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Working Paper No. 25

Animal Health Information Systems

by

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Gavin Ramsay[1]

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[1] School of Economics, The University of Queensland, St. Lucia Campus, Brisbane QLD 4072, Australia
Contact Clem Tisdell: Email: c.tisdell@economics.uq.edu.au

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'The overall goal of this project is to develop and evaluate the .necessary tools to provide decision-makers with reliable animal health information which is placed in context and analysed appropriately in both Thailand and Australia. This goal will be achieved by improving laboratory diagnostic procedures; undertaking research to obtain cost-effective population referenced data; integrating data sets using modern information management technology, namely a Geographical Information System (GIS); and providing a framework for the economic evaluation of the impact of animal diseases and their control.

A number of important diseases will be targeted in the project to test the systems being developed. In Thailand, the focus will be on smallholder livestock systems. In Australia, research will be directed at the northern beef industry as animal health information for this sector of livestock production is presently scarce.'

For more information on *Research Papers and Reports Animal Health Economics* write to Professor Clem Tisdell (c.tisdell@economics.uq.edu.au) or Dr Steve Harrison,(s.harrison@uq.edu.au) Department of Economics, University of Queensland, Brisbane, Australia, 4072.

ANIMAL HEALTH INFORMATION SYSTEMS

ABSTRACT

This paper examines the development of animal health information systems at the farm, national and international level, with examples of some systems that have been developed. Methods for the assessment of animal health information systems are then examined. This is followed by an outline of the national animal health information system (NARIS) currently being developed in Australia, with special emphasis on the system of Structured Animal Health Surveillance (SAHS) being set up in Central Queensland.

Keywords: Animal disease, animal health information systems, animal disease prevention

JEL Classification: Q160

ANIMAL HEALTH INFORMATION SYSTEMS

1. Introduction

Animal health information systems are systematic methods for the collection and analysis of animal health data. Animal health information is recognised as necessary for the setting of animal health priorities (Morris, 1991).

Animal health data can consist of observations on the occurrence of disease, laboratory diagnoses of disease and the results of serological studies. These data can be transformed by a variety of methods of analysis into animal health information. Animal health data can be collected and analysed on an individual farm, regional, state, national or international level (Morris, 1991; Blajan and Chillaud, 1991) and are used for a variety of purposes including:

- determining the level of disease occurrence and the effect of disease on livestock production. This information can then be used to estimate the benefits of controlling the disease (Faugere et al., 1991);
- determining if a disease is present or absent from an area for the purposes of trade. This may involve certifying that an area is free of a disease for, export certification or to prevent imports from areas where the disease occurs (Blajan and Chillaud, 1991);
- detecting new disease outbreaks or the onset of epidemics of specific diseases (Moore et al., 1992). This includes detecting the spread of a disease from one place to another within and between countries;
- providing information on the way diseases not currently present in a country may spread should they gain access (Ellis, 1993: Sanson et al., 1991);
- monitoring the progress of specific disease control or eradication programs (Ryan and Yates, 1994);
- maintaining consumer confidence in the quality of the product (Anon., 1996)

Each of these requires different information from the analysis of the animal health data and may require that specific methods of data collection and analysis are set up to meet the requirements (Dohoo, 1994; Morris, 1991).

In the past, national disease information systems have been of limited value. This has been

especially so where government veterinary services have simply collated and published the distribution of outbreaks of diseases that are legally notifiable and have been reported to them (Ellis, 1993; Leech, 1971). In this case the information rarely provides a useful indication of the disease situation in the country because of under- reporting of disease by farmers and the inability of government veterinary services to provide coverage of all livestock producers (Ellis, 1993). Additional data were in some cases collected by the use of national surveys such as those carried out in Britain (Leech, 1971). The aim of these surveys was to provide a general picture of the diseases affecting farm livestock.

Dohoo (1994), Martinez et al. (1992), Morris (1991) and McLeod and Tyler (1991) have reviewed the requirements of, and methods for, the development of animal health information systems. In the development of a system it is important that the purpose for collecting the data and the method for the analysis of the data are clearly defined before the collection of data begins. Once in place, the system should be reviewed regularly to determine the validity of the findings and the effectiveness of the collection and analysis (Morris, 1991). The users of the information may require training to enable them to make effective use of the information being produced (Dohoo, 1994).

This paper examines the development of animal health information systems at the farm, national and international level, with examples of some systems that have been developed. Methods for the assessment of animal health information systems are then examined. This is followed by an outline of the national animal health information system (NARIS) currently being developed in Australia, with special emphasis on the system of Structured Animal Health Surveillance (SAHS) being set up in Central Queensland.

2. Individual Farm Animal Health Information Systems

Animal health information systems are used by individual farmers and their advisers to determine ways in which livestock productivity and profitability can be improved by the implementation of disease prevention measures. This section examines information systems developed for cattle farms.

Early information systems were developed to support herd health programs on dairy farms. Dairying is an intensive enterprise which allows regular data collection on cow health and production (Morrow, 1963; Cote, 1963). The herd health programs were developed as a result

of the realisation by farmers and veterinarians that subclinical disease is a significant contributor to reduced livestock production (Radostits and Blood, 1985, p. 4). These systems collect and analyse health and production data that can then be compared with targets set by the farmer and his advisers. The reasons for failure to achieve the targets are identified, and changes in management are made to improve the herd's health and production (Radostits and Blood, 1985, p.4).

Initially, card systems were used to record health and performance data for individual animals (Cote, 1963). In the 1970's computer programs were developed to record health and production data and enable rapid analysis of those data (Blood et al., 1978; Weaver et al., 1987; Radostits and Blood 1985, p. 13). Lissemore (1989) has reviewed the development of dairy herd health programs and examined their development from production recording systems to microcomputer programs.

