Enhancing Influenza Surveillance Using Electronic Surveillance System for the Early Notification of Community-Based Epidemics (Essence)

Victor H. MacIntosh, MD, MPH, LTCOL, USAF, MC
Division of Preventive Medicine
Walter Reed Army Institute of Research
503 Robert Grant Avenue
Silver Spring, Maryland 20910-7500

Victor.MacIntosh@na.amedd.army.mil

ABSTRACT

INTRODUCTION Influenza is a cause of preventable morbidity and mortality; timely analysis of surveillance data may allow earlier recognition of outbreaks, potentially including those caused by new influenza strains. Influenza-like Illness (ILI) is of particular interest in surveillance because many biowarfare and bioterrorism agents cause flu-like syndromes. RATIONALE The Department of Defense Global Emerging Infections Surveillance and Response System (DoD-GEIS) sponsors two programs, ESSENCE (The Electronic Surveillance System for the Early Notification of Community-based Epidemics) and the DoD Influenza Surveillance Program, that could assist in influenza outbreak detection and response. ESSENCE utilizes military beneficiary population outpatient visits data to detect aberrations in daily counts of ICD-9 based syndrome groups. Begun in 1999 in the Washington, DC area and expanded in 2001 following the events of September 11, this system analyses outpatient visit data across DoD military treatment facilities (MTFs), in the US and abroad. A prior study assessed the value of ESSENCE data in detecting yearly influenza activity by comparing it to a traditional influenza surveillance system used by the Centers for Disease Control and Prevention (CDC). Results of that study showed similarity between the rates of ILI visits to sentinel physicians in the South-Atlantic region and military facilities in the National Capital Area. METHODS & RESULTS Soon after September 11, 2002, ESSENCE began receiving outpatient data from all US MTFs in the world and making syndromic surveillance data easily available throughout DoD installations. Utilizing an ICD-9 code group chosen to represent ILI, the ESSENCE structure and graphic user interface and a database developed for this purpose, we developed an automated daily graphical display showing the ILI rate (proportion) graphed over time in weeks with an appropriate numerator (ILI) and denominator (outpatient visits for primary or urgent care) for each MTF. These data were also aggregated and displayed regionally, using CDC regions and three additional non-CDC regions. These data were available through the ESSENCE infrastructure in near real time, being refreshed three times per day. This new source of surveillance information was analysed, compared to other DoD and US data, including laboratory data, and incorporated into the DoD Influenza Surveillance Program weekly surveillance report. CONCLUSIONS the data show correlation of ILI activity in the military communities with CDC sentinel physician-detected activity regionally and with influenza positive cultures. Near real-time analysis and reporting, by MTF, region, and DoD, of ILI activity was accomplished. An unexpected benefit occurred during the SARS outbreak; it was useful to examine ILI rates for adverse trends and stimulate increased local public health scrutiny when indicated. Negative information, i.e. no adverse trend, was of value to local and higher authorities in assessing and communicating SARS risk to their populations.
(Disclaimer: The material in this abstract reflects the views of the authors and should not be construed to represent those of the Departments of the Army, Air Force or Navy or the Department of Defense).

Paper presented at the RTO HFM Symposium on "NATO Medical Surveillance and Response, Research and Technology Opportunities and Options", held in Budapest, Hungary, 19-21 April 2004, and published in RTO-MP-HFM-108.

1.0 INTRODUCTION

Influenza is a cause of preventable morbidity and mortality; timely analysis of surveillance data may allow earlier recognition of outbreaks, potentially including those caused by new influenza strains. Influenza-like Illness (ILI) is of particular interest in surveillance because many biowarfare and bioterrorism agents cause flu-like syndromes.

2.0 RATIONALE

The DoD operates the Global Influenza Surveillance Program through Air Force executive agency with support from the DoD Global Emerging Infections Surveillance and Response System (GEIS). Another GEIS sponsored program is ESSENCE, the Electronic Surveillance System for the Early Notification of Community-based Epidemics. ESSENCE had been a developmental program for syndromic surveillance using data from the National Capital Area, but following the events of September 11, 2001 ESSENCE began receiving data from all military medical facilities in DoD. The global influenza surveillance program is primarily laboratory-based surveillance while ESSENCE is syndromic surveillance. Both are high-priority programs for GEIS that could assist in influenza outbreak detection and response. Previously ILI information, when it was collected in DoD facilities, was primarily used for local surveillance and not summarized for timely use above the local level. Laboratory information from DoD could be shared and compared with national and global data, but ILI could not. In early 2002 it appeared to be technically feasible to modify ESSENCE in order to obtain timely ILI data from all medical visits in DoD. As part of this conference COL Kenneth Cox discusses how this initiative has enhanced DoD influenza surveillance; this presentation focuses on the methods used and how this was achieved.

Experience with syndromic surveillance is growing in the US and elsewhere – ESSENCE is one such system using DoD health administrative data from ambulatory medical encounters. ICD-9 coding is used DoD-wide for this purpose. The methodology for ILI surveillance focusing on ESSENCE data, aided by DoD laboratory and national influenza surveillance data, is the aim of this study. A prior study[1] assessed the value of ESSENCE data in detecting yearly influenza activity by comparing it to a traditional influenza surveillance system used by the Centers for Disease Control and Prevention (CDC). Results of that study showed similarity between the rates of ILI visits to sentinel physicians in the South-Atlantic region and military facilities in the National Capital Area. Subsequent to developing the ILI capability in ESSENCE described here, two presentations, Foster, et al[2] and Elbert[3] at the NATO meeting on pandemic influenza planning held in 2002 in St. Petersburg, Russia presented ILI data from this method. A recent presentation by Gould, et al from the DoD global influenza program examined validation between DoD viral isolates and ICD-9 codes used by providers from ESSENCE.

To understand syndromic surveillance using ESSENCE, it is helpful to show how it is displayed for the user. Shown in figures 1-2 are two views from ESSENCE one sees from a typical desktop computer. The "Worldview" here is shown superimposed on the globe to add emphasis the need to view the data globally, but as seen in figure 2, one can adjust the view as needed. Each rectangle in the outer circle represents an installation (or geographic cluster) with regional groupings closer to the center. "TCR" stands for Tri-Care Region. Colors are used to automatically bring attention to alerts. Many more views could be shown, but this is beyond the scope of this presentation. A full discussion and tutorial is available at **www.geis.ha.osd.mil** (the link provided for ESSENCE).

