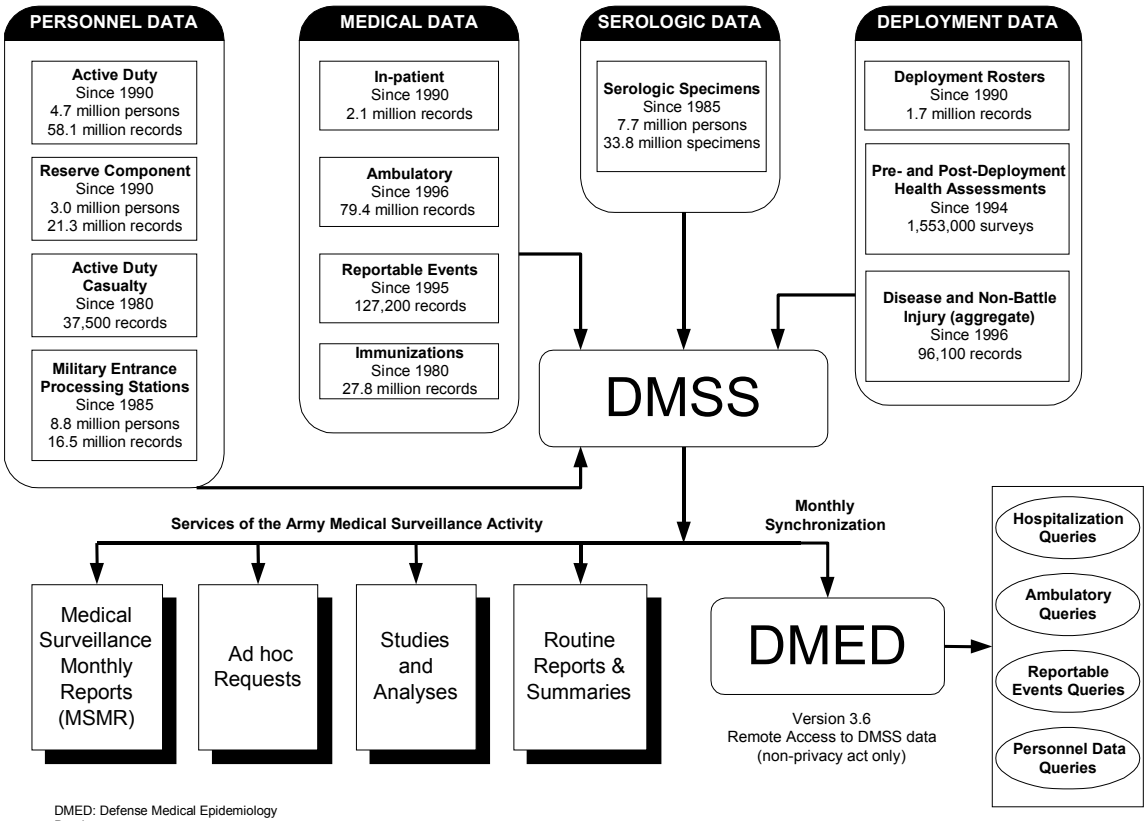

Figure 3: DMSS structure and functional relationships

2.4 Department of Defense Serum Repository (DoDSR)

The DoDSR is the central archive of sera drawn from U.S. Armed Forces personnel for medical surveillance purposes. The repository contains over 3.3 million serum specimens from over 7.7 million personnel, and it has a capacity to hold 40 million specimens. The sera are stored at precisely documented locations in large walk-in freezers held at –30ºC, and all specimens are linked to demographic, military, and medical information via the DMSS. Specimens contained in the DoDSR are available to researchers and other investigators within the DoD for the purposes of conducting militarily relevant investigations.

2.5 Defense Occupational and Environmental Health Readiness System (DOEHRS)

The DOEHRS is the occupational health migration system for the DoD. It consists of an automated system designed to support the programs of Industrial Hygiene, Environmental Health, Hearing Conservation, and Occupational Medicine. It serves as an operational data store and data repository, and it produces periodic reports, answers to ad hoc queries, and trend analysis.

