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IMPLEMENTATION OF A SIMPLE OUTBREAK RESPONSE MANAGEMENT SYSTEM FOR DEVELOPING COUNTRIES USING A LOW-COST GIS

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Au cours des programmes de contrôle et d'éradication des maladies, une réponse rapide et efficace aux épizooties est toujours difficile à mettre en oeuvre. Les autorités responsables du contrôle des maladies ont besoin pour gérer les épizooties d'un accès rapide à un ensemble d'informations en vue de planifier et de coordonner leur réponse. Un exemple d'une telle réponse est donné pour une région dans laquelle un périmètre vaccinal est envisagé face à un foyer de fièvre aphteuse. Des systèmes informatiques complexes et puissants avaient été mis en place pour le contrôle des épizooties de fièvre aphteuse intégrant des modèles de diffusion de la maladie et des évaluations économiques. Ces systèmes étaient cependant coûteux et exigeaient beaucoup de données.

La présente communication décrit un système de gestion des épizooties simple et peu coûteux adapté aux pays en voie de développement et basé sur un système d'information géographique (SIG). Le système procure un accès à des données sur les ressources matérielles requises (nombre de doses de vaccins), les ressources humaines disponibles (emplacement des agents de terrain en relation avec l'épizootie), la charge de travail (nombre d'animaux et emplacement des villages nécessitant une vaccination) et le contrôle des mouvements de troupeaux (nombre, emplacement et nature des carrefours routiers). L'avantage d'un tel système est qu'il peut procurer un accès très rapide à l'information critique requise pour gérer une épizootie, demande seulement un ordinateur et un logiciel relativement bon marché, et est d'un grand intérêt dans un environnement pauvre en données.

INTRODUCTION

The management of the response to disease outbreaks is a challenge to all animal health planners and administrators. For both exotic diseases, and endemic diseases which are the target of control or eradication programs, the effectiveness of this response is critically important. Ineffective outbreak control may result in rapid spread of the disease to previously unaffected areas. This in turn may dramatically increase the task of eradication and seriously delay the final goal of achieving eradication. In addition, the economic losses incurred during an outbreak are multiplied if the outbreak spreads or lasts for an extended period of time.

In Thailand, the national Foot and Mouth Disease eradication plan outlines a staged approach to rid the country of the disease. The principles of the plan are similar to that used in many other countries. The plan is being implemented progressively from the south to the north. In the initial stages, mass vaccination is used to lower the incidence of disease outbreaks. As the incidence decreases, individual outbreaks are suppressed by the use of ring vaccination of all susceptible animals in a buffer zone surrounding the site of the outbreak. Once freedom from the disease has been achieved in an area, mass vaccination will cease. Outbreaks will then be addressed by use of ring vaccination, or stamping out. Finally all vaccination will cease, and any outbreaks will be controlled by stamping out alone.

During the intermediate stages, ring vaccination around the site of the outbreak is an important tool for control of the disease. As the eradication program continues, more and more areas of the country will be using this approach. The requirements for the successful use of ring vaccination to control a disease outbreak are:

- Vaccination must be implemented very rapidly after the onset of the outbreak. Animals at risk in surrounding areas must be protected before they are exposed to the virus and this protection takes several days to develop after vaccination.
- Livestock movement must be controlled. No animals should move out of the buffer zone, and no unvaccinated animals should enter it.
- A very high proportion of susceptible animals within the buffer zone should be vaccinated and achieve adequate titres to protect from infection.
- The vaccination buffer zone must be large enough to control the spread of the disease.

In order to achieve a high level of vaccination coverage, over a relatively large area, in a very short period of time, relevant, reliable information must be readily available to the planners of the outbreak response, so that they can mobilise the labour force and materials required quickly.