Sophisticated computer-based decision-support systems have also been developed which make use of the information produced by animal health information systems and allow the fanner to simulate the effects of disease control decisions on herd production. An example of such a system is the one developed by Jalvingh (1994) which uses a computer model to simulate herd dynamics and can be used to calculate the consequences of disease management strategies on herd structure and production. In another example, the decision support system, DairyORACLE, has been designed to link directly to an animal health information system, DairyCHAMP (Marsh et al., 1987).

Animal health information systems for beef cattle properties have been fewer and slower to develop. One reason for this is beef cattle production is less intensive. Stock are yarded less frequently hence there are fewer opportunities to collect animal health data, and to make use of these data in decision making. Methods to collect data on disease and production, other than the collection of individual data, are needed for these systems. Some animal health information systems developed for individual farms are listed in Table 1.

3. National and Regional Animal Health Information Systems

The most common aim of national animal health information systems is to provide quantitative and reliable information that can be used by veterinary administrators and field veterinarians to evaluate progress in disease control and determine future directions for

disease control efforts (Morris, 1991).

Table 1 Examples of animal health information systems

International	National and regional	Farm
OIE (Blajan & Chillaud, 1991)	NAHIS (Gamer and Canon, 1994)	DairyCHAMP (Marsh et al., 1987)
HandiSTATUS (Bernardo et al., 1994)	NAHMS (King, 1990)	APIDN (Dohoo, 1988)
CAPdat (Pegram et al., 1996)	Namibia (Hare and Biggs, 1996)	FAHRMX (Bartlett et al., 1986)
Haemoparasite Information Network (Vokaty et al., 1994)	Israel (Van-Ham, 1994)	Daisy (Stephens et al., 1982)
	CDR (Ogwang & Heinonen, 1994)	DHMS (Menzies et al. 1988)
	Nigeria (Ogundipe et al., 1989)	COSREEL (Russell and Rowlands, 1983)
	APHIN (Dohoo, 1988)	Danish pig health scheme (Willeberg et al., 1984)
	CORRAL (Lees & Fedorick, 1994)	
	Switzerland (Stark, 1995)	
	QARDS (Elder, 1976)	
	Thailand (Meephuch, 1993)	
	New Zealand (Ryan & Yates, 1994)	
	REPS (Christensen et al., 1994)	

Many national systems are passive and rely on disease outbreaks to be reported to government officials or specimens to be submitted to diagnostic laboratories. Such a system is in place in Nigeria but has been found to suffer from late and inaccurate reports as well as under-reporting (Ogundipe et al., 1989). However, in spite of these difficulties the system was felt to have a beneficial role in several areas, including epidemiologic and economic studies, determining vaccine requirements on a regional basis, the planning of veterinary education and. assisting decisions on the most appropriate locations for new livestock enterprises (Ongundipe et al., 1989).

In other national animal health systems, information is provided on the progress of specific disease control programs. An example of such a system is the one developed for the monitoring of bovine tuberculosis in New Zealand (Ryan and Yates, 1994).

Two systems, one national, the National Animal Health Information System (NAHMS) in the U.S.A, and one that is at both farm and regional level, the Animal Productivity and Health Information System (APHIN) in Canada, are examined in Sections 3.2 and 3.3 respectively.

The two systems contrast in the way they have been developed, with NAHMS developed by a government organisation and APHIN by a group comprising government, university and producer agencies.

3.1 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 geographical information systems (GIS). The role of a GIS has been defined as to "efficiently capture, store, update, manipulate and analyse geographically referenced data" (Sharma; 1993). Modem GIS provide a number of capabilities including:

- the rapid generation of maps indicating the spatial characteristics of animal health information, for example, livestock populations, disease incidence, risk factors and control activities, and
- the examination of the association between partial variables by the combination of database layers within the system, for example, the association between disease incidence and characteristics of the livestock population.

Animal health information has spatial characteristics and the GIS are becoming an integral part of animal health information systems. Applications of GIS in animal health were reviewed by Sanson et al. (1991) who notes that GIS has been applied in three main areas, namely:

- to support general disease surveillance, control and eradication (Arambula and Astudillo, 1991; Vander Logt et al., 1994),
- to manage information for specific livestock diseases and information on disease spread (Norman et al., 1994; Carpenter et al., 1994; Marsh et al., 1991; Lessard et al., 1990), and
- to support major national exotic disease eradication programs (Glanville et al., 1994; Sanson et al., 1994; Sanson et al., 1991).

A complex integrated animal health information system using a GIS as a base is being developed in Thailand to collect and analyse animal health information as part of an ACIAR project (Baldock, 1994; Sharma, 1994).

3.2 The national animal health monitoring system

In the United States a system was developed in response to calls to monitor endemic diseases of livestock. The system was developed following a recommendation that a national system be implemented to define animal disease problems through effective morbidity and mortality reporting (Poppensiek and Budd, 1966 cited in King, 1990).

The National Report of Animal Diseases (NRAD) that was developed used monthly reports from private veterinary practitioners augmented by records from veterinary school clinics and state diagnostic laboratories. The National Animal Morbidity Report (NAMR) was developed to supplement the NRAD and covered disease control and eradication programs. The NRAD was discontinued because it was expensive to maintain and regarded as biased, often misleading and of little practical use (King, 1990).

The need for a system that would allow the collection of valid data and its unbiased interpretation was recognised. In order to produce such a system the objective was further defined as "to develop methods for accurately estimating the prevalence, incidence, trends and economic impact of economically significant diseases and conditions in the United States" (King, 1985). This system is known as the National Animal Health Monitoring System (NAHMS). Initially a number of pilot programs were carried out to examine the methods to be used. The results of these programs have been published by Gardner et al., 1990, Hurd and Kaneene, 1990, Kaneene and Hurd, 1990, Salman et al., 1991, Hird et al., 1991 and Wittum et al., 1990.