2.6 Deployment Environmental Surveillance System

Initially created to maintain environmental surveillance data for Operation Joint Endeavor, the Deployment Environmental Surveillance System is the central information system for the CHPPM Deployment Environmental Surveillance Program (DESP), and is integrated with the Laboratory Information Management System at the CHPPM. The system serves as a project management tool, provides for a standardized collection format, manages and validates field data, manages and validates analytical data, and serves as a data repository. Ultimately, the system is designed to be integrated with the Industrial Hygiene module of the DOEHRS.

2.7 Emerging Geographic Information System (GIS)-Based Applications

GIS refers broadly to a class of computer-based systems that are used to store, create, and manipulate geographic information. It expands the use of traditional paper maps, particularly by overlaying diverse data layers. GIS enables the user to answer geographical health-related questions and reveal relationships, patterns, and trends. The background data can be obtained from a wide variety of sources including government assets and commercial sources; however, satellite imagery is one of the most powerful tools. The background data are overlaid with specific military data such as troop locations, infrastructure information, situation reports, engineer data, and operational deployment orders. The resulting solution is a map that shows the locations of hazards in operational areas.

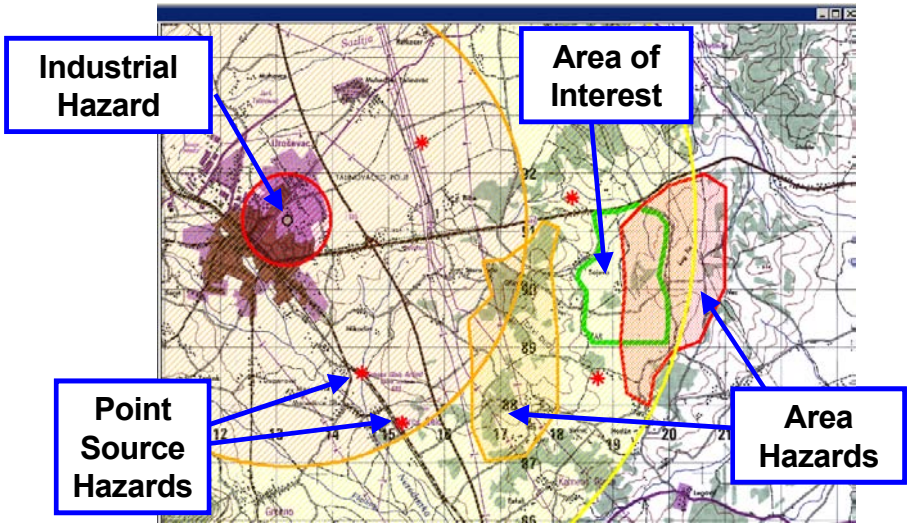

Figure 4: Use of GIS technology for chemical hazard risk analysis

GIS has already been used for assessment of chemical and disease risks. As one example, GIS can be used to identify a variety of local chemical hazards and associated risks prior to deployment, so that such areas can be avoided or exposure risks can be mitigated in other manners (Figure 4). GIS may also be used for spatial analysis for casualty planning. For example, one could use modeling of case-specific conditions (chemical release or meteorological conditions) to determine the potential impact from an accidental or intentional release of a chemical. GIS may also be used for spatial and temporal analysis to track the change of conditions over time and to direct sampling efforts in the affected area. GIS is also being used in combination with thermal imaging and disease vector surveillance techniques to identify areas of potential high vector concentration (Figure 5). The ability to model disease outbreaks based on satellite imagery that provides an indication of the local ecosystem is emerging. Recent studies have shown, for example, that Ebola outbreaks appear to be preceded by local drought conditions and can be predicted by analysis of satellite images that measure the color of the forest canopy.

