ANIMAL HEALTH SURVEILLANCE IN THE UNITED STATES VIA THE NATIONAL ANIMAL HEALTH MONITORING SYSTEM (NAHMS)

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Résumé

Le système national de surveillance de la santé animale (NAHMS = National Animal Health Monitoring System) est un système national intégré de surveillance qui collecte des informations sur l'incidence, la prévalence, la mortalité, les fréquences des divers modes de conduite d'élevage et les coûts associés aux diverses maladies. Les activités de surveillance reposent sur une collaboration entre des institutions gouvernementales, des universités, des laboratoires de diagnostic, des vétérinaires praticiens privés et des associations de producteurs. Dans ce document sont décrits la création et le développement du programme de surveillance national de la santé animale, deux programmes de surveillance qui impliquent des laboratoires de diagnostic et des vétérinaires praticiens sentinelles, ainsi que des enquêtes sur les diverses filières de production animale. Ces diverses enquêtes par filière de production intègrent des données confidentielles sur les paramètres de santé collectés sur le terrain et des paramètres biologiques à partir d'échantillons récoltés dans les fermes selon un échantillonnage statistique approprié et des mesures d'estimation qui permettent une estimation pour l'ensemble des filières à l'échelon national. Une enquête réalisée en 1990 concernant les facteurs de santé chez les truies et leurs portées et la future étude des facteurs de santé chez les finisseurs-engraisseurs qui sera réalisée en 1995 sont utilisées comme exemples pour illustrer les diverses composantes de telles enquêtes.

Summary

The National Animal Health Monitoring System (NAHMS) is an integrated national surveillance system which collects data on disease incidence and prevalence, mortality, frequency of management practices, and disease costs. Surveillance activities rely on collaboration with government agencies, universities, diagnostic laboratories, private veterinary practitioners, and producer organizations. The historical development of the NAHMS program, two surveillance programs involving diagnostic laboratories and sentinel veterinary practitioners, and national commodity studies are described in the paper. National commodity studies incorporate confidential on-farm collection of health data and biological specimens and use statistically-based selection and estimation procedures which allow inferences to national livestock populations. A national survey of sow and litter health in 1990 and the proposed study of grower/finisher pig health in 1995 are used to demonstrate the components of such studies.

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I - INTRODUCTION
HISTORICAL BACKGROUND OF NAHMS

The 1920 United States Livestock Sanitary Association's (USLSA) Committee on Animal Morbidity and Mortality Reporting recognized the need for collection of reliable information on the occurrence and impact of animal diseases on a national scale. Because a complete system of animal morbidity and mortality reporting was considered to be an important foundation for animal disease prevention, control, and eradication, the Committee recommended the collection of animal health statistics from states on a periodic, regular basis. However, little cooperation ensued over the next several decades. While many lists of animal diseases were available from specific disease reporting systems including state / federal meat inspection and state reporting systems, uses were limited since the information was gathered and collated for differing purposes [Poppensiek and Budd 1966].

There followed a prolonged struggle to fulfill the need for reliable animal health information with many committees reiterating the same recommendations yearly. The 1947 Committee on Morbidity and Mortality lamented that there had been "much encouragement by verbal acclaim, but no real fundamental cooperation. A national reporting agency has not been established." The primary problem tended to be lack of cooperation among states. While there existed a considerable number of regularly published reports of various diseases, the information tended to be collected for a variety of purposes and in many different ways. Although all were convinced of the usefulness of such information, there was no national coordination, summation, or evaluation of these reports. The animal disease statistics collected by states were found to be unreliable, inconsistent, and non-additive [Hutton, 1974 ; King, 1983].

The call for national coordination, summation, and evaluation of animal disease data was renewed in the late 1940's and 50's. Several committees tried various approaches. The USLSA's Committee on Morbidity and Mortality, which sought support for the establishment of a national system of collecting and disseminating vital statistics data, directed their efforts toward the regular reporting of diseases by practitioners. With these objectives in mind, the Committee called for the teaching of vital statistics in veterinary schools to train disease reporters of the future, and later prepared a reportable disease manual.

The American Veterinary Medical Association's (AVMA) Committee on Vital Statistics was founded "to study, formulate, and place into operation a workable system of collecting and compiling vital statistics on animal diseases." While 40 states had some type of reporting system, they all proved to be inadequate in producing reliable information on disease incidence and cost. "The greatest single difficulty in a disease-reporting program proved to be the failure of vets to file reports" ,Poppensiek and Budd 1966]. The Committee concluded that the development of such a national system was beyond their capabilities and deferred responsibility for its development to the United States Bureau of Animal Industry (BAI).

The National Research Council established a Committee on Veterinary Services for Farm Animals out of concern of the country's economic loss caused by morbidity and mortality of livestock. One project that developed out of this Committee was the Iowa program led by Snedecor at the Statistical Laboratory in Ames, Iowa. This was perhaps one of the earlier references to the consideration of using national surveys as part of a national animal disease surveillance system. This reporting system collected data directly from farmers either by monthly visits from non-practitioner veterinarians or at three month intervals by hired interviewers. Accuracy of information reflected that of the farmer's records, but was generally considered adequate [Poppensiek and Budd, 1966].