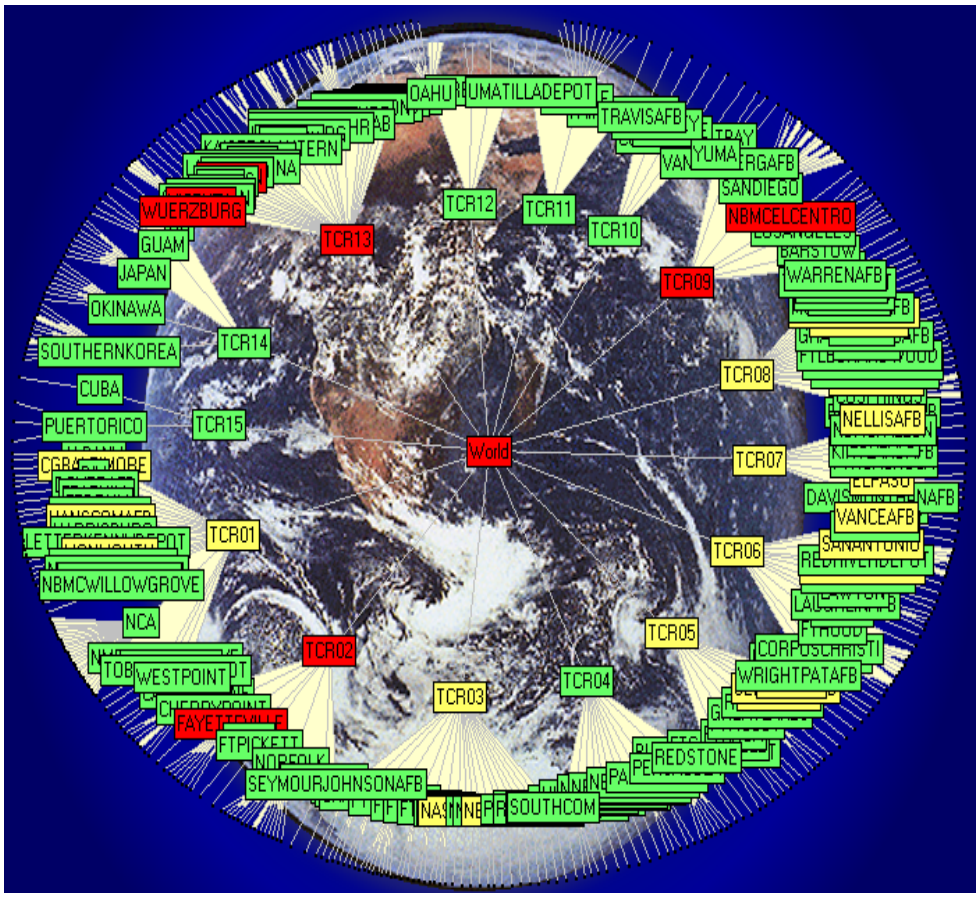

Figure 1: ESSENCE Worldview

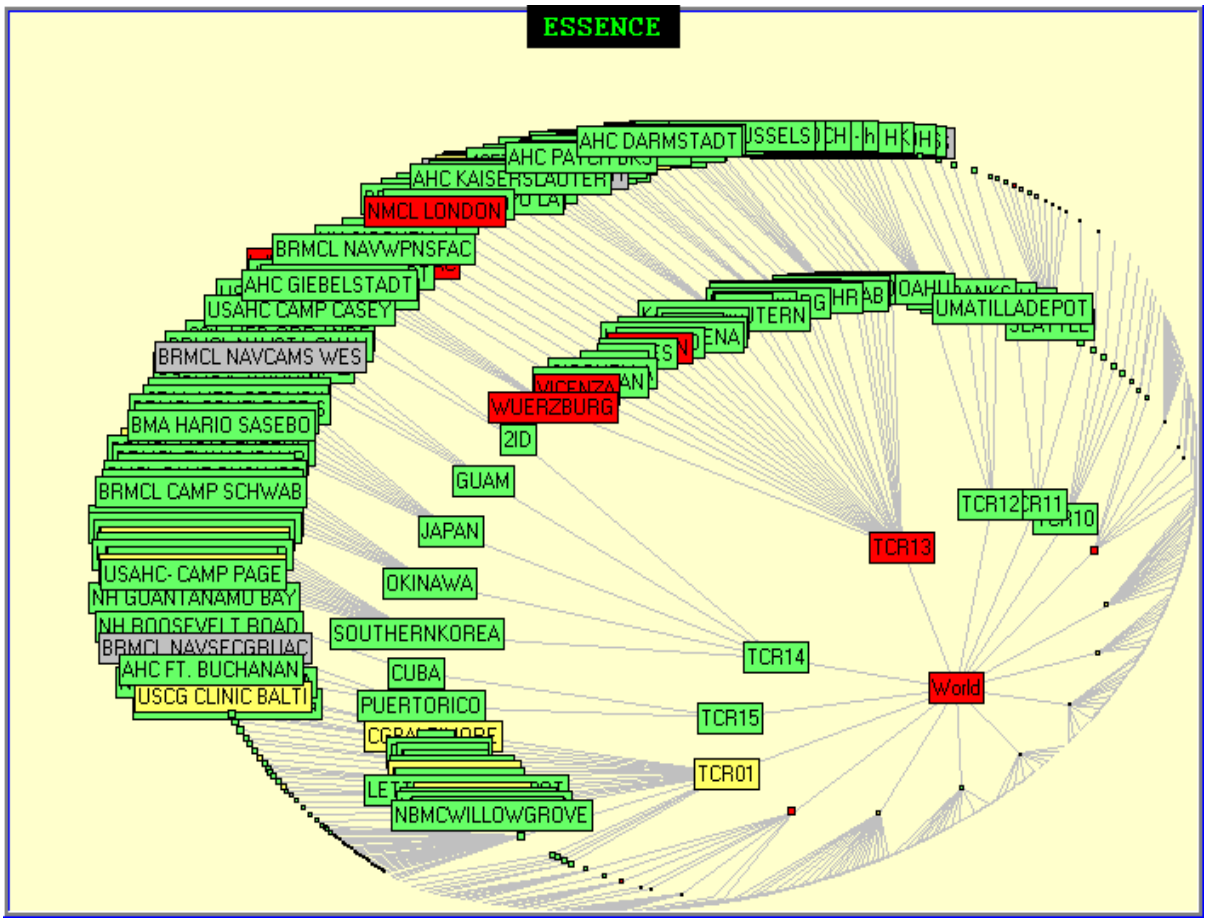

Figure 2: An "exploded" view from the Worldview shown in figure 1

3.0 METHODS

Beginning with the end result in mind, this system was envisioned as a surveillance system useful at a number of levels - military base / local area, regional and DoD-wide. Although the reason for DoD developing ESSENCE was primarily for detection of biological warfare or terrorist events, it has obvious usefulness for naturally occurring epidemics such as influenza. Also, since other national surveillance systems exist and since influenza outbreaks occur regularly, comparison and validation with US national data is possible. CDC surveillance uses four systems as shown. The sentinel physician system is based on voluntary ILI reports from a sample of physicians (about 900) across the US and reports the percentage of ambulatory patients seen for ILI, based on a case-definition. Figure 3 is an example of CDC ILI surveillance from week 1 of 2004. Figure 4 shows US laboratory-based data from the WHO/NREVSS system. Comparable data exist in DoD for both, but until recently only DoD laboratory data was readily available for surveillance. Comparison with non-US ILI surveillance data is possible as well in areas of Europe and the Pacific Rim where DoD bases are located but this has not yet been done.

Sentinel physicians (ILI)	WHO/NREVSS collaborating laboratories*
122 cities mortality	Survey (weekly) of state epidemiologists

- DoD Global Influenza Surveillance program is a collaborating laboratory

Table 1: Four methods for Centers for Disease Control and Prevention (CDC) influenza surveillance

