DEVELOPMENT OF A NOVEL MONITORING AND SURVEILLANCE SYSTEM FOR ENDEMIC ANIMAL DISEASES IN NEW ZEALAND

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Abstract

Disease surveillance of animal populations has taken on renewed importance. The literature regarding disease surveillance systems, particularly with respect to animal diseases is summarised in section 1.

Section 2 explores three potential sources of dairy cattle endemic disease data, with a view to utilising this data within the national disease surveillance system and as a model for gathering data from other animal species.

Disease records stored on farm computers were retrospectively sourced from forty dairy farmers, from paper records of their servicing veterinary practices and from laboratory records held by the practice for these same farmer's animals. In this way, the loss of data on recorded disease events from farmer to veterinarian to animal health laboratory could be quantified and characterised. Frequency and magnitude of veterinary activity on farms was also quantified, as an indicator of "coverage" of the dairy cattle population, with respect to disease surveillance capability.

As expected farmers recorded the largest number of disease events (14.6 per 1000 cow months at risk, the veterinary practitioners the next (5.2 per 1000 cow months) and animal health laboratories the least (0.58 per 1000 cow months). Twenty-five percent of farmers did not record any disease data. Of those farmers who did record diseases, 84% of records were cases of lameness or mastitis. Farmers rarely recorded veterinary diagnoses.

When lameness and mastitis were excluded, veterinary records gave the highest rate (3.6 per 1000 cow months) and spectrum of diseases events recorded. Veterinary records had a high (22%) percentage of undiagnosed or unspecified cases when compared to farmer records.

Veterinary practices visited the farms on average 17.8 times per year and handled on average 156 cows per 1000 cow months.

The animal health laboratories made positive disease diagnoses at a rate of 0.24 per 1000 cow months. Approximately half of these were milk samples for routine culture and sensitivity testing.

Veterinary practice records offer valuable information for monitoring the temporal and spatial pattern of disease events on farms.

Section 3 outlines elements of a prototype palmtop recording system (VetPAD), which offers easy standardised data capture.

Section 4 explores a possible future for Veterinary Practitioner Assisted Disease Surveillance (VetPAD) using a syndromic disease reporting approach.

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Literature Review: Monitoring and Surveillance of Animal Diseases

Introduction

As with any decision making process, there is a need for reliable information on which to make decisions in animal disease management. Monitoring and surveillance systems (MOSS) are one such source of information. The OIE recognise that monitoring and surveillance are highly relevant to risk analysis (anonymous, 2001c) in order to provide credible estimates of animal health status. The robustness or validity of any decision made using such information is heavily influenced by the quality of the information gathered. The various sources of information gathered by a monitoring and surveillance system have strengths and weaknesses that need to be taken in to consideration when used in a decision making process. This review looks at the potential sources of disease information and their strengths and weaknesses with examples of ovine, bovine, equine, porcine and canine disease characterisation.

Definition of Terms

In common usage, monitoring and surveillance have often been used interchangeably. Within the veterinary epidemiology literature they have distinct meanings, although there is some inconsistency in the usage.

The word surveillance reputedly dates back to the French revolution (Doherr & Audige, 2001) or the Napoleonic wars (Noordhuizen & Dufour,1997), when subversives were kept under close observation with a view to taking action against them if the need arose (Doherr & Audige, 2001). According to the Concise Oxford Dictionary, the word has both French and Latin roots, with the Latin word *"vigilans"* referring to the need to be vigilant. With the passage of time and the differing levels of education present in a team charged with vigilant observation, it is not hard to imagine how the word's subversives and "*vigilans"* may have become merged to form the term surveillance. Strictly speaking surveillance is monitoring with the intent to intervene if a disease breaches a pre-determined level of prevalence or incidence. Implicit in the disease intervention strategy of a surveillance system is the ability to diagnose the disease in all it's forms (clinical, sub-clinical and carrier), vectors or environmental sources and take action that

will reduce the disease to an appropriate level (Yekutiel 1980).

Thrusfield (Thrusfield1995) describes monitoring as "the routine collection of information on disease, productivity and other characteristics possibly related to them in a population." He reserves the term surveillance for a special case of monitoring that is intensive and "designed so that action can be taken to improve the health status of a population and therefore frequently used in disease control campaigns."

Christensen (Christensen, 2001) further expands the surveillance definition with three essential components (1) a defined disease monitoring system, (2) a predefined disease intervention strategy and (3) a defined threshold of disease frequency, above which action will be taken.

Noordhuizen (Noordhuizen & Dufour,1997) has based his definition of a monitoring and surveillance system (MOSS) on "a network of locations". This description has the weakness of not specifying the animal population or the temporal components involved in any monitoring and surveillance system. This is addressed by others, (Christensen, 2001) (Hueston, 1993) (Stark & Salman, 2001) who use the population of interest referenced to a time and location. The term MOSS appears to be more common in literature from European authors and is not often used by other authors.

A monitoring and surveillance system can be further subdivided in to active or passive. Active monitoring and surveillance is where the data are collected for that particular disease (Christensen, 2001) (Doherr & Audige, 2001) (Thrusfield1995). Passive monitoring and surveillance refers to disease data collected as a byproduct of an active surveillance system. Christensen further points out that the passive system may involve no sampling, instead only reporting of clinical suspicion. Doherr and Audigé (Doherr & Audige, 2001) give more possible ways of classifying a MOSS with respect to the objectives of the data collection, the type of information collected and the data sources. While not clearly specified in any source, the implication is that a population that is sampled until no more cases are found pertains to the intent to change the disease status of the population from which the data was drawn eg tuberculosis or foot and mouth disease control, while sample based data collection pertains to characterisation of the population of interest.

Baldock (Baldock et al.,1999) and Thrusfield (Thrusfield1995) have both described veterinary or national animal health and monitoring system as the process of collecting, managing, analysing and reporting information in accordance with the needs of particular user groups within a country. The borderline between a simple database and an information system is indistinct because stored data, even before they are processed, can have value as information. A distinguishing feature of an information system is its ability to deal with large, complex issues (eg the national control of epidemics) (Thrusfield1995).

Within some of the more complex veterinary information systems, are decision support systems (DSS) (Sanson et al., 1999). A decision support system is an interactive system providing information, tools or models to help managers or professionals make decisions in semi-structured or unstructured situations (Crauwels et al., 2001), such as an outbreak of a highly contagious disease eg FMD or CSF.

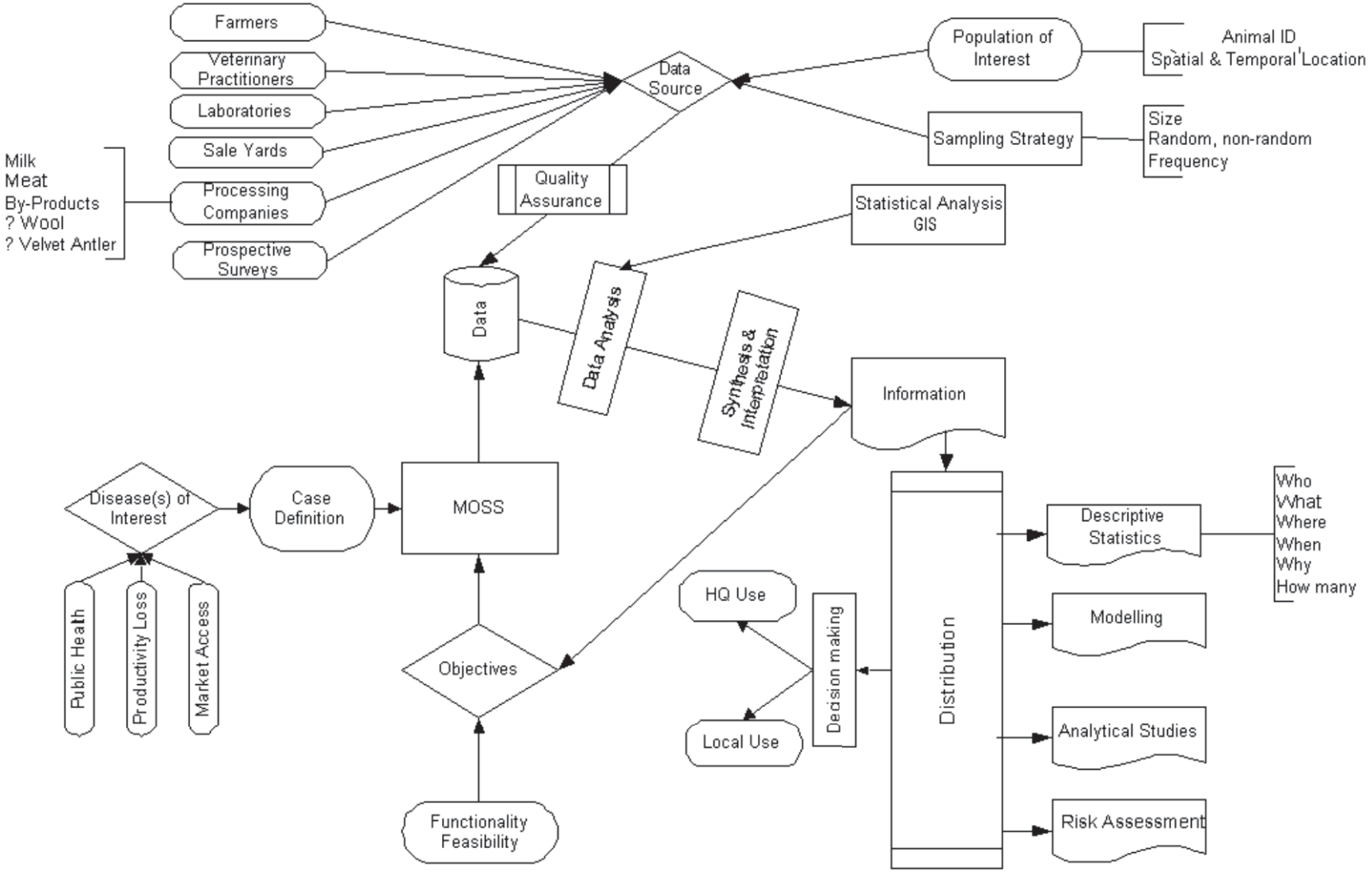
Monitoring and surveillance systems need quality assurance systems built in to them. Quality has been described as "the totality of characteristics of an entity that bears its ability to satisfy stated and implied needs" (Nannini et al., 1999).
Syndromic disease reporting is the reporting of clinical signs of disease according to strict case definitions before laboratory confirmation is available (Durrheim et al., 2001).

Concepts of monitoring and surveillance

The fundamental role of a monitoring and surveillance system is to provide decision-makers (national, regional and local disease control specialists and farmers) with information. Noordhuizen (Noordhuizen & Dufour,1997) correctly notes it is a tool for decision making and not a goal in itself. Where the information comes from and how it moves through the process of changing from raw data to useful information, invokes a conceptual model of an effective monitoring and surveillance system. There are multiple potential sources of raw data and multiple uses for information produced from the data. There are often competing demands on the system to provide information that appears at first glance to be mutually exclusive. For example quick and cheap descriptive statistics versus detailed and expensive data suitable for modelling, analytical studies and risk analysis When designing a monitoring and surveillance

system, consideration needs to be given to an overview of the objectives and some of the associated issues of data collection and use. Figure 1 is an attempt to show some of the inter-relationships between data collection and information use.

Figure 1: Inter-relationships between components of a monitoring and surveillance system for food animals



Noordhuizen has given a series of "operationalization steps" and a checklist of considerations and questions to be answered positively for the development of a monitoring and surveillance system (Noordhuizen & Dufour,1997). These provide a framework to consider when designing a monitoring and surveillance system. Morris (Morris, 1991) has defined several criteria that should be assessed in advance to see if the data should even be collected. Some of these overlap with Noordhuizen.

1. There should be a clearly defined purpose for gathering the data. This purpose must be agreed upon by all participants before data collection starts.
2. The system for analysis and interpretation of the data should be worked out before the data collection begins
3. Analysis of the data should be carried out promptly after it is received.
4. There should be effective quality control procedures built into the undertaking to provide adequate assurance of the validity of the findings
5. There should be prompt feedback of some sort to the various suppliers of the data so they know they are making a useful contribution. If possible, suppliers should receive some tangible or intangible benefit from their involvement.
6. Each individual data-gathering exercise should either have a defined end point or be subject to periodic review.

The ideal monitoring and surveillance system would provide near real time disease incidence data, for an exactly defined population at all points in time and space. The disease diagnosis system would have 100% sensitivity and specificity and would record all the relevant risk factors. This data would then be analysed and reported to all those involved in, the monitoring and surveillance system, animal production, animals and animal product trade and relevant veterinary and public health officials. Several problems arise when attempting to implement such a system.

The first problem with this definition is at what point do we start collecting data on diseases. Is it when the animal dies or at the other extreme, is it the moment the animal first becomes infected? Generally farmers are not unduly concerned with disease until there is tangible production loss associated with the illness (or the possibility of it) and do not seek veterinary intervention unless they see a potential return (loss minimisation) on the investment (cost of veterinary visit and associated treatment). This problem is

really an issue of case definition. When the case definition is satisfactorily defined the timing of data collection sorts itself out. For the majority of diseases the timing of disease becoming a case is not an important issue. With diseases with a long pre-clinical stage, this timing may be very important when considering aspects of reduced animal productivity. A good example is ovine or bovine Johne's Disease, where the infected animal does not suffer loss of body condition, until the final stage of the disease, years after first becoming infected. Conversely with control and eradication schemes it is often desirable to use diagnostic testing to detect infected animals prior to any evidence of either reduced productivity or clinical signs of disease. This is a problem that has had to be conveyed to farmers in the New Zealand Enzootic Bovine Leukosis (EBL) disease control program, where only a very small proportion of infected animals develop clinical signs of disease.

The next problem with the definition of the ideal system is defining the population. It is usually not possible to monitor all animals all of the time. Consequently a decision has to be made about selection of animals for subsequent monitoring. This in turn depends on the disease of interest and the objectives of data collection. If the disease affects the very young, then they will obviously need to be included in the group tested. Conversely if the disease has a very long incubation (eg Johne's Disease, BSE) then older animals will constitute the group of interest. All of this does not even begin to consider sample size issues and spatial distribution characteristics of the monitored population. The nature of the disease being monitored also is a matter of consideration.

