



Review of current problems and shortcomings in the Tanzanian animal health information system with suggestions on improvement

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ABSTRACT

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Livestock diseases have always been the focus of the Tanzanian Veterinary Authorities. However, they have become more important since the formation of the World Trade Organisation and subsequent implementation of the various multilateral agreements on trade. There is also a strong political desire to improve the animal health status as part of poverty alleviation strategies. As a result there is a need to develop better systems for investigating and reporting of animal diseases. In order to follow the OIE pathway and to obtain a disease free status, reliable evidence of freedom from particular diseases is becoming an issue of major interest. Assessment of the Tanzanian animal health information system revealed two major problems; firstly, the absence of disease information that accurately reflects the health status of the source population, and secondly, an inefficient information management system which is unable to provide useful information on the spatial component of animal health. A strategic approach is proposed that involves the collection of animal health information using active surveillance techniques and the introduction of a geographic information system. This approach should improve the management and reporting of animal health information.

Keywords: Geographical information system, information system, sampling techniques, surveillance, Tanzania

INTRODUCTION

Tanzania ranks the third in Africa after Ethiopia and Sudan, in the number of livestock kept. Agriculture is the backbone of the national economy, and employs about 85 % of the population. Second to land, livestock is often one of the most important assets for the rural population of Tanzania. Animal diseases can cause severe financial loss, as well as disruptions to livelihood. At the national level the presence of diseases such as foot-and-mouth disease (FMD), contagious bovine pleuropneumonia

(CBPP), African swine fever (ASF) and Newcastle disease (ND) may act as barriers to the export of animals or their products to countries free of these diseases. For Tanzania, with a predominantly agricultural economy this implies that one potential rich source of foreign exchange is not exploited. Additionally, the endemic nature of FMD in cotton producing areas of Tanzania might result in Tanzanian cotton soon being barred from the international markets under the World Trade Organisation (WTO) and Sanitary and Phyto-sanitary (SPS) agreements.

Accurate information about the health of the national herd is critical in the fight against animal diseases (FAO 1999). Without accurate estimates of disease prevalence and economic importance, the govern-

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ment's efforts of setting priorities for disease control are almost impossible. Without a comprehensive disease reporting system and determination of disease incidence, the effectiveness of any control programme and the endpoint of an eradication programme are impossible to measure (FAO 1999). Without an internationally acceptable system of epidemiological surveillance and animal health information management, the establishment of national freedom from disease or a disease-free zone is impossible to achieve (FAO 1999). Animal diseases in Tanzania are usually severe, widespread, and inflict serious socio-economic damage (Mtei 2000; Mwamhehe, Mulangila, Salum & Mtambuki 2000). At the same time, the resources available to identify, assess, and control them are often scarce; it is therefore important that any resources available are effectively directed to those areas where they will achieve the most benefit.

Unfortunately, the current system for collection, management and reporting of animal health information is not able to collect the type of information that is required for informed priority setting. It is not able to meet international requirements for the authentication of claims of freedom from disease (FAO 1999). This is in spite of substantial investment in infrastructure and other disease control programmes, such as laboratory diagnostic facilities and vaccination programmes (for example the recent CBPP and ASF episodes). The information system at the national epidemiology unit is based on passive disease reporting using information from field officers, laboratory submissions and farmers' information, which yield biased estimates of disease occurrence. Information is often processed through an extensive paper-based system in which the important details may be lost, or altered, and the resulting reports can be misleading, awkward or difficult to interpret. The issues relevant to the design and development of animal health information systems form the basis of this paper.

The problem

Given the environmental, economic, logistic, social, political and cultural restraints, is it possible to sustainably improve the collection, management, and reporting of animal health information in ways that are appropriate to Tanzania? In this paper an attempt is made to improve animal the animal health situation by addressing the problems of lack of reliable population based information, poor data management and reporting. The primary goal is to assess whether a significant improvement in the system can be achieved by the development and

implementation of new techniques. The paper tests the hypothesis that an animal health information system incorporating an active surveillance and geographic information system (GIS) will be able to improve the collection, management and reporting of animal health information in Tanzania.