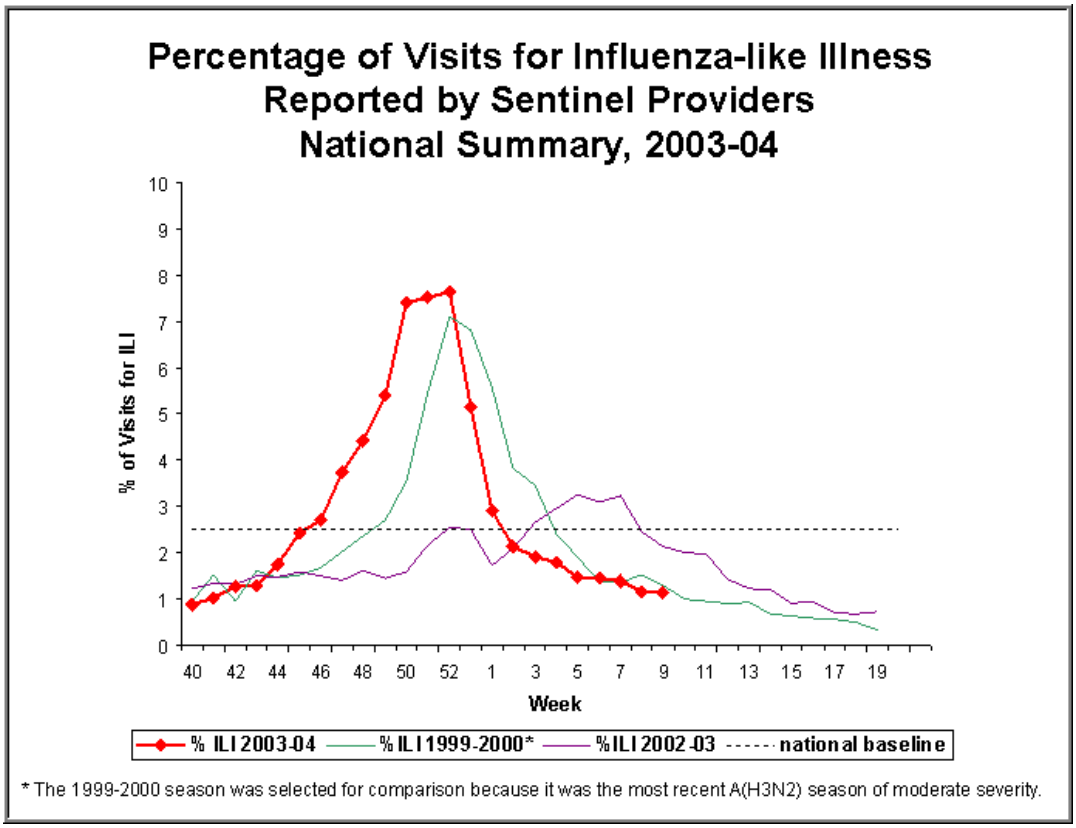

Figure 3:CDC ILI surveillance Based on Sentinel Physician in US, Week 9 2004

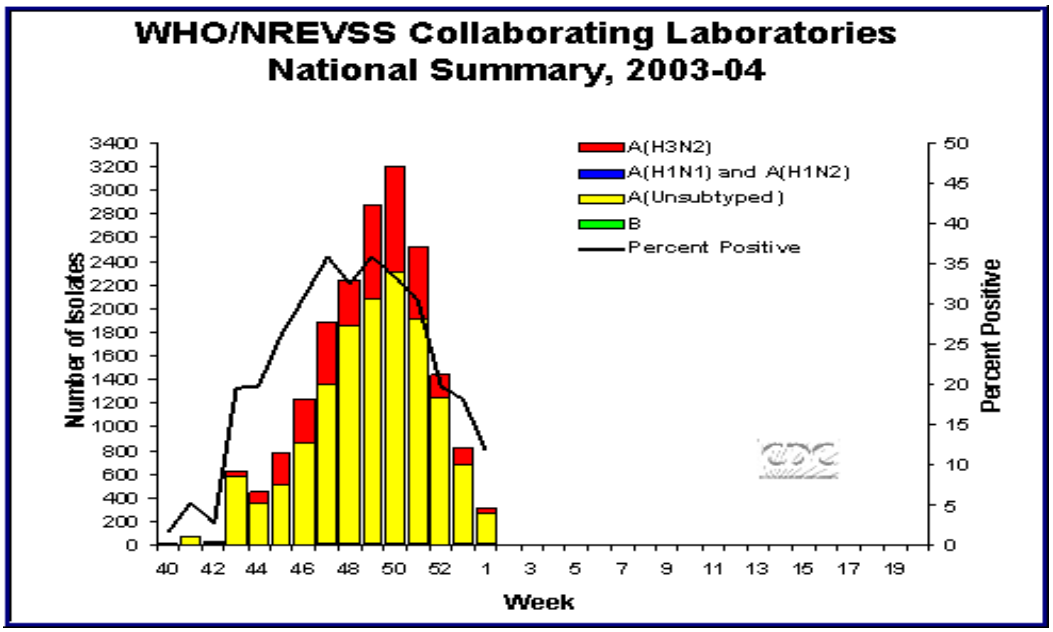

Figure 4:US Laboratory Based Surveillance, Week 1 2004

Examples of US national reporting are shown in the graphs in Figures 3 & 4 show CDC data from sentinel physician ILI system and from laboratory based surveillance. Note that each has a line graph display of percent (or proportion) over time in weeks. This actually is a cumulative proportion for the week for the ILI display. For the 2003-2004 influenza season shown, ILI peaked at about week 52 and laboratory viral isolates for influenza, as percent positive, peaked between weeks 47 and 49. 122 Cities Mortality from Influenza and Pneumonia surveillance (not shown) indicated a later peak than ILI and lab-based surveillance, indicating some lag between epidemic and mortality. Our intent was to develop ILI reporting that was automatic and would parallel that of the CDC sentinel physician system but would not use additional resources, using ESSENCE.

Soon after September 11, 2002, ESSENCE began receiving outpatient data from all US MTFs in the world and making syndromic surveillance data easily available throughout DoD installations. An ICD-9 code group was chosen to represent ILI as seen in table 2. The ESSENCE structure and graphic user interface were but modification was needed for an added capability; proportions were needed in addition to count, or numerator, data. The ESSENCE group, primarily Mr. Mansfield, modified the programming code (ESSENCE-1B version so that medical encounters resulting in these ICD-9 categories and the appropriate visits were counted; once developed this program ran three times a day to update the database developed for this purpose and it continues to do so. Data from 313 medical facilities are included; distributed according to Service as shown in figure 5. Minor modifications have been made to the ILI ICD-9 code set since inception; updated codes can be seen on the GEIS website listed above for ESSENCE and we anticipate future changes as validation proceeds.