By 1956, the Committee on Morbidity and Mortality felt it had completed its objectives of encouraging development of organized state reporting systems and developing a list of reportable diseases. It therefore announced its termination. With this ground work laid three national reports on morbidity and mortality resulted. The National Report on Animal Diseases (NRAD) began in 1958. The list of diseases was compiled primarily through mailings to practitioners, while some States supplemented

these data with information from Animal Health Diagnostic Laboratories [Beal, 1983]. The NRAD was supplemented by the National Animal Morbidity Report (NAMR), which summarized counts of diseases such as tuberculosis, brucellosis, pseudorabies, rabies, anthrax, and paratuberculosis by state, and the Consolidated Report of Animal Diseases at Public Stockyards and Establishments (RADPS) which summarized disease events at federally-inspected stockyards.

It was soon evident that this national morbidity and mortality reporting system "could not reveal anything concerning disease prevalence or economic significance for any area of the country. Also, disease trends could not be estimated with any degree of confidence" [Beal, 1983]. In 1966, the problems encountered in this first series of national animal disease statistics prompted an in-depth review of morbidity and mortality reporting in the US by the National Academy of Sciences. This review was primarily historical in nature and did not address future development of a such a system or impediments to its development.

In 1971, Veterinary Services (VS) of the United States Department of Agriculture performed their own review which resulted in the discontinuation of NRAD and RADPS . The issues leading up to the rapid demise of a national animal disease reporting system can be attributed to one of appropriateness and validity of the data collected. For a national animal disease reporting system to be useful, it must collect information that is appropriate for its users, and the collected data must be of sufficient validity to produce reliable results which can in turn be published in timely reports. The National Morbidity and Mortality Reporting system failed on both counts [McCallon and Beal, 1982 ; Beal, 1983].

A second VS study in 1977 researched various methods proposed for data collection of animal disease information. To seek improvement over the failed post-card reporting system, the state of Minnesota sought to incorporate a statistically sound survey design into a reporting system. However, it was erroneously touted as a statistically sound, probability sampling scheme [Diesch et al., 1974 ; Beal, 1983] when the sample selection was by non-probability methods and the reporting system was crippled by non-response and selection bias.

While the Minnesota system essentially reproduced previous errors using new methods, it did provide the impetus for renewed efforts of establishing a national animal disease surveillance system using more statistically sound methods of data collection. More importantly, it documented once again that regardless of the program design, private practitioners provide an inadequate means for the passive reporting of valid animal health information. Consequently, in 1979, the Committee on Morbidity and Mortality was revived and a movement began to develop a surveillance system using regulatory Veterinary Medical Officers (VMO) to collect data directly from randomly selected farms.

II - GENERAL ASPECTS AND STRUCTURE OF NAHMS

The Committee on Animal Health of the National Academy of Sciences (NAS) was given the task of designing a system for nationwide surveillance of animal health to meet the following objectives :

> To design a nationwide system for the continuous surveillance of animal health for the reporting and evaluation of reliable information that can be used to produce geographical and seasonal estimates of disease incidence and prevalence in domestic livestock ; to warn of new or emerging diseases ; to establish indices for projection of future disease patterns and trends ; to develop epidemiologic data to aid in control, prevention and eradication of disease and to design the system so as to be concerned with livestock, poultry, pets, laboratory animals, furbearing animals, zoological specimens, wildlife and aquatic animals [Hutton, 1974].

The panel addressed methods for the collection of animal disease surveillance data as well as a description of the interests of potential users of surveillance information. The resultant publication, A Nationwide System for Animal Health Surveillance, served as a blueprint for the formation of a center for national animal disease surveillance [Hutton, 1974]. Two essential

elements for the success of the Center were proposed :

First, the size and complexity of the task require the full interdisciplinary participation of three major disciplines - epidemiology, economics, and statistics - within a single organization. Second, the organization must serve as a focal point for all animal disease surveillance activities in the nation if it is to provide comprehensive analysis and avoid the extremely high costs of fragmented efforts [Hutton, 1974].

The recommended objectives for such a center are listed in Table I. The Center for Animal Health Monitoring (CAHM) serves as the focal point for the National Animal Health Monitoring System (NAHMS). The Center consists of a multi-disciplinary team of veterinary epidemiologists, agriculture economists, statisticians, computer specialists, technical writers, and support staff. The Center is housed with the Centers for Epidemiology and Animal Health (CEAH), a unit of Veterinary Services (VS) of the USDA and currently employs approximately 16 staff.