Methodology

An assessment of the value of the techniques proposed in this paper, and whether the hypothesis is supported or not, depends on a comparison between performance of these techniques and the performance of the existing system. In order to make such a comparison, the existing information system in Tanzania is described, and the differences between the existing and the proposed system, incorporating active surveillance and the use of GIS to show disease distribution, can then be assessed and any improvements judged.

An ideal animal health information system

An animal health information system simply refers to a "data base" for collection, storage, analysis and reporting of information related to animal diseases and their determinants. The general aim is to provide information that enables decision makers to help improve or maintain the health and productivity of the national herd, and through this the well-being of their owners. A number of more specific objectives for an ideal system have been published, such as those by Martin, Meek & Willeberg (1987), Thrusfield (1995) and Noordhuizen, Frankena, Van der Hoofd & Graat (1997). These can be grouped in three major categories.

Basic information

Basic animal health information is needed to identify what diseases are present, as well as their level, distribution, risk factors and impact. These estimates must be unbiased and of known precision. Other objectives of an animal health information system are to gather basic ancillary information. Livestock population figures constitute the most basic pieces of information needed for the calculation of epidemiological indices (Martin *et al.* 1987). Other examples include data on livestock movement patterns, and veterinary infrastructure.

To support the implementation of disease control programmes

The system should be able to provide continuous monitoring of carefully selected diseases, to assist

in the development and evaluation of control programmes. Additionally, the system must be able to respond to emerging diseases.

International disease reporting obligations

The information system must provide the information required to meet international disease reporting requirements and to justify disease status claims for the purposes of international trade.

A range of different data is needed to meet these objectives. All the data, however, have one common feature: they all refer to an identifiable geographic location, and underlying the objectives, is the requirement to take the spatial component of disease distribution into account.

COMPONENTS OF AN ANIMAL HEALTH INFORMATION SYSTEM

A comprehensive information system should contain the following components (Martin *et al.* 1987).

Data gathering

Available data sources include reports from diagnostic laboratories, slaughterhouses and slaughter-slabs information, on-farm management information and records, livestock censuses/surveys, disease control programme implementation and monitoring records and notifiable disease reporting records.

Data collation

This involves a series of administrative procedures to get the data from the farmer to the place where it will be used. Most systems are based on the use of forms to record the data and to transmit them to zonal, regional or national centres for collation.

Data storage and manipulation

An effective system must be able to handle a large amount of information efficiently. Paper-based systems are inefficient, and are limited in the volume of information they can handle and the uses to which the information can be put. Computerized systems are more efficient, and in order to store and manipulate spatially referenced data, geographical information systems are required.

Data analysis

Data analysis is required to convert data into information that can be used to assist decision makers.

This may involve descriptive statistics, analytical studies, disease or infection modelling, and risk analysis.

Reporting

The results must be made available to, for example, livestock owners, industrial bodies, local and national veterinary authorities, and international organizations.

THE EXISTING ANIMAL HEALTH INFORMATION SYSTEM IN TANZANIA

Tanzania's animal health information system functions through an administrative ladder; the department of livestock development (DLD) in the Ministry of Water and Livestock Development is responsible for veterinary services, but there is no single centralized division responsible for handling of animal health information. Field services are coordinated through seven veterinary investigation centres (VIC), 113 local government authorities, 2 410 wards and 10 102 villages. Very few villages have village extension officers (VEO) and/or livestock field auxiliary officers (LFAO). Village extension officers have basic animal health training at a certificate or diploma level and are responsible to the local government authorities. They provide basic services for village livestock industry, such as treatments and vaccination.

Disease information is based primarily on clinical observations. Field reports of disease outbreak investigations and treatment records are all paper-based. In a typical situation, the farmer contacts the VEO who fills in a surveillance form for submission to the district veterinary officer (DVO). The DVO submits surveillance forms from the field every fortnight. In the case of a notifiable disease, notification of the outbreak is compulsory, and each notified outbreak must be investigated by the DVO and samples of tissues from diseased animals sent to the VIC for confirmation. A series of reports must be made: the first is notification of the outbreak, followed by those monitoring its progress, and finally the confirmation of its resolution. The DLD office, which is responsible for national and international reporting, compiles these reports. However, in practice, these regulations are rarely observed. Information on livestock population and vaccination is only available from the submission forms, but no records on livestock movements are made. There is no formal analysis of these records, although they are compiled for national and international