Morris notes in his review of information systems for animal health (Morris, 1991) that when considering endemic, productivity constraining diseases, they are usually widely distributed and as a consequence the sample size can be far smaller than would be the case for diseases which are unevenly distributed. When proving disease absence or looking for rare diseases, a quite different approach is needed, where the focus shifts to high-risk groups of animals (Doherr & Audige, 2001) (Doherr et al., 2001). It may be that the population at risk may be defined in another database, distinct from the disease recording database.

Having settled on the appropriate population (including spatial and temporal descriptors) and sample size, we can turn our attention to data quality. If the information

that is used in decision making is to be of any use, the data quality must be of a high standard. One such use of the information is risk assessment. Stark and Salman (Stark & Salman, 2001) discuss some of the problems in risk assessment when the data quality is inadequate and suggest quality assurance steps be put in place in a MOSS to ensure valid data. The OIE (anonymous, 2001b) and others (Nannini et al., 1999) have provided guidelines for including quality assurance steps in the development of veterinary infrastructure including monitoring and surveillance systems. If these features are considered in some detail when designing a system, then users of the information could have confidence in the underlying data and its analysis. This is especially so when consideration is made of the number of people involved in the process from data recording and collection, through analysis to final reporting. Clearly it will be rare if not impossible for one person to be involved in all steps. Assessment of a monitoring and surveillance system for the key determinants of a quality system is a complex process. Hueston (Hueston, 1993) provides a useful checklist and scoring system that can be used to assess a monitoring and surveillance system.

The data need to be appropriately analysed to ensure that the information extracted is sound and that full use of the data is made. Anything less constitutes a data graveyard (Noordhuizen & Dufour,1997), which is a waste of time and resources to collect.
Inevitably the information produced will be incomplete in itself or based on incomplete data. This leads to the idea of needing to make predictions from limited data. This prediction may take the form of disease indices (prevalence, incidence etc) or conditions suitable for a disease outbreak eg susceptible animals or environmental conditions.

A monitoring and surveillance system is only as good as the data that is entered in to it. If farmers do not recognise the need for the monitoring and surveillance system and do not co-operate with veterinary authorities (or those charged with data collection) when collecting data, then the value of it will be very much diminished. For any monitoring and surveillance system that requires farmer support (financial, logistic, political etc) Schwabe (Schwabe et al.,1977b) recommends collaboration with individuals qualified in anthropology and other social sciences during its development. In doing so veterinary authorities will better understand farmer (producer) views and gain their support.
Schwabe further states (Schwabe et al.,1977c) "Despite the common absence of comprehensive data collection machinery, the collection aspects of existing veterinary

mortality and morbidity data programs probably are more adequate than are their analysis, interpretation and dissemination aspects." In the intervening twenty five years since this was written, the availability of relatively cheap and powerful computers, software and systems capable of rapidly completing this aspect has increased immensely, so that agencies charged with this work do not have this limitation to contend with. The biggest limitation is still lack of people (ideally epidemiologists) with the expertise to conduct this type of work.

Information Systems to Support Monitoring and Surveillance Systems

The central concept of a monitoring and surveillance system is the collection and analysis of data. To be available for analysis, the data must be stored in a readily accessible form. The most common of these are now computer based storage systems, because of the vast quantities of data collected and the complex analyses that are performed. The data is coded in a format that can be readily loaded in to the computer. Data can be stored in custom built databases or commercially available generic database software will often suffice. If a relational database is used, the data can be readily queried to look for relationships between various data records (Thrusfield1995).

Spreadsheets are not suitable because of poor data security (relationships easily lost) and extraction difficulties. To readily convert data to information, often more than a database is needed. Add-ons to a database to form an information system include geographical information systems (GIS) (Sanson et al., 1991), analytical tools and decision support systems (DSS) (Sanson et al., 1999) (Crauwels et al., 2001). Within a DSS there is likely to be an expert system that uses rules defined by experts in the particular field to calculate complex predictive models based on the data currently available. A well known example is EpiMAN FMD (Sanson et al., 1999).

A well recognised maxim with respect to database construction and management is "'garbage in, garbage out". In other words if care is not taken at the outset to collect what is needed and no more or less, then the information outputs will be considerably reduced in utility. In the United Kingdom, veterinary laboratory diagnoses from MAFF (England &Wales) and SAC (Scotland) are stored on the VIDA (Veterinary Investigation Diagnosis Analysis) database. Cadlow (Caldow et al., 1993) reports that this database records diagnoses to county level. Clearly from an epidemiological

perspective this laboratory database is unsuitable for epidemiological analyses as denominator values (animals and farms at risk) are essential in the calculation of basic disease indices. The disease and vector integrated database (DAVID) is a GIS for managing field data on tsetse, trypanosomiasis and livestock (Robinson & Hopkins 1999). Built in to it are several features that allow some control on the quality of the data entered. These include controls on who can modify database settings, look-up tables and drop-down lists for data entry and double data entry on the premise that it is unlikely an incorrect data point will be entered twice if there are checks against the two entries.

Laboratory Surveillance

Role

Traditionally, laboratory based surveillance of animal disease has been considered the core of any disease surveillance system. Historically, in New Zealand laboratory surveillance relied on veterinary practitioners submitting material from farm animal cases at little or no cost to the client or practitioner for the laboratory work. This was intended to ensure that cost was no barrier to submission of material that may have been of interest to the surveillance system. Schwabe reports that this approach was used in California to augment the Alameda and Contra Costa counties Animal Tumour Registry (Schwabe et al.,1977a). Over the last twenty years the New Zealand animal health laboratory system has moved from state funded to some cost recovery to full cost recovery to a state owned stand alone business to a fully privatised laboratory network. These changes have necessitated ongoing changes in the capture and management of endemic disease information, as it becomes essentially, private property. Another threat to the laboratory's viability and ability to collect disease data is the increasing use of in-practice blood testing equipment such as IDEX. Most months a quick review of the positions available page in VETscript (anonymous, 2002c) will reveal at least one clinic indicating they have an IDEX machine as part of their clinic facilities.

There has been the impression in some quarters, that the laboratory system should be the best place for "housing" a surveillance system. This I believe has historical roots, in the laboratory (in particular the pathologist) being the putative Gold Standard in diagnosis and because laboratories were also the first part of many disease control systems to have access to computers. Access to computers allowed large amounts of

data to be collected, stored and in theory at least, analysed. Neither of these reasons should prohibit effective disease surveillance and management being located outside the laboratory.

Networks (National & International)

With the sale of the New Zealand government owned AgriQuality laboratory network to Gribbles Veterinary Pathology and their subsequent purchase of two other private veterinary laboratories in the South Island (LabWorks Animal Health Ltd and LABNET Invermay Ltd), a true national network of laboratories has reformed. Whether this network results in an improvement in the surveillance capability of the laboratories or just business efficiencies for Gribbles is yet to be seen.

Current NZ Laboratory Surveillance Contract with MAF

The New Zealand Ministry of Agriculture and Forestry, Biosecurity Authority (MAF BA) source most of their laboratory surveillance information from privately owned commercial laboratories. Other sources being the National Centre for Disease Investigation (NCDI), meat harvesting plants and a sentinel animal program (anonymous, 2001a). This information allows MAF BA to meet national and international obligations and as an early warning of the presence of an exotic and or new disease. All the laboratories supplying information have to meet a minimum standard to be able to become "Approved Veterinary Diagnostic Laboratories". Once this status is attained a laboratory can then contract to supply animal disease surveillance reports to the MAF BA. The minimum standard is set out in the Standard for MAF Biosecurity Authority Approved Veterinary Diagnostic Laboratories (anonymous, 2001a). The standard is subject to periodic review. The minimum requirements cover issues such as diagnostic capability, availability of suitable case material, retention of case material and records for further examination, quality control systems, lines of reporting and accountability.

Quarterly reports produced by the laboratories are published in the MAF publication Surveillance, for example (Brooks et al., 2001). Typically these are descriptive case reports with a varying degree of detail regarding the denominator and numerator values for the population affected and at risk respectively. It is highly unlikely that any epidemiologically sound measures of production loss could be estimated from the

material provided. The reports do give an indication of the extent and depth of the New Zealand veterinary infrastructure.

Medical / Veterinary Interface

Animal health laboratories are encouraged to submit samples from all cases of Salmonellosis diagnosed, to a central medical laboratory (Institute of Environmental Science & Research Limited (ESR)) for strain typing [1]. In the standard for Approved Veterinary Diagnostic Laboratories, MAF BA have a requirement for all Salmonella isolates that cannot be serotyped by the laboratory receiving the samples, to refer them to a nominated reference laboratory. Currently this is ESR (anonymous, 2001a). Cases of psittacosis (*Chlamydia psittaci)* are required to be reported to the regional Medical Officer of Health under section 87A of the Health Act 1956.

Occasionally veterinary surveillance systems are the first to report emerging diseases with human health consequences. In New York City, USA, a Bronx zoo veterinary pathologist was one of the first to recognise the possibility that what was subsequently identified as *West Nile Virus*, might have been the common cause of crow and other bird deaths and a serious illness in residents of Queens, New York City (Miller et al., 2001). Subsequently dead birds, particularly American crows proved to be excellent sentinels for viral activity and subsequent human infections (Eidson et al., 2001, Eidson et al., 2001). In New Zealand an epidemic of ovine abortion caused by *Salmonella* Brandenburg (Bailey, 1997) was the harbinger of a smaller epidemic of severe diarrhoea and intestinal cramps in farmers and farm workers (Clarke et al., 1999) as well as a large epidemic in the southern South Island sheep flock and sporadic cases in other species in subsequent years.

Examples of laboratory surveillance output

Laboratories that keep detailed records over many years can extract these records at a later date and use them in conjunction with other data, or new knowledge to make useful conclusions about some diseases. Retrospective analysis of clinical biochemistry tests and clinicopathological data for 740 equine cases, revealed significant associations between disease and different biochemical analytes (Knox et al., 1996) . This lead to the development of a biochemical decision support system. Using reports of neoplasms

[1] Institute of Environmental Science & Research Limited, personal communication

from the registration files of the Section of Pathology of the Veterinary Research Institute, Onderstepoort, Republic of South Africa, over a 40 year period from 1935 to 1974, the relative importance and location on the animal of various forms of bovine neoplasms was reported (Bastianello, 1982). Because there is no denominator value associated with these reports it is difficult to draw conclusions about the importance of these diagnoses with respect to the population of interest. They do provide clinicians with a guide as to what sort of tumour may be expected if they are confronted with something they are unfamiliar with or are unable to have samples analysed themselves.

Slaughter Surveillance

Role

Within New Zealand, all meat slaughtered at a processing plant certified for export meat production, is certified by a Ministry of Agriculture and Forestry, Verification Agency veterinarian. This certification process is backed up by a range of verification processes that include ante-mortem inspection of animals. This provides an ideal way for government veterinarians to inspect (or have inspected for them by trained technicians) on a daily basis, an extremely large number of animals drawn from geographically widespread areas. The implication is that almost all farm animals eventually find their way to a meat processing plant. This may be the only time in the life of the animal that a veterinarian sees it. If these animals are showing any sign of disease either at the ante-mortem or post-mortem inspections, this can be recorded and if appropriate, traced back to the farm(s) of origin and laboratory tests initiated.

The role of slaughter surveillance had a major psychological lift when a slaughterhouse in southern England was the first to detect the recent (2001) outbreak of Foot and Mouth disease in the United Kingdom (Scudamore, 2002). While the role of detection of potential exotic disease is vital to the maintenance of export markets, it is the role of monitoring and reporting on endemic animal disease detected at slaughter that has the greater potential to lift animal productivity. Individual cases of endemic disease may result in small loss of productivity, but the potentially large number of animals at risk magnify's the economic consequences of the disease. The potential to improve farm profitability by modest enhancements in animal productivity through improved health

status has broad appeal to farmers and animal health advisers alike. This is particularly important in the intensive animal industries (pig and poultry) where feed costs represent a large proportion of the cost of production. In reality, the barriers to achieving these enhancements are considerably more than identifying diseased animals at slaughter.

This should not however detract from attempts to detect and quantify diseases, provided the biases and limitations are recognised in advance. Any case that is severe enough to result in the animal dying or being unable to reach marketable weight will automatically be excluded. This will result in underestimation of the true prevalence and cost of the disease in question. Not all diseases will be evident at slaughter, even if they may have marked affects on farm productivity eg sub-clinical mastitis. An understanding of the size of the population at risk is also often not readily available unless use is made of other sources of population census data.

Slaughterhouse surveillance also has a role in detection of cases of notifiable disease that would otherwise escape detection. This then allows subsequent follow up actions designed to find and eliminate other in contact cases and possibly identify common risk factors or exposure. In New Zealand, detection of bovine or cervine cases of *mycobacterium bovis* infection is the classic example of this.

Sub-clinical disease monitoring at slaughter

Most diseases affecting animals fit for slaughter are by definition (emergency slaughter excepted) a sub-clinical disease. The signs of disease detected are usually historical or very mild and not affecting the ability of the animal to reach slaughter weight in the case of young animals or not sufficient to result in rejection of the animal at ante-mortem inspection. This may be determined by the location of any lesions. For example sub-clinical mastitis would not have any deleterious effect on the slaughter value of a cull dairy cow, because the udder is relatively walled off from the body and not kept for human consumption. As an example of what can be done with slaughter records, McIlroy et al analysed abattoir data, consisting of condemnation records covering a ten year period by comparison with meteorological data (McIlroy et al., 1987). The authors were able to demonstrate significant associations between meteorological events and recorded lesions of pigs (presumptive Ascaris suum) and sheep (pleurisy and pneumonia), in the examples given. Both of these diseases are of considerable interest

to farmers and veterinarians because of the potential for deaths and production losses in both species.

Farmer Surveillance

Farmers by virtue of their close and frequent interaction with their animals are ideally suited to detect changes in demeanour, appearance and productivity that may be the first indicators of disease. For these reasons and others, various groups have sought to collect and use disease records sourced directly from farmers. Problems with this approach have included inconsistent recording and reporting by farmers and a lack of sensitivity and specificity with recorded diagnoses. Balanced against this is the greater range and magnitude of disease seen by farmers when compared to that reported by veterinary practitioners and animal health laboratories.

Ruppanner (Ruppanner, 1972) in California, USA was one of the first to attempt to quantify interview data from farmers and others as a source of endemic disease data of a general nature. He found the method useful to discover opinions, facts and issues that would otherwise have escaped detection by traditional veterinary surveillance. The Northern Ireland Department of Agriculture (DANI) surveyed beef producers regarding bovine mortalities. The findings were presented as percentages, with minimal reference to explanatory variables. The paper appeared to have a lot of detailed results that would have benefited from more detailed analysis (Menzies et al., 1994).

