Evaluation of a syndromic surveillance for the early detection of outbreaks among military personnel in a tropical country

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ABSTRACT

Background To evaluate a new military syndromic surveillance system (2SE FAG) set up in French Guiana.

Methods The evaluation was made using the current framework published by the Centers for Disease Control and Prevention, Atlanta, USA. Two groups of system stakeholders, for data input and data analysis, were interviewed using semi-structured questionnaires to assess timeliness, data quality, acceptability, usefulness, stability, portability and flexibility of the system. Validity was assessed by comparing the syndromic system with the routine traditional weekly surveillance system.

Results Qualitative data showed a degree of poor acceptability among people who have to enter data. Timeliness analysis showed excellent case processing time, hindered by delays in case reporting. Analysis of stability indicated a high level of technical problems. System flexibility was found to be high. Quantitative data analysis of validity indicated better agreement between syndromic and traditional surveillance when reporting on dengue fever cases as opposed to other diseases.

Conclusions The sophisticated technical design of 2SE FAG has resulted in a system which is able to carry out its role as an early warning system. Efforts must be concentrated on increasing its acceptance and use by people who have to enter data and decreasing the occurrence of the frequency of technical problems.

Keywords early warning, evaluation, real-time surveillance, syndromic surveillance

Introduction

Syndromic surveillance systems gather pre-diagnostic health-related data with the objective of detecting earlier disease outbreaks and epidemics than would be possible using traditional surveillance data, e.g. confirmed diagnoses and laboratory reports.¹,² Many different types of data may be collected, either by manual input or by automatic collection. These may include recording numbers of school or work absenteeism, over the counter medication sales, phone calls to hotlines such as National Health Service Direct and hospital presenting complaint reporting.³–⁶

The use of syndromic surveillance throughout the world is increasing. At the start of 2000, very few syndromic surveillance systems were in use, yet by the end of 2003 ~100 different states and local health authorities in the United States were using some form of syndromic surveillance.⁷ Despite this increase in use, evidence that these systems are effective in their objective of early outbreak detection is still being gathered, mainly through the evaluation of the existing systems. There are an increasing number of opinions in the literature, showing that investment in these systems is not justified without a better evidence base for their use.⁷–¹¹

The Centers for Disease Control and Prevention (CDC)
have issued several guidelines and revisions on the evaluation of public health surveillance systems, with the latest focusing on surveillance for early detection of epidemics of a natural or aggressive nature. These guidelines provide a semi-standardized method of evaluation of syndromic surveillance systems. Other guidelines have also been published, but are far less in-depth than those published by CDC. Although several evaluations have been published using the CDC guidelines, many evaluations have been carried out which have not. However, it is clear that further evaluations of syndromic surveillance systems are required to understand their place in public health disease surveillance, for early detection of outbreaks but also for other uses and values.

The ‘Surveillance Spatiale des épidémies au Sein des Forces Armées en Guyane’ (2SE FAG) system has been in operation since October 2004. It is a prototype, near real-time syndromic surveillance system operating among some 3000 armed forces in French Guiana. The system is designed to allow, in near real time, geo-location and epidemiological analysis of cases of fever (temperature, ≥38°C) occurring in members of the armed forces anywhere in this South America French overseas department where tropical diseases responsible for outbreaks exist, such as dengue fever and malaria. This system has already demonstrated successful outbreak detection; it detected the dengue epidemic which occurred in French Guiana in 2006 several weeks before the traditional civilian surveillance system, based on the weekly surveillance of biologically confirmed cases within the 200,000 general population, issued an alert.

The aim of this study was to evaluate the syndromic system 2SE FAG using the CDC guidelines ‘Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks’.

**Methods**

This study used both quantitative and qualitative methods.