reporting purposes. A CBPP control programme is currently under way, but there is not any active surveillance to back up the programme. The main problems associated with the current information system include under-reporting and delayed reporting as a result of a lack of commitment and morale by the field officers. The proportion of reported cases is estimated to be $\leq 10\%$, $1 - 0.1 = 0.90$ being the level of underreporting. The existing system is known for its inherent bottlenecks including lack of reliable population information, lack of staff trained in epidemiology and information management at the district and regional levels, lack of equipment for computerized information management, weak organization, lack of a well established communication network and inadequate logistical support. Veterinary services are under the control of district local authorities, leading to difficulties in the coordination of animal health activities. In addition, due to the chronic lack of funds, the VICs and the central veterinary laboratory (CVL) have not been able to conduct the required routine diagnostic work with the result that there is no information to record. Despite these problems some data is maintained on computer spreadsheets. These deficits have resulted in inadequate flow of information to producers, decision-makers, donor agencies, and researchers, local and international authorities. The consequences of this are weaknesses in livestock policy formulation, poor resource allocation, and inefficient extension service to livestock keepers, low production, low private and public sector investment, environmental pollution and reduced impact of donor-funded projects. Economic evaluation of inputs and outputs of the livestock industry are difficult because the present official reporting system is run down.

Dissemination of information

The usual flow of animal health information is from the farmer through the VEO / LFAO, DVO and VIC to the national epidemiology unit. National and international reporting is achieved through participation at local (Tanzania Veterinary Association) and international conferences, publications and occasional reporting to the Office des International Epizooties (OIE).

Failures of the existing system to fully meet the objectives

Basic information

The existing system is only partially able to identify which diseases are present and their spatial pat-

terns. Information from laboratory submissions may be used to identify which diseases are being diagnosed more frequently (assuming effective and correct laboratory diagnosis), and provides reliable information on which diseases are present in the country. However, it does not provide any information about which diseases are not present, or the significance of those present. Furthermore, such information is highly biased. The system is unable to make valid incidence or prevalence estimates. The disease information upon which these estimates must be based comes from the diagnostic laboratory submissions. The proportion of actual cases of diseases that results from submissions and the source population are unknown. The only type of figure that can be calculated is, for instance, the number of blood slides per 1 000 cattle submitted for the diagnosis of theileriosis. This figure is influenced by so many factors that it is of no use as an indicator of disease occurrence.

The system is not able to collect valid, quantitative epidemiological data that are necessary to determine the epidemiology, geographical and temporal patterns of disease, and risk factors associated with the major diseases. There is no capability to manage, analyse or report information on the spatial distribution of diseases, except in crude tabular form, or through the use of inaccurate, hand-drawn maps. The system does not collect information on the impact of diseases. Studies to collect this information would enable estimates of the economic impact of diseases.

The statistics unit of the Ministry of Agriculture and Food Security collects village livestock population figures, which can be used to estimate the population at risk for incidence or prevalence calculations. Although these data sources may be reported, there is no integration of this data with the rest of the system. For example, vaccine usage data for a particular area cannot be easily linked to outbreak data from submission database, or population data to help determine the likely number of susceptible animals in the area. Livestock movement data is not recorded and analysed for movement patterns that could be linked to outbreak data in order to predict areas of likely spread. There is no capability for this type of spatial analysis or modelling.

Weaknesses in the current system, such as the inability to make assessments of the relative economic impact of different diseases, mean that the basis on which decisions are made may not be valid. This hinders rational and informed national policy formulation and evaluation. The analytical

and data integration capabilities are non-existent, so that the correct information is often not available for decision makers. A good example of the latter is that of the 2000 CBPP episode where the Government was informed that the major problem to CBPP control was lack of funds. Reporting systems are based on the use of written or verbal communication and tabulated data. These forms of communication may make it difficult for the decision makers to grasp the real issues.