More recently Black (Black & Vujich 2002, Black et al., 2001) has looked at farmer records as qualitative sources of disease data. He found this a useful source of data to compare with veterinary practice records. In exploring various ways of capturing data he has moved from handheld computers to web based reporting by farmers. It is yet to be determined how successful the web based approach will be.

Sales of various drugs and vaccines will also give an indirect indicator of the importance of various diseases of animals. The weaknesses of this approach are that the drug or vaccine may be used for a problem that does not exist or is only sporadic in appearance. This is especially so for drugs that are freely available to farmers as opposed to those requiring a veterinary consultation before dispensing. Commercial sensitivity of this information may also limit its availability.

A modified version of farmer surveillance is the use of dairy herd records by national herd improvement companies as a source of surveillance data. The milk quality records are laboratory derived records and as such are less subject to the vagaries of farmer reporting, although if farmers are collecting samples, there is still the need for care in the sample collection. Other records that may be available are farmer recorded diagnoses and the results of targeted surveillance programmes run by the herd improvement company. In the New Zealand context, Livestock Improvement Corporation, a farmer owned dairy herd improvement company has been active in the area of collecting farmer records through its MINDA programme and also targeted surveillance and control of Enzootic Bovine Leukosis virus. These records are a source of surveillance data.

Veterinary Surveillance

Veterinary practitioners in New Zealand are required by law to report any notifiable diseases they suspect, to the relevant authorities. Practitioners are recognised as the frontline of disease reporting capability. However the diseases they see are usually not of interest to regulatory authorities. Professional standards also require veterinarians to report adverse reactions to registered animal remedies. The appropriate New Zealand regulatory authorities generally note that veterinarians do not report as many cases of adverse reactions as they would expect to occur. From a clinical practitioners perspective the reporting process is just another job to do in a busy day, with little or no useful feed back expected. Consequently under-reporting is highly likely. The UK Suspected Adverse Reaction Surveillance Scheme (SARSS) produced a short summary report that at the least gave practitioners some indication of the reported rate of reactions (Gray, 1998).

Endemic diseases of farm animals have received scant attention from regulatory authorities in New Zealand in recent years. An informal small survey of animal health professionals, conducted by the author, highlighted surveillance of these endemic diseases as an area needing greater attention (McIntyre, unpublished data, 2000).

Examples

Examples of where veterinary practitioners have been the first to detect cases of

diseases of interest include the first recorded case of *Brucella canis* infection in the UK, in a pet dog that passed through six months of quarantine in the UK (anonymous, 2002a) and five cases of canine leptospirosis in New York (anonymous, 2002b). In both cases the practitioners involved showed considerable clinical expertise to detect cases that would not have been expected to be on their list of routine differential diagnoses.

An epidemic of canine distemper in Indiana, USA, was confirmed by a mail survey of private veterinary practices (Johnson et al., 1995). The authors were able to confirm an increased prevalence of canine distemper infection during 1991 and 1992 by analysis of the responses from 223 practices. The authors noted the value of private veterinary practices to confirm suspected disease outbreaks in companion animals. There is no

reason why this methodology could not be extrapolated to food animal medicine practices also.

Black et.al. (Black et al., 2001) and Mellor et.al. (Mellor et al., 2000) have collected data from veterinary practices to measure events such as frequency and type of contacts with farmers and diseases seen at a visit. An understanding of such parameters is the first stage in validating practitioners and the data they collect as sources of disease surveillance data.

A Medical Example of an Innovative Method of Disease Surveillance.

Rapid or widespread movement of people make the development and maintenance of disease surveillance systems essential. If resources and or infrastructure are limited then novel ways of responding to the problem need to be developed. In Mpumalanga Province, South Africa, disease surveillance specialists considered that under-reporting by communicable disease control coordinators compromised the ability of the medical system to detect and respond in a timely manner to diseases with major public health significance (Durrheim et al., 2001). These communicable disease control coordinators are senior nurses appointed to manage disease control programs in each of the 16 health districts. As a response to this weakness, the system was enhanced by reducing the number of diseases the coordinators had to report to nine clinical syndromes with a high reporting priority, clear cut clinical case definitions, regular (monthly) training and networking opportunities for the nurses and effective feedback on the outcomes of the

reporting. Weekly reporting where there were zero cases of the syndromes of interest was also instigated, as an indicator that the system was still alert and functioning.
The outcome of this was investigated by review of hospital records and responses to detected cases of notifiable diseases. The improvements were considered a success because of disease detection and containment for several contagious diseases. In one example only 19 secondary cases of Cholera were detected, where the potential was 20 - 30 000 cases if reporting had been tardy. By the end of the programs second year of operation, all coordinators were filing the weekly zero cases, reports on time.

From a quantitative epidemiologist's perspective, the greatest weakness in this system is the lack of understanding of the size of the population at risk. However this was not the aim of this system and should not detract from its achievements.

The implications of this model are that for disease surveillance to be effective, the people on the ground in the areas where the diseases are occurring need to be need to be responsible for reporting and managing of outbreaks, with laboratories and distant specialists as tools to be used to assist with the process and not primarily responsible. This of course is dependent on the people on the ground reliably recognising the disease syndrome(s) of interest. Syndromic reporting is far less demanding in terms of diagnostic expertise than making a correct diagnosis, but suffers from a lack of specificity.

SECTION 2 :

Use of Veterinary Practices to Define Baseline Patterns of Animal Disease for National Animal Health Surveillance

Introduction

New Zealand is recognised internationally as being free from several important diseases of livestock that afflict many countries producing livestock products for international trade. Underpinning New Zealand's claims of freedom from specific diseases is the existence of a veterinary infrastructure that would detect these specified diseases, were they to be introduced. Private veterinary practices service farms in all parts of New Zealand that are commercially farmed. The frequency of veterinary involvement varies with intensity of livestock management, from very regular in intensive dairy farming to occasional for more extensive pastoral enterprises. However, this relationship between New Zealand livestock industries and practitioners has yet to be effectively harnessed for the purpose of animal disease surveillance. It is employed for notifiable disease reporting but not for recording patterns of occurrence of endemic diseases.

Historically the Ministry of Agriculture and Fisheries provided regional laboratory services at little or no cost to veterinary practitioners or farmers, thereby gaining access to a range of diagnostic material that underpinned disease surveillance activities. Submission rates from production animals declined dramatically after the introduction of a user-pays philosophy in the mid 1980s. At the same time laboratory services became fragmented as private laboratories established in the main regional centres. Former state laboratory service veterinarians founded some of these. Many veterinary practitioners who had formed working relationships with them continued to use their services in the private laboratories. This further depleted the supply of surveillance material to the state service, to the point where private laboratories were offered government contracts to provide diagnostic laboratory surveillance services.

Currently surveillance information is sourced from submissions by veterinary practitioners to their preferred diagnostic laboratory. Laboratories approved by MAF Biosecurity as recognised providers of surveillance reports for appropriate diseased animal cases provide summaries of data to MAF on a quarterly basis. The approval

process involves contractual obligation to operate to a specified standard. Briefly this covers issues such as diagnostic capability, availability of suitable case material, quality control systems, lines of reporting and accountability.

Dairy farmers are required by law to record diseases occurring in, and treatments given to, animals providing milk for human consumption. In some cases these records are held in a computer program. At the time this research was conducted, a program commonly used on New Zealand dairy farms was DairyWIN©, developed by Massey University and marketed by Livestock Improvement Corporation. Farmer records represent a source of data that could contribute to national disease surveillance.

In this pilot project, we compared data of animal disease events obtained from records of veterinary practices, computerised farm records, and laboratory submissions as potential sources of endemic disease data for surveillance.

Program objectives

Objective: Collect, evaluate and compare disease data recording and the underlying patterns of disease, as recorded by farms, veterinary practices and laboratories.

Materials and Methods

Practice recruitment

Nine veterinary practices (four lower North Island, four upper South Island and one lower South Island) were approached to see if they would provide computerised clinic records pertaining to selected dairy clients who used the DairyWIN© program. DairyWIN© was chosen because the returned data would be in a digital format readily imported in to an MS Access database. DairyWIN© users were also expected to be among the better data-recording farmers. Two North Island practices were unable to assist because of logistical difficulties and two South Island practices did not have enough consenting clients using DairyWIN©. The practices were chosen purposively based on location and relationships with the authors that gave some confidence that suitable data could be collected. All were staffed with veterinary practitioners with substantial (10-36 years) dairy cattle practice experience,

Selection of farms

The DairyWIN© clients were identified in a number of ways. Some were known personally to the author, two were identified by response to a mail drop within one practice area, and the majority were identified by the veterinary practitioners directly or indirectly by asking identified DairyWIN© users if they knew of any other users in their area. Each farmer was sent a letter explaining the purpose of the study and requesting their signed consent to release their records held by the veterinary practice, and to return a copy of their DairyWIN© records. Records requested were for the period 1 July 1999 through to 31 May 2001. A further condition for eligibility was that a farm used a single veterinary practice for all veterinary work.

Data collection

Participating veterinary practices were asked to provide clinic charging records for the 1999-2000 milking season and the period from 1 December 2000 to 31 May 2001. Records provided by veterinary practices (laboratory records and clinic charging records) were print-outs of computer records and photocopies of laboratory results. Printed records were checked for obvious anomalies and the lines of interest highlighted. The relevant records were then manually loaded in to the relational database (Microsoft Access 97 ©). In some cases data were entered in to Microsoft Excel 97 prior to being copied in to the database.

Veterinary practice farm visit records were separated into those that pertained to sick or injured animals and those that pertained to healthy animal interventions, such as pregnancy testing. An intervention was defined as any examination or treatment of an individual animal on any given day. Where more than one intervention was applied to a subset of animals from a herd without identification of animal identity, it was assumed that the interventions were applied to different cows for data recording. Multiple interventions were recorded on the same cows only if records allowed identification of each animal receiving each intervention, or if the whole herd received more than one intervention at one visit. For example, a group of cows pregnancy tested and a group injected for early induction of calving were treated as separate interventions.

“Sick” animals included cows examined and treated for no observed oestrus activity. In some calculations these animals were excluded, and these instances are noted where appropriate in the results. The diseases shown in Appendix 3 (Disease Code

Categories), were used to code the diagnosis provided by the veterinarian. Some interpretation of what the practitioner described was needed on many occasions to enable a coding conclusion. Sometimes the diagnosis was not stated, but could be readily inferred from the treatment provided. For example, uterine infections could be inferred from use of products licensed for uterine infusion. Where the diagnosis could not be determined with confidence, the field was coded undiagnosed / unspecified.

Each individual animal intervention or examination generated a case record consisting of a farm identifier, date, type of intervention or diagnosis, type of animal examined (e.g., cow or calf), and in a few instances the identity of the individual animal examined. Farm identifiers were related back to practices. Each practice was located distant to the others so there was no overlap of practice areas. Animal type was as indicated in the records provided. There is likely to be some overlap between the heifer and cow classifications. Where no indication was provided, this field was left blank. Only records pertaining to cattle were included.

Laboratory records were coded as either “sick animal” or “production profile” cases. A record was created for each individual animal sampled. A record consisted of farm identity, date of sampling, sick or production coding, animal type and animal identity. “Production profile” means samples for trace element analysis and metabolic disease assessments of more than one cow. “Sick” applies to all other samples including milk samples for bacteriology.

Farmers returned backup copies of their DairyWIN© records, either on floppy disks or by e-mail attachment. One farmer who initially indicated he was using DairyWIN© subsequently provided his records as a Microsoft Excel spreadsheet. These were re-coded into DairyWIN© format and treated the same as DairyWIN© records. The disease and cow tables were imported in to Microsoft Access 97 and the records extracted to a new table. Herd size (number of milking cows) was taken from the DairyWIN© records. These estimates are likely to be slightly conservative as they reflect herd size at drying off, rather than at the start of the milking season. Records were checked against quantities of vaccine purchased to confirm that the value given was approximately correct. In the case of the farmer who provided his records in

spreadsheet format, herd size was estimated as the number of cows examined by the practice during whole herd pregnancy testing. The herd size estimate was held constant for those herds who had two years of veterinary clinic data.

Data analysis

Data were loaded in to a relational database (Microsoft Access 97) (Microsoft Corporation, 1996) and manipulated to produce useable cross-tabulation output. Statistical analyses were conducted using Microsoft Excel 97 (Microsoft Corporation, 1997), SYSTAT version 10 for Windows (SPSS Inc, 2000), SAS, version 8.1 for Windows (SAS Inc, 2002) and Confidence Interval Analysis (CIA version 2, Bryant T, University of Southhampton, UK, 2000).

Calculation of visits per farm per month for each clinic was as follows. The numerator was the sum of the farm visits for that month, divided by the number of years' data contributing to that month. The denominator was the number of farms contributing. To calculate monthly visits per 100 cows for each clinic, the mean monthly number of visits was divided by the sum of the participating herd's sizes linked to the clinic and multiplied by 100.

The number of animals seen at each visit was also of interest from a disease surveillance perspective. Herd size is shown as the independent variable because it is reasonable to expect larger herds to have more cows seen than smaller herds. Cows seen per month is the count of all cows seen on the farm divided by the number of months the farm is represented in the data.

Statistical analysis of sick cow examinations by clinic and month was performed by Poisson regression using a negative binomial model, estimated by maximum likelihood, in PROC GENMOD, running under SAS, version 8.1 for Windows. Model checking involved examination of likelihood ratio and deviance statistics.

Results

A total of five clinics provided data for the study: one from the southern South Island, two from the northern South Island, and two from the central North Island. Two clinics provided records covering the 23-month period in its entirety; another clinic provided records going back ten years. One clinic provided what was requested (Methods and Materials – Data Collection), but the last two months were unusable, because of insufficient detail regarding the timing of events. One clinic could only provide ten months records as computer systems had been changed and obtaining the earlier data was not practical. Another of the clinics provided records that could only be identified to month of visit, rather than day.

Most farmers were happy to assist with provision of records once they understood what was involved. Two refused outright and two others dropped out because they felt their records were inadequate. Two others failed to return computer records in time for analysis. A total of 40 farmers provided records that could be used. Herd sizes (mean 338 cows) varied from slightly below the national average of 236[2] (1999-2000 milking season) to just over double (Table 1). Across the 40 farms and five clinics, the study population encompassed approximately 13,600 cows (steady state) and 267,461 cow-months at risk.