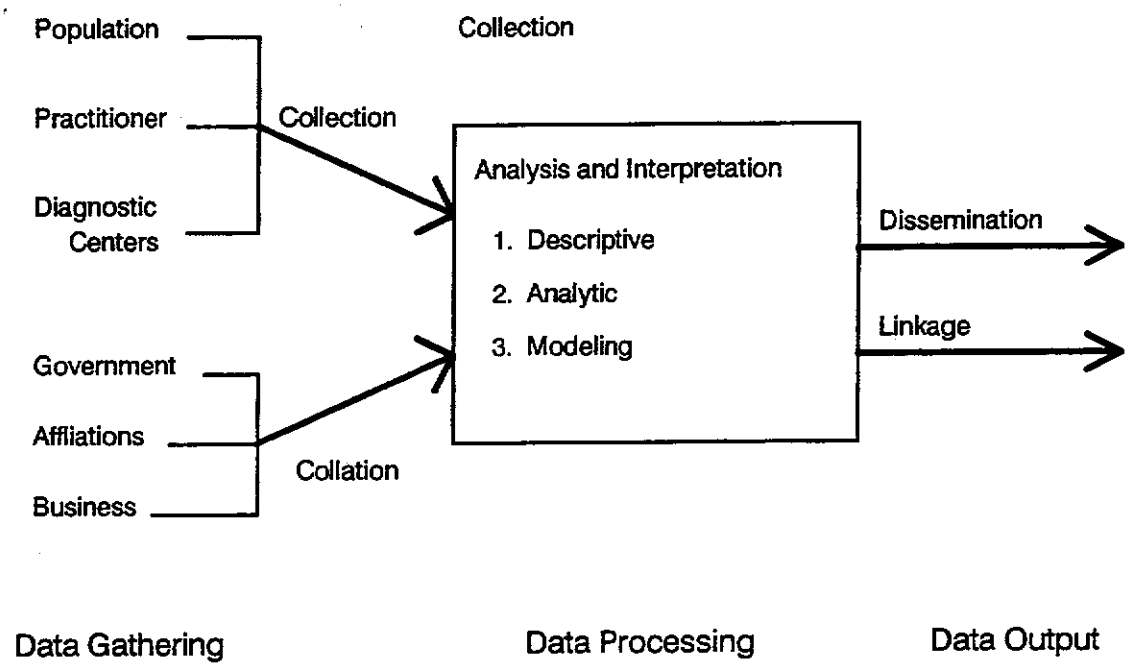
Table I : Objectives of a Center for national animal health surveillance [Hutton, 1974]

The specific objectives of the Center are :
• To establish an overall sentinel system for animal disease surveillance by ...
• To establish a system for relaying information on animal diseases to state and federal regulatory agencies by ...
• To estimate prevalence and incidence of selected diseases and conditions in defined animal populations by ...
• To determine the economic impact of animal diseases and assess the economic implications of alternative approaches to animal health management by ...
• To make intensive epidemiologic investigations, utilizing multidisciplinary teams ;
• To establish procedures for timely reporting of surveillance information to the private and public sectors ; and
• To provide federal, state, and local agencies with consultation and technical assistance on animal disease surveillance.

The NAHMS represents an important effort of public veterinary medicine to adapt to and meet new needs of the rapidly changing food animal industries and demands of the public [Hueston, 1990]. The availability of scientifically and statistically reliable information is essential to the improvement of the health and productivity of animal populations. The role of VS as the brokers of reliable animal health information is consistent with the original mandate legislated for the USDA in 1862 "to acquire and diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of the word" (Statutory Law 387, 1862) [King, 1990].

Consistent with this charge, and the epidemiologic and economic needs and resources at hand, the mission of the NAHMS is "to protect and improve animal and human health, ensure quality and abundance of food and fiber, and keep US agriculture competitive by collecting, analyzing, and providing users with information on the epidemiology and economics of animal health and production" [Hueston, 1990]. The accomplishment of this mission is fulfilled by the cycling through the surveillance process (Figure 1) where (1) users are involved in developing methods for (2) the collection of and (3) the epidemiologic and economic analysis of statistically reliable data on animal health and production which will (4) provide timely information useful to the broad scope of beneficiaries of this information. Constant evaluation and feedback will in turn provide insight into areas for the improvement of the information system [Hueston, 1990].

Figure 1 : Diagram of Surveillance Systems.



The NAHMS system developed in five phases as described at its inception by Poppensiek and Combs [1981]. The early efforts of the NAHMS focused on the research and development of statistically sound methodology for sampling, data collection, analysis and dissemination of animal health information. Subsequent to the initial planning and evaluation, the next two phases consisted of the organization and implementation of pilot studies at the state level.

After developing experience with on farm data collection in Ohio and Tennessee, pilot studies were then launched for all species, using a variety of sampling designs, in 7 states. Most state programs were a collaborative effort between VS, state officials, and colleges of veterinary medicine. During this phase, the need for a NAHMS became more convincing and several valuable lessons were learned as outlined by King [1986].

The final phases of development of a national surveillance system for animal health involved the standardization of state efforts in the design for sample selection and the methods of data collection. The swine industry was chosen as the target for the first coordinated collection of statistically valid data regarding animal health on a national basis. In 1990, eighteen states participated in the first National Swine Survey (NSS) which focussed on diseases of the sow and her litter. The population base needed for NAHMS national sample was set at 70 p. cent of the total animals and 70 p. cent of the herds in the US [Hueston, 1988]. The NSS, commencing in November 1989, covered 95 p. cent of the hogs and 84 p. cent of the swine herds in the United States [Bush et al., 1995].