Implementation of disease control programmes

No continuous monitoring is taking place in the 2000 CBPP control programme, so there is no data available that may assist in programme evaluation. The laboratory submission system that is currently in place is appropriate for detection of emerging diseases. If specimens are submitted from unusual cases, then new diseases may be identified. However, problems may occur when a disease appears in areas where submission rates are low; the 2001 ASF epidemic occurred in the Mbeya region near the Tanzania-Malawi border in March 2001, and

was diagnosed and confirmed in June 2001, after it had spread to Dar es Salaam some 1500 km away.

International disease reporting obligations

The requirements of the OIE are to report the presence or absence of list A and B diseases, and to give figures for the number of cases. These requirements represent the lowest common denominator of information that most countries should be able to supply and do not request valid estimates of disease prevalence or incidence. Assuming competent laboratory diagnosis, the current system is able to provide reliable information on which diseases are present and have been diagnosed. However, the system is unable to provide credible measures of disease occurrence or support claims of a disease-free status.

Furthermore, the existing database does not provide reliable information. For example, Table 1 shows the number of animals affected by FMD in Tanzania between 1996 and 2001 as reported to the OIE (OIE 2002) whereas Table 2 shows the

TABLE 1 Foot-and-mouth disease status in Tanzania as reported to the OIE between 1996 and 2001

Year	Species	Outbreaks	Cases	Deaths	Serotypes
1996	Bovine	105	1 013	15	SAT-3 ^a ; O
1997	Bovine	55	3 450	11	SAT-3 ^a ; O
1998	Bovine	19	1 378		
1999	Bovine	287	40 291	1 190	SAT-1; SAT-2; O
	Caprine	2	113	6	—
	Swine	2	21	1	—
2000	Bovine	113	7 189	597	SAT-1; SAT-2; O
2001	Bovine	75	7 655	165	

^a Reported for the first time in Tanzania by the United States Animal Health Association

TABLE 2 Foot-and-mouth disease status in Tanzania as compiled from the reports sent to the Animal Disease Research Institute by the veterinary investigation centres for the period 1996 to 2001

Year	Species	Outbreaks	Cases	Deaths	Serotypes
1996	Bovine	786	12 354	528	O
	Swine	21	108	63	—
1997	Bovine	1 713	20 594	856	O; SAT-1
1998	Bovine	203	6 872	412	O
	Caprine	98	653	1 334	—
	Ovine	103	587	1 256	—
	Swine	74	39	27	—
	Bovine	420	3 872	793	SAT-1; SAT-2
1999	Swine	53	209	115	—
	Bovine	335	16 895	2 745	SAT-1; SAT-2; O
2000	Caprine	83	1 438	378	—
	Ovine	76	589	204	—
	Swine	30	637	388	—
	Bovine				

corresponding data as compiled from veterinary investigation centres reports at the Animal Disease Research Institute. Such inconsistencies in reporting weaken the credibility of disease status claims. For international trade purposes, trading partners are now in position to demand epidemiologically sound substantiation of claims of disease freedom or of disease prevalence levels. The existing system in Tanzania is not able to provide proofs that would withstand epidemiological scrutiny. The agreement on Application of Sanitary and Phytosanitary (ASPS) introduces the concept of disease-free zones. If FMD is endemic in only part of the country, it is possible to establish infected and disease free zones in order to retain partial access to international livestock markets.

There are many reasons for these failures, most of which are outside the control of the veterinary authorities: for example education and training, infrastructure, and financial constraints. However, it is clear that two key shortcomings within the veterinary authorities severely limit the effectiveness of the existing animal health information system: the absence of suitable measures of disease occurrence at the population level, and problems with data management.