The sampling design used in NAHMS was stratified random sampling with the probability of selection proportional to size (King, 1990). Randomly selected herds and flocks are also stratified relative to herd or flock size and according to species and production type. Inferences can therefore be made within each of these defined sub- populations (King, 1990).

The NAHMS data are collected using several methods which include interviews of livestock owners and the maintenance of health and productivity diaries by participating farmers. In addition, biological specimens such as blood samples are collected and analysed. Locally collected data are analysed and forwarded to a national centre where they are aggregated and regional and national reports produced. Reports for individual producers are also produced.

NAHMS has concentrated on the collection of data from pig and dairy industries but has also

examined the more difficult area of rangeland beef production (Salman et al., 1990; Wittum et al., 1990, Hird et al., 1991). Management and environmental inputs are characterised in terms of farm performance, profitability and risk through the combination of descriptive statistics and risk factor identification (Heuston, 1990).

Information on the cost of various disease problems has also been collected in an attempt to clarify and define the disease priorities (Kaneene and Hurd, 1990; Miller and Dorn, 1990; Sischo et al., 1990; Hird et al., 1991; Salman et al., 1991). The cost data provides a baseline on the health and production of the herds sampled. The main use of this information has been to compare the animal health performance between properties and to enable producers to improve management of animal health. This information has been that most desired by the producers (King, 1990). While NAHMS examines the expenditures made by farmers on controlling and treating specific diseases, the system does not provide a framework for the analysis of the costs and benefits of controlling these diseases.

Brown et al. (1993) have made use of these baseline data to estimate the benefits of internal parasite control. They found the NAHMS information provided a useful description of a typical farm and provided most of the high quality information needed to determine the economic impact of animal health problems. However, they also noted several deficiencies in the database and raised the issue of the ability of NAHMS. to detect animal health problems not considered important by the survey designers. NAHMS now provides, on the internet, the results of its studies.

3.3 Animal productivity and health information network

The Animal Productivity and Health Information Network (APHIN) was developed at the Atlantic Veterinary College and makes use of a number of microcomputers located on farms, in veterinary practices, in the processing industry, in Department of Agriculture laboratories and offices, and in the Atlantic Veterinary College, all of which are linked to a central computer. These computers operate independently of the central computer and use farm-based animal health information systems which meet most of the needs of local users. The central computer collates and analyses the data to provide regional information and information to allow comparisons to be made on animal health and production between farms (Dohoo, 1988).

4. International Animal Health Information Systems

The major international animal health information system is that run by the Office International des Epizooties (OIE). This system has three main aims (Blajan and Chillaud, 1991); they are:

- to alert countries threatened by an epizootic,
- to strengthen international cooperation on the control of animal diseases, and
- to facilitate international trade in animals and animal products.

To meet these aims the OIE collects information from member nations, analyses and summarises the information and provides reports for all member nations. In doing so it provides information on the geographical distribution of diseases throughout the world.

HandiSTATUS is the computerised interface for the exchange of information on animal health between countries and international organisations (Bernardo et al., 1994). It was originally developed for use by people working in isolation in small countries but has come into much wider use. HandiSTATUS can be used to provide information on the international distribution of diseases that are considered in the international trade in livestock and livestock products and it is used in over 100 countries in the world (Bernardo et al., 1994). The internet is used to provide updated copies of the software, the submission of disease reports to OIE and receipt of summary reports from OIE (Bernardo et al., 1994). The aim of this system is to improve the timeliness, accessibility and accuracy of international animal health information.

The Haemoparasite Information Network for the Guinas was established to enable three neighbouring countries, French Guinea, Guyana and Suriname to share information on a small number of diseases, in particular, haemoparasite infections in livestock. This system was set up in order to increase knowledge of the epidemiology and clinical and economic importance of haemoparasite infections (Vokaty et al., 1994). The Animal Health and Production Information System (AHPISA) for the Association of South- East Asian Nations (ASEAN) is a collaborative effort of the ASEAN countries with much broader aims. This system has been set up to improve animal health information systems at both national and international levels within the ASEAN region. Initially each country is strengthening its national information system with benefits to ASEAN through harmonisation, and information sharing achieved by the use of standardised software and collaboration in the development of

common information systems where common needs exist (Hutabarat et al., 1994).

5. Australia's National Animal Health Information System

The national system being developed in Australia aims to produce representative information on the health status of Australian livestock in order to quantitatively demonstrate which diseases are present and to provide evidence to support claims of freedom from specific disease agents (Baldock, 1995).

In Australia several reasons have been given for the collection, analysis of animal health data and reporting of animal health information. These mostly relate to the need to provide a reliable assessment of animal health status in Australia. In 1975, the Australian national animal health information system (ANADIS) was proposed as a computer-based system for recording, analysing and reporting animal health information. The system was initiated using the production of information for the brucellosis and tuberculosis eradication campaigns as a first step; however, it did not progress beyond this role (Garner and Canon, 1994).

In 1989 animal health authorities in Australia formed a working party to review animal health information needs. The findings of the working party were further examined by a taskforce set up by the Australian Animal Health Committee in 1993. The emphasis of this meeting was to determine the information needed and how such information could be obtained economically (Garner, 1993). The taskforce agreed with the working party's finding that the main areas in which better quality animal health data are needed are:

- to support Australia's exports of live animals and animal products,
- to provide high quality information to satisfy Australia's international reporting obligations on animal health,
- to aid decision making in relation to policies on imports of live animals and animal products,
- to assist in the assessment and setting of research priorities, and
- to assist in planned allocation of State, Commonwealth, and industry resources to animal disease control activities and programs, and to monitor the effectiveness of these programs (Garner, 1993).