Table 1: Number of study herds, herd size, and duration of clinic records for participating veterinary practices

Practice	Average herd size	Range	Participating farmers	Months of clinic records
1	267	92 – 644	6	23
2	210	97 – 288	5	10
3	476	307 – 874	9	16
4	419	191 – 861	9	23
5	256	106- 803	11	23

[2] Livestock Improvement Corporation, personal communication

Veterinary clinic records

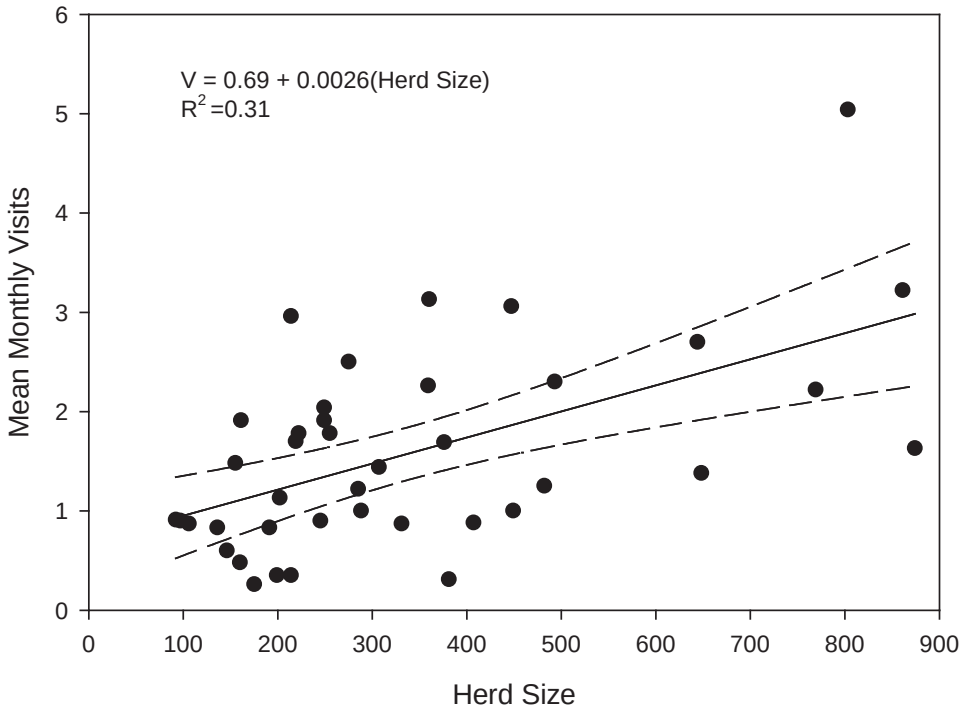
Clinics from Southland (3), Marlborough (2), Tasman (5), Horowhenua (4) and Northern Wairarapa (1) participated in this study. A database was created consisting of 41,675 veterinary interventions, 728 laboratory records of individual animals and 12,342 individual animal records extracted from farmer computer records (DairyWIN and MS Excel). Only one practitioner regularly recorded cow tag numbers and this only for relatively small numbers of animals (n=33). Ages of animals were not usually given in the clinic record, but could be inferred in some instances. As the animals grew older the reliability of this inference reduced. A diagnosis was not specified in 5.5 % of sick animals examined (22% if non-cycling cows are excluded). Practice principals reported that clinic staff involved in data entry were reluctant to enter any diagnosis with difficult spelling, pronunciation or similar attributes and often simply entered 'sick' on the computer records.

The frequency of visits to farms each month was calculated for each clinic (Table 2), with data consolidated from multiple years when available. Because larger herds had higher frequencies of monthly visits than small herds (Figure 1), visit frequency was also expressed as visits per month per 100 cows to standardise for herd size. Thirty-one percent of variation in visit frequency and 61% of number of cows examined each month variation was explained by herd size. There was no significant effect of clinic on visit frequency (p=0.18).

Table 2: Frequency of farm visits per-month and per-month per 100 cows

Practice	Mean number of visits per farm per month	Range	Mean number of visits per farm per month per 100 cows	Range
1	0.9	0.2 - 2.0	0.06	0.01 – 0.12
2	1.2	0.2 - 2.6	0.11	0.02 – 0.25
3	1.6	0.4 - 3.3	0.04	0.01 – 0.08
4	1.8	0.6 – 3.7	0.05	0.01 – 0.10
5	1.8	0.7 – 3.9	0.06	0.03 – 0.14

Figure 2: Association between frequency of herd visits (V) and herd size (simple linear regression with 95% confidence limits around the mean; P < 0.001)



As could be expected with seasonal calving systems, frequency of herd visits varied greatly among months (Figure 2), and visit frequency was 5.2 times higher in the busiest month (August) than in the quietest month (June). This pattern varied little among clinics (Table 3)

Figure 3: Frequency of veterinary visits per farm by month

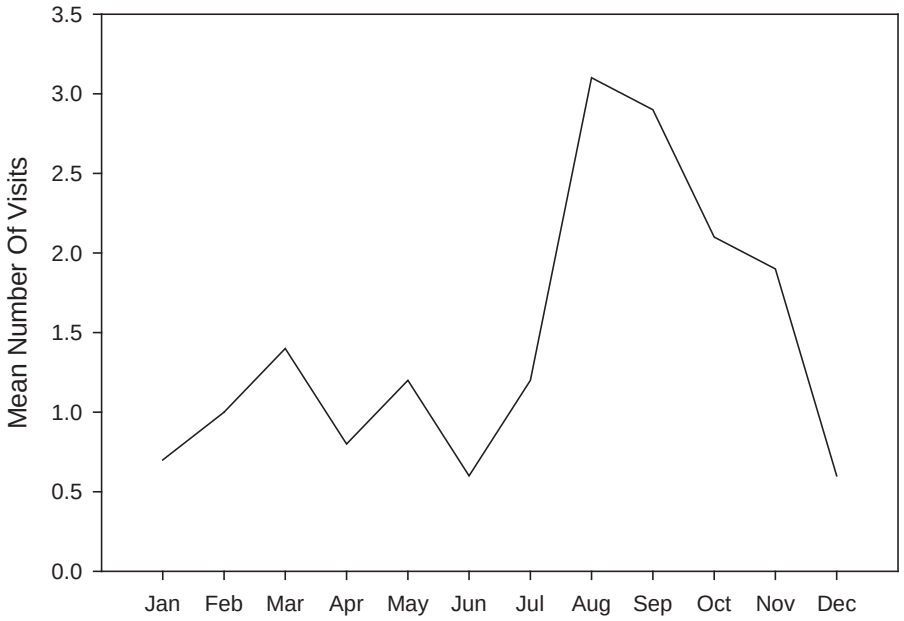


Table 3: Mean number of visits per farm per month by each participating clinic

Practice	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	0.7	0.3	0.4	0.9	1.2	0.4	0.9	1.8	2.0	0.9	1.0	0.2
2	0.6	0.8	0.4	0.2	0.4	NA	NA	2.6	2.6	2.4	1.6	0.2
3	1.0	1.4	2.6	0.9	1.3	0.8	0.4	3.3	3.3	2.1	2.2	0.8
4	0.6	0.8	1.8	1.1	1.7	0.6	2.4	3.7	3.4	2.6	2.5	0.8
5	0.7	1.5	1.7	1.1	1.4	0.7	1.2	3.9	3.4	2.4	2.4	1.0
Mean	*0.7*	*1.0*	*1.4*	*0.8*	*1.2*	*0.6*	*1.2*	*3.1*	*2.9*	*2.1*	*1.9*	*0.6*

The mean number of cows seen on each farm per month shows a steady, approximately linear increase with herd size (figure 4). The relationship is statistically significant even with an outlier present. When this farm (at herd size 870) is excluded (figure 5) the coefficient of determination (r^2) improves from 0.49 to 0.61. That is 61% of variation in the mean number of cows seen per month for each farm, is explained by herd size. On this excluded farm, something other than herd size influences the mean number of cows seen by a veterinarian each month. Although the relationship between mean monthly farm visits and herd size is weak (r^2 = 0.31), the relationship with cows examined / handled each month is stronger (r^2 = 0.61). Increasing herd size is therefore more strongly predictive of an increase in the number of cows examined at each veterinary

visit than it is of an increase in the number of visits per month by the veterinarian. This is likely to be motivated by attempts to reduce veterinary costs and also time constraints affecting these larger farms.

Figure 4: Association between number of cows seen each month by a veterinarian (N) and herd size (simple linear regression with 95% confidence limits; P < 0.000)

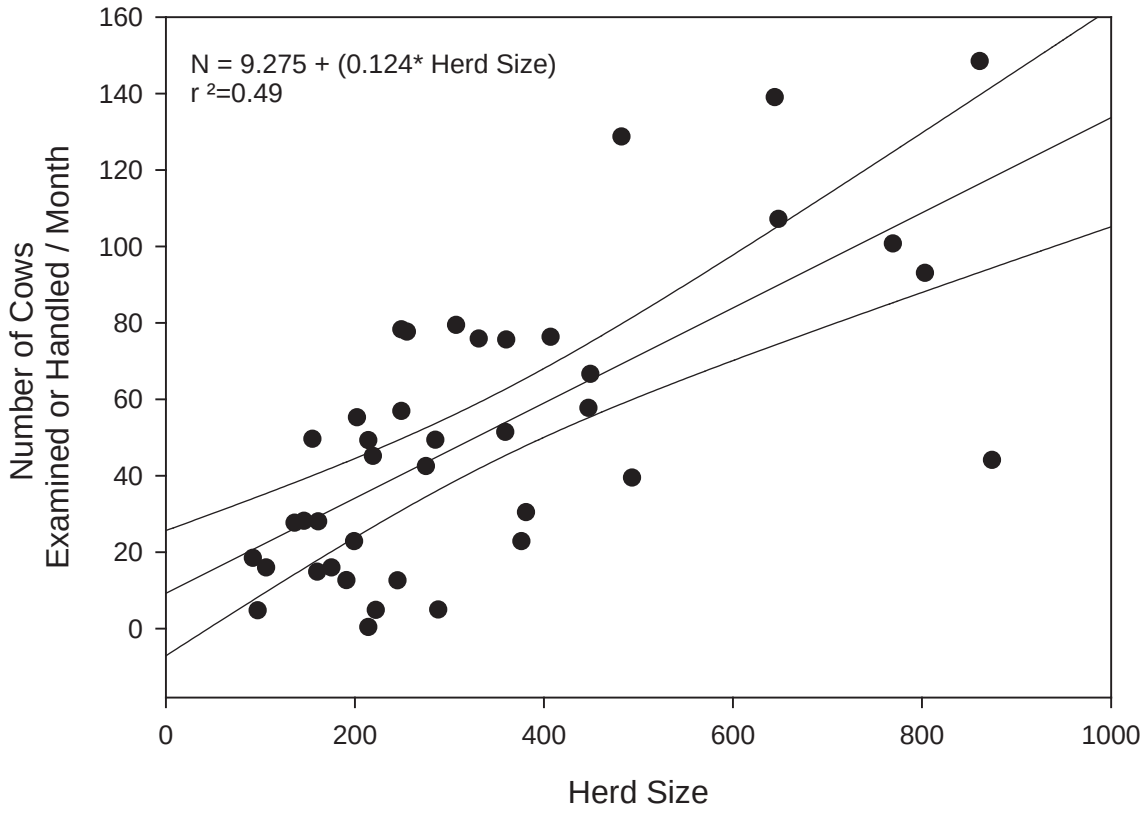
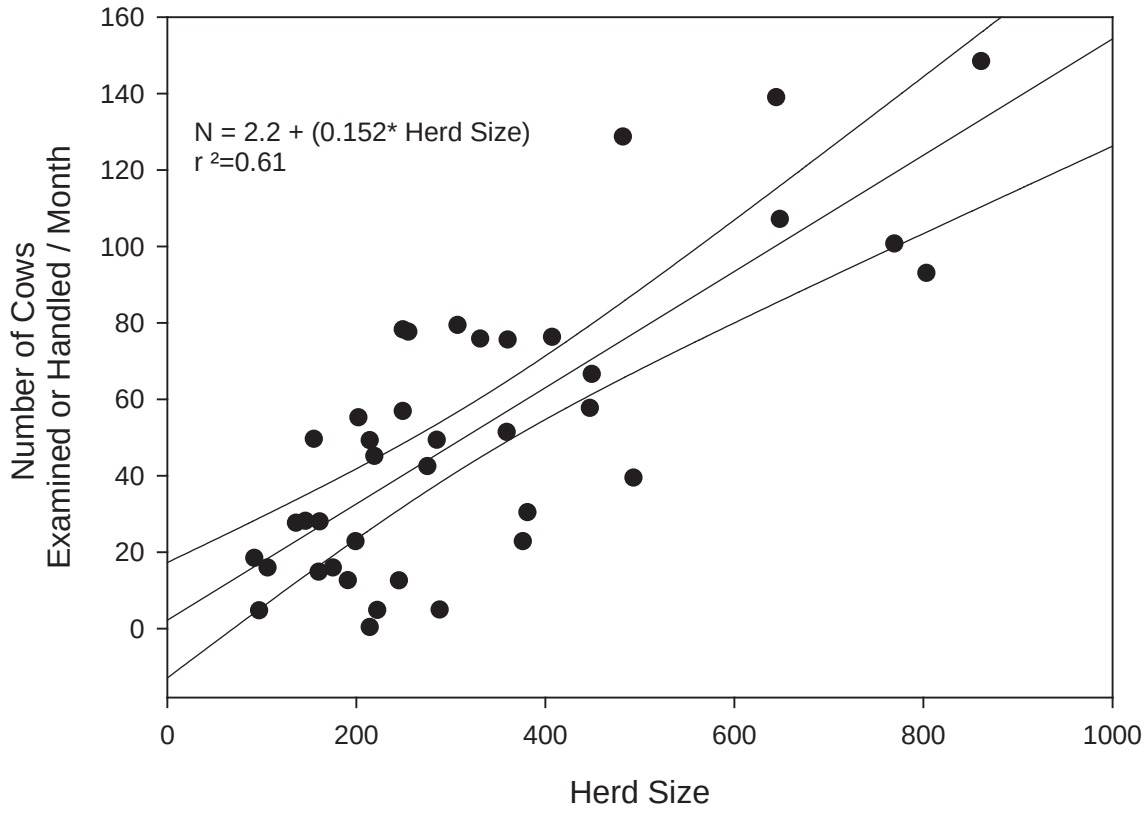