Absence of suitable measures of disease occurrence

Disease information in the current information system is collected primarily through the field reports and diagnostic laboratory submission forms. This is a passive surveillance system, meaning that veterinary authorities do not initiate the collection of the information, but instead, wait for the information to come to them. The farmers initiate the process by case reporting and, in some instances, by submission of tissue specimens to a laboratory in order to arrive at a diagnosis, so that the disease problem can be solved. The use of this data for the animal health information system is secondary to the reasons why the data is being generated. Passively-acquired data has the advantage that it may be less expensive to use than other data sources. All that is needed is a recording system, as the data is already being generated for diagnostic purposes. The disadvantage of passive surveillance is that the disease information is usually incomplete and reliable measures of disease occurrence cannot be calculated. One of the goals of passive surveillance is to calculate the incidence of specific diseases and thus the complete enumeration of cases is assumed. Every case of the target disease is assumed to have been recorded. If the size of the

population at risk is known or can be reliably estimated, then the disease prevalence can be calculated. Unfortunately, the assumption that every case is reported is rarely valid, and as a result, the routine analyses of data from most passive reporting systems are of marginal value. The completeness of passive reporting depends on factors influencing the probability that the farmer will seek advice for the problem, and on those influencing the probability that the person whose advice is sought will report the case to the authorities maintaining the disease database. In real life the disease would be an unusual, spectacular, debilitating disease which does not cause sudden death, and which can be easily diagnosed. Furthermore, it could be a disease that has been the subject of the education campaigns, or compulsory notification legislation, so that animal health professionals are likely to report the disease to the appropriate authorities (e.g. the 2000 CBPP epidemic in Tanzania has been declared a national disaster and therefore has a high rate of reporting).

Data management

Each different type of data is analysed and reported in isolation, that is, laboratory submission data, livestock population data, movement data, vaccination data and surveillance data. To provide value-added information to decision makers and disease control programme administrators, these different data sources need to be linked together, so that the relationships between them can be better understood. The current data management system is not able to fully incorporate the spatial component of animal health information. A proper understanding of the geographical distribution of livestock diseases is essential for the development of national disease control programmes, the establishment of disease-free zones, and management of veterinary resources (English 1992). Currently, only tabular breakdowns by administrative units—districts/regions—are routinely available. These provide no information as to the relationships between neighbouring areas, or trends. The spatial component of disease distribution is another form of data that needs to be integrated with existing data sources to achieve better data management and more efficient analyses.

APPROACHES TO IMPROVE THE ANIMAL HEALTH INFORMATION SYSTEM IN TANZANIA

Many problems have been identified with the existing information system; a wide range of solutions

would be needed to address them all. Many of these problems are beyond the control of the veterinary services and are dependent on the gradual process of national development for solutions. Various other components are required for a fully functional information system, such as effective diagnostic laboratories. However, what is proposed in this work is that the main limitations of the Tanzanian information system can be addressed using a strategic approach to implement the key elements necessary for an effective system. These key elements are: improve information gathering, based on active surveillance, to quickly collect data for reliable, unbiased measurements of disease occurrence; and application of a GIS to improve animal health information management, reporting and priority setting. In order for these key elements to be effective in the Tanzanian context, they must meet a set of four key criteria arising from the constraints faced by the country. Any solution must be able to be implemented at a reasonable cost relative to the benefit achieved. The information must be reliable and be able to be gathered and processed quickly, so that it is still relevant when it is used for decision-making. Any solution must be able to be practically applied and be appropriate for the situation in which it will be used.

Active surveillance

Surveillance may be thought of as having a broad definition, in the sense of watching an animal population closely in order to see if a disease makes an incursion. The object of surveillance is early detection of disease. Last (1988) defines surveillance as "on-going scrutiny, generally using methods distinguished by their practicability, uniformity and, frequently, their rapidity, rather than by their accuracy. Its main purpose is to detect changes in trend or distribution in order to initiate investigative or control measures". Passive surveillance is usually thought of as regular—and perhaps infrequent—visits to an area by veterinary staff to assess the local animal situation and determine livestock populations. It would include voluntary disease reporting by farmers, traders and perhaps other individuals such as private veterinarians. "Active" surveillance entails frequent and intensive efforts to establish the presence or absence of disease in an area. Any activity, which is frequent, intensive and aims at establishing the presence or absence of a specific disease, could be described as "active" surveillance. Once the presence of a disease is confirmed, and similar techniques are then used to follow trends in its development, this would (at least in terms of cur-

rent terminology) be called "monitoring". There is no doubt that active surveillance activities can be expensive and time-consuming. There are benefits, however, that in the long run will outweigh the costs. In the first instance, commencing active surveillance (at least for diseases such as rinderpest and FMD) means that vaccination has ceased, and huge amounts spent on blanket vaccination campaigns will be saved. Secondly, there are trade benefits to be gained—eventual proof of disease absence will allow the opening-up of hitherto untapped markets.