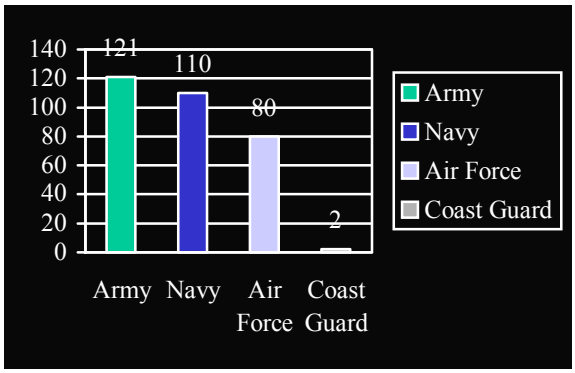

Figure 5: DoD Installations Contributing ESSENCE Data, By Service Branch

ICD-9 CODES USED FOR INFLUENZA-LIKE ILLNESS (ILI) IN ESSENCE-1B			
079.89	Viral infection NEC	466	Acute bronchitis and bronchiolitis
079.99	Viral infection NOS	466.0	Acute bronchitis
460	Acute nasopharyngitis	466.1	Acute bronchiolitis
462	Acute pharyngitis	466.19	Acute bronchiolitis due to other infectious organism
464	Acute laryngitis and tracheitis	478.9	Other and unspecified diseases of upper resp tract
464.0	Acute laryngitis	480	Viral pneumonia
464.1	Acute tracheitis	487	Influenza
464.10	Acute tracheitis w/o obstruction	487.0	Influenza with pneumonia
464.2	Acute laryngotracheitis	487.1	Influenza with other respiratory manifestation
464.20	Acute laryngotracheitis w/o obstruction	487.8	Influenza with other manifestation
465	Upper resp infection multiple or unspecified sites	490	Bronchitis not specified as acute or chronic
465.0	Acute laryngopharyngitis	780.6	Fever
465.8	Upper resp infection of multiple sites	784.1	Throat pain
465.9	Upper resp infection of unspecified sites	786.2	Cough
466	Acute bronchitis and bronchiolitis		

Table 2: ICD-9 Code set for Influenza-Like Illness in ESSENCE-1B

Data normally was aggregated in ESSENCE by installation and geographic cluster and then by logical hierarchical groupings as shown in Figures 1 & 2 (other views were available as well); we chose to add different geographic groupings so that ILI data could obtained and automatically displayed by regions used by CDC and three additional regions suitable for DoD as shown in Figure 6. Thus data from DoD facilities in these regions are organized according to CDC regions for ease of display and to facilitate comparison. Encounters included for numerator and denominator were aggregated & logically grouped by base or relevant locale. ESSENCE has 179 geographical groupings but these could be customized in the analysis to produce different local, regional and global data and graphs.