**Qualitative data**

Two main groups of stakeholders were identified and interviewed using separate semi-structured questionnaires: the data input and the data analysis stakeholders. Separate questionnaires were used due to different areas of expertise of these two groups of stakeholders. Twenty-one people who have to enter data were identified, all doctors, nurses and paramedics. Questions were devised to assess the system using the CDC themes of timeliness, data quality, acceptability, usefulness and stability. Seven data analysis stakeholders were identified, all epidemiologists working in France and French Guiana. These stakeholders were interviewed to assess portability and flexibility as well as data quality, acceptability, usefulness and stability. Every person interviewed was given an information sheet on the study, and any questions were answered. They were then asked to sign a consent form confirming their willingness to participate in the project. All information was kept strictly anonymous; this was made clear to all interviewees to avoid any unnecessary bias in their answering of questions. People who have to enter data were interviewed in person by visiting the various armed forces regiments based in French Guiana. Data analysis stakeholders were emailed their questionnaire.

**Quantitative data**

The quantitative part of the study was concerned solely with the assessment of validity. The frequency and timing of reporting cases of fever by syndromic surveillance was compared with the traditional surveillance system ‘Message Epidémologique Hebdomadaire’ (MEH), which has been in use among the French armed forces for some time. Data concerning all cases of fever, suspected and confirmed cases of dengue fever and confirmed cases of malaria dating from January 2005 to December 2006 were taken from both systems and the performance of syndromic surveillance was compared with that of the traditional one. A case of suspected dengue fever, for syndromic surveillance, was defined as a sudden onset of fever with no evidence of other infection (particularly malaria, when rapid diagnostic tests and/or thick blood smears were negative), associated with one or more non-specific symptoms including headache, myalgia, arthralgia and/or retro-orbital pain. As traditional surveillance is a weekly reporting system and syndromic surveillance is a real-time reporting system, data from syndromic surveillance was converted into a weekly format to allow comparison. Statistical assessment was carried out to ascertain agreement between the two systems when reporting on three different categories—all cases of fever, dengue fever and malaria. For each category, an initial paired Student’s t-test and correlation coefficient were calculated to assess the presence of a relationship between the two sets of data, respectively. A method of assessing agreement between data sets was then used. This method allows ‘limits of agreement’ to be calculated, giving an
indication of how wide discrepancies between the two data sets will be in 95% of cases. These limits are calculated as ratios, if the difference between the ratios is small, the systems are in good agreement, thus if it is large the systems are not. For instance, if the limits of agreement are between 0.5 and 3, syndromic surveillance reports between 0.5 and 3 times the number of cases of traditional surveillance in 95% of cases; this would be a poor result as the limits are very wide. All data used were supplied by the Institut de Médecine Tropicale du Service de Santé des Armées (Marseille) and the Direction Interarmées du Service de Santé (Cayenne). Data analysis was carried out using SAS®, version 9.1 (SAS Institute Inc., Cary, NC, USA).

Results

Nineteen of the 21 people who have to enter data (11 doctors and 8 nurses) and 6 of the 7 data analysis stakeholders were interviewed. The remaining stakeholders were unavailable for interview. The average time of involvement with the system was 1.5 years for the people who have to enter data and 3.0 years for the data analysis stakeholders.

System description

System purpose and stakeholders

The aims of 2SE FAG were to allow the operational study of a real-time surveillance system using a specific military prototype, to evaluate the value of such a system before its generalization and to develop an interoperable system for allied cooperation.30 The stakeholders are shown in Table 1.

System operation

The system consists of two networks30: the declaration network and the analysis network (Fig. 1). Whenever a member of the armed forces in French Guiana presents with a symptom of fever, the medical staff member attending is required to record specific information regarding the patient into an available IT system with syndromic surveillance software installed. Depending on the location of the consultation, this IT system may be a computer in a permanent medical unit or a personal digital assistant (PDA) on a mission. Later, when biological results are available, these are added to the system. Finally, a clinical closure form is completed at the conclusion of each case, recording both the final diagnosis and the final outcome. The declaration network is heavily dependent on data input by the medical staff within the armed forces, without whose contribution the system would have nothing to analyse.