Surveillance in a resource-poor country

Surveillance often presents itself as a thorny issue in developing countries because it is seen as a costly operation necessitating an enormous army of surveillance personnel on the ground. This need not be so, and judicious deployment of resources can often achieve what is needed without great expense.

Critical point identification

The first step in setting up a "low-cost" surveillance system involves identifying critical points or critical surveillance areas. These would include areas under direct threat of disease (perhaps due to the presence of a nearby focus), border crossings, watering points or slaughter-slabs near migration routes, auction pens and other major livestock assembly points, and abattoir lairages. These are valuable sources of data, particularly when it comes to diseases that present laboratory diagnostic difficulties, such as CBPP. Export abattoirs are always closely monitored by veterinary officials, and instituting a reporting system to extract information from them would present no problem. Smaller abattoirs and slaughter-slabs present something of a problem in that there may not be enough official staff to keep them under surveillance. Possible solutions to this would include entering into agreements with those running smaller facilities—or even butchers at slaughter-slabs—to alert the authorities in the event of a possible trans-boundary disease being detected on slaughter. This will require some investment in terms of basic meat inspection training and the recognition of characteristic lesions, but it may be well worth the outlay. Random inspection of slaughter-slabs or small abattoirs by officials who might spend a day or half a day keeping watch on the proceedings at a particular place, and then move to other duties, or to the next slaughter-slab, is another possibility, as is intensive inspection

activity that could be reserved only for those facilities perceived as being in "high-risk" areas. A suggested way of improving reporting and overall compliance with disease prevention is to make the seller of an animal responsible for both on-site and off-site costs associated with selling an animal with a notifiable disease. This would tend to make the market place a centre for disease control rather than its spread (Hanson & Hanson 1983).

Resource deployment

The bulk of veterinary resources should then be deployed at these critical points, with high frequency surveillance designed to move staff amongst such points with relative rapidity for whatever type of surveillance is deemed appropriate—visual (for detecting clinical/pathological signs), detection of antibody, and detection of the causative agent. Such surveillance is fairly structured but not sufficiently randomised for movement along an OIE pathway. It would, however, qualify a country for entrance to a pathway if it gained sufficient evidence of clinical disease absence - the point is that the work would have to be restructured along more "scientific" lines in order to move further along an OIE pathway. The frequency of surveillance at these critical points is a matter of common sense and would have to be determined by the perceived risk of each point, with the higher risk points receiving the most frequent attention. Frequency of surveillance will, on the one hand, be determined by the frequency of population turnover (e.g. along trade routes) and by the incubation period of the main disease feared at the time.

Non-critical areas

All other parts of the country would be deemed to be non-critical areas where surveillance could consist of relatively infrequent visits by field personnel (perhaps once or twice per year) or annual Rapid Appraisals relying heavily on group interviews. Useful information can also be gathered from other existing networks, e.g. non-governmental organization (NGO) workers, crop extension officers who may happen to be in the area and consultants. An essential item in any surveillance system is farmer awareness. Training local livestock owners in disease recognition and encouraging them to report the presence of any suspicious clinical signs is a very cost-effective means of improving the quality of disease surveillance, both in critical and non-critical areas. There may even be a possibility of a small incentive to be provided for evidence leading

to the discovery of a disease, e.g. a fee to be paid should a farmer submit part of a diseased lung for CBPP examination. Data from private veterinarians and para-veterinarians are important items not to be forgotten. Capture of this may be via questionnaires sent to them regularly, a legal requirement for them to report certain diseases to the authorities, and by making the use of an official government questionnaire obligatory when sending samples to the laboratory. In this way, data from laboratory submissions will enter the system automatically.

Survey sampling techniques

Surveillance would have to be organised so that it is random, representative of the target population, allows inference back to that population, produces unbiased estimates and covers the required number of animals at a 95 % confidence level to give reasonable assurance of the absence of disease. However, in the Tanzanian context there is a pressing need to use practical, rapid techniques rather than those that are extremely precise. A standard design employed by the WHO offers suggestions of how surveillance systems may be adapted to suite local conditions.