Figure 5: Association between number of cows seen each month by a veterinarian (N) and herd size (simple linear regression with 95% confidence limits; P < 0.000) with outlier (at herd size = 870) removed



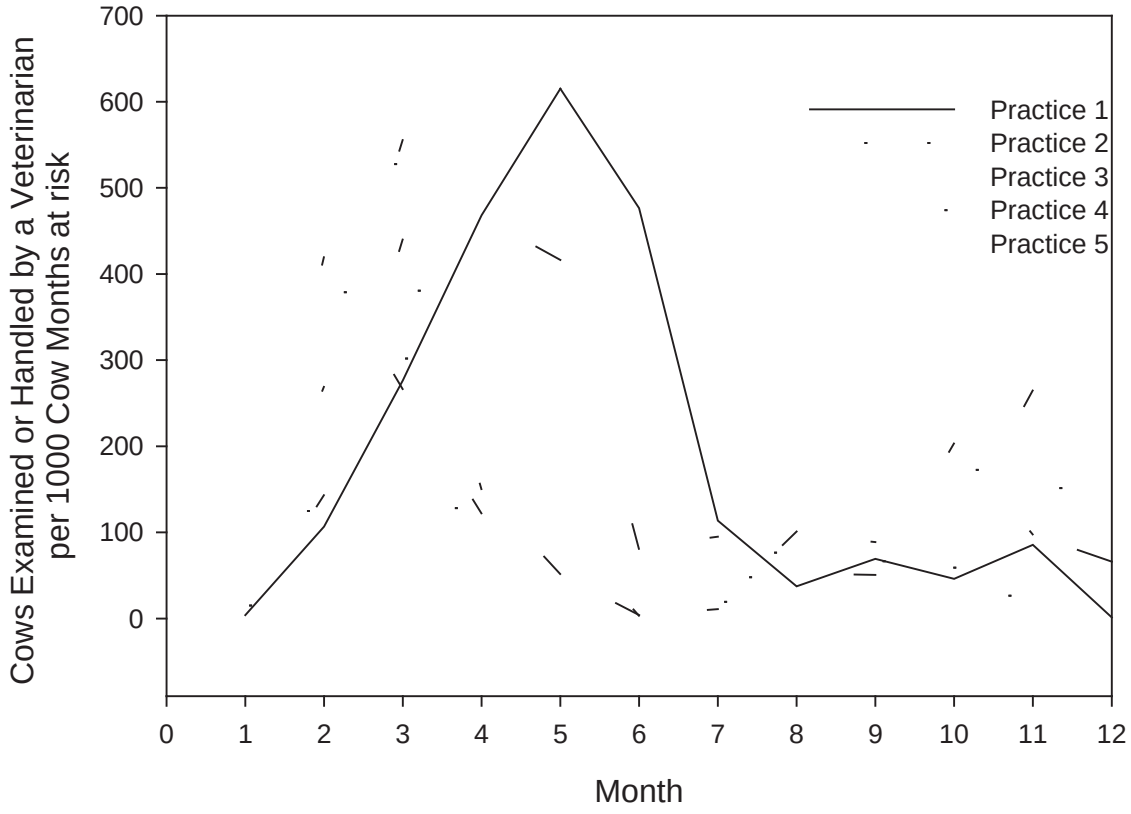


Figure 6: Cows handled each month by clinic per 1000 cow months at risk.

In contrast to the visit frequency (figure 3), which peaks in the spring months, the autumn months are when large numbers of animals are handled for routine manipulations such as pregnancy testing and vaccination. The effect of month (p=0.000) but not practice (p=0.061) was significant (at the 5% level) in a general linear model, with no interaction term. The interaction term between month and practice was not specified because there are insufficient degrees of freedom in this model. When months were converted to season (spring = months 8,9 and 10 and so on) to accommodate an interaction term, season (0.000) and the interaction term between practice and season (p=0.018) were both significant at the 5% level.

After excluding non-cycling cows, the mean number of sick animals seen per farm per month by participating clinics ranged from 0.7 to 2.5 (Table 4). Among 1402 sick animal events, 80.7% were from milking cows, 6.9% from calves, 3.8% from heifers,

1.2% from bulls, and 7.4% were of unspecified cattle type. However, likely inconsistency among veterinarians in distinguishing between and recording animals as cows or heifers must be considered.

Table 4: Mean and range of number of sick animals seen per farm per month by clinic and same standardized to 100 cows.

Practice	Mean number of sick animals seen per farm per month (excludes non-cyclers)	Range	Mean number of sick animals seen per month per 100 cows	Range
1	0.7	0.0 - 1.9	0.05	0.00 – 0.12
2	1.9	0.0 - 10.0*	0.18	0.00 – 0.95
3	2.1	0.6 – 7.2	0.05	0.01 – 0.17
4	2.5	0.6 – 6.0	0.07	0.01 – 0.16
5	1.6	0.2 – 4.6	0.06	0.01 – 0.16

*Maximum value elevated by one outlier month, in which a large number of subclinical mastitis cases were recorded on one farm on a single day. If these cases are excluded, the maximum value is 6.6.

Diseases reported

For clarity of presentation the diseases were categorised as shown in Table 5. Cows showing no oestrus ("non-cyclers") have been excluded from the table. They affect just two months of the year, albeit spectacularly. Cows seen in October with reproductive problems increase 38 fold when "non-cyclers" are included and for November the figure is 126 fold. Of interest with respect to BSE surveillance, only three cases (0.21 percent of sick animals) were diagnosed with non-metabolic neurological disease - two cases were recorded as polioencephalomalacia (1 cow, 1 calf), and 1 case as brain tumour or abscess in a cow. There were 74 cows, 1 heifer and 1 unknown animal recorded as downer cows (5.4 percent of sick cows), another group considered at higher risk for BSE. It is likely that some of these were revisits to the same animal, although this could not be identified from the data provided. It is also likely that the great majority of these are metabolic disease or calving paralysis, but again it is not possible to confirm this from the data provided.

A full breakdown of diseases reported is shown in Appendix 1

Table 5: Incidence rates for reported disease categories (Cases per 1000 cow months)

Category	Incidence Rate	Lower 95% CI	Upper 95% CI
Digestive system	0.29	0.23	0.37
Locomotory System *	1.50	1.35	1.65
Mammary Gland	0.35	0.29	0.43
Metabolic Disease	0.12	0.08	0.16
Other	0.38	0.31	0.47
Reproductive System	1.42	1.28	1.57
Undiagnosed / Unspecified	1.17	1.04	1.31
	5.24	2.79	5.24

* Includes downer cows that may be metabolic cases

Table 6: Incidence rates for reported disease categories by month (Cases per 1000 cows / month)

Category	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Digestive system	0.12	0.15	0.31	0.23	0.37	0.05	0.48	0.55	0.46	0.32	0.55	0.08
Locomotory System *	2.00	1.31	0.65	0.51	0.74	0.24	0.72	2.07	2.85	1.80	2.85	2.31
Mammary Gland	0.08	0.04	0.04	0.05	0.18		0.56	1.52	1.52	0.32	0.28	
Metabolic Disease		0.04	0.04	0.05		0.05	0.08	0.32	0.46	0.32	0.05	0.04
Other	0.23	0.35	0.23	0.23	0.41	0.15	0.72	0.74	0.74	0.51	0.55	0.19
Reproductive System	0.12	0.08	0.27	0.23	0.09	0.10	2.81	5.71	5.62	1.80	0.92	0.19
Undiagnosed / Unspecified	0.77	0.73	0.77	0.74	0.78	0.58	1.20	2.16	3.45	1.52	1.01	0.65

* Includes downer cows that may be metabolic cases

Although the limited scope of this pilot study does not involve replication in all regions, the potential for temporospatial analysis of endemic disease is evident in these temporal and regional patterns (Tables 6, 7). Variability in incidence of disease recorded by practitioners among regions or over time may be a relatively sensitive indicator of changing patterns of disease.

Table 7: Incidence of cases in reported disease categories expressed as cases per thousand cow months at risk for each practice (1 - 5).

	Practice				
Category	1	2	3	4	5
Digestive system	0.2	0.5	0.1	0.2	0.5
Locomotory System *	1.0	2.2	1.0	1.8	1.9
Mammary Gland	0.2	2.5	0.1	0.3	0.4
Metabolic Disease	0.0	0.2	0.0	0.1	0.2
Other	0.3	0.7	0.3	0.4	0.5
Reproductive System**	0.6	2.8	1.1	1.2	1.9
Undiagnosed/Unspecified	0.5	0.4	1.3	2.2	0.6

* Includes downer cows that may be metabolic cases

** Cows with no observed oestrus excluded because inadequate reporting of numbers seen by clinic 2 adversely affects regional comparisons.

Table 8: Estimates of relative risk (RR) of examination of sick cows and 95% confidence intervals, for practice (relative to practice 5) and months (relative to month 12) generated by Poisson Regression using a negative binomial model.

Parameter		DF	Estimate	Error	Wald Chi Sq	RR	95%CI Lower	95%CI Upper
Intercept	1		-7.65	0.27	<.00			
Practice	1	1	-0.70	0.23	0.00	0.50	0.32	0.78
Practice	2	1	0.06	0.25	0.80	1.06	0.66	1.72
Practice	3	1	-0.22	0.21	0.29	0.80	0.53	1.21
Practice	4	1	0.11	0.21	0.59	1.12	0.75	1.67
Practice	5	0	0	0				
Month	1	1	0.24	0.35	0.49	1.27	0.64	2.50
Month	2	1	-0.10	0.35	0.77	0.90	0.46	1.78
Month	3	1	-0.38	0.35	0.27	0.68	0.34	1.36
Month	4	1	-0.48	0.36	0.18	0.62	0.30	1.25
Month	5	1	-0.26	0.35	0.47	0.77	0.39	1.54
Month	6	1	-0.44	0.40	0.27	0.65	0.30	1.41
Month	7	1	0.16	0.35	0.66	1.17	0.58	2.35
Month	8	1	1.46	0.33	<.00	4.29	2.27	8.12
Month	9	1	1.79	0.33	<.00	5.99	3.14	11.44
Month	10	1	0.80	0.33	0.02	2.22	1.16	4.26
Month	11	1	0.74	0.33	0.03	2.10	1.09	4.04
Month	12	0	0	0				

Laboratory records

A total of 728 laboratory records of individual animals pertaining to the time periods of interest for each of the clinics were available for analysis. These represented 157 separate laboratory submissions. Individual animals were identified in 49% of these cases. One clinic provided the laboratory records in a format that did not allow

identification of individual animals. When this clinic was excluded, 70% of samples were individually identified.

Of the sick animal laboratory reports examined, 48 of 115 animals from four clinics (one clinic excluded because of insufficient data to make this judgement) were able to have a diagnosis made or confirmed. Another eight were able to have a tentative diagnosis made, but not confirmed. The remaining 59 could not have a diagnosis made or confirmed on the laboratory result alone. Of the 48 positive diagnoses, 23 were milk samples submitted for routine culture and sensitivity. The remaining 25 positive diagnoses included Johne's disease (4), hypomagnesaemia (3), hypocalcaemia (4), hypocupraemia (6, all on one farm), bovine virus diarrhoea (2), rotavirus diarrhoea (1), salmonellosis (4; 3 on one farm), and facial eczema (1)

Table 9 summarises the percentages of animals examined that were sampled for further laboratory work up. Practices with a higher proportion of healthy animal interventions such as vaccination have a below average percentage of animals sampled for laboratory work. When only sick animals (excluding those examined because of no observed oestrus) are considered the relative rankings change, with those clinics having a low percentage of total animals sampled rising to about average or above.

Table 9: Percentage of all animals and sick animals examined that were sampled for laboratory submission by clinic; percentage of laboratory submissions that were sick animals or production profiles by clinic

Practice	Animals sampled * as a percentage of animals examined	Percentage of "sick" animals sampled. **	Percentage of laboratory submissions	
			"sick"	"production profile"
1	1.4	13	14	86
2	3.5	4	15	85
3	2.1	6	8	92
4	1.5	12	37	63
5	1.1	9	23	77
Mean	*1.9*	*9*	*19*	*81*

* Animals (n=62) sampled under EBL testing scheme excluded from all laboratory record calculations.
** Excludes cows with no observed oestrus.

Farmer Records

Of the 40 farmers providing computerised records for the study, only 25 had recorded any disease events during the period of interest. Another 4 recorded veterinary reproductive examinations. The great majority of these disease events were mastitis (acute, chronic and sub-clinical) and lameness under various sub-categories (Appendix 2). Of these disease events, 177 were reported as diagnosed by veterinarians, 1829 by the farmer and 1924 not specified. Seven (28%) farmers reported 94% of the disease events.

Comparison of the numbers of sick animals the veterinarians reported with the numbers the farmer reported the veterinarian examined, indicated poor recording by the farmers overall. Only 1 farmer recorded 100% of the veterinary examinations, and the mean was 19% reporting (median 4%). Interestingly only one of the 7 larger farms mentioned above, recorded an above average percentage of the veterinary diagnoses. One farmer from Southland recorded five cases of ephemeral fever, a disease considered exotic to New Zealand.

Discussion

The overriding purpose of animal disease surveillance is to minimise the detrimental effects of animal disease on animal populations, animal industries and the general public through early identification of unusual events or abnormal trends in rates of disease occurrence. Increasing recognition of the importance of animal disease surveillance can be partly attributed to greater movement of people, animals and animal products among countries, and ongoing problems with emerging (e.g. BSE) or re-emerging (e.g. FMD) diseases in many parts of the world (Doherr & Audige, 2001). Credible documentation of regional or national freedom from specific diseases, and ability to detect and respond to changes in animal disease incidence rely on systems that enable timely collection, analysis and dissemination of animal disease data.

The main conclusions of a recent review of animal health surveillance in the United Kingdom (Meah & Lewis, 1999) were that a clear strategy for surveillance was needed, as was a transparent and open system for prioritising surveillance. A risk-based approach to determining priorities was recommended, as was exploration of novel sources of validated information. There are precedents for using veterinary practices for surveillance of specific diseases (Johnson et al., 1995) (Mellor et al., 2000) but the current study and that of Black et al. (Black et al., 2001) appear to be the only efforts to assess the usefulness of veterinary practice records for national disease surveillance. Attempts to use practice-based records have been frustrated by poor reporting by practices and difficulties in transfer and handling of data at a central level.