A portfolio of surveillance activities makes up the totality of the NAHMS program - rather than a single monolithic system of gathering animal health information. Federal/state animal health officials, diagnostic laboratories, producers, private practitioners all serve as valuable sources of data on disease incidence and prevalence, death loss, frequency of management practices, and disease costs. Thus NAHMS has forged an integrated and coordinated approach to animal health surveillance. Most surveillance activities rely heavily on collaboration with other groups such as National Agriculture Statistical Service (NASS), university researchers, other government agencies, as well as producer organizations, private practitioners, and diagnostic laboratories. A variety of methodologies are used for the collection of primary data including on-farm interviews, computer assisted telephone interviews (CATI), and mail. Some activities, however, rely on the collation of secondary data via electronic transmission of data.

While the bulk of NAHMS activities have centered around the implementation of large scale national commodity studies, such as the 1995 National Swine Survey (Swine '95), two other NAHMS programs also will be highlighted : the Veterinary Diagnostic Laboratory Reporting System (VDLRS) and the Sentinel Feedlot Monitoring program (SFM).

III - DESCRIPTION OF TWO SURVEILLANCE PROGRAMS OF THE NAHMS

A - ANIMAL HEALTH SURVEILLANCE USING DIAGNOSTIC LABORATORIES

The VDLRS relies on surveillance of selected diseases from 29 cooperating laboratories in 26 states in addition to the National Veterinary Services Laboratory and surveillance data from national disease eradication and control programs such as tuberculosis, brucellosis, and pseudorabies. Though the NAHMS staff coordinates program administration, the direction for the VDLRS is provided by American Association of Veterinary Laboratory Diagnosticians (AAVLD) and the United States Animal Health Association (USAHA). Data are compiled from national animal disease control and eradication programs ; patterns of selected diseases based on veterinary diagnostic laboratory data ; selected etiologic agents associated with specific animal health events such as bovine abortion ; global disease distribution ; and notes from veterinary diagnostic laboratories about unusual laboratory findings or new diagnostic procedures [Hueston, 1995]. Results are published quarterly in the DxMonitor, a USDA publication, and distributed via mail and electronic bulletin boards.

Data are limited in their use currently but they are helpful for identification of disease trends, especially with diseases of low prevalence or disease events which are clearly defined. Animal health diagnostic laboratories results can be beneficial in animal disease surveillance if they are standardized and can be related to the population at risk. The VDLRS also provides an excellent forum for the standardization of disease classification and diagnostic methodologies.

B - ANIMAL HEALTH SURVEILLANCE USING SENTINEL PRACTITIONERS

Primary animal health data can also be collected from veterinary practitioners. The SFM program is made up of 6 feedlot consultants who gather inventory and mortality data from 60 feedlots. Feedlot operators report inventory by cow type and risk classification, 30 day receipts, and death loss by cause (respiratory, digestive, and other) to their veterinary consultant by the 5th day of each month. Consultants transmit data to the NAHMS staff via facsimile by the 10th of the month. Computerized programs are used for data entry, validation, and processing, and generation of reports and graphs. Inventory, receipts, and mortality ratios by month are reported for a feedlot as well as the average for all feedlots. Reports and graphs of mortality ratios by month are distributed to feedlot operators and practitioners by the 15th of the month.

Data collected through the SFM program allow NAHMS to monitor death loss in over 1.2 million head of cattle on feed (15 p. cent of industry). The regular measurements of death loss in cattle on feed are used to monitor trends and serve as an early warning system for aberrant patterns. In addition, the information is used to assess seasonal fluctuations in death loss.

IV - DESCRIPTION OF NAHMS NATIONAL COMMODITY STUDIES

The first NAHMS national study was conducted in 1990 when over 1600 randomly selected pork producers provided information regarding management practices for their operation and recorded animal health events for farrowing sows and piglets. Since that time a total of 37 states have participated in at least one of four NAHMS national studies addressing pork, dairy, beef cow/calf, and beef feedlot production. The hallmarks of a NAHMS commodity study include : a statistically based design regarding selection and estimation ; a national focus defined as a target population made up of at least 70 p. cent of the national population ; and the voluntary and confidential on-farm collection of health data and biological specimens.

NAHMS serves as the impetus for federal, state, industry, and university collaboration to gather new information to fill important data gaps. Through national studies, these multi-disciplinary resources gather data and generate descriptive statistics on animal health, productivity, and management. The development of a NAHMS national commodity study begins with a needs assessment and cycles through a design phase, implementation, analysis, and dissemination phase. A key player in the administration of a national on-farm study are the state coordinators in each of the participating states. State coordinators serve as an intermediary for the CAHM staff who design a national study and the VS field veterinarians who implement it. To date, 37 states have participated in at least one national study. The completion of a national on-farm study involves about 16-20 staff years by VS employees.