In the Expanded Programme for Immunisation (EPI) a range of techniques for Rapid Epidemiological Assessment (REA) has been developed (Smith 1989). These techniques include inexpensive, rapid survey techniques using a two-stage cluster sampling strategy. REA cluster surveys involve selection of 30 villages (selected with probability proportional to size) and seven people from within each village (the "30 by 7" design). The logic underlying this design is that a target precision in estimation of a population proportion of $\pm 10\%$ is sought. If we assume that the actual proportion (p) is not known, and we wish to estimate within 10% of the true level 95 % of the time, the required sample size is: $n = Z^2_{\alpha}/4 * L^2 = 1.96^2/4 * 0.1^2 \approx 97$. Using an intra-cluster correlation coefficient (ρ) of 2.0 (assuming that two stage sampling is half as efficient as simple random sampling), a sample size of at least about 200 is indicated. The standard design of $n_1 n_2 = 30 * 7 = 210$ meets this requirement. However, in practice there is often some loss of randomness in the second stage of sampling because of difficulties in selecting households and individuals which may dictate a larger sample size. Although the data produced from such a small survey is not very precise (aiming at a confidence interval of $\pm 10\%$) it is unbiased, of known precision and can be quickly col-

lected (Anker 1991). The advantages of this design for Tanzania are that it is operationally simple, inexpensive and reasonably robust (Henderson & Sundaresan 1982)

Estimating the cost of sampling

A widely used cost function for two-stage sampling is the following formula of Snedecor & Cochran (1989): $K = k_0 + k_1k_1 + k_2k_1k_2$, where k_0 are the overhead costs, k_1 and k_2 are costs per primary (k_1) and secondary (k_2) sampling units respectively. In practice, overhead costs are sometimes ignored in sample-size determinations, since they do not depend on n_1 and n_2 . One may vary the number of primary and secondary units selected according to the costs of sampling primary units (e.g. villages) as well as the costs of sampling secondary units (e.g. herds within the village). In a FMD survey the cost of travelling to a village to obtain samples may be large relative to the cost of obtaining a sample from an individual animal once on the farm. This would suggest an increase in the number of secondary units and a decrease in the number of primary units to reduce the total cost of sampling. The appropriate number of secondary units to select, minimising costs for a given precision (Snedecor & Cochran 1989), is $n_2 = \sqrt{(c_1S_2^2/c_2S_1^2)}$. Despite the high cost per village, the relatively large between-village variability dictates that a large number of villages are required. In this case, if $c_1 = c_2$ the ratio $(S_2^2/S_1^2)^{1/2}$ indicates that one herd per village should be selected.

The use of geographical information systems in animal health

An advance in information systems, which provides a powerful tool in spatial analysis, has been the development of a GIS. The role of a GIS has been defined as to "efficiently capture, store, update, manipulate and analyse geographically referenced data" (Sharma 1994). A modern GIS provides a number of capabilities including the rapid generation of maps indicating the spatial characteristics of animal health information, for example, livestock populations, disease incidence/prevalence, risk factors and control activities. While an understanding of the spatial distribution of disease is important for a full appreciation of the epidemiology of the disease, this information is even more important for some of the other roles of an animal health information system. To effectively support disease control and eradication programmes, the spatial distribution of the disease and the susceptible popula-

tion must be understood. Spatial patterns of livestock movements are able to help predict the risk of disease spread. The establishment of a disease-free-zone for international trade purposes requires a clear understanding of the spatial distribution of diseases and their determinants in and around the zone, and the examination of the association between spatial variables by the combination of database layers within the system, for example the association between disease incidence and characteristics of the livestock population. A GIS can also be used in the operational management of an outbreak to outline the protection, buffer and surveillance zones.

Animal health information has spatial characteristics and the GIS are becoming an integral part of animal health information systems. Applications of a GIS in animal health have been reviewed by Sanson, Liberona & Morris (1991) who noted that a GIS had been applied in three main areas, namely: to support general disease surveillance, control and eradication; to manage information for specific livestock diseases and information on disease spread, and to support major national emerging disease eradication programmes.