The first of these was considered to be the most important. However, the groups did not consider private decision making, and the information produced in the national animal health information system can be used to assist farmers decide on disease control priorities.

There is difficulty in setting targets for an animal health information system to support exports because specific guidelines, accepted by the World Trade Organisation (WTO), have not been set. OIE is responsible for establishing these guidelines. The criteria OIE use for a country to demonstrate freedom from a specific disease provide some guidance as to what these guidelines will be (Morris, 1995). They may be summarised as:

- effective veterinary services must be present in the country and these services must be able to monitor animal health status throughout the country,
- for at least ten years no control measures have been used for the disease in question which would tend to suppress signs of that disease,
- throughout the ten year period no clinical or pathological evidence of the disease has been found,
- all evidence suggestive of the disease is investigated by field and laboratory methods, and
- there is an effective system in place to prevent the introduction of infection.

An animal health information system would be expected to provide information to support the above if it is to provide effective information for use in trade negotiations.

The taskforce proposed that the Australian national animal health information system would make use of data that were already being collected routinely by state services (such as laboratory diagnoses), but would need additional data on specific diseases and from specific regions.

To meet the expected trade requirements NARIS will collect information on disease occurrence, surveillance effort, livestock distribution, distribution of disease vectors and cases of zoonoses (Garner and Canon, 1994). The states submit summaries of field and laboratory data quarterly. Using these data NARIS produces annual reports of Australia's disease status, reports on trends of specific diseases, animal disease situation updates, information to fulfil international reporting obligations as well as information to support trade negotiations (Garner and Cannon, 1994). These reports take the form of:

- Animal Health Surveillance Quarterly,
- Animal Health in Australia, an annual report,
- Reports to the OIE quarterly and annually, and
- World Wide Web page for which a prototype has been developed.

In addition reports are produced as required for specific purposes such as trade negotiations.

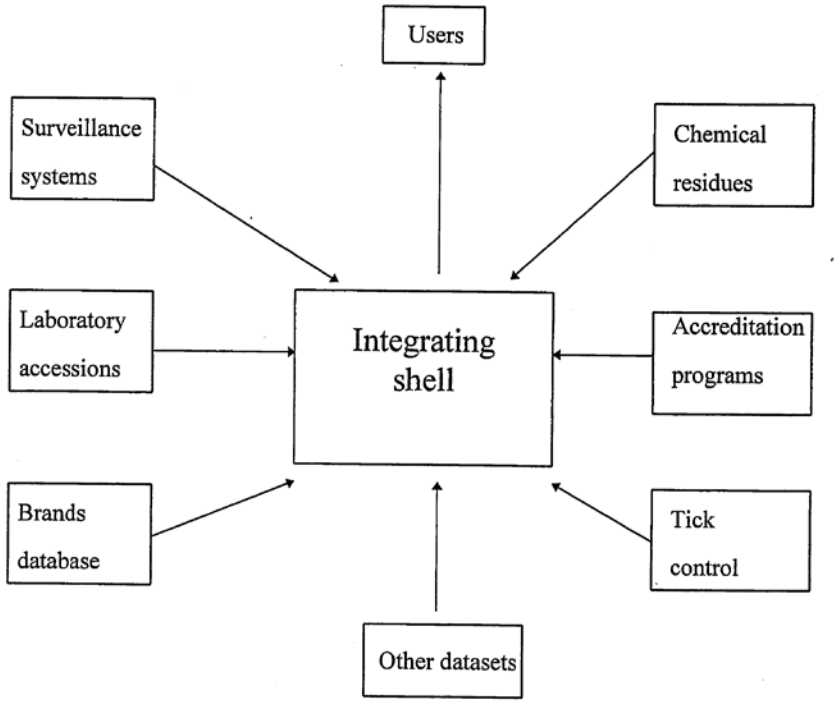
6. Animal Health Information in Queensland

In order to meet the needs of NAHIS, QDPI is developing a system to collect and analyse animal health data. In particular, methods to collect animal health data from extensively grazed areas are being developed. The animal health information system in Queensland is part of a broader project known as the Queensland Animal Information Network (QUAINT). The main aim of this project is to provide a framework for the integrated management of information on livestock disease and production to meet international, national, state and regional animal health information requirements for market protection, exotic and endemic disease management and productivity (Baldock, 1995).

The QUAINT system involves the integration of a number of existing databases, including the existing diagnostic laboratory database. To this information is added information from newly developed activities, and in particular, Structured Animal Health Surveillance. A schematic representation of QUAINT is presented in Figure 1.

The figure shows the databases that make up QUAINT and the integrating shell that enables the production of animal health information from the data in the databases.

Figure 1: Schematic representation of QUAINT



Source: Baldock (1995).

5.1 Structured animal health surveillance

SAHS is defined as a planned method of data collection, collation, analysis, interpretation and reporting to provide information representative of the population tested for defined purposes (Anon, 1995). It is a significant part of the animal health information system in Queensland and aims to provide representative data on disease occurrence for the QUAINT system. SAHS involves the active collection of animal health data (Baldock, 1995) and is a particularly important part of animal health surveillance in areas where animals are grazed in extensive systems and disease information is scarce.

