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Real-Time Symptom Surveillance – Experience in the United Kingdom Using the "Portable Remote Illness and Symptoms Monitor" (PRISM)

Submitted by the United Kingdom

Introduction

1. This paper describes experience in the UK with a real-time symptom surveillance system. It gives an overview of the PRISM (Portable Remote Illness and Symptoms Monitor), a symptom based surveillance system currently being developed as part of the CBRN (Chemical, Biological, Radiological & Nuclear) defence capability for the United Kingdom Armed Forces. It also discusses how a similar system could be used for surveillance of civilian populations, and some of the issues that may be encountered with its implementation.

The role and importance of symptom surveillance

2. Models designed to determine how most effectively to save lives in large-scale populations exposed to a biological agent have demonstrated the necessity for early detection, which leads to the initiation of the most appropriate responses (such as instituting medical countermeasures, personal and collective physical protection, decontamination measures, etc.). In the military context, there are three possible stages for detection of an attack with a biological warfare (BW) agent. These are: detection near the moment of release using an environmental bio-sensor; a symptom surveillance alert, some time after an attack; and clinical diagnosis, sometime later still. How and when detection occurs defines the time available to respond, and the nature and efficacy of that response.

3. For example, modelling demonstrates that, in the ideal situation of a BW attack being detected quickly by an environmental detector, and effective medical countermeasures, such as broad spectrum antibiotics, being issued immediately, 100% of casualties can be avoided. If, on the other hand, detection of the attack relies on clinical diagnosis alone, some 5 or so days after the

attack has occurred, then only 12% of casualties are avoided even if a response with medical countermeasures is instituted.

4. However, in this model, symptomatic surveillancemay detect the attack 2 days earlier than clinical diagnosis, resulting in 71% of casualties being prevented. The efficiency of environmental biosensors to detect BW attacks is, of course, to some extent dependent on the nature of the agent used, and how it is delivered or disseminated. Thus this model highlights the potential benefits that symptomatic surveillance alerts could bring to detection of, and response to, a BW attack.

Symptom surveillance using PRISM

5. PRISM is a continuous signs and symptoms surveillance system designed to inform UK military Medical Officers of unusual medical events that may be BW-related. It is designed to provide continuous symptom surveillance of individuals in near real-time to provide the earliest indications of illness.

6. Initially conceived before 1990, an early system used during the Gulf War utilised paper reports to capture and collate signs and symptoms from soldiers. The data was signalled back to the UK for analysis by medical staff.

7. In 1992 a program of work was initiated to digitally collect signs and symptoms data from selected military and civilian populations in the UK, via general practitioners, and analyse this data to see how best this could be processed to warn of a possible exposure to a BW agent. One of the aims of the project was to see if an automated alarm system could be developed which would look for unusual medical events that could be indicative of a BW attack.

8. Later, the project focused on technologies for reporting digital information in the field and reporting it back to a central server. Trials were completed with scripted events, which were used to simulate a BW attack, to ascertain if the alarm logic would detect a modelled attack.
The present system uses bespoke software, based on a Geographical Information System (GIS) software platform, to display and provide temporal-spatial analyses of data with integrated alarm algorithms. The main components of the PRISM system are data collection, data communication and data analysis.

9. Data is collected via handheld computers with integrated geographical positioning system (GPS), which are deployed in the field with frontline medical personnel. Data comprising of personnel service number plus signs and symptoms is manually entered onto a handheld computer, and is then transmitted to a central server by secure satellite communications. The central server receives the data, decrypts it and performs data analysis. It has integrated alarm logic that interrogates the data to look for unusual events. At the end of the processing a report of the results is generated. The data can also be interrogated manually to look for abnormalities or trends.

10. Recently, a trial of PRISM was carried out as part of a large UK military exercise overseas, where the system was used to collect real medical data. Some scripted incidents were fed into the

system to test the alarm logic. In these blind trials, operators in the UK processed the reports generated by the alarm logic, analysing the data to see if any simulated events could be spotted.

The importance of continuous surveillance

11. Continuous surveillance allows a background data set to accumulate, against which new data can be compared. This will contain seasonal fluctuations of symptom levels, which can be normalised out, removing resultant variations. Furthermore, a continuous system is necessary to collect signs and symptoms in “near real time”, to give as much warning, and time to respond, as possible.

Signs and symptoms – some important issues to be considered

12. Signs and symptoms are the earliest indications of illness and disease in the absence of medical testing. A *sign* is something that is physically observable by medical staff or the patient (e.g., a rash, bruising, swelling, etc.). A *symptom* is an experienced feeling, discomfort or pain. Physiological signs are easy to evaluate using measurements, estimations of affected area, colour, swelling, and appearance. Symptoms are less easily measured, but can be scored semi-quantitatively, e.g., on an increasing scale of intensity from 1 to 10. Signs and symptoms can be easily grouped into *syndromes*, which collectively indicate or characterise a disease, psychological disorder, or other abnormal condition. However, unlike systems based solely on syndromic surveillance, PRISM’s flexibility to incorporate data on signs, symptoms and syndromes, as appropriate, may be advantageous.