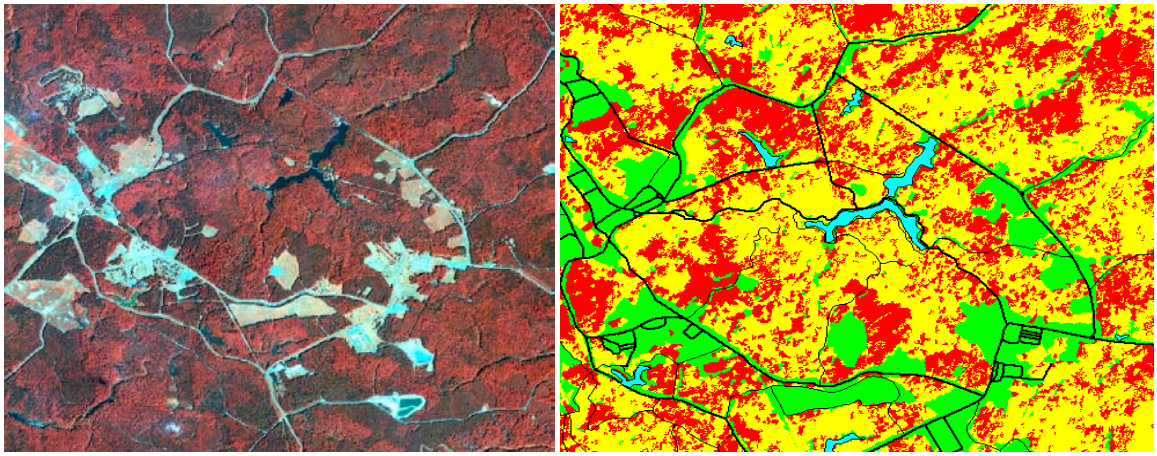

Figure 5: Use of GIS technology for disease vector analysis. Left image is an IKONOS satellite image with near infrared band of the study area. This type of satellite image allows identification of different vegetation types and is used to characterize tick habitat. The right image is a theoretical threat assessment of a map of the same area showing the probability of encountering lone star ticks that spread Lyme disease. The satellite image has been "classified" into three categories representing the likelihood of encountering lone star ticks, with red, yellow, and green representing high, moderate, and low probabilities, respectively, of encounter.

3.0 FUTURE SYSTEMS

New technologies are emerging that will push surveillance capabilities even farther forward. This will be made possible by the miniaturization of computing capabilities and new sensor technologies, as well as by the ability to connect these systems to the larger surveillance system of systems.

3.1 Battlefield Medical Information System-Tactical (BMIS-T)

The BMIS-T is an example of these emerging capabilities. It is a point-of-care handheld assistant that enables military providers to record, store, retrieve, and transmit the essential elements of patient encounters in an operational setting (Figure 6). Reference materials, diagnostic and treatment decision aids, and logistic support software can also be included, thus facilitating patient care, skill sustainment training, and mission planning. Initially designed for Special Forces medics and other first responders, BMIS-T can be used by

providers at all echelons along the health care continuum. BMIS-T gives medical providers an all-in-one tool for medical readiness, clinical information capture, diagnosis, and logistics to improve patient care and record keeping and contribute to a better informed, more effective military force. By streamlining data capture and reporting, BMIS-T helps to ensure more complete patient records. As medical practice evolves, BMIS-T has the flexibility to incorporate new procedures, protocols, medical databases, and mission requirements. The BMIS-T provides data from forward encounters into the Composite Health Care System II - Theater (CHCSII-T). CHCSII-T is a clinical operations data system designed for Level I to Level III treatment facilities in operational settings. Although not intended as a primary surveillance system, it supplies raw data for surveillance inquiries.

Figure 6: The BMIS-T, shown at left, is a handheld system that will allow capture of medical encounter information by far-forward medics. A sample display screen is shown at right.

3.2 Individual Status Monitoring

Looking still further into the future, technologies are emerging for collection of near-real-time information on individuals' exposure to toxic, disease, and other health threats. Work is currently being undertaken to understand the genomic response to various health threats and identify diagnostic patterns. Once this information is in hand, it is possible to envision forward deployable gene chip-based systems that will provide early warning of disease outbreaks and ability to assess toxic hazard exposures. Such systems would still require a sample to be drawn from an individual and so require some type of encounter with the health care system. Ultimately, however, sensor technologies are expected to evolve to the point where useful information can be obtained in near-real-time from soldier-worn sensors. The Warfighter Physiological Status Monitor (WPSM) is an overarching concept for a series of technology insertions into the soldier's individual ensemble. In the near-term, WPSM is being designed to monitor sleep status, thermal state, and hydration. However, mid-term and far-term goals include the integration of ability to not only detect exposures to toxic chemicals and biohazards, but also assess their biological significance.