The potential benefits for animal health information systems are clear, but the use of powerful GIS systems seems to be limited to specific research projects and a few information systems in developed countries. The Namibian experience (Larbodiere, Goutard, Amuthenu, Bamhare & Hendrikx 2001) shows that this is not necessarily the case and affordable personal computers that are currently available provide enough power to run a fully-fledged GIS package. A simple national system could conceivably be run on a single machine. Even when data availability is limited, as is the case in Tanzania, establishing a very useful and cost-effective system is possible.

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REFERENCES

- ANKER, M. 1991. Epidemiological and statistical methods for rapid health assessment. Introduction. *World Health Statistics Quarterly*, 44:94-97.
- ENGLISH, D. 1992 Geographical epidemiology and ecological studies. *Geographical and environmental epidemiology*.

- Methods for small-area studies*, edited by P. Elliot, J. Cuzick, D. English & R. Stern. Oxford: Oxford University Press.
- FAO 1999. New technologies in the fight against transboundary animal diseases, *Animal production and health paper*.
- HANSON, R.P. & HANSON, M.G. 1983. *Animal diseases control: Regional programmes*. Ames: Iowa State University Press.
- HENDERSON, R.H. & SUNDARESAN, T. 1982. Cluster sampling to assess immunisation Coverage: A Review of experience with simplified sampling method. *Bulletin of the World Health Organisation*, 60:253–260.
- LARBODIERE, L., GOUTARD, F., AMUTHENU, N.S., BAMBARE, C. & HENDRIKX, P. 2001. Epidemiological information systems for communal areas: The Namibian experience, edited by B. Gummow & P.N. Thompson. Southern African Society for Veterinary Epidemiology and Preventive medicine. *Proceedings of a Meeting held at the Onderstepoort Veterinary Institute, Onderstepoort, Gauteng, South Africa*, 2001: 2–10.
- LAST, J.M. (Ed). 1988. *A dictionary of Epidemiology*, 2nd ed. New York.
- MARTIN, S.W., MEEK, A.H. & WILLEBERG, P. 1987. *Veterinary epidemiology: principles and methods*. Ames: Iowa State University Press.
- MTEI, B.J. 1999. Hundred years of fighting rinderpest in Tanzania. *Proceedings of the 17th Scientific Conference of the Tanzania Veterinary Association held at AICC, Arusha, Tanzania, 30th November to 2nd December 1999*, 19:57–166.
- MWAMHEHE, H.A., MULANGILA, R.C.T., SALUM, M.R. & MTAMBUKI, R. 1999. Transboundary diseases outbreaks: their current and future implication on survival of the live-stock sector in the southern Tanzania. *Proceedings of the 17th Scientific Conference of the Tanzania Veterinary Association held at AICC, Arusha, Tanzania, 30th November to 2nd December 1999*, 19:207–210.
- NOORDHUIZEN, J.P.T.M., FRANKEN, K., VAN DER HOOFD, C.M. & GRAAT, E.A.M. 1997. *Application of quantitative methods in veterinary epidemiology*. Wageningen: Wageningen Pers.
- OFFICE INTERNATIONAL DES EPIZOOTIES 2002. *World animal health reports*. <http://www.oie.int/>
- SANSON, R.L., LIBERONA, H. & MORRIS, R.S. 1991. The use of a geographical information system in the management of a foot-and-mouth epidemic. *Preventive Veterinary Medicine*, 11:309–313.
- SHARMA, P. 1994. Use of geographic information systems in animal health programmes, in *Diagnosis and epidemiology of foot and mouth disease in southeast Asia*, edited by J.W. Copland, L.J. Gleeson & C. Chamnanpood. Canberra ACIAR.
- SMITH, G.S. 1989. Development of rapid epidemiologic assessment methods to evaluate health status and delivery of health services. *International Journal of Epidemiology*, 18: S2–S15.
- SNEDECOR, G.W. & COCHRAN, W.G. 1989. *Statistical methods*, 8th ed. Ames: Iowa State University Press.
- THRUSFIELD, M. 1995. *Veterinary Epidemiology*, 2nd ed. London: Blackwell Science.