13. Although signs and symptoms are not always recorded when treating a patient, some Medical Information Systems do use codes to record such data. For example, the International Statistical Classification of Diseases and Health Related Problems (ICD), published by the World Health Organisation (WHO), is an alpha numeric coding system for categorising diagnoses, signs, symptoms, causes and other relevant factors. However, code systems such as ICD are not necessarily ideal for use in symptom surveillance systems such as PRISM. Therefore, the wider application of syndrome surveillance systems has implications for the standardisation of data collection and coding.

Advantages of symptom surveillance for BW agent detection

14. A distinct advantage of symptomatic surveillance is that its ability to detect a BW attack is largely independent of the agent used (i.e., it is a non-specific detector), and of the mode of dissemination or routes of exposure. If the BW attack makes people ill then it should be detected by such a system.

15. Indeed, for many infections caused by potential BW agents, the early stages are characterised by very similar influenza-like symptoms. Thus, for a symptom surveillance system to be effective it must be able to give an alarm as early as possible in spite of this fact, by detecting changes in the incidence of these types of non-specific symptoms.

16. In addition, as well as detecting potential BW attacks, it also provides the ability to detect earlier naturally occurring disease outbreaks.

Application of PRISM to a civilian surveillance system

17. The main differences between surveillance systems aimed at civilians, and those for the military, are the relative scales of the target populations, their age and gender distributions, levels of physical fitness and vaccination status.

18. A system designed for the military is likely to cover thousands of people, whilst a civilian system will be aimed at millions. Therefore, in the latter case, the volume of data collected and analysed is likely to be several orders of magnitude greater than the former. This has important implications for the cost and complexity of implementing such a civilian surveillance system.

19. The data glut for civilian populations is compounded by their demographics, as noted above, which are very different from those of military populations and will affect the incidence of illness. In general, the levels of signs and symptoms are higher within civilian populations compared with military populations.

20. However, it is also the case that a military system is likely to be employed to protect the military personnel whilst they are in operations in a foreign country. In this situation, the occurrence of signs and symptoms may rise in the military population due to exposure to different pathogens and higher levels of physiological stress. This may make them much more susceptible to natural disease and increase the background of illness. This in turn may make the detection of a BW attack more difficult due to a high and fluctuating background of symptoms caused by natural disease. This further highlights the necessity for continuous surveillance in both civilian and military populations, as mentioned previously, if such systems are to be effectively employed.

Data Collection

21. Signs and symptoms data collection for a civilian population may rely on data input by medical personnel when individuals present as ill. Although allowing medical personnel to record the data should ensure its quality, there will as a result necessarily be a time delay between the start of signs and symptoms and examination of the patient at medical facilities or when emergency medical assistance is called.

22. However, such a time delay could be ameliorated by telemedicine systems, such as NHS Direct in the UK, which allow individuals to obtain medical advice at home via the telephone. Such systems could provide another data feed into a surveillance system at an early stage before qualified medical examination is undertaken.

23. In this case, location information can be inferred from an individual enquirer’s postcode allowing spatial analysis of data via GIS to analyse for clusters, alignment with prevailing winds, etc.

24. Thus in setting up civilian surveillance, it is important to decide: what data is to be collected, and how often; who inputs the data, what is their level of training and what decisions will they have to make in the process; and, how and when is the data to be transmitted?

Integration with other systems

25. Traditionally, the surveillance system for infectious diseases within the UK has been by classification of certain diseases as “notifiable”. In this case, their occurrence, or suspicion of their occurrence, has to be reported by clinics, hospitals and laboratories to public health officials. Since the threat from bio-terrorism has increased, a goal has been the linking up of IT systems that record such medical information. The aim is to allow it to be communicated quicker and in a more structured format, resulting in better surveillance.

26. The integration of a symptom surveillance with other systems - such as those for health surveillance, pharmacy sales, veterinary surveillance, meteorological and pollution monitoring - may allow other key factors to be used to improve the sensitivity of the system.

27. For example, meteorological inputs such as temperature and pollution levels within cities have a proven influence on the health of populations, and may therefore affect “background” levels of illness. Furthermore, alignment of index cases with prevailing winds may be indicative of a BW aerosol attack.

28. Some potential BW agents are zoonotic pathogens, and following an attack may cause signs and symptoms in animals before humans, due to their greater susceptibility. In this instance, a veterinary surveillance system may detect the event before a human surveillance system. A linkage between such symptoms could therefore be beneficial.

Response to a Symptom Surveillance Alarm

29. If a symptom surveillance alarm is deployed, procedures for responding to the alarm must be also in place. It is important to note that a symptom surveillance alarm only gives an indication that an epidemic *may* be occurring at a particular time, and in a particular area. It will not, however, give an indication of specific cause of the disease, nor its extent, infectivity, virulence, etc. Thus investigation of these issues will also have to take place concurrently with any control measures that are implemented.

30. In all cases, the response must be timely, appropriate and proportional, and not engender unnecessary public concern or, indeed, panic. Responses to an alarm may include: rapid diagnostics; medical countermeasures; quarantine; restriction of movement; emergency response; co-ordination of multiple agencies; and international co-operation.

Summary

31. It is clear that a civilian symptom surveillance system, if implemented successfully, may provide many benefits for early detection of natural or deliberate infectious disease outbreaks. Even

greater improvement and integration of information systems will allow for better and faster data sharing, which in turn will be of benefit not just in outbreak detection, but to public health in general. This large-scale task will require the co-operation of multiple agencies. Further investment, research and development in this field will be required to fully realise the true potential of such a system.