A crucial step in designing a surveillance system is to define the objectives, which will depend on the animal disease profile of a region and the potential animal and public health, and economic impacts of respective diseases. Appropriate allocation of resources for animal disease surveillance requires consideration of the costs of data collection against the quality of the data that can be obtained from respective sources. Clearly, 'trade offs' exist between scope (range of species and diseases), representativeness of target populations, and refinement (accuracy and reliability of diagnosis) of different sources of data. Traditional 'passive' laboratory-based surveillance has advantages of

low cost of collection and high level of refinement, but shortcomings with respect to scope and representativeness. Targeted surveys of specific diseases should be both representative and reliable, but tend to be expensive, restricted in scope of disease and species, and cross-sectional (requiring replication to discern possible temporal trends). Advances in information technology and their uptake by both the veterinary and livestock industries provide novel opportunities for capturing data of animal disease events for purposes of surveillance.

This project was designed to assess and compare farmer records, veterinary clinic records, and laboratory submissions as indices of animal disease in a defined population of dairy herds. The dairy industry was chosen due to its national importance, relatively high veterinary inputs, and well-established use of computerised farm records. Only farms using a computerised herd management program enabling recording of disease and treatment events (DairyWIN©) were included, and all participating veterinary clinics were well experienced in dairy herd health. These preconditions for the study design arguably present an assessment of a 'best case' scenario for practice-based and farmer-based surveillance under prevailing industry conditions in New Zealand. However conditions for representative data collection apply throughout New Zealand and could be applied for national surveillance through structured selection of data providers and the use of multiple sources of information.

Due to the purposive (ie non-random) selection of both veterinary clinics and farms to obtain a best case estimate of the various parameters presented, these data cannot be portrayed to be nationally representative with respect to farm conditions (larger and likely more 'progressive'), or veterinary clinics and 'farm-clinic' interactions. One would expect considerable variability among 'farm-clinic' entities with respect to frequency of veterinary visits, and subsequent laboratory submission rates for each population at risk.

As expected, farmer records yielded the highest rate of recorded animal disease events (14.6 disease events per 1000 cow-months at risk), followed by veterinary clinics (5.2), and laboratory submissions (0.58). Laboratory records were biased towards production profiling. When all records were considered there were 2.6 animal records per 1000 cow-months at risk. Features of farm-based data were high levels of under-reporting on

many farms, a high proportion of mastitis and lameness events (84% of farmer-recorded disease events compared with 28% of veterinary events), a low proportion of undiagnosed / unspecified events (0.3% vs. 22% for veterinarians), and a general failure to specify which diagnoses were made by veterinarians. Over one-third of farmer participants recorded no animal disease events despite a selection process that was deliberately biased to include farmers thought to be more likely to be recording disease events. Of the farmer recorded disease events, 98% were diagnosed by farmers or unspecified and only 2% were recorded as veterinary diagnosis. These last 177 events would represent only 20% of disease events recorded by practitioners on the 25 farms that recorded health events. Although it is possible that farmers kept additional data on disease events in other repositories, it is only data in electronic form that can be retrieved practically for surveillance purposes.

Reliability of farmer-based diagnoses is generally considered to be poor (Vaillancourt et al., 1993) (Christensen & Svensmark, 1997) but is likely to vary greatly according to the conditions involved. Our data suggest a farmer recording bias towards the most common conditions endemic to dairy herds (mastitis and lameness problems), for which farmer interest may be highest, and also confidence in diagnostic specificity may be relatively high. As expected, veterinary attention appears not to be sought for many animals affected with these groups of conditions and data from veterinary practices will grossly underestimate incidence. Arguably, where farmers are motivated to record data, farm-based data may provide the most reliable indication of incidence of these problems. If lameness and mastitis were excluded, the incidence of other farmer recorded disease events was 2.1 events per 1000 cow months at risk, while the corresponding figure for veterinary clinics was 3.6 per 1000 cow months at risk. Thus for general surveillance purposes, the data indicate that veterinary clinical records currently offer a more prolific source of dairy animal disease data than do farmer based records. Although some individual farms did record veterinary interventions relatively effectively, these were in the minority and the feasibility of improving general farmer recording of disease events for surveillance purposes is questionable.

The recent survey by Black et al (Black et al., 2001) reported an average of 14.0 visits per year to dairy herds, similar to the figure of 17.8 farm visits per year in the current study. Black et al (Black et al., 2001) categorised visits as either sick animal or routine

farm visits. In our study many sick animals were seen at the same time as routine work was carried out. The computational methods used in the two studies differ, however some general comparisons of results can be made. Gastrointestinal signs were reported as affecting 7 percent of dairy animals (Black et al., 2001) while the corresponding figure for this study was 5 percent. Similarly coughing or respiratory signs were reported in 1.2 percent of dairy animals by Black et al and 1 percent in the current study. The most striking difference was for arthritis, lameness or musculoskeletal signs where Black et al (Black et al., 2001) found 5.7 percent affected while our study found 23 percent. The reason for this difference is not obvious. Black acknowledges the likely presence of under-reporting of this disease syndrome in his study (Personal Communication).

Seasonal and practice differences in the occurrence of various categories of sick cattle (no observed oestrus excluded) were explored by Poisson regression (see table 8). Differences were detected in both practice and monthly relative risk of illness for "all sick animals examined". Relative to practice 5, practice 1 recorded only half the number of cases of illness in cattle across all their contributing farms. Whether this reflects an inherently healthier population at risk or under-reporting for whatever reason is pure conjecture. As would be expected for a seasonal calving dairy system, the spring months of August to November had a significantly ($p < 0.027$) higher relative (compared to December) risk of reporting ill cattle. The magnitude of this seasonal variation in relative risk varies between 2.1 and 6. That is the spring months have 2 to 6 times more sick cows than December. The other months do not differ significantly from December.

When the data were stratified by category of illness (see tables 5,6,7) the model was able to reach convergence for only the locomotory category. The likely cause of non-convergence for the other categories is the absence of cases for many month and practice pairs. For example reproductive and metabolic problems are heavily biased to spring occurrence in seasonal calving dairy herds. In the case of the locomotory category (all cases of lameness and cases of downer cows and any other marked restriction on movement), cows from practice 1 again had approximately half (0.538) the relative risk of being reported with this problem ($p=0.053$). The months of March and April, June and July had had a relative risk of locomotory disease being reported that was approximately 20 and 30 percent of that reported in December ($p<0.015$).

It was concluded that veterinary practice records have markedly greater potential than farmer records for purposes of general disease surveillance for the dairy industry in New Zealand. The risk of highly erroneous diagnoses (e.g. ephemeral fever cases in this study) also downgrades the utility of farm based data. The results of this study also indicate a much greater and vastly different yield of disease data was obtained from veterinary practices compared with diagnostic laboratories. Despite these findings, some farmer records offer more information than do other sources of records on diseases such as lameness and mastitis although the accuracy of their data could not be determined in this study. Information on these diseases may be of interest to the dairy industry, the pharmaceutical industry, research groups and welfare agencies and should not therefore be disregarded out of hand. It is likely that interest in future surveillance activities will not be confined to national disease control authorities but will command a wider interest allowing a more complete overview of production animal industries and sharing of costs of data collection and analysis. Furthermore it is likely that a judicious blend of data from multiple sources will prove to be the most useful.

For veterinary records to become a regular component of a national disease surveillance system, several obstacles will need to be overcome. A means of easily capturing the data in a consistent format needs to be developed. Ideally this would involve electronic capture by the diagnosing veterinarian in the field, to minimise non-specified diagnoses and inaccuracies involved in retyping the data by lay personnel. Further, it would need to meet quality control system standards. Once captured the data would need to be collected to a central database for epidemiological analysis. To encourage and maintain veterinary interest in the project, a mechanism for feed-back to those who contribute data needs to be put in place, which could involve both financial and disease reporting incentives. However none of these are serious obstacles and existing technology can adequately deal with all of those issues. To this end the author developed a prototype data collection tool designed for use with palm held computers (VetPAD - Veterinary Practitioner Assisted Disease Surveillance) in conjunction with the analytical component of this project. The software design prototype shown in section 3 outlines the proposed electronic data capture mechanism. To make such a tool appealing to veterinary practitioners, it was designed to provide parallel functionality to facilitate practice management with respect to record keeping, billing and inventory management.

With rapid changes in technology, the technological barriers to electronic capture of veterinary clinical events are unlikely to present a long term problem.

Broader issues involve the validity of veterinary clinical diagnosis and management of the volume of data that could potentially be obtained. Some problems in interpretation of clinical records that were encountered in this study could be mitigated through a standardised collection mode (e.g. VetPAD) and potentially through accreditation of practices supplying data (as currently done with diagnostic laboratories). Although national disease surveillance has been the focus for this study, other parties such as the livestock and pharmaceutical industries, whose interests are likely to differ, are potential users of veterinary clinical data. The sheer volume of data collected in this small project (over 40,000 veterinary interventions) indicates that for all potential users, efficient means of extracting the appropriate customised data must be devised. Again, this presents a technical barrier that is not insurmountable. For surveillance purposes, the desired structure for practice based sampling would need to be defined. For example, sentinel practices might be recruited in relation to livestock demographics.

Issues related to data ownership and client remain to be addressed. However, there are several possible models with which surveillance data could be collected while farm identity remains anonymous. Areas for further research include validation of the findings in the wider dairy and dairy practitioner population, and evaluation of this approach in other livestock species. Further investment in validation of data and quality assurance systems for all the steps in the process of data gathering from diagnosis to analysis and reporting should be considered given the encouraging findings in this study. Future plans include production of software for collection of data using a handheld computer that can be tested with practitioners.

SECTION 3:

VetPAD - Veterinary Practitioner Aided Disease Surveillance System

Introduction

For electronic capture of veterinary practitioner recorded animal disease data to be feasible and practicable the mechanism needs to be simple, workload neutral and provide benefits to the practice. Normal billing practice would be for the veterinarian to provide office staff with a formatted paper charge sheet filled out with the necessary details. This information is then be entered in to the computer by office staff.

The author has led the design of a prototype system and software (VetPAD - veterinary practitioner aided disease surveillance system) to enable practitioners to enter billing data in the field on a handheld computer. This will synchronise with the practice management software at the end of the day to allow rapid and accurate transfer of the data to the office computer. This eliminates the time and cost of data entry and the need for duplicate handling of the data with attendant risk of data entry errors. It also has the opportunity for more timely provision of management information, for example products sold. One veterinary practice manager cited stock control as the most important reason to take up such a system. Although most practitioners at this time do not appear to want point of sale billing, [3] this software would open up the possibility of point-of-sale billing for work leading to reduction in trade debt and more even cash flow. A further small advantage to the practice would be the opportunity of updating billing records. (Some farms have redundant accounts under different names with the one practice and or inaccuracies in the information held).

To be workload neutral the software would need to be simple and fast to use. The Palm operating system with it's instant on feature is an obvious choice for a busy practitioner who very likely would not wait for a slower windows based operating system to boot up, say on a notebook or Pocket PC. Drop down menus and a pick stick, make for rapid and standardised reporting of diagnoses, descriptions of affected animals and the treatment given. Linking this with the client name and address and any laboratory submissions will provide powerful epidemiological records.

[3] Various practitioners- expressed during user needs assessment

Overview of proposed VetPAD Logic

It is envisaged that the VetPAD software would form part of a more general Veterinary Practitioner Assisted Disease Surveillance System. The software will have practical functionality for veterinary practitioners in clinical practice, to record all data related to an individual client account. It will link to existing practice management software (PMS) to allow information recorded on farm in VetPAD to be transferred to PMS and used for billing, inventory and stock reconciliation purposes. Synchronization of information between hand-held and PMS will ensure that VetPAD will always contain the most current data with respect to the client list and the products and materials list.

In addition, veterinarians will be able to record disease information relating to individual dairy cows using VetPAD on a hand held computer. This information will subsequently be compared to data held in a GIS database to make regional and national inferences.

In contrast to DairyWIN and CowPAD which are primarily intended to record records from single herds, VetPAD is intended to collect partial herd data from a large number of herds.

Client list information

Client name

Client code to link with PMS

Products and materials

Product name

Product code to link with PMS

Product unit size identifier.

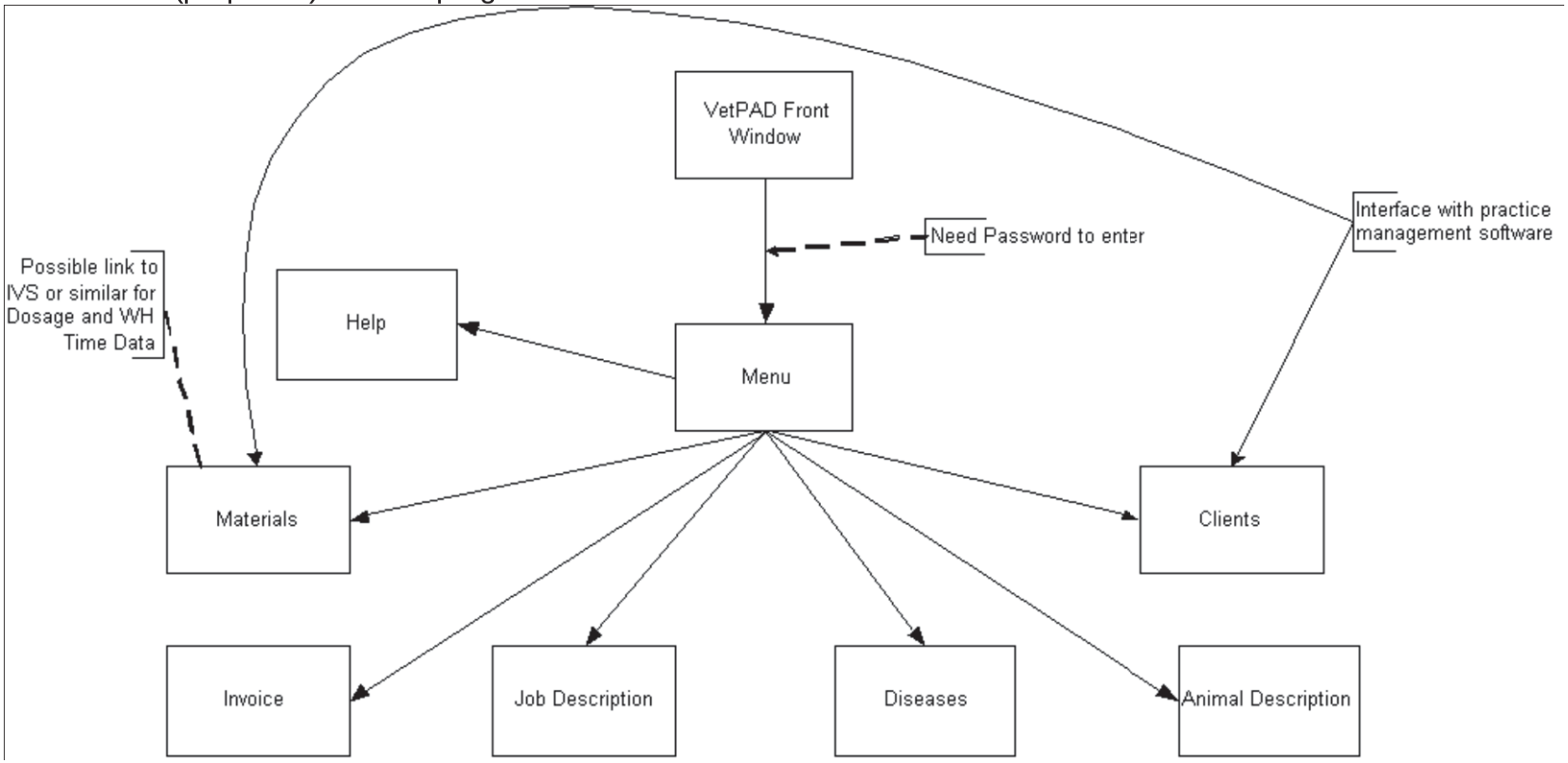
Product sale unit. (For example Ketofen 10% is sold in 10 ml and 100 ml vials. The practice may sell the 10 ml vials by the vial and the 100 ml vials by the ml)