Baldock (1995) outlines six guiding principles that are being used in the development of Structured Animal Health Surveillance in Queensland. These principles can be summarised as:

- a pilot model should be developed initially for the extensive beef industry,
- contributors should have access to the information derived,

- the system should operate on an annual cycle with a major visit to producers for detailed data and specimen collection on an annual basis,
- confidentiality needs to be maintained to ensure the cooperation of livestock producers,
- the database developed must be flexible to allow continuing development, and
- those involved in the data collection and use of the information should be involved in the development of the system.

Regular visits by government veterinary staff to selected properties to collect data on disease occurrence and the collection of blood specimens for serological testing were felt to be the most effective way of collecting disease information (Baldock, 1993). However, while planned annual property visits were seen as the ideal method of data collection, the need to explore other methods was also acknowledged. The collection of blood samples from animals at an abattoir, followed up by a telephone questionnaire, is one of the alternatives (Baldock, 1995).

Structured Animal Health Surveillance in Central Queensland involves the collection and analysis of serum specimens from cattle in randomly selected herds and the completion of a questionnaire on the occurrence of disease in the cattle herd in the past year. The serum samples are tested for antibodies to a number of infectious diseases. The diseases are selected on the basis that suitable serological tests are available and the diseases are of economic importance (Baldock, 1993). The diseases tested and the type of laboratory tests used are indicated in Table 2.2.

Table 2 Diseases tested for and serological tests used in Structured Animal Health Surveillance in 1994

Disease tested	**Test used**
Babesia bovis	ELISA/IFAT
Babesia bigemina	IFAT
Anaplasma marginate	CAT
Bovine ephemeral fever	SNT
Bovine pestivirus	SNT
Bluetongue	ELISA/SNT
Leptospira pomona	SAT
Leptospira hardjo	SAT
Akabane virus	SNT

CAT card agglutination test

ELISA enzyme linked immunosorbent assay

IFAT indirect fluorescent antibody test

SNT serum neutralisation test

SAT micro agglutination test

7. Assessing the value of an animal health information system

In assessing the value of an animal health information system it is important to define exactly what is to be assessed. While this is a problem faced in any evaluation, it is particularly so for animal health information systems where the setting of the system boundaries, variables and relationships is difficult. This is because the system that must be considered is wider than the information system alone and because information does not have an intrinsic value but only has value if it is used to improve decision making. It is, therefore, necessary to consider how the information generated will be used. In addition, the economic evaluation of an animal health information system needs to examine costs and benefits from the individual producer through to the national and international level (where the information is used to improve the decision making of importing as well as exporting countries). In doing this it is important to be aware the animal health information system is only part of the overall animal health management system.

In general terms an animal health information system would be expected to:

- reduce the costs of providing decision-support information. In practice computerised information systems rarely reduce the costs of producing information but rather produce higher quality information at a greater cost (Harrison, 1996);
- provide information more rapidly to support animal health programs; and
- increase the tasks that can be performed within an animal health program due to the better quality and more rapidly accessed information (Harrison, 1996).

More specifically the information system would assist decision makers by providing improved information in specific areas including

- the demonstration of freedom from specific diseases
- development of infrastructure and planning
- setting disease control priorities

These are very similar to the uses of an animal health information system suggested by Garner (1993).

7.1 Valuing the improved decision making due to improved animal health information

Rarely in animal health studies have attempts been made to value animal health information. Sanson (1995) describes an approach to quantify the benefits of a national animal surveillance system in New Zealand. The role of the system is to provide early warning of the introduction of a new disease into the country and to measure the occurrence of existing diseases. This system requires the collection and analysis of animal health data and can be classified as an animal health information system. Sanson (1995) considered the effect of delayed detection or delayed diagnosis of a disease, due to reduced animal health surveillance, which resulted in considerably larger outbreaks of disease than would have occurred with more effective surveillance. While examining the difference in the size of the outbreaks Sanson (1995) did not value the benefits of having a more effective surveillance system in place.

Verstegen et al. (1994) examined the benefits of a management information system (MIS) developed for pig producers in the Netherlands. They found that farmers using the MIS increased production more rapidly than farmers not using the MIS. To do this the results of

two surveys carried out nine years apart were used.

In other studies examining the benefits of herd health programs, such as that carried out by Williamson (1980), the analysis involved not only the value of the information collected as part of the herd health program but also the actions of the veterinarian in using that information to control disease. Menzies et al. (1988) carried out a study of the use of dairy herd management software for dairy farms and veterinary practices but did not examine the benefits from the better decisions made using the software. These studies demonstrate the difficulty in defining boundaries for the assessment of the value of collecting additional information.

Harrison (1996) suggests the use of the expected value of perfect information (EVPI) and expected net gain from sampling (ENGS) as methods to determine the benefits of information. Use of this approach will be examined in a later discussion paper.

In Australia there are two main benefits of improved animal health information via an animal health information system. These are, the maintenance of export markets and improvement of public and private decision making on livestock disease control.

Animal health information systems are systematic methods for the collection and analysis of animal health data into information for decision makers. It has been noted that a variety of systems have been developed on a farm, regional, national or international level. A national animal health information system is presently being developed in Australia. This system requires data inputs from each of the states in Australia. QDPI is developing a system of structured animal health surveillance which will be used in association with data from the diagnostic laboratory database to provide information for the NARIS. In Central Queensland SAHS is based on the collection and analysis of serological specimens from cattle from a representative sample of properties in the region.

8. References

Anon., 1995. Structured Animal Health Surveillance Workshop, 15-16 February, 1995 Rockhampton Queensland, Queensland Department of Primary Industries 15 pages.

Anon., 1996. Urgent need for national cattle database, says industry working group. *Veterinary Record*, 139: 198.

Baldock, F.C., 1995. A Queensland response to changing information needs in animal health, Epidemiology Chapter of the Australian College of Veterinary Surgeons, Proceedings, *Australian Veterinary Association Conference*, Melbourne, pages 54-59.