Table 1 People who contribute to the syndromic surveillance system 2SE FAG

<table>
<thead>
<tr>
<th>Types of people who contribute</th>
<th>Data input</th>
<th>Data analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Doctors</td>
<td>To record the data</td>
<td>To collect the data from the data input stakeholders</td>
</tr>
<tr>
<td>Nurses</td>
<td>To send the data to the data analysis stakeholders</td>
<td>To analyse the data</td>
</tr>
<tr>
<td>Paramedics</td>
<td></td>
<td>To send the results to the commanders</td>
</tr>
<tr>
<td>Functions</td>
<td></td>
<td>To send a feed-back to the data input stakeholders</td>
</tr>
<tr>
<td>Types of data used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>French Forces in French Guiana (FAG)</td>
<td></td>
<td>Institut de Médecine Tropicale du service de santé des armées (IMTSSA)</td>
</tr>
<tr>
<td>Service de santé des armées (SSA)</td>
<td></td>
<td>Université de la Méditerranée</td>
</tr>
<tr>
<td>Direction Interarmées du Service de santé (DIASS)</td>
<td></td>
<td>Institut Pasteur de la Guyane (IPG)</td>
</tr>
<tr>
<td>Subsidiary of Centre National des Etudes Spatiales (CNES)</td>
<td></td>
<td>French Ministry of Defense</td>
</tr>
</tbody>
</table>

The analysis network of syndromic surveillance, also known as ‘Communauté de Services Internet pour la Surveillance Syndromique’ (CS3), is based around four system modules (Fig. 2). Each system module is made up of web servers which host web services dedicated to that modules function. Computers hosting these servers may be based anywhere, as the communication backbone is based on a virtual private network (VPN) which operates via the Internet.30 Automated alarms are issued from the syndromic system based on a current past experience graph (CPEG).31 There is no automated alarm for traditional surveillance, which also uses CPEG for its non automated weekly analysis of data.

Outbreak detection

Timeliness

Under ideal circumstances, i.e. prompt reporting and transmission of cases by medical officers, there were ~60 min between the presentation of a case and the detection by the system post-analysis. However, qualitative results showed
that this ideal scenario is often not the case (Table 2). These results showed that although the system has the ability to report cases of fever in near real time, this often did not occur due to delays in reporting by medical officers at the start of the process, and in several instances there was no reporting at all.

Data quality
The response of people who have to enter data to questions regarding completeness of data entry were: very often, 26.4% (5/19); often, 31.5% (6/19); sometimes, 10.5% (2/19); never, 10.5% (2/19); and non-appreciated 21.1% (4/19). The results showed that although the majority of people who have to enter data were completing report forms in full when they used the system, there were still a large number who were not utilizing the system in the correct manner by not fully completing report forms. This adversely affected the quality of data supplied to the analysis network.

Validity
In both 2005 and 2006, traditional surveillance reported more cases of fever than syndromic surveillance by 12.6%
(196–152) and 8.4% (230–206), respectively (Table 3). Significant correlation coefficients were calculated in both years \( (P = 0.0431 \text{ in } 2005 \text{ and } P = 0.0001 \text{ in } 2006) \). The \( t \)-test result showed evidence of relationship in 2005 \( (P = 0.028) \) but not in 2006 \( (P = 0.387) \). The limits of agreement were wide in both years (Table 3), indicating poor agreement between the two systems.

Dengue fever case reporting in 2005 and 2006 was higher by syndromic surveillance compared with traditional surveillance by 67% (151–23) and 29% (162–89), respectively (Fig. 3). This striking difference, especially in 2005, is probably due to the fact that traditional surveillance reports confirmed cases only and syndromic surveillance reports suspected cases. Correlation between the systems was weak in 2005 \( (P = 0.9002) \) and higher in 2006 \( (P = 0.0001) \). The \( t \)-test showed evidence of relationship in both years \( (P = 2.098 \times 10^{-5} \text{ in } 2005 \text{ and } P = 0.007 \text{ in } 2006) \), indicating consistently higher reporting by syndromic surveillance in both years. The limits of agreement were narrower than all cases of fever data in both years (Table 3), indicating better agreement between the systems when reporting on dengue fever cases.

Only malaria data comparison was carried out for 2006. Traditional surveillance reported 49% more cases of malaria than syndromic surveillance \( (99–34) \), although correlation between the data sets was high \( (P \leq 0.0001) \) and peaks in cases between the systems appear to have coincided (Fig. 4). However, the limits of agreement were wide (Table 3), indicating poor agreement between the systems.