3.3 Joint Medical Workstation (JMeWS)

The JMeWS is an example of a system that brings all of the forward-deployed surveillance assets to a focus (Figure 7). The JMeWS is an integrated system composed of the Mobile Medical Data Store database and client/server data input and viewing applications. It utilizes Oracle Enhanced Security Module 3DES encryption and Secure Socket Layer for secure storage and access to the database. The reporting module is a package of custom-designed data entry forms composed of the Annex Q and patient reports. The Annex Q includes medical situation and blood reports. The patient reports document patient treatment and provide patient movement and visibility information. The MDSS is an information and decision support system for medical planning staffs and operational commanders based on advanced data analysis methods for predicting and implementing expedited preventive health measures. The MDSS imports patient encounter data from the JMeWS database, analyzes the data for DNBI incidence rates and trends, and displays the data for medical surveillance alerting and reporting functions.

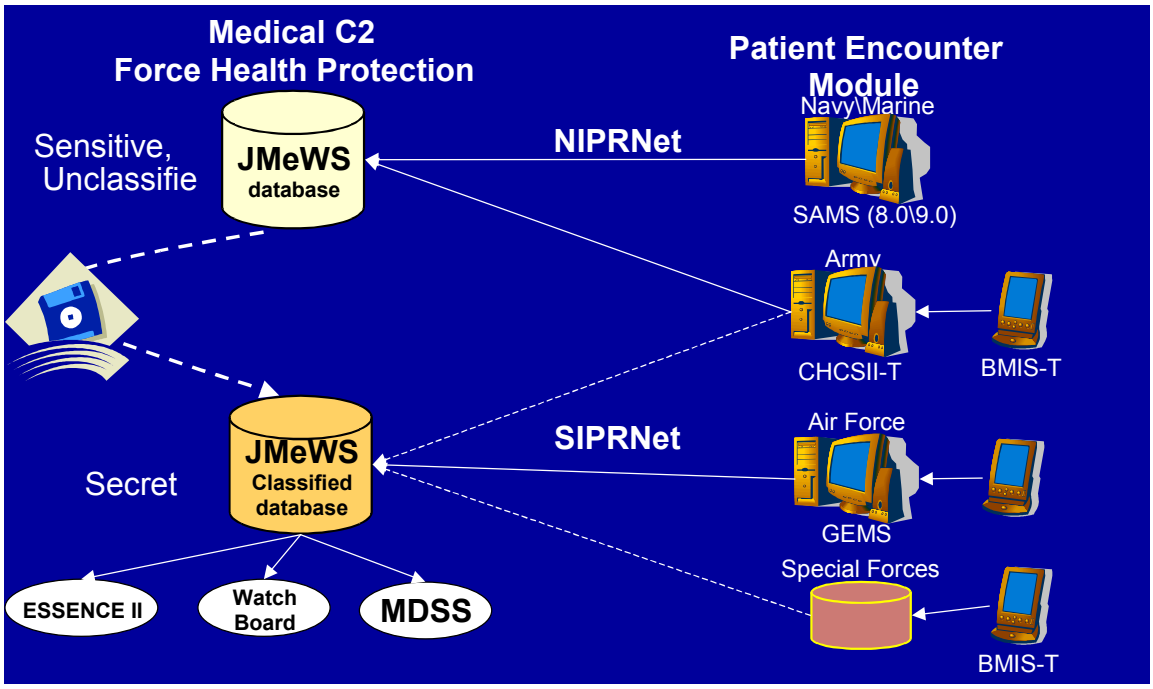

Figure 7: JMeWS, functional linkages to patient information and surveillance systems

4.0 SUMMARY AND CONCLUSIONS

A comprehensive deployment health surveillance program is required to assist the commander in assessing the impact that DNBIs are having on the ability of deployed forces to accomplish the mission and employing appropriate countermeasures as a force multiplier. The program must identify both acute and chronic health risks from environmental threats as well as intentional attacks with biological, chemical, or radiological weapons. To make surveillance systems smaller and deployable farther forward, one must embrace new technologies and conduct active research into and development of more powerful tools. Deployment health data are an important component of a force health protection life cycle that begins pre-accession and extends continuously to post-separation or retirement. A successful deployment health surveillance program depends

on trained personnel that employ active, passive, and sentinel procedures and have access to technological tools and systems that communicate and interact. Many of the necessary component technologies are available now or will be soon - the key will be integrating them to provide visibility of events throughout the soldier's total life cycle. These tools form a "system of systems" that serves to protect the force and support the accomplishment of the mission.