Bartlett, P.C., Kaneene, J.B., Kirk, J.H., Wilke, M.A., Martenuik, J.V., 1986. Development of a computerized dairy herd health data base for epidemiologic research. *Preventive Veterinary Medicine*, **4**: 3-14.

Bender, J.B., Robinson; R.A., Marsh, W.E., Collins, J.E., 1994. How representative are routine diagnostic laboratory submissions of all livestock producers? *The Kenya Veterinarian*, **18**: 337.

Bernardo, T.M., Schotman, C.Y.L., Chillaud, T., 1994. The future of international animal health reporting. *The Kenya Veterinarian*, **18**: 44-46.

Biggs, H.C., Hare, K.M., 1994. Essential features of an integrated veterinary disease information system for Namibia. *The Kenya Veterinarian*, **18**: 29-31.

Blajan, L., Chillaud, T., 1991. The OIE world animal disease information system. *Revue Science Technology Office International Epizootiques*, **10**: 71-87.

Blood, D.C., Morris, R.S., Williamson, N.B., Cannon, C.M., Cannon, R.M., 1978. A health program for commercial dairy herds 1. Objectives and methods. *Australian Veterinary Journal*, **54**: 207-215.

Brown, M.I., Lloyd, J.W., Kaneene, J.B., Staatz, J., 1993. Theoretical financial benefit of internal parasite control for Michigan dairy farms using National Animal Health Monitoring System data. *Preventive Veterinary Medicine*, **17**: 47-56.

Carpenter, T.E., Snipes, K.P., Hird, D.W., 1994. A spatial epidemiologic investigation of fowl cholera. *The Kenya Veterinarian*, **18**: 487-489.

Christensen, J., Ellegaard, B., Petersen, B.K., Willeberg, P., Mousing, J., 1994. Pig health and production surveillance in Denmark: sampling design, data recording, and measures of disease frequency. *Preventive Veterinary Medicine*, **20**: 47-61.

Cote, J.F., 1963. Herd health practice. Canadian Veterinary Journal, 4: 181-184. Dohoo, I.R., 1988. Animal productivity and health information network. *Canadian Veterinary*

Journal, **29**: 281-287.

Dohoo, I.R., 1992. Dairy APHIN- an information service for the dairy industry in Prince Edward Island, Canada. *Preventive Veterinary Medicine*, **12**: 259-268.

Dohoo, I.R., 1994. Specific issues concerning the application of information systems in developing countries. *World Animal Review*, **3**: 19-24.

Dohoo, T.R., 1993. Monitoring livestock health and production: service-epidemiology's last frontier? *Preventive Veterinary Medicine*, **18**: 43-52.

Elder, J.K., 1976. A functional computer recording system for a veterinary diagnostic laboratory. *Australian Veterinary Journal*, **52**: 24-35.

Ellis, P.R., 1993. Information systems in disease control programs. In: Copland, J.W., Gleeson, L.J., Chamnanpood, C. (Editors), *Diagnosis and Epidemiology of Foot-and-mouth Disease in Southeast Asia*. ACIAR, Canberra, pp. 111-115.

Faugere, O., Merlin, P., Faugere, B., 1991. Evaluation of health and productivity of small ruminants in Africa: the example of Senegal. *Revue Science Technology Office International Epizootiques*, **10**: 131-150.

Frerichs, R.R., 1991. Epidemiologic surveillance in developing countries. *Annual Review of Public Health*, **12**: 257-280.

Gardner, LA., Hird, D.W., Utterback, W.W., Danaye-Elmi, C., Heron, B.R., Christiansen, K.R., Sischo, W.M., 1990. Mortality, morbidity, case-fatality, and culling rates for California dairy cattle as evaluated by the National Animal Health Monitoring System, 1986-87. *Preventive Veterinary Medicine*, **8**: 157-170.

Garner, G. convener, 1993. ARC task force report on an Australian national animal health information system, *Report to Animal Health Committee*, Canberra, July, 1993, 19 pages.

Garner, M.G., Cannon, R.M., 1994. A national animal health information system for Australia - an update, Proceedings of the Epidemiology Chapter of the Australian College of Veterinary Scientists, Australian Veterinary Association Annual Conference, 1994, Canberra..

Hare, K.M., Biggs, H.C., 1996. Design and evaluation of a veterinary information system for Namibia. *Preventive Veterinary Medicine*, **26**: 239-251.

Harrison, S.M., 1996. Cost-benefit analysis with application to animal health programmes: animal health programmes and information systems, *Research Papers and Reports in Animal Health Economics* Number 23, Department of Economics, University of Queensland, Australia.

Hird, D.W., Weigler, B.J., Salman, M.D., Danaye-Elmi, C., Palmer, C.W., Holmes, J.C., Utterback, W.W., Sischo, W.M., 1991. Expenditures for veterinary services and other costs of disease and disease prevention in 57 California beef herds in the National Animal Health Monitoring System (1988-1989). *Journal of the American Veterinary Medical Association*, **198**: 554-558.

Hueston, W.D., 1990. The National Animal Health Monitoring System: addressing the animal health information needs in the U.S.A. *Preventive Veterinary Medicine*, **8**: 97-102.

Hurd, H.S., Kaneene, J.B., 1990. The National Animal Health Monitoring System in Michigan. II. Methodological issues in the estimation of frequencies of disease in a prospective study of multiple dynamic populations. *Preventive Veterinary Medicine*, **8**: 115-125.