A typical sequence of tasks required of outbreak response managers before any action can commence may include the following: When a sample from a suspected outbreak is submitted to the diagnostic laboratory, it must be analysed and typed as quickly as possible, and the results passed to the response manager. The village of origin of the sample must be identified, and all villages that fall within a certain radius (the vaccination buffer zone) determined. The total livestock populations in these villages needs to be estimated, and enough

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vaccine to protect these animals obtained. The staff responsible for carrying out the vaccination need to be notified of the villages requiring vaccination, and the number of animals to be vaccinated in each village. Extra staff from nearby areas may need to be coopted into the work. A work schedule needs to be drawn up with estimates of how much time will be required to vaccinate each village. Some villages at remote locations may take significantly longer to access than nearby villages. Road check points to control livestock movement in and out of the vaccination buffer zone need to be established, usually with the assistance of other authorities, such as the police. The locations and staffing requirements of all such checkpoints need to be established.
The systems previously used in Thailand to gather this information on an *ad hoc* basis may have taken several days to a week. This would mainly have been done by contacting district staff, and sending out teams from the diagnostic laboratory epidemiology divisions.
This paper describes a simple computerised outbreak response management system which was developed specifically for use in implementing ring vaccination in Thailand, but could be applied to a variety of countries. This system is able to provide in seconds the key information required for response planning. The system, using a variety of linked data sources, is based on a relatively low-cost GIS.

PROGRAM OVERVIEW

The Outbreak Response Management System is implemented in the ArcView[4] program, using the in-built Avenue programming language. The system runs on a single microcomputer with a Pentium processor. It draws on a range of geographic data sources and attribute data, in a series of dBASE files. The program has a simple interactive graphical interface, in which the user is required to select the village in which the outbreak has occurred, and specify the radius of the ring vaccination buffer zone. Both a graphic representation of the buffer zone and a report are produced with the key planning information required, as well as a table listing the details of all villages in the buffer zone. The program requires no knowledge of GIS systems and can be used by anybody familiar with the Windows operating system. The system combines available geographic data (feature location) and attribute data (feature properties) using a series of spatial operations.
There are four key elements of geographic data required for full operation of the system. These are village locations, district boundaries, roads, and the location of district veterinary offices. Other spatial data, such as waterways, may be added to aid with interpretation.
Each of the four geographic data coverages is linked with one or more attribute data files. The village locations are linked to files containing village, subdistrict, district and province names, and to a database containing village-level livestock figures. The district boundary coverage is linked to files giving district and province names. The road coverage contains data on the type and number of each road. District veterinary office locations are linked to a database containing the name and contact details of the responsible officers in each district.

SYSTEM OUTPUTS

When the outbreak village has been selected (by clicking with a mouse), and the radius of the vaccination buffer zone specified, the program marks the outbreak village, draws a circle representing the vaccination buffer zone, and highlights all villages falling within the circle. It then carries out a number of calculations a lists the results in a report containing the following sections:

- *Outbreak village*: the name, subdistrict, district and province of the village with the outbreak.
- *Villages in the vaccination buffer zone*: the total number of villages, the total number of cattle and buffalo separately and combined, and the average number of cattle and buffalo in each of the villages. These summary figures represent an estimate of the total number of doses of vaccine that will be required for the ring vaccination.
- *Breakdown by district*: For each district that contains villages in the vaccination buffer zone, totals are calculated. Local planning and field operations take place at the district level.
- *Distance from the district veterinary office to the outbreak village*: Some districts are large, and the veterinary office may be located a long way from the outbreak. In such cases it may be more appropriate to use district veterinary officers from other districts who are located closer to the problem area.
- *Number of villages in district*: The total number of villages that require vaccination which are located in the district. This is the component of the work that the district officer is responsible for.
- *Total livestock*: The total number of cattle and buffalo in the vaccination buffer villages in the district. This is an estimate of the number of doses of vaccine that will be require by that officer.
- *Name and telephone number*: Contact details mean that the responsible officers can be contacted quickly and told of the villages for which they are responsible.
- *Road blocks for livestock movement control*: The program calculates the total number and exact location of road blocks that may be required to prevent movement of animals into or out of the vaccination buffer zone. For each potential road block, its exact location in Universal Transverse Mercator coordinates is displayed, as well as the type of road. This information can be transmitted to the police, who can use standard topographical maps to pinpoint the location of the required road blocks. The number of people required to staff each road block can be estimated by the road type.
- *Village access*: The number of villages which lie further than two kilometres from a road is shown. These villages are either accessed by roads not displayed on the map, or in some cases may have no road access. These villages will take more time to access than other more accessible villages.