Animal health information is collected by VMO administered questionnaires (retrospective data), producer recorded diaries or logs (prospective data) and laboratory analysis of biological specimens collected on the farm (cross-sectional data). The NAHMS coordinator of each state is responsible for the implementation of the study including training of VMO's, sample assignments, overseeing the collection and handling of data till it reaches the NAHMS staff, and feedback of results back to participating producers.

ANIMAL HEALTH SURVEILLANCE USING ON-FARM DATA COLLECTION (PRODUCERS)

The 1995 NAHMS national study will address the information needs of the U.S. pork industry. NAHMS spent much of 1994 surveying pork producers and allied professionals and holding focus group meetings in order to identify current information gaps. The critical elements of the needs assessment phase are the commodity overview, identification of information gaps, and the establishment of design specifications. The commodity overview provides an understanding of the context in which the study will take place by shedding light on recent trends/developments and current conditions. The needs assessment activities identify information gaps for the industry and provide an opportunity for stakeholders at all levels to have input into the study content. Food safety, product quality, and environmental issues surfaced as important issues for NAHMS to address. (A fact sheet summarizing these efforts was released in December 1994). These key areas were used to identify seven objectives for the NAHMS 1995 national swine survey and will direct the design of the study.

Many important decisions are made during the design phase. The target population, sample selection and allocation, sample size for the different phases, methods of data collection including development of data collection instruments, and survey content are decided at this time. Shells of the expected output tables are created before initiation of the study to guide development of questions and to limit its scope. During this phase input is received from VS field personnel, university researchers, and other industry experts on important aspects of the study design. Input is gathered via conference calls, electronic lists, and other personal communications.

The 1995 NAHMS study will have two components : a National BASELINE study and a grower/finisher ON-FARM study. Both studies will be carried out in the top 16 pig-producing states which represent over 90 p. cent of the U.S. hog inventory. The baseline study will be

administered in June of 1995 in conjunction with the Quarterly Agriculture Survey (QAS) conducted by NASS. Approximately 3000 producers will be queried by CATI on their hog inventory, mortality, and general farm practices related to biosecurity, facilities, disease prevention and other such areas. Producers with at least 300 market hogs will be invited to participate in the on-farm study which will consist of two visits by state/federal VMO's between July 17, 1995 and January 19, 1996. Two questionnaires will be administered to obtain data on areas such as feed management, quality assurance practices, marketing, and biosecurity practices. Producers will be given the option of submitting 30 blood samples from gestating sows and finishers for testing for porcine respiratory and reproductive syndrome virus. Serum will be banked for further research on new emerging pathogens and seroprevalence studies. Optional submission of feed samples from the gestation and last finisher ration will be tested for Salmonella and mycotoxins. Up to 160 producers may submit 50 fecal samples from finishing pens for testing for Salmonella. Fecal samples will also be tested for *E. coli* O157:H7 and other food-borne pathogens.

All participants will receive information from the 1990 National Swine Survey at their first interview. Participants in the on-farm study will receive summarized results of all data analyses as they are released and test results for their farm, except for *E. coli* O157:H7. Results *of E. coli* O157:H7 tests will only be summarized at a national level to determine whether or not it exists in the U.S. hog population.

Several stages of analysis were identified in the planning of a national animal health surveillance program. Initial efforts are to be directed at producing descriptive statistics for the national herd. National estimates will be derived for the frequency of management practices, prevalence and incidence of disease, as well as the costs of certain animal health activities. Second, methods of analytical epidemiology will identify potential risk factors for "disease", followed by the modeling of interactions between host, environment, and agent which affect health and productivity [Hueston, 1990]. Further analysis of data will shed light on important relationships between various risk factors and their effects on disease, production, and profit of the enterprises.

Of utmost importance to the completion of a national commodity study is the dissemination of reliable data that have been appropriately analyzed and interpreted. Results must be distributed to potential users in a timely fashion. Many Swine '95 results will be compared to those of the NAHMS 1990 National Swine Survey to measure changes in the health of the national swine herd and identify management trends. Composite summaries of Swine '95 information will be provided to veterinarians, producers, educators, researchers, animal health officials, and others. In addition, Statistical Analyses System (SAS) data tapes are made available to university researchers. Linkage with USDA's Extension Service may facilitate future efforts at dissemination of results to those involved at the herd level. Users of national animal health data have been well summarized by a number of authors [Hutton, 1974 ; King, 1983 ; King, 1985 ; Poppensiek, 1985].

V - RESULTS/BENEFITS OF NATIONAL ANIMAL HEALTH SURVEILLANCE

Who benefits from a national animal health surveillance system? The livestock owner is the initial beneficiary. "The individual producer has too little information on economically significant diseases and even less on the cost-effectiveness of initiating or changing management strategies to increase efficiency of production. National Animal Disease Detection Service can fill this information void by quantifying disease problems and their economic impact and observing the effectiveness of control strategies through longitudinal studies and analyses" [King, 1984]. Reliable animal health information will provide the broad base of knowledge needed by herd managers to make effective management decisions. It will provide knowledge of factors which diminish production efficiency, estimates of the cost of dealing with a disease, and allow determination of the probability of a herd becoming infected and/or the economic consequences of management decisions made [Hutton, 1974].