Hutabarat, T.S.P., Widowati, N., Johar, M.S., Ghazali, M.T., Mateo, A.A.B., Joco, M.L., Meephuch, Y., Sarataphen, N., Dohoo, I.R., 1994. Animal health and production information for the ASEAN (APHISA); a regional initiative to develop and strengthen information systems. *The Kenya Veterinarian*, **18**: 32- 34.

Jalvingh, A.W., 1994. Dynamic livestock modelling for on-farm decision support. Ph.D. Dissertation, Wageningen Agricultural University, pp. 160.

Kaneene, J.B., Hurd, H.S., 1990a. The National Animal Health Monitoring System in Michigan. I. Design, data and frequences of selected dairy cattle diseases. *Preventive Veterinary Medicine*, **8**: 103-114.

Kaneene, J.B., Hurd, H.S., 1990b. The National Animal Health Monitoring System in Michigan. III. Cost estimates of selected dairy cattle diseases. *Preventive Veterinary*

Medicine, **8**: 127-140.

King, L.J., 1985. Unique characteristics of the National Animal Disease Surveillance system. *Journal of the American Veterinary Medical Association*, **186**: 35-39.

King, L.J., 1990. The National Animal Health Monitoring System: fulfilling a commitment. *Preventive Veterinary Medicine*, **8**: 89-95.

Leech, F.B., 1971. A critique of the methods and results of the British national surveys of disease in farm animals. I. Discussion of the surveys. *British Veterinary Journal*, **127**: 511-522.

Lees, V.W., Fedorick, D.J., 1994. CORRAL: computerised agricultural health surveillance for small developing countries. *The Kenya Veterinarian*, **18**: 38-40.

Lessard, P., L'Eplattenier, R., Kundert, K., Dolan, T., Craze, H., Walker, J., Irvin, A., Perry, B., 1990. Geographical information systems for studying the epidemiology of cattle disease caused by Theileria parva. *Veterinary Record*, **126**: 255-262.

Lissemore, K.D., 1989. The use of computers in dairy herd health programs: a review. *Canadian Veterinary Journal*, **30**: 631-636.

Marsh, W.E., Damrongwatanapokin, T., Larntz, K., Morrison, R., 1991. The use of geographic information system in an epidemiological study of pseudorabies (Aujeszky's disease) in Minnesota swine herds. *Preventive Veterinary Medicine*, **11**: 249-254.

Marsh, W.E., Dijkhuizen, A.A., Morris, R.S., 1987. An economic comparison of four culling decision rules for reproductive failure in United States dairy herds using DairyORACLE. *Journal of Dairy Science*, **70**: 1274-1280.

Martinez, T.A., Kaneene, J.B., Lloyd, J.W., Brown, M.I., 1992. Potential users and user requirements of an animal-health monitoring system in a developing country: case study of Honduras. *Preventive Veterinary Medicine*, **13**: 1-11.

McKay, B.J., 1988. DairyMAN: a Massey University animal management program. *Proceedings of the New Zealand Society for Animal Production*, **48**: 127-130.

McLeod, A., Tyler, L., 1991. Steps in the implementation of a micro-computer approach to the management of animal disease information. *Revue Science Technology Office International Epizootiques*, **10**: 25-49.

Meephuch, Y., 1993. An information system developed for monotoring foot-and- mouth disease control in Thailand. II}: Copland, J.W., Gleeson, L.J., Chamnanpood, C. (Editors), Diagnosis and epidemiology of foot-and-mouth disease in Southeast Asia. ACIAR, Canberra, pp. 116-118.

Menzies, P.I., Meek, A.H., Stahlbaum, B.W., Etherington, W.G., 1988. An assessment of the utility of microcomputers and dairy herd management software for dairy farms and veterinary practices. *Canadian Veterinary Journal*, **29**: 287-293.

Miller, G.Y., Dorn, C.R., 1990. Costs of dairy cattle diseases to producers in Ohio. *Preventive Veterinary Medicine*, **8**: 171-182.

Moore, P.S., Plikaytis, B.D., Bolan, G.A., Oxtoby, M.J., Yada, A., Zoubga, A., Reingold, A.L., Broome, C.V., 1992. Detection of meningitis epidemics in Africa: a population-based analysis. *International Journal of Epidemiology*, **21**: 155-162.

Morris, 1995. Convincing other countries we have eradicated a major disease, Epidemiology Chapter, Australian College of Veterinary Scientists, Proceedings, Australian Veterinary Association Conference, Melbourne, pages 238-244.

Morris, R.S., 1991. Information systems for animal health: objectives and components. *Revue Science Technology Office International Epizootiques*, **10**: 13-23.

Morrow, D.A., 1963. Developing a dairy herd health program. *Veterinary Medicine*, **58**: 308-312.

Norman, H.S., Sischo, W.M., Day, R.L., Pitcher, P., Nesselrodt, A., 1994. Evaluating the influence of neighbouring swine herd status on the spread of pseudorabies virus using a geographical information system. *The Kenya Veterinarian*, **18**: 490-492.

Ogundipe, G.A.T., Oluokun, S.B., Esuruoso, G.O., 1989. The development and efficiency of the animal health information system in Nigeria. *Preventive Veterinary Medicine*, **7**: 121-135.

Ogwang, F., Heinonen, R., 1994. Computerised district reporting (CDR) with help of geographical information system for veterinary services in Uganda. *The Kenya Veterinarian*, **18**: 58.

Peauroi, J.R., Case, J.T., Hird, D.W., 1991. Patterns of bovine dairy submissions to the California veterinary diagnostic laboratory system. *Journal of Veterinary Diagnostic Investigation*, **3**: 334-341.

Pegram, R.G., Rota, A., Onkelinx, R., Wilson, D.D., de Castro, J.J., Nisbett, B., Swanston, G., Vanterpool, P., 1996. The Caribbean free from the Tropical Bont Tick (A. variegatum): the need for a coordinated approach. *World Animal Review*, **87**.