Commentary

Location of farm using any of several methods:

1. XY coordinates from on-line map or paper maps
2. Herd ID as location of herd known in time and space
3. Hand held GPS unit
4. Rural emergency numbers

Overview of (proposed)VetPAD program structure



Draft Disease Code Categories for proposed VetPAD

Group	Type	Sub-type	Species affected	DairyWIN code
Cancer's			B	
	Cancer, unspecified		B	CANCERUNSPEC
Cardiovascular, Blood and Lymphatics			B	
	EBL		B	EBL
	Cardiovascular disorder, unspecified		B	CARDIOMISC
Congenital Defects			B	
	Cardio-pulmonary defects		B	
	Congenital defect, unspecified		B	
	Gastrointestinal defects		B	
	Hepatic defects		B	
	Immune system		B	
	Multiple defects		B	
	Musculoskeletal		B	
		White muscle disease	B	
	Nervous system		B	
	Urinary tract defects		B	
Dermatological Disorders			B	
	Biting flies		B	
	Dermatophylosis		B	
	Lice		B	LICE
		Biting lice	B	
		Sucking lice	B	
	Mange		B	MANGE
	Milk allergy		B	MILKALLERGY
	Mites		B	
	Photosensitivity		B	PHOTOSENSIT
	Ringworm		B	RINGWORM
	Skin disorder, unspecified		B	SKINMISC
	Skin TB		B	
	Ticks		B	
	Warts		B	WARTS
Digestive System Disorders			B	
	Abomasal disorders		B	DMISCABOMAS
		Abomasal displacement, left		
		Abomasal displacement, right		
		Abomasal ulcer	B	DMISCABOMAS
		Abomasal disorders, unspecified		
	Diarrhoea/scours		B	DMISCSCOUR
		Campylobacteriosis	B	
		Colibacilosis	B	DMISCSCOUR
		corona virus	B	
		cryptosporidiosis	B	
		Diarrhoea	B	DMISCSCOUR
		Enteritis	B	DMISCSCOUR
		rotavirus	B	

	Salmonella	B	SALMONELLA
	Yersiniosis	B	YERSIN
Intestinal disorders		B	DMISCGASTRO
	Gastrointestinal, unspecified		
	Johnes disease	B	JOHNES
	Obstruction	B	
	Prolapse rectum	B	DMISCGASTRO
Hepatic disorders		B	
	Liver disorder, unspecified		
	Hepatitis-necrotic	B	DMISCLIVER
	Hepatitis-unspecified	B	DMISCLIVER
Oro-pharyngeal disorders		B	
	Calf diphtheria	B	
	Dental disease	B	
	Lumpy Jaw	B	LUMPYJAW
	Mouth disorder, unspecified		
	Papular stomatitis	B	
	Salivary glands	B	
	Stomatitis	B	DMISCGASTRO
	Wooden Tongue	B	WOODENTONGUE
Oesophageal disorder		B	OESPHOGEAL
	Oesophageal obstruction – FB		
	Oesophageal, unspecified		
Parasitic gastroenteritis		B	
	Coccidiosis	B	DMISCGASTRO
	Liver fluke	B	LIVERFLUKE
	Ostertagia	B	OSTERTAGIA
	Parasitic gastroenteritis, unspecified		
	Rumen flukes	B	
Peritonitis		B	DMISCOTHER
Rumen disorder		B	
	Bloat	B	DMISCBLOAT
	Bloat, frothy	B	DMISCBLOAT
	Bloat, grain	B	DMISCBLOAT
	Grain poisoning	B	GRAINPOIS
	Hardware disease	B	DMISCGASTRO
	Indigestion	B	INDIGESTION
	Off feed	B	DMISCOTHER
	Rumen disorder, unspecified		
	Vagus indigestion	B	DMISCGASTRO
Endocrine Disorders		B	
Endocrine disorder, unspecified		B	
Environmental Influences		B	
Electric shock		B	
Environmental influence, unspecified		B	
Generalised Disorders		B	
Malignant oedema		B	DMISCOTHER
Hypothermia		B	DMISCOTHER
Septicaemia		B	DMISCOTHER

Ephemeral fever		B	DMISCOTHER
BVD		B	BVD
Toxoplasmosis		B	TOXO
Enterotoxaemia		B	DMISCOTHER
Immune System Disorders		B	
Immune system disorder, unspecified		B	
Lameness Disorders		B	
Arthritis		B	ARTHRITIS
	Arthritis-degenerative	B	ARTHRITIS
	Arthritis-septic	B	ARTHRITIS
Bruising		B	BRUISE
Dislocation		B	DISLOCATION
Footrot		B	FTROT
Fracture/Broken leg		B	FRACTURE
Injury		B	INJURY
Lame		B	DLAMENESS
	Lame, foot	B	DLAMENESS
	Lame, spine	B	DLAMENESS
	Lame, unspecified	B	DLAMENESS
	Lame, upper limb	B	DLAMENESS
Laminitis		B	LAMINITIS
Musculoskeletal		B	MSKELDISEASE
Overgrown claw		B	OGCLAW
Sole ulcer		B	ULCERSOLE
Wall crack		B	DLAMEWCRK
	Wall crack, abaxial	B	DLAMEWCRK
	Wall crack, axial	B	DLAMEWCRK
White line disease		B	WTLINE
Mammary Gland Disorders		B	
Mastitis, clinical		B	MASTACUTE
Mastitis, subclinical		B	MASTCHRONIC
Mastitis, unspecified		B	MAST
Ruptured suspensory ligament		B	RUPSUSLIG
Teat end lesions/Cracks		B	MASTTLES
Teat injury		B	TEATINJURY
Udder abscess		B	UDDERABSC
Udder disorder, unspecified		B	MASTUDDER
Udder oedema		B	UDDEROEDEMA
Metabolic Disorders		B	
Downer cow		B	DOWN
Ketosis/Acidosis		B	KETO
Magnesium/Grass staggers		B	GSTAG
Metabolic disorder, unspecified		B	METDIS
Milk fever		B	MLKFEV
Pregnancy toxaemia		B	PREGTOXAEMIA
Sodium deficiency		B	
Musculoskeletal Disorders		B	
Blackleg		B	BLACKLEG
Musculoskeletal, unspecified		B	

No Abnormality Detected		B	
Nervous System Disorders		B	
	Nervous disorder, non metabolic	B	NERVOUSD
	Botulism	B	DMISCOTHER
	Hepatic encehalopathy	B	
	Malignant catarrh	B	MALIGCATARRH
	Meningitis/encephalitis	B	
	Polioencephalomalacia	B	POLIO
	TEME	B	
	Tetanus	B	DMISCOTHER
Other conditions		B	
	Abscess, unspecified	B	ABSCES
	Actinobacillosis other than tongue	B	
	Laceration	B	LACERATION
	Navel Infection	B	NAVELINFECT
	Severe Injury	B	SEVEREINJURY
Parasitic Disorders		B	
	Parasite, unspecified	B	PARASITEUNKN
Parturition Disorders		B	
	Calving Disorders Assisted calving	B	ASCALV
	Calving disorder, unspecified		
	Calving paralysis	B	CLVPAR
	Prolapsed uterus	B	PROUT
	Retained membranes	B	RETMEM
Poisoning's		B	
	Poisoning, organic (plants etc)	B	
	Acorn	B	
	Algal	B	
	Backen fern	B	
	Buttercup	B	
	Cyanide	B	
	Goats rue	B	
	Hemlock	B	
	Macrocarpa	B	
	Ngaio	B	
	Oleander	B	
	Phalaris spp	B	
	Pinus spp	B	
	Ragwort	B	
	Rhododendron spp	B	
	Stinging nettle	B	
	Trefoil dermatitis	B	
	Tutu	B	
	Yew	B	
	Not specified/diagnosed	B	
	Poisoning, inorganic/iatrogenic	B	
	Arsenic	B	
	Bloat remedies	B	
	Copper poisoning	B	

		Endectcoides	B	
		Lead	B	
		Nitrate / nitrite	B	
		OP's	B	
		Salt	B	
		Selenium	B	
		Sodium monofluroacetate (1080)	B	
		Superphosphate	B	
		Urea	B	
		Not specified/diagnosed	B	
		Zinc	B	
	Anaphylactic/adverse reactions		B	
		Registered remedies	B	
		Other	B	
	Poisoning, unspecified		B	POISONOTHER
	Mycotoxicoses		B	
		Zearalenone	B	
		Ryegrass staggers	B	POISONRYE
		Facial eczema	B	ECZEMA
		Not specified/diagnosed	B	
Poor Productivity Syndromes			B	
	Chronic disease unspecified		B	
	Nutritional		B	
		Cobalt deficiency	B	DEFICCO
		Copper deficiency	B	DEFICCU
		Iodine deficiency / Goitre	B	
		Malnutrition	B	DMISCILL
		Phosphate deficiency	B	
		Selenium deficiency	B	DEFICSE
		Trace element deficiency unspecified		
	Severe Ill Thrift/Weight Loss		B	DMISCILL
	Weight loss		B	DMISCILL
Putative Treatment Resistant org..			B	
	Bacteria		B	
		Enteric organisms	B	
		Mastitic organisms	B	
		Other	B	
	Internal parasites		B	
		Ostertagia	B	
		Trichostrongylus	B	
		Cooperia	B	
		Other	B	
	External parasites		B	
		Lice	B	
		Other	B	
Reproductive Disorders			B	
	Female	Abortion	B	ABORT
		Neosporosis	B	
		BVD	B	
		Fungal	B	

		Other	B	
		Unconfirmed	B	
	IPVV/IBP		B	
	Mummified foetus		B	
	Non cycler		B	NONCYCLER
	Ovarian cyst/neoplasm		B	
	Prolapsed vagina		B	PROVAG
	Reproductive disorder unspecified			
	Uterine infection		B	UINFECTION
	Vaginal cyst		B	
	Vaginal discharge		B	DISCHA
	Vaginal injury		B	VAGINJ
	Vaginitis		B	
Male	Azoospermia		B	
	Broken penis		B	
	Corkscrew penis		B	
	Inflammation of accessory sex glands			
	IPVV/IBP virus		B	
	Low libido		B	
	Necrospermia		B	
	Orchitis / epididymitis		B	
	Blanoposthitis		B	
Respiratory Disorders			B	DMISCRESP
	IBR(Infectious bovine rhinotracheitis)			
	Lungworm		B	LUNGWORM
	Nasal granuloma		B	DMISCRESP
	Pleuritis		B	DMISCRESP
	Pneumonia, bacterial		B	DMISCRESP
		Corynebacteria		
		Pasturellosis	B	
	Pneumonia, inhalational		B	
	Pneumonia, interstitial		B	DMISCRESP
		Fog fever	B	
	Pneumonia, unspecified		B	DMISCRESP
	Pneumonia, viral		B	DMISCRESP
	Respiratory, unspecified		B	DMISCRESP
	Rhinitis		B	
Special Senses			B	
Eye			B	
	Cancer eye		B	CANCEREYE
	Eye injury		B	EYEINJURY
	Pinkeye		B	PINKEYE
	Eye unspecified			
Ear			B	
Nose			B	
Undiagnosed/Unspecified			B	UNDIAGNOSED
Urinary Tract Disorders			B	
Bacillary heamoglobinuria			B	
Cystitis			B	
	Corynebacterium renale		B	

Postparturient Haemoglobinuria	B	
Pyelonephritis/nephrosis	B	
Urethritis	B	
Urinary tract unspecified		
Urolithiasis	B	
Zoonoses	B	
Anthrax	B	
Brucellosis	B	BRUCELLOSIS
Leptospirosis	B	LEPTO
Listeria	B	LISTERIA
Tuberculosis	B	TB