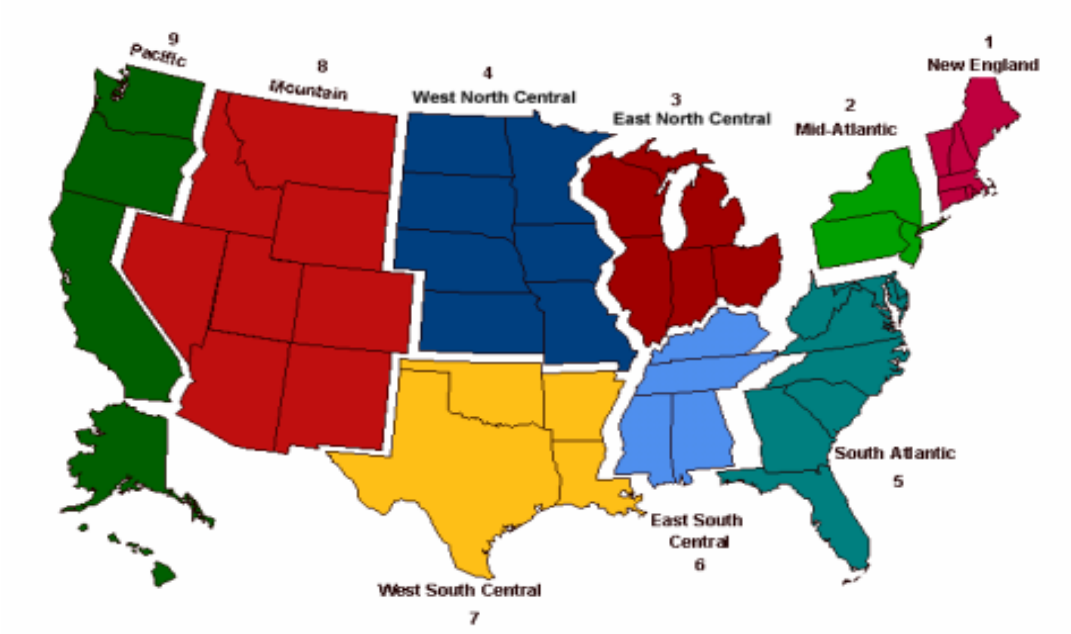

Figure 6: Regions of the US as used for influenza surveillance reporting

A cumulative weekly proportion was chosen as the best estimator of the ILI rate for the purpose of this endeavor. For the ILI proportion, the numerator data, or inclusion criteria, are medical encounters for the week coded (ICD-9) within the defined ILI code group. These syndrome groupings are a subset of "Fever" & "Respiratory" codes already used in ESSENCE. Different code sets could be used in subsequent validation or sensitivity studies, using similar methods; this flexibility was part of the original design. The denominator includes all medical encounter visits for the same time period to primary, urgent or emergency care in MTFs & medical centers. Some types of visits were excluded, for example orthopedics clinics, where they could be identified as unlikely to belong in the denominator.

4.0 RESULTS

We developed an automated daily graphical display showing the ILI rate - the cumulative proportion for 1 week - graphed over time in weeks for each MTF having standard DoD Ambulatory Data System (ADS) capability. Data are also aggregated and displayed regionally and globally. These data are made available through the ESSENCE infrastructure in near real time, being refreshed three times per day. This new type of surveillance information was analysed, compared to other DoD and US data, including laboratory data, and incorporated into the DoD Influenza Surveillance Program weekly surveillance reports.

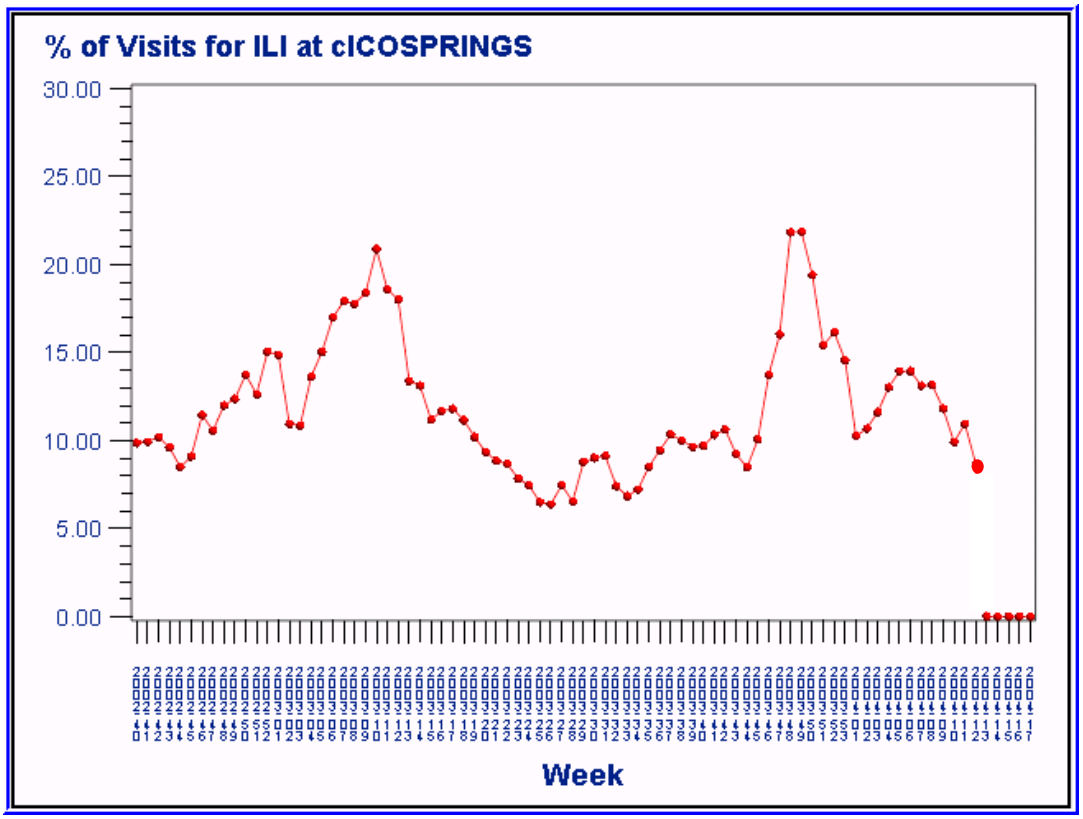

Figure 7: ILI ESSENCE graph for Colorado Springs (local) grouping, week 12 2004

The graph in figure 7 shows ILI rate over time in weeks for the Colorado Springs local area from week 40 2002 through week 12 2004, spanning nearly two influenza seasons. The peaks are consistent with reports of influenza activity in this area. A regional view is shown in figure 8 and DoD global data in figure 9 for the same period. This is the global graph that includes all available DoD data for the time period. Similar graphs are available to users through ESSENCE in near real time. This automated graph is available for bases, CDC-like regions and DoD and the data can be readily accessed. Each location will experience its own baseline level of ILI activity even in the absence of influenza. Keep in mind that that there are many illnesses that mimic flu and that potentially can be detected through surveillance. Also the magnitude of the proportions, as shown on the Y-axis has a range of 6-22% approximately and the baseline is nearly 10%. In contrast, CDC's sentinel system has a baseline below 2.5%; CDC use of a case definition and our use of an ICD-9 code set is the major reason for this difference in magnitude of ILI measurement. In addition to infectious disease occurrence, coding practices may be quite variable at different locations and influence these rates. By aggregating data from MTFs, coding variability among providers and MTFs tends to have less influence on ILI as measured. Rates for the current week will also show more variation on Monday and Tuesday than on Friday because it is the cumulative ILI proportion for that week is measured, with more data added as the week progresses. Likewise holiday periods may show unusual patterns, but in each of these circumstances, the fact that a proportion is used makes the measure more stable.