**System experience**

**System costs**

The initial development of the system cost \( \sim 275 \text{ 000€} \), which included the purchase of all necessary hardware, software development, subscription to communication services and salaries of those involved. Annual costs are \( \sim 235 \text{ 000€} \).

**System flexibility and portability**

Sixty-seven percent of data analysis stakeholders (four of six stakeholders) were of the opinion that the system would cope well with a change in disease conditions in French Guiana, and all agreed (six of six stakeholders) that the system could be adapted to detect syndromic information other than fever. This adaptation has already occurred in Djibouti, where an updated version of 2SE FAG has been used among the French armed forces for the past 6 months. This system uses an altered interface to allow recording of 69 different symptoms and signs, including those of a non-infectious nature. Although it is too early to assess how successful the adaptation to the Djibouti system has been, 83% of data analysis stakeholders (five of six stakeholders) thought that the system could be transferred to other areas without significant change in personnel and resources.

**System usefulness**

Ninety-six percent of all stakeholders (24 of 25 stakeholders) agreed that alarms issued by the system-stimulated activities

### Table 2 Questionnaire responses by people who enter the data regarding case logging and transmission

<table>
<thead>
<tr>
<th>Cases are logged/transmitted</th>
<th>Case logging into system (% of respondents)</th>
<th>Case transmission to IPG server (% of respondents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Within 1 h</td>
<td>7 (36.7)</td>
<td>7 (36.7)</td>
</tr>
<tr>
<td>At the end of the day</td>
<td>4 (21.1)</td>
<td>2 (10.5)</td>
</tr>
<tr>
<td>Within 1 week</td>
<td>4 (21.1)</td>
<td>5 (26.4)</td>
</tr>
<tr>
<td>Never</td>
<td>4 (21.1)</td>
<td>5 (26.4)</td>
</tr>
</tbody>
</table>

### Table 3 Statistical results comparing syndromic surveillance (2SE FAG) and traditional surveillance (MEH), 2005/2006

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MEH</td>
<td>2SE FAG</td>
</tr>
<tr>
<td>No. cases reported</td>
<td>196</td>
<td>152</td>
</tr>
<tr>
<td>( t )-Test P-value</td>
<td>0.028</td>
<td>0.387</td>
</tr>
<tr>
<td>Correlation coefficient ( (r) )</td>
<td>0.282</td>
<td>0.611</td>
</tr>
<tr>
<td>Limits of agreement (ratios)</td>
<td>(-0.73) to 5.07</td>
<td>(-0.74) to 3.59</td>
</tr>
<tr>
<td>Dengue fever</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. cases reported</td>
<td>29</td>
<td>151</td>
</tr>
<tr>
<td>( t )-Test P-value</td>
<td>( 2.098 \times 10^{-5} )</td>
<td>0.007</td>
</tr>
<tr>
<td>Correlation coefficient ( (r) )</td>
<td>0.018</td>
<td>0.548</td>
</tr>
<tr>
<td>Limits of agreement (ratios)</td>
<td>(-0.91) to 1.00</td>
<td>(-0.88) to 1.85</td>
</tr>
<tr>
<td>Malaria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. cases reported</td>
<td>99</td>
<td>34</td>
</tr>
<tr>
<td>( t )-Test P-value</td>
<td>( 2.179 \times 10^{-7} )</td>
<td>0.741</td>
</tr>
<tr>
<td>Correlation coefficient ( (r) )</td>
<td></td>
<td>( P \leq 0.0001 )</td>
</tr>
<tr>
<td>Limits of agreement (ratios)</td>
<td>(-0.36) to 3.26</td>
<td></td>
</tr>
</tbody>
</table>
related to prevention and control of disease (strengthening of individual and collective vector control measures, adaptation of health education, etc.) and 84% (21 of 25 stakeholders) agreed it was better at detecting febrile episodes than traditional surveillance. All the data analysis stakeholders (six out of six stakeholders) stated that the system consistently and adequately detected disease outbreaks whose primary symptom was fever. Eighty-three percent of data analysis stakeholders (five of six stakeholders) said that the introduction of a standardized...
response protocol would increase the system’s ability to aid the control of epidemics detected.