Additionally, improved services will be available through veterinary practitioners who are armed with knowledge of geographic and seasonal occurrences of diseases as well as other patterns of disease. The private practitioner benefits from disease detection efforts which epidemiologically connect sporadic cases or promote early detection of new diseases or epidemics. Relating individual cases in a community empowers the diagnostic ability of practitioners [Blood et al., 1978 ; Brachman, 1985 ; Brachman, 1991]. With better discernment of their client's needs, they will apply more specific and appropriate control and prevention procedures. Future veterinarians will arrive on the farm with a more complete understanding of the epidemiology, pathogenesis, and economics of animal disease.

The use of surveillance data in the planning of national control and eradication programs is well recognized [Thacker et al., 1983]. Understanding patterns of disease is useful in describing the natural history of a disease, and providing an archive of disease occurrence. Knowledge of the extent and distribution of disease, monitoring disease trends, assessing emerging risks all serve to abet failure of national control efforts by allowing for effective planning and optimal use of resources [Thacker et al., 1983 ; Brachman, 1985 ; Brachman, 1991].

Many other groups evaluate and use the vast pool of information collected by the NAHMS. Pharmaceutical and biological companies consider prevalence of disease and occurrence of preventive practices for the planning of research and evaluation of marketing strategies for their products. Regulatory officials have statistically sound disease information on which to base control policies. Furthermore, reliable information allows for effective planning of eradication programs, permits cost-benefit evaluation and risk analysis of trading policies, and bolsters the protection of disease-free zones. Researchers have enhanced ability to justify grants knowing the prevalence and economic impact of certain conditions. Such a pool of reliable information on animal health events and practices will serve to strengthen the viability and marketability of U.S. food animal industries [Hutton, 1974 ; Poppensiek, 1985 ; King, 1990].

VI - GENERAL PERSPECTIVES OF NAHMS (Analysis of strengths and weaknesses)

NAHMS programs collect animal health surveillance data on a regular ongoing basis allowing users to assess patterns of disease and trends in management changes. Epidemiologic studies differ from surveillance in that the latter are on-going in nature and occur on a periodic basis. The frequency of the surveillance cycle varies from the monthly collection of mortality information in the SFM to estimates of management practices from national commodity studies occurring every 5 years.

The first component of a surveillance system is obtaining accurate information pertaining to health related events from a defined population. NAHMS fulfills an important niche in animal health by focusing on the national population. NAHMS develops a standardized approach for the collection of data from cooperating parties. Therefore information is not simply pieced together on an ad hoc basis but generated in a consistent manner allowing for summarization at the national level.

The heart of the health 'industry' is made up of populations of hosts, agents, vectors, and reservoirs ; medical professionals who directly care for and monitor the above populations ; and the diagnostics centers which support them both. The bulk of NAHMS surveillance data are collected from these sources. Surveillance data also can be compiled from other sources such as those groups which exist to service the health industry via regulation, administration, and commercial supply of all related materials and services.

Regardless of the source of surveillance data, valuable information must be generated and disseminated to users in a timely fashion. Table II lists items which may be included in reports arising from national surveillance programs. For benefits to be realized at the national level, strong links must exist with policy makers and regulatory officials.

Table II : Information to be disseminated in national reports
[King, 1985]

Reports should include :
1. Current, cumulative, and comparative reports of disease and conditions subject to continuous surveillance
2. Periodic, more in-depth data on select disease
3. Progress reports regarding specific control measures
4. A warning system to alert producers to new, changing, or potential problems
5. Summary reports concerning specific follow-up of cases/outbreaks
6. Predictions of disease patterns
7. Economic analysis of diseases
8. Risk evaluations of disease factors

A - PERSPECTIVES ON SURVEILLANCE USING VETERINARY DIAGNOSTIC LABORATORIES (VDL)

Animal health surveillance has traditionally had strong ties with veterinary diagnostic laboratories (VDL) especially with regard to national control and eradication programs. VDL document results from an endless barrage of diagnostic assays, creating a storehouse of epidemiological intelligence for use in surveillance systems. Data collected from VDL have the advantage of being detailed and accurate [Hird, 1986]. VDL are especially useful for surveillance of non-specific diseases requiring laboratory diagnosis e.g. abortions [Thacker et al., 1983]. In addition, they provide useful data for the detection of trends in disease occurrence and alerting authorities to disease outbreaks requiring further investigation.

Other roles of VDL include monitoring progress of eradication programs, evaluating efficiency of diagnostic tests, and characterizing etiologic agents. Serum banks are increasingly being used in national surveillance systems. They can be used to uncover the origin of newly discovered infectious diseases, document the periodicity of epidemics, and serve as guides for vaccine priorities [Christiansen, 1980 ; Thacker et al., 1983].