Pollari, F.L., Bonnett, B.N., Allen, D.G., Bamsey, S.C., Martin, S.W., 1996. Quality of computerised medical record abstract data at a veterinary teaching hospital. *Preventive Veterinary Medicine*, **27**: 141-154.

Radostits, O.M., Blood, D.C., 1985. Herd Health. W.B. Saunders Company, Philadelphia, pp. 456.

Rambulo, P.V., Astudillo, V. 1991. *Preventive Veterinary Medicine*, **11**: 345-352.

Rogers, D.J., Williams, B.G., 1993. Monitoring trypanosomiasis in space and time. *Parasitology*, **106** Supplement: S77-S92.

Russell, A.M., Rowlands, G.J., 1983. COSREEL: computerised recording system for herd health management. *Veterinary Record*, **112**: 189-193.

Ryan, T.J., Yates, E.M., 1994. The New Zealand national livestock database. *The Kenya Veterinarian*, **18**(2): 325-327.

Saatkamp, H.W., Dijkhuizen, A.A., Geers, R., Huime, R.B.M., Noordhuizen, J.P.T.M., Goedseels, V., 1996. Simulation studies on the epidemiological impact of national identification and recording systems on the control of • classical swine fever in Belgium. *Preventive Veterinary Medicine,* **26**: 119-132.

St George, T.D., 1986. The epidemiology of bovine ephemeral fever in Australia and its economic effect, Arbovirus Research in Australia - Proceedings of the Fourth Symposium, Brisbane.

Salman, M.D., King, M.E., Odde, K.G., Mortimer, R.G., 1991. Annual costs associated with disease incidence and prevention in Colorado cow-calf herds participating in rounds 2 and 3 of the National Animal Health Monitoring System from 1986 to 1988. *Journal of the American Veterinary Medical Association*, **198**: 968-973.

Salman, M.D., King, M.E., Wittum, T.E., Curtis, C.R., Odde, K.G., Mortimer, R.G., 1990. The National Animal Health Monitoring System in Colorado beef herds: disease rates and their associated costs. *Preventive Veterinary Medicine*, **8**: 203-214.

Sanson, R.L., 1995. A modelling approach to the quantification of the benefits of a national surveillance program, Epidemiology Chapter Proceedings, Australian College ofVeterinary Scientists, Jubilee Conference, Sydney 10-12 February 1995.

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.

Sanson, R.L., Stern, M.W., Morris, R.S., 1994. InterSpread- a spatial stochastic simulation model of epidemic foot-and-mouth disease. *The Kenya Veterinarian*, **18**: 493-495.

Sellers, F.B., 1971. A critique of the methods and results of the British national surveys of disease in farm animals. II. Some general remarks in population surveys of animal disease. *British Veterinary Journal*, **127**: 587-592.

Sharma, P., 1993. Use of geographic information systems in animal health information programs. In: Copland, J.W., Gleeson, L.J., Chamnanpood, C. (Editors), Diagnosis and epidemiology of foot-and-mouth disease in Southeast Asia. ACIAR, Canberra, pp. 119-125.

Sischo, W.M., Hird, D.W., Gardner, LA., Utterback, W.W., Christiansen, K.H., Carpenter, T.E., Danaye-Elmi, C., Heron, B.R., 1990. Economics of disease occurrence and prevention on California dairy farms: a report and evaluation of data collected for the National Animal Health Monitoring Scheme, 1986-87. *Preventive Veterinary Medicine*, **8**: 141-156.

Stark, K.D.C., 1995. Animal health monitoring and surveillance in Switzerland, Epidemiology Chapter Australian College of Veterinary Scientists, Proceedings,

Australian Veterinary Association Annual Conference, Melbourne, pages 50-53.

Stephens, A.J., Esslemont, R.J., Ellis, P.R., 1982. Daisy in veterinary practice. Planned animal health and production services and small computers *Veterinary Annual*, **22**: 6-17.

Vander Logt, P.B., Morris, R.S., Hathaway, S.C., 1994. The analysis of chemical residue data gathered at abattoirs by means of geographical information systems. *The Kenya Veterinarian*, **18**: 496-498.

Van-Ham, M., 1994. Israel animal health monitoring system. *The Kenya Veterinarian,* **18**: 41-43.

Verstegen, J.A.A.M., Huirne, R.B.M., Dijkhuizen, A.A., 1994. Economic profitability of veterinary management information systems in swine farming. *The Kenya Veterinarian*, **18**: 442-444.

Vokaty, S., Desquesnes, M., de la Rocque, S., Applewhaite, L., Favre, J., Liew-A-Joe, R., Bansse-Isse, L., Parris-Aaron, M., 1994. Hemoparasite Information Network for the Guianas. *The Kenya Veterinarian*, **18**: 35-37.

Weaver, L.D., Goodger, W.J., 1987. Design and economic evaluation of dairy reproductive health programs for large dairy herds Part I. *The Compendium on Continuing Education for the Practicing Veterinarian*, **9**: F297-F310.

Willeberg, P., Gerbola, M.A., Kirkegaard Petersen, b, Andersen, J.B., 1984. The Danish pig health scheme: nation-wide computer-based abattoir surveillance and follow-up at the herd level. *Preventive Veterinary Medicine*, **3**: 79-91.

Wittum, T.E., Salman, M.D., Curtis, C.R., King, M.E., Odde, K.G., Mortimer, R.G., 1990. The National Animal Health Monitoring System for Colorado beef herds: management practices and their association with disease rates. *Preventive Veterinary Medicine*, **8**: 215-225.

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