Proposed Job Description -Bovine

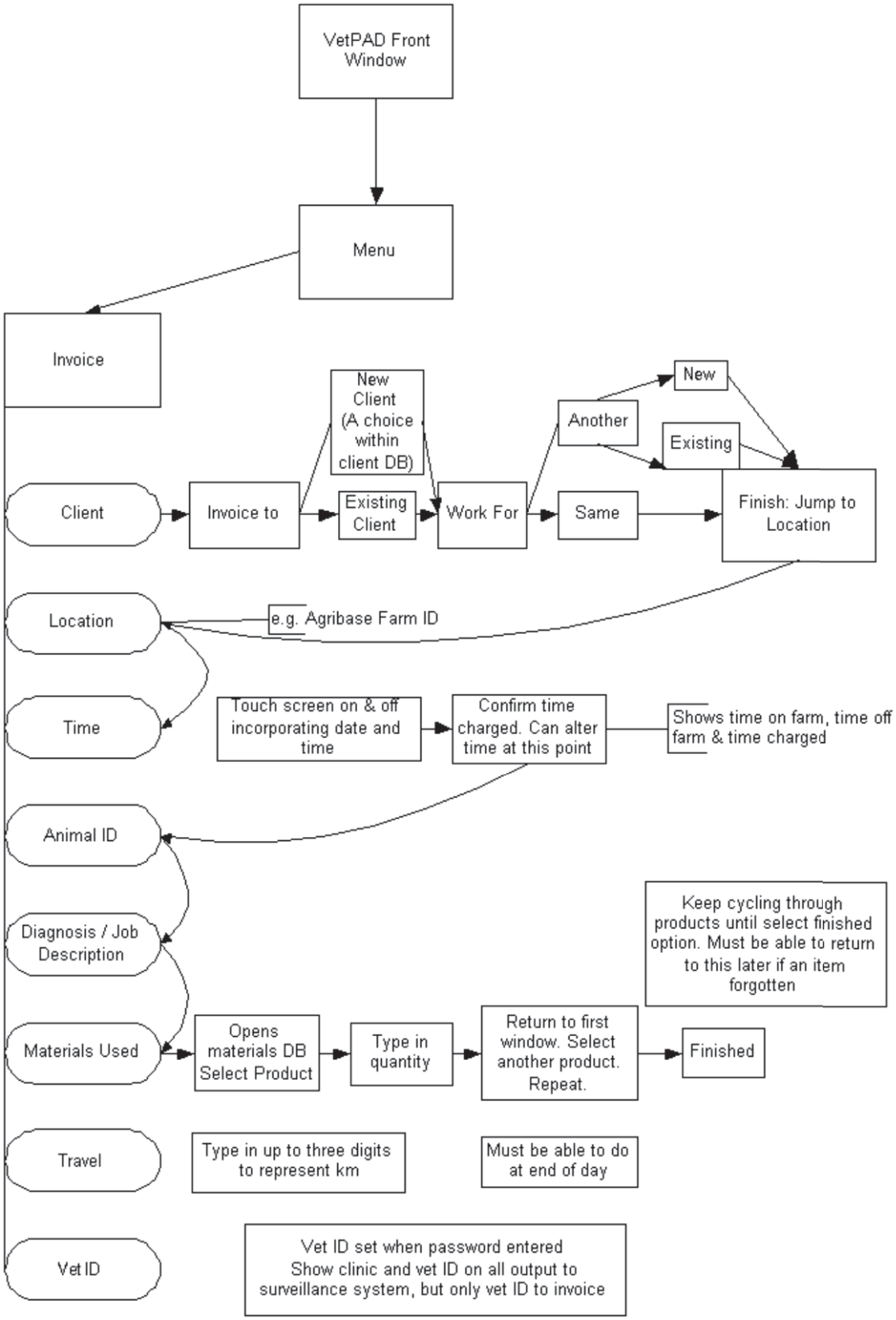
Variable	Primary choice	Secondary choice
Autopsy		
Consulting		
	Herd Health/ Farm Management Discussions	
	Mastitis or Dry Cow Therapy Consultations	
	Discussion group/ Field day	
	Animal welfare assessment	
Disease Testing		
	Tb testing	
	EBL testing	
Euthanasia		
Pregnancy Termination		
	Abort	
	Induce calving	
Procedures		
	Blood Samples	
	Caesarean section	
	Castration	
	Claw amputation	
	Dehorning adults	
	Disbudding calves	
	Epididymectomy	
	Eye ablation	
	Liver Biopsy	
	Lumpectomy	
	Repair bloat stab wound	
	Teat pea	
	Teat removal	
	Teat surgery	
	Third eyelid flap	
	Tooth removal	
	Vaccinations	
		BVD
		Clostridial diseases
		IBR
		Leptospirosis
	Vasectomy	
	Other	
Reproductive exam		
	Pregnancy testing	
		Manual

		Ultrasound
	Bull Soundness exam	
	Premating reproductive assessment- female	
		Non Cyclers
		At risk cows
	Artificial Breeding (Synchrony, AI, ET etc)	

Proposed Animal Description

Variable	**Choice**	**Default**	**Format**	**Comment**
Species	Avian, Bovine, Canine, Caprine, Cervine, Equine Feline, Ovine, Porcine.	Bovine		Only Bovine shows initially
Type	Dairy , Beef	Dairy		Choice depends on “Species”
Breed	J, F, JxF, Ayrshire, Shorthorn, other	Last entered		Choice depends on “Type”
Sex	M,F,Castrate	Female		
Age	Year, Month, Day,	Y		
Age input	Made in “Age” above	Nil	99	
Lactation status	Lactating, Dry	Last entered		Only shows if Female
Fertility	Pregnant, MT, UK	Nil		Only shows if Female
ID	Any alphanumeric	Nil	ABCD9999	
Group code	Count =			Only possible for calves age< 1 mth or Beef or other species
Number		Nil	999	

Overview of (proposed) VetPAD program structure for invoicing a client



SECTION 4:

General Discussion

Section 1 described surveillance systems and some selected outputs. Section 2 evaluated three sources of disease information that maybe useful to strengthen the national disease surveillance system. The "coverage" of veterinary practitioners was also assessed, as this to is essential to minimise bias in the data.

This last section is intended to be more general and crystal ball gazing. For syndromic disease data from practitioners to become accepted as a source of disease information, there have to some fundamental changes in collection, analysis and use of the information gathered. Starting at the top with potential users of the information, governmental representatives both here in New Zealand and overseas will need to move away from the pathologist's mindset of reaching a specific diagnosis, to an understanding of an evolving syndromic approach.

A syndromic approach to disease reporting will show trends over time and space, without necessarily ever having a specific diagnosis reported. In time this may prove to be equally (or more) powerful but quite different to traditional surveillance information. With linkages created between the syndromic information and the laboratory information, opportunities exist for more detail to be extracted from the syndromic data.

For the regulatory authorities, there will need to be considerable thought about appropriate uses for such information. Over time a body of data will accumulate that will show syndromes expressed as a rate moving up and down in response to seasonal and other variables. Over the same time it will be possible to begin to define expected upper and lower limits of syndrome occurrence - for example a 95% confidence interval.

One of the first things to be thought about is a definition of what constitutes a syndrome "out of control" and what is to be done about it. At this point traditional laboratory interventions may take over to better describe the syndrome and possibly make a definitive diagnosis.

At the veterinary practitioner level, there will also need to be a change in mindset of the value of the data collected. As with the current situation where practitioners collect tissue samples for submission to a pathology laboratory, there may soon come a time where practitioners collect and submit digital data (samples) to a commercial "digital diagnostic laboratory". Digital samples are not constrained by international borders in the same way that tissue samples are, although some of the political risks are the same.

This is already a reality in an informal sense with the EpiCentre and others analysing data for a number of commercial and regulatory groups. As with tissue samples sent to a pathologist, digital samples need to have characteristics of quality, representativeness and covering a broad enough range of variables to allow biologically plausible inferences (a "diagnosis") to be made about the data provided. As with a pathology laboratory, a digital laboratory would need quality assurance systems and standard operating procedures to meet some user requirements.

To facilitate veterinary practitioner disease data collection, mechanisms of data capture need to be available. One of these mechanisms is the proposed VetPAD software and associated systems. To be successful it needs to be thought of as a system rather than software. Veterinary practitioners vary greatly in their ability and desire to use computers for day to day business management. The rollout of such a system would involve a considerable amount of software set-up and training. Provision of a helpdesk facility would be essential. Beyond the software would be the need for training in the necessity of quality assurance systems, and the concept of what constitutes good data collection (sample collection in pathology parlance) procedures.

Another opportunity for some practices and the digital laboratory mentioned earlier, is the analysis, interpretation and archiving of disease and production data provided by farmers.

Between the veterinary practice and the users of syndromic disease information, there needs to be what I have loosely called a digital diagnostic laboratory. This may draw on data housed in one or more organisations. They will pull together different threads of information from these various sources to produce customised reports suited to the

needs of the client. The ability to use and manage vast databases will be essential. For example the detection of a new disease "idiopathic neurological syndrome", may require data from VetPAD (number of cases, age of those affected, spatial and temporal location, species affected), from Agribase (population at risk, ownership) and meteorological records (rainfall, maximum and minimum temperature, relative humidity), feed companies (type and quantity of feed shipped, batch numbers, origin of raw materials) and pharmaceutical companies (type and quantities of product shipped, batch numbers, origin of raw materials).

In summary the concept of using veterinary practitioner recorded disease data is valid but evolving. There are many hurdles to be overcome, but it is likely that in some form these data will go some way to providing enhanced disease surveillance capability, both in New Zealand and overseas.

Appendices

Appendix 1: Count of diseases seen by practitioners

Disease	Bull	Calf	Cow	Heifer	Unknown
Abortion				1	
Abortion Unconfirmed, Uterine infection, Retained					1
Abortion-Other		1			
Abortion-Unconfirmed			2		
Abscess, unspecified		8	12	1	1
Arthritis			1		
Arthritis-septic		4	1		
Assisted calving			101	1	8
Blind			2		
Bloat			1		
Bloat + Uterine infection			1		
Calf diphtheria		1			
Calving disorder, unspecified			2	1	1
Calving paralysis			10		1
Cancer eye			10		3
Cardiovascular disorder, unspecified			2		
Congenital Defects, musculo-skeletal		3			1
Congenital Defects, multiple		1			
Dental disease			2		
Dependent oedema			2		
Dermatophylosis		3			
Diarrhoea		2	7	1	
Diarrhoea + Uterine infection			1		
Dislocation			1		
Dislocation Hip			1		
Downer cow			74	1	1
Enteritis			2		
Eye unspecified			5		2
Facial eczema			1		
Footrot	1	2			2
Fracture/Broken leg			1	2	1
Gastrointestinal, unspecified			7	1	
Hernia repair		1			
Hypothermia			2		
Indigestion			1		
Injury unspecified		1		1	1
Intestinal disorders, Obstruction		2	2		
Johne’s disease			2		
Ketosis/Acidosis			2	1	
Laceration		1	4		
Lame, Arthritis			1		
Lame, Bruising					2
Lame, foot	2	1	58	1	
Lame, Injury					1
Lame, spine			1	1	

Disease	Bull	Calf	Cow	Heifer	Unknown
Lame, unspecified	9	2	207	2	9
Lame, upper limb		1	1		
Lame, White Line Disease					2
Lame-Injury			3	1	
Liver disorder, unspecified			1	1	
Lumpy Jaw			2		
Magnesium/Grass staggers			9		
Mastitis, clinical			53		4
Mastitis, subclinical			17		5
Metabolic disorder, unspecified				1	
Milk fever			16		2
Mouth disorder, unspecified			6	2	
Musculoskeletal		1			
Nervous disorder-non metabolic			1		
Non cycler			3002	11	4
Non cycler- RV inject ODB			1219		
Oesophageal obstruction – Foreign body			1		
Ostertagia				1	
Other conditions, Laceration					1
Ovarian cyst/ neoplasm					2
Overgrown claw					1
Parasitic gastroenteritis, unspecified		4			
Peritonitis			3	1	
Peritonitis +Vaginal injury			1		
Pinkeye	2		2		
Pinkeye +Ryegrass staggers			1		
Pneumonia, bacterial			1		
Pneumonia, unspecified		1	6		
Poisoning, organic (plants etc) -Not specified/diagnosed					1
Poisoning, organic (plants etc)-Hemlock				4	
Polioencephalomalacia		1	1		
Postparturient Haemoglobinuria			1		
Prolapsed uterus			14		
Prolapsed uterus Revisit			1		
Reproductive disorder unspecified			2		
Respiratory, unspecified		1	3		
Retained membranes			44		11
Rhinitis			1	1	
rotavirus		1			
Rumen disorder, unspecified			4		
Salmonella			4		
Septicaemia		1			
Severe Ill Thrift/Weight Loss				1	
Severe Injury		2	3		
Skin disorder, unspecified			2		
Sole ulcer					1
Teat injury			2		1
Teat pea			1		
Udder disorder, unspecified			11		1

Disease	Bull	Calf	Cow	Heifer	Unknown
Undiagnosed/ Unspecified-Revisit			3		
Undiagnosed/Unspecified	3	53	220	16	18
Urinary tract unspecified			1		
Uterine infection			155		11
Uterine infection + Peritonitis				1	
Vaginal cyst			1		
Vaginal discharge			2		
Vaginal injury			1		2
Vaginitis			1		2
Weight loss			1	1	
Wooden Tongue			5	1	3

Appendix 2: Count of diseases recorded by farmers as diagnosed by farmers, veterinarians or unspecified.

Disease intervention	FARMER	VET	Unspecified
Abscess	2	5	4
Assisted calving	3	1	5
BLM #	2		
Bloat			1
Blood			1
Sole bruise	158	3	141
Cancer eye		3	1
CL #	23	2	
Calving paralysis	4	1	9
Colic		1	
COP #			1
Hoof crack, abaxial	6		2
Hoof crack, axial	9	1	1
Vaginal Discharge	6	9	43
Dislocation			1
Lame	97	7	110
Respiratory, miscellaneous			2
Downer cow	2	2	3
DPE #[#]		1	
Facial eczema			1
Ephemeral fever	4	1	
Foot abscess			3
Fracture	1		
Foot rot	122	20	64
Grass staggers	8	1	7
Indigestion		1	1
Injury	2	3	5
Ketosis	2		1
Lame, spine	1		17
Lame foot	145	22	179
Lame upper-limb	1		3
Lumpy jaw		1	1
M #			3
Mastitis	428	8	456
Mastitis, acute	533	20	422
Mastitis, chronic	153	4	52
Metabolic disease	11		1
Milk fever	26	4	16
Mouth, unspecified			6
Musculo-skeletal lameness			2
Nasal granuloma	1		
Off food	6	2	1

[#] As recorded by farmers. Meaning unknown.

Disease intervention	FARMER	VET	Unspecified
Proud Flesh	1	3	6
Pinkeye		1	
Pneumonia		1	
Pneumonia, viral	2		
Pregnancy toxaemia	1		
Prolapsed rectum		1	
Prolapsed uterus	1	2	2
Respiratory		2	
Retained foetal membranes	43	22	65
Scour	2	1	
Subclinical mastitis			133
Swelling	1	1	2
Teat injury	2	1	7
Udder abscess			3
Udder oedema	4		2
Uterine infection			1
Undiagnosed	4	3	7
Upset			2
Vaginal injury	1		
Weight loss			1
Wooden tongue		4	2
White line disease	11	12	125

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