That data collected from laboratories are biased is well recognized [Christiansen, 1980 ; Hellstrom, 1980 ; Thacker et al., 1983]. A selection bias results from those diseases not requiring medical attention. VDL rarely collect active surveillance data directly but instead rely on submission of data, as short diagnostic forms and biological samples, from practitioners in the field. Cases brought to the attention of private practitioners are 'picked over' and those eventually submitted are subject to the idiosyncrasies of the submitter. Misclassification bias results depending on the expertise of staff and the sensitivity and specificity of diagnostic procedures being employed. VDL have the added disadvantage of not having vital statistics available for the estimation of population at risk. Therefore, unbiased disease prevalence and incidence cannot be calculated from data collected at VDL [Hellstrom, 1980].

The suitability of data collected from VDL depends on the existence of a standard definition of "disease". Adequate classification systems used in laboratories often require large amounts of data to be stored. This translates into difficulty in maintaining quality of data. VDL can play an important role in the expansion of surveillance beyond infectious diseases alone. Prevalence estimates of nutritional deficiencies, metabolic diseases, toxins and anemias can be made using diagnostic center data. The mapping of distribution and frequency of genetic markers, biological monitoring of the environment, and

serum banking are additional contributions diagnostic centers can provide to surveillance systems [Schwabe et al., 1977].

B - PERSPECTIVES ON SURVEILLANCE USING PRIVATE PRACTITIONERS

Public health surveillance has historically relied heavily on practitioner reporting of notifiable diseases. Disease must be recognized and then accurately diagnosed. Practitioners must report notifiable diseases encountered and are often involved in follow-up investigations for detection of rare diseases or localized epidemics. The passive surveillance of disease often applies to all practitioners whereas active surveillance is effectively applied to sentinel practitioners. Perhaps as an attempt to improve surveillance data collected from medical practitioners, the use of sentinel practices has increased, e.g. Ambulatory Sentinel Practice Network and the French Sentinel General Practitioners [Thacker et al., 1983 ; Valleron et al., 1986 ; Orenstein and Bernier, 1990].

The use of veterinary practitioners for disease reporting in animal health surveillance has historically floundered. Beside the erosion of cooperation by veterinarians due to waning motivation, there exists the difficulty of one busy professional having to 'demand' forms from another busy professional whose good will and cooperation are needed in other relations. At the first point the practitioner must collect forms from his livestock producer client and at the second point the district veterinarian has to collect compiled forms from the practitioner [Martin and Diesch, 1980].

The NAHMS SFM program has succeeded in contrast to past efforts to use veterinary practitioners. This underscores the importance of timely dissemination of surveillance data to users. For the SFM, mortality ratios and summary statistics for a feedlot along with comparisons to all lots by month are returned to practitioners within five days. Furthermore, the information returned is deemed useful by those collecting the data. Thus, practitioners may be more effective in active surveillance systems than passive ones. This is the case with the Danish Pig Health Scheme which has made use of veterinary practitioners in the dissemination and linkage phase of their national surveillance system. This appears to be a more rational role for veterinary practitioners to play in surveillance systems of a national scope.

Surveillance data based solely on data collected from practitioners are unlikely to provide a highly accurate indication of the true prevalence or incidence of diseases. Underreporting is always a factor with passive reporting of disease morbidity and mortality. Selection bias exists when there is greater interest by practitioners in new diseases [Hellstrom, 1980]. This holds true for the SFM where neither practitioners nor feedlot operators are randomly selected. Collection of animal health information from practitioners selects against poor owners, mild diseases and hopeless cases where a vet is unlikely to be called, as well as diseases easily treated by the owner [Thrusfield 1986].

Case reporting by private practitioners tends to be prompt, simple, and accurate. It is especially useful for those diseases which are rare, such as death loss in a feedlot, or represent an unusual case of a common disease [Brachman, 1991]. Factors influencing the usefulness of practitioners as a data source include the awareness and interest of the producer and his veterinarian ; the ability to make an accurate diagnosis once the veterinarian is involved ; and the existence of incentives for non-reporting [Hellstrom, 1980]. Motivation is the prime influence on the quality of data collected from practitioners.

C - PERSPECTIVES ON SURVEILLANCE USING PRODUCERS (FARMS)

One of the most difficult segments of the health industry from which surveillance data can be collected is the population. The population may vary in size and definition. It may refer to a small well-defined group or to a national population. The target of surveillance may be the population at risk, the vector population, or a population which serves as a reservoir for disease. The population may be approached either via a census or a sample survey, although the latter is more cost-effective.

Surveys collect data directly from populations through the use of questionnaires [Simpson and Wright, 1980], either by mail or by personal interview. Until the development of the USDA's NAHMS, population surveys were rarely used in animal health surveillance at a national level.

Several herd-level commercial surveillance programs collect information using standardized forms directly on the farm e.g. Dairy Herd Improvement Association and PigChamp. Herd level recording systems may capture a different set of parameters from objectives of larger surveillance systems. These differences may impede responsiveness of producers or completeness of data recorded. This was the experience of Frank et *al.* in pilot beef feedlot studies by the NAHMS. "It was evident that the NAHMS recording system, and its purposes, differed from the purpose and the records of the feedlot" [Frank et al., 1988]. This is a problem for on farm surveillance of animal health since several producers make use of commercial or unique programs for monitoring on farm trends important to the producer in making management decisions. Diaries for NAHMS projects are likely to be different in intent but similar in form, appearing as a duplication of effort to the producer.