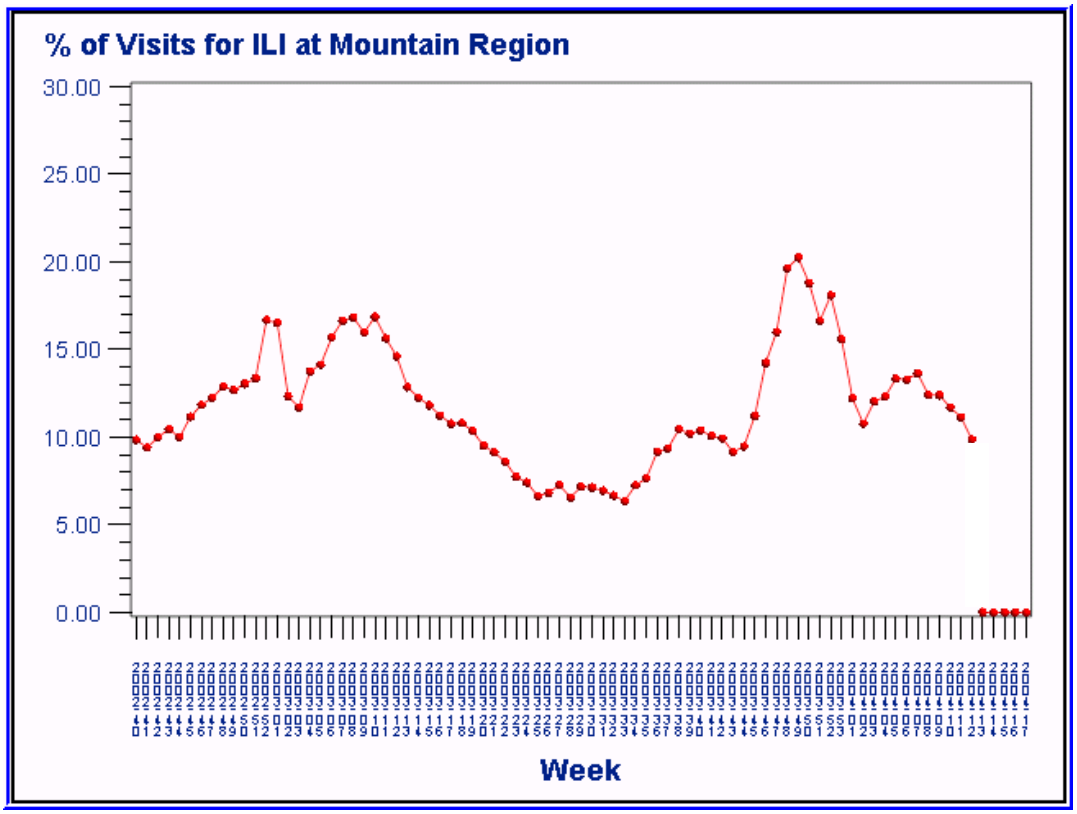

Figure 8: ILI ESSENCE graph for CDC Mountain regional grouping, week 12 2004

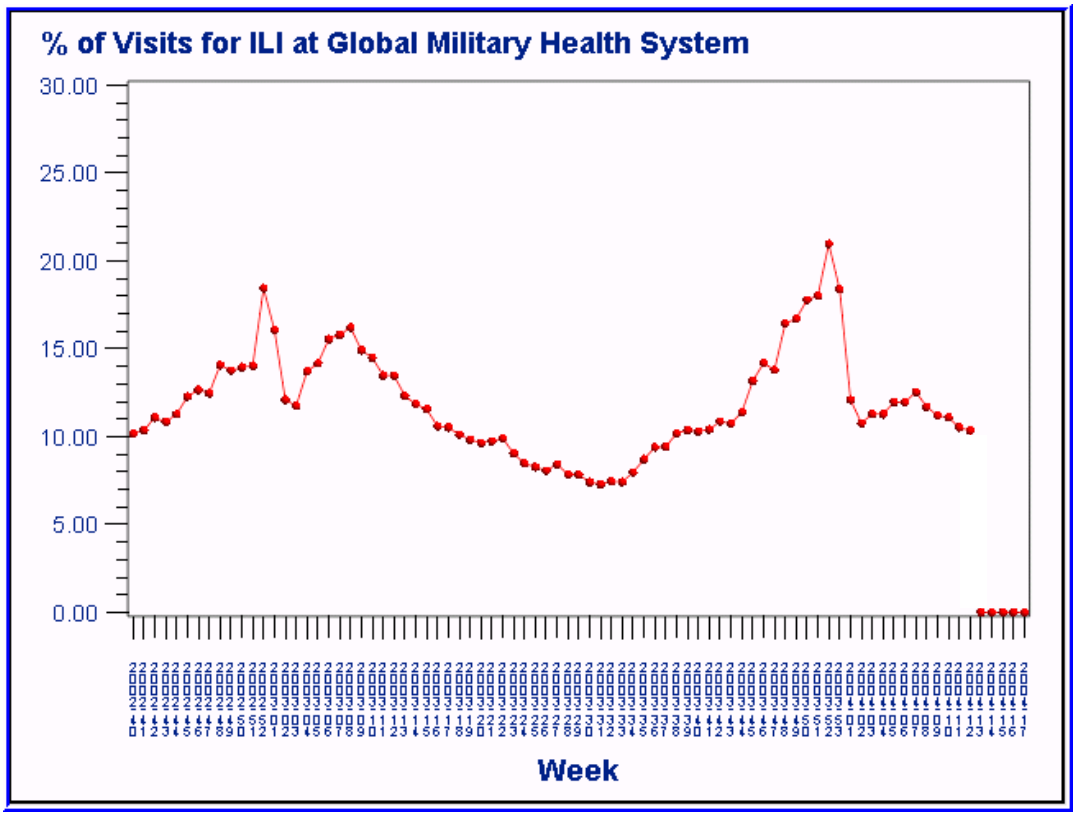

Figure 9: ILI ESSENCE graph for all DoD data, week 12 200

Currently ILI ESSENCE data are available to all operators with access through a secure website for ESSENCE. Instructions and documentation for ESSENCE and the ICD-9 set for ILI are available at DoD-GEIS public website www.geis.ha.osd.mil. The primary uses for this system currently include DoD's Global Influenza Surveillance weekly report and DoD SARS surveillance. The goal is improved and timely outbreak detection & monitoring for respiratory/flu-like illness in DoD, augmenting other systems. Places where expertise is developing in the use of this data are the Services epidemiology centers (Army Center for Health Promotion and Preventive Medicine (CHPPM), Navy Environmental Health Center (NEHC), Air Force Institute for Operational Health (AFIOH)), regionally (Army regional medical centers, Navy Environmental and