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[4] ArcView GIS Version 3.0, Copyright © 1992-1996, Environmental System Research Institute, Inc.

In addition to the report, the program creates and displays a database (in dBASE format), listing each village, along with its subdistrict, district and province, number of families, human population, and numbers of cattle, buffalo, pigs and chickens, as well as whether the village has an electricity supply.
After generation and display of the results, the map display remains visible and is available for any of the wide range of further analysis options available in ArcView. This may involve interactively querying any feature by clicking on it, to display all the currently linked attribute data associated with that feature. This could be used to examine the livestock population of villages that fall just inside or outside the boundary of the buffer zone, to consider inclusion or exclusion from the group of villages to be vaccinated. More complex spatial or database queries can be performed, to examine a subset of the buffer zone villages (eg those with large pig populations) or to add further villages to the vaccination buffer (eg villages along a major livestock transport which passes through the outbreak village). All maps and reports can be exported for import into other documents, or printed directly.

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POTENTIAL ENHANCEMENTS

The information provided by the system utilises all the relevant data which is currently available. While already providing most of the key information required for outbreak response management, there are a number of other data sources which may become available in the future, which could further enhance the system.
A potentially valuable enhancement would be to link the village database with a centrally collected database of vaccination records. This database would contain the village identifier, the date of vaccination, the number of animals vaccinated, and the type of vaccine used. This information could be incorporated into the system to estimate the number of animals that may already be protected against the particular virus type responsible for the outbreak, and thus decrease the number of animals needing to be vaccinated. This assumes that either vaccinated animals could be individually identified(perhaps through owner recall), or that the proportion of animals vaccinated during a village vaccination round is high enough to be able to consider the entire village as "protected" for a given time after the vaccination. District level administrative data on the routine vaccination program could be linked to the district veterinary officer database, to provide an indication of the vaccine stocks available at each district office. For emergency buffer vaccination, the adequacy of existing stocks could be assessed, and the location of nearby excess stocks determined.

DISCUSSION

This implementation of a simple outbreak response management system demonstrates how a low-cost GIS can be used with multiple linked data sources to provide fast effective disease control program management information. It also demonstrates how a relatively simple program, written in the Avenue language, allows users with little knowledge of GIS and data linking to access a range of important information instantly.
Several very powerful specialist geographic information systems for animal health, and in particular exotic disease outbreak response exist (Sanson et al., 1993). The system described here is capable of a small part of the functionality of these comprehensive systems. There are two main differences between the two types of system: firstly the current system was much less expensive to develop and maintain, implemented on a single personal computer, and set up by a small team in a short period of time; secondly, the current system uses a relatively small number of existing data sources. For both these reasons, it's outputs are very modest compared to those of its more comprehensive relatives. However these same two factors make the system appropriate for use in developing countries, where improved management of disease control and eradication schemes is much more urgently needed. Government animal health services in these countries are unable to invest the funds in high-end specialist information systems, and the data required to feed these systems is simply not available.
This system was developed specifically for the management of outbreaks of Foot and Mouth Disease in Thailand, by use of ring buffer vaccination. Modification of the system for use in other countries and with slightly different data sources is a simple procedure. The program may also be modified for use with other diseases that occur in outbreak form, and for which ring vaccination is a practical control method. Finally, virus dispersion models, which form a feature of the high-end systems, could be implemented in a very simple form, based on available data on prevailing winds, humidity and temperatures, which is currently available. However, long distance airborne spread of Foot and Mouth Disease virus does not appear to be a significant means of spread in South East Asia. The value of such models, where livestock movements, direct contact or fomites are the main modes of spread, is therefore questionable.

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