**System acceptability**

Some lack of acceptability of the system is already evident from areas such as data quality and timeliness. Eighty percent of all stakeholders (20 of 25 stakeholders) either agreed or strongly agreed that the system was an important tool for the armed forces, 84% (21 of 25 stakeholders) agreed or strongly agreed that they had received adequate training in the use of the system and 72% (18 of 25 stakeholders) agreed or strongly agreed that they felt their contribution was important for the effective functioning of the system. However, 48% (12 of 25 stakeholders) thought that the time taken to use the system was not proportional to its benefit and 24% (6 of 25 stakeholders) believed the system was not easy to use.

**System stability**

The reliability of the system was one of the main problems that people who have to enter data had with the system: 68% of all them (13/19) said that the system was not always available when needed, and many commented on the problems concerning case logging and transmission. These problems were of sufficient severity that PDAs were never and satellite phones rarely used on missions.

**Discussion**

The results indicated that although there was a belief that the system is important among its stakeholders, specific areas of acceptability, such as the time taken to use the system and actual use of the system by people who have to enter data, were areas which could be significantly improved. The importance of technical issues was also highlighted, as previous studies had shown problems with the use of PDAs while on missions.

The high sensitivity and low specificity of syndromic surveillance noted in the dengue fever results is characteristic of these types of systems, the detection of syndromic information generally leads to many false positives. This lack of specificity may lead to costly false alarms. However, the sensitivity of the system means that if utilized correctly by its stakeholders, it is unlikely to miss any disease epidemics where the primary symptom is fever. A historical recording of when alarms occur, whether they are true or false and what action is taken in each case will greatly help the adjustment of such parameters.

The timeliness of the system was one of its major strong points. It had a true ability to report in near real-time any case of fever occurring within the armed forces in French Guiana, with the only major limits on the time taken to process a case being the interval before an individual presents to a medical officer and how long it takes the officer to log and transmit the case. One of the main drawbacks of this study was that it did not completely investigate the benefits of the near real-time nature of syndromic surveillance, as all data were converted into a weekly format for comparison with traditional surveillance. In reality, cases reported by syndromic surveillance may be entered and detected by the system at any time, whereas traditional surveillance only collects data weekly. Delays between the two systems within a week were not accounted for by this study. Despite this ability, this swiftness was often not due to delays in data input. Many users believed that the logging of patients into the system took too much time, outweighing its potential benefit. It seemed unlikely that these stakeholders would take the time to use the system in busy or emergency situations. This finding may indicate a need to simplify the data input forms, preventing too much time being taken on the system, also potentially increasing acceptability. Also important to timeliness and usefulness of the system is the introduction of a standardized protocol for responding to system alarms, to ensure thorough and swift investigation of all alarms.

The use of the CDC guidelines to evaluate such military systems is by no means perfect. Specific elements of the systems may be missed using the guidelines. Ongoing updating of the guidelines will be required in the future as new systems need to be evaluated. The military specificities will have to be integrated in the guidelines, as proposed by some authors, e.g. variability of geographical conditions for missions, high mobility of the armed forces in the field, important turn-over of the military people and increasing multi-nationality of the external operations.

2SE FAG is a prototype system under development. The study comprised part of that development. Despite the system having given an early warning of the dengue epidemic of 2006, it has yet to be given the opportunity to repeat this feat. The technical design of 2SE FAG has resulted in a system that is sophisticated enough to carry out its role as an early-warning system based on syndromic surveillance. Efforts must now be concentrated on increasing its acceptance and use by people who have to enter data as well as minimizing the occurrence of hindering technical problems, so that the system is able to fulfil its potential.

The use of syndromic surveillance for early-warning of epidemics is still a relatively new concept, with many potential public health applications. The development and
modification of systems such as 2SE FAG is critical to advance the understanding of what place syndromic surveillance has in a military public health setting and how it may be most effectively deployed.

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References