Preventive Medicine Units (NEPMU's) and at research centers, especially the Naval Health Research Center (NHRC) in San Diego that partners with AFIOH in the influenza program.

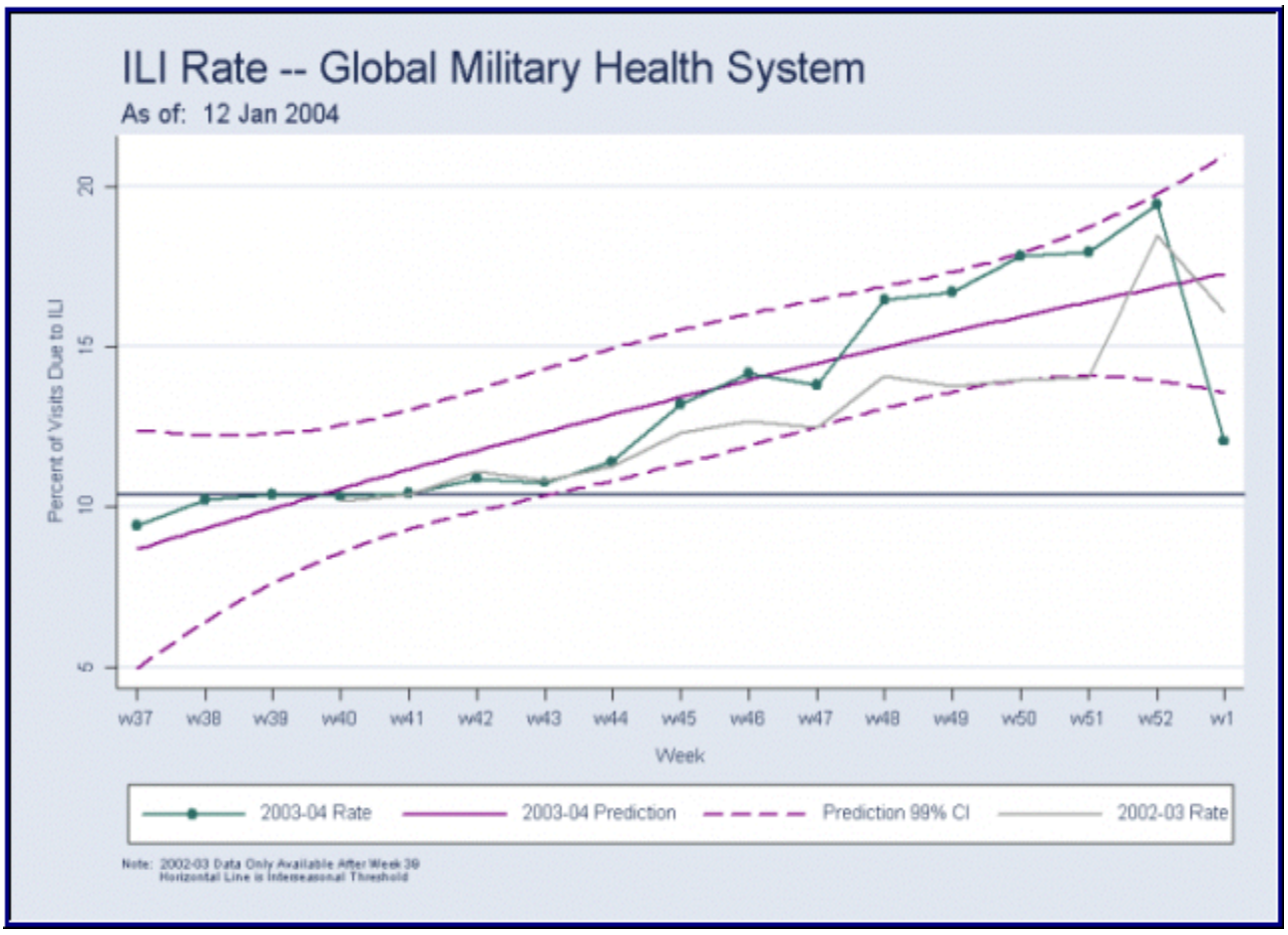

Figure 10: ILI graph from the weekly DoD Global Influenza Surveillance Program published report, AF Institute for Operational Health, Brooks City Base, San Antonio, Texas, week 1 2004

Figure 11 combines surveillance data from DoD and the CDC for comparison; DoD ILI activity (globally), DoD laboratory, CDC laboratory and ILI sentinel physician data are represented graphically. Traditionally percentage positive is used for influenza laboratory-based surveillance reporting as shown in the trend line in figure 4, right side Y-axis and that convention is used here but shown on the standard Y-axis in figure 11. Correlation between DoD and CDC data can be seen in the global and regional data for military populations and national data and for laboratory data as shown. Work is in progress to better quantify this correlation.

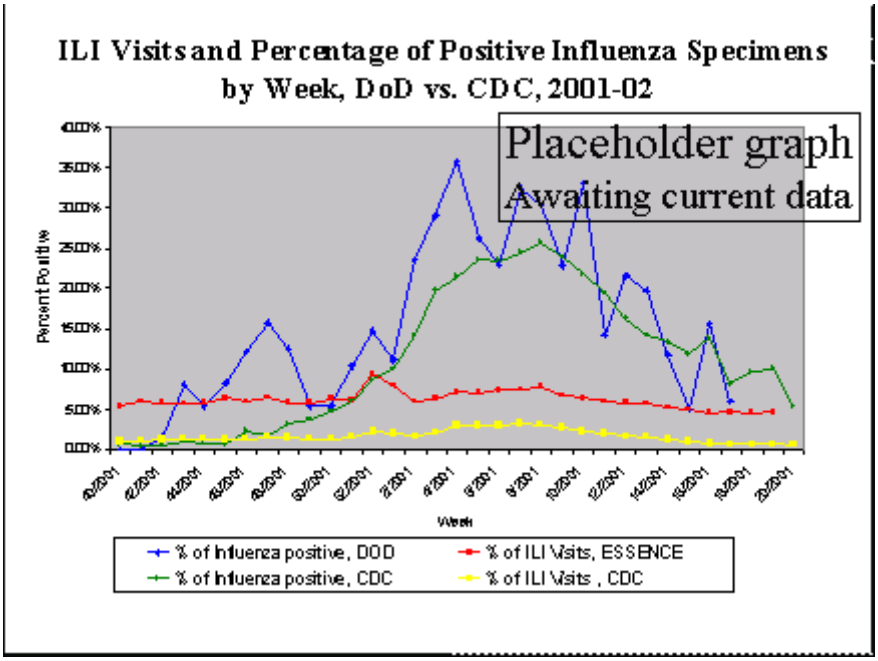

Figure 11: ILI data from DoD and CDC surveillance

There were unexpected benefits derived from the methods for ILI ESENCE surveillance when SARS surveillance needed to be quickly developed; because this study quickly resulted in an operational surveillance system just prior to WHO's SARS outbreak notification early in 2002, the collaborators in this study and GEIS were especially well positioned to use and integrate all partners' surveillance, including ILI ESSENCE, reporting and response capacity for this outbreak. System architecture, communication and reporting were already in place; vital links already existed in the influenza program between epidemiology and public health laboratory personnel who were already familiar with this project. ILI data baselines were already established when SARS concern arose. Timely DoD data suitable for respiratory disease outbreaks was logically organized and available for key leadership. Beyond this there is potential to use ILI data to facilitate targeted sampling for influenza strains or other respiratory pathogens and for prioritization of samples to improve surge capacity in epidemics or pandemics. Capability developed for SARS and influenza have implications for pandemic influenza planning and response as well.

5.0 CONCLUSIONS

Timely ILI surveillance is feasible with this methodology, as each patient becomes a sentinel using existing electronic data, ESSENCE infrastructure and global influenza surveillance collaboratively with GEIS. There is correlation of ILI activity in the military communities with CDC sentinel physician detected activity regionally and with influenza positive cultures. Useful comparisons can be made with national influenza surveillance system data. This surveillance capability is one component of a larger surveillance system that integrates and leverages existing respiratory disease surveillance through a unique linkage between syndromic and laboratory-based approaches. In concept it is analogous to the CDC's sentinel physician system but requires no special data collection from physicians and utilizes existing data sources, requiring little to no additional resources to operate. As part of influenza surveillance and ESSENCE this enhancement is

operational now, validation is underway and uses expand. An important DoD-wide SARS surveillance system followed immediately.

6.0 LIMITATIONS

ICD-9 code data is not the same as a medical diagnosis or a case definition; it is less specific. Although this technique has not yet been validated, work has begun on validation and the design facilitates this. No inpatient or mortality data is included and no medical encounters during deployment are captured. As yet only DoD medical encounters captured but the method is not limited to DoD. Finally there are some special problems generalizing from DoD populations. Some important factors to consider include: geographic, US & international, coverage is not homogeneous as military populations are clustered in some areas and not in others, demographics are different (e.g., age distribution, gender) and influenza vaccination rates are much higher for military than civilian populations. Although these limitations are important to remember, this technique and military population data can be used for DoD population surveillance and to augment other surveillance systems.

7.0 ACKNOWLEDGEMENTS

We would like to recognize these organizations and their personnel for their collaboration, achievements and contribution to this work.

- DoD-GEIS Central Hub, WRAIR, Silver Spring, MD
- ESSENCE group, Division of Preventive Medicine, Walter Reed Army Institute of Research, Silver Spring, MD
- Air Force Institute for Operational Health, Brooks City Base, San Antonio, TX
- Naval Health Research Center, San Diego, CA
- Office of the Assistant Secretary of Defense (Health Affairs), Washington, DC

8.0 REFERENCES

[1] RTO Reference Text – to be completed

(Disclaimer: The material in this abstract reflects the views of the authors and should not be construed to represent those of the Departments of the Army, Air Force or Navy or the Department of Defense.)

SYMPOSIA DISCUSSION - PAPER 10

Authors Name: LtCol MacIntosh (Col Cox speaker) (US)

Discussor's Name: Prof. Dr Fosse (NO)

Question:
How do you ensure the quality of the input to the global data base?

Author's Reply:
I am not aware of any system-wide validation, though work proceeds in this area at DoD GEIS-ESSENCE. There have been focused areas of validation at sites where there were confirmed outbreaks, including record review combined with evaluation of what appeared in the ESSENCE database. There is also comparison of ILI trends between ESSENCE and CDC data, as described in this paper. Finally, there are ongoing efforts on the clinical quality assurance side of the house to improve coding accuracy at MTFs across the DoD, including hiring more nosologists and making it simpler for providers to translate their diagnosis into ICD-9 codes.

Authors Name: LtCol MacIntosh (Col Cox speaker) (US)

Discussor's Name: Dr Nieuwenhuizen (NL)

Question:
The last slide read "no deployment data available". What is the role of the DOEHRS systems?

Author's reply:
DOEHRs system is garrison – related. There are, however, some data sources available for the field. In the future, TMIP (Threat Medical Information Program) will feed theater data, both health encounter and occupational/environmental, to CHCS-2, DOEHRS, and other systems.

Authors Name: LtCol MacIntosh (Col Cox speaker) (US)

Discussor's Name: Dr Reifman (US)

Question:
Influenza may not be a "good" illness to validate a syndromic system against, as influenza is part of the "normal " pattern of cyclic illnesses.

Author's Reply:
It is difficult to validate a syndromic surveillance system. Using a disease which is both common and has "gold standard" laboratory confirmation available is an advantage. We can also adjust the historical data to eliminate known outbreaks in an effort to better capture the "true" underlying baseline flu activity. We are also validating the system against other known outbreaks e.g., norovirus.