The NAHMS program should recognize the difficulty in standardizing data collected from representative large feedlot operations {or other livestock production enterprises}. Nevertheless, after systematizing the records, we believe the data collected from this feedlot met the requirements of NAHMS. The study has shown that, for the purpose of comparison, it is possible to use standardized forms to collect information from a variety of customized record systems. An important benefit is that the collected data can be used to evaluate the existing herd health program [Frank et al., 1988].

Surveillance programs at the herd level may not be adequate or complete for surveillance programs operating at the national level. For the collection of national surveillance data to be successful the design should be flexible enough to adapt to various methods of recording keeping that exist on farms. On the other hand, data must be collected in a standardized and consistent manner. This is a constant difficulty faced by surveillance systems collecting farm data on a national level.

There are many advantages to collecting surveillance data directly from populations. Farmer attitudes to the severity and cost of disease can be assessed in order to establish guidelines for control programs and/or priorities for research. Secondly, data that are collected close to the user will often be of higher quality due to the greater interest in the results [Simpson et al., 1980 ; Thacker et al., 1983]. However, this is not necessarily the case as with producer-recorded causes of death loss in swine [Vaillancourt et al., 1990]. Lastly, surveillance systems collecting data from the population are particularly useful for investigating new or unusual disease pr blems which require special programs e.g. *E. coli* O157:H7 in the NAHMS 1995 NSS [Thacker et al., 1983].

VII - CONCLUSION

NAHMS represents an evolution of animal health activities of UDSA:APHIS:VS to adapt to the changing needs and demands of the livestock producing industries and consumers. The development of NAHMS in association with universities, other government agencies, and producer organizations has ensured that features central to its success have been appropriately incorporated into the design and evaluation of the system.

For national studies of livestock health, these include a statistically valid sample, a large population base and timely dissemination of results to interested groups. The NAHMS program is ambitious and relatively expensive, yet at the same time it is an innovative model for the delivery of public veterinary medicine in the United States into the 21st century.

VIII - REFERENCES

Beal V. C. - Perspectives on animal disease surveillance. Proc 87th Annu Meet U.S. *Anim Health Assoc*, 1983, 359-385.

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

Brachman P. S. - Section C. Epidemiology of Infectious Disease : Principles and Methods. In : Principles and Practices of Infectious Diseases. Mandell G. L., Douglas R. G., and Bennett J. E., eds. 2nd ed. New York : John Wiley and Sons, 1985, 96-103.

Brachman P. S. - Surveillance. In : Bacterial Infections of Humans, Epidemiology and Control. Evans A. S., and Brachman P. S., eds. 2nd ed. New York : Plenum Medical, 1991, 59-72.

Bush E. J., Cowen P., Morrow W. E. M., Dickey D. A., Zering K. D. - Empirical similarity of responses of two random samples of North Carolina swine producers to a management questionnaire used in the US National Swine Survey. *Prev Vet Med*, 1995, **22**, 1-13.

Christiansen K. H. - Laboratory Management and Disease Surveillance Information System. *Proc Second Int Symp Vet Epidemiol Econ*, 1980, 59-64.

Diesch S. L., Martin F. B., Johnson D. W., Christensen L. T. - The Minnesota Disease Reporting System for food producing animals. *Proc 78th Annu Meet U.S. Anim Health Assoc*, 1974, 3-27.

Frank G. R., Salman M. D., MacVean D. W.- Use of a disease reporting system in a large beef feedlot. *J Am Vet Med Assoc*, 1988, **192**, 1063-1067.

Hellstrom J. S.- Utilization of disease scheduling as a surveillance technique. *Proc Second Int Symp Vet Epidemiol Econ*, 1980, 143.

Hird D. W. - Planning for surveillance systems in the new California Veterinary Diagnostic Laboratory. *Proc Forth Int Symp Vet Epidemiol Econ*, 1986, 368.

Hueston W. D. - NAHMS : Where we are and where we are going. *Proc 92nd Annu Meet U.S. Anim Health Assoc*, 1988, lvi - lviii.

Hueston W. D. - The National Animal Health Monitoring System : addressing animal health information needs in the USA. *Prev Vet Med*, 1990, **8**, 97-102.

Hueston W. D - DxMonitor. *Emerging Infectious Diseases*, 1995, **1**, 36.

Hutton N. E. - A nationwide system for animal health surveillance. *National Academy of Sciences*, 1974, Publ 1346.

King L. J. - National animal disease surveillance : A sense of the future. Proc 87th Annu Meet U.S. *Anim Health Assoc*, 1983, 351-355.

King L. J. - Concerns of the industry about NADDS and the APHIS response. Proc 88th Annu Meet U.S. *Anim Health Assoc*, 1984, 97-103.

King L. J. - Unique characteristics of the National Animal Disease Surveillance system. *J Am Vet Med Assoc*, 1985, **186**, 35-39.

King L. J. - The National Animal Health Monitoring System (NAHMS) : an early assessment. Proc 90th Annu Meet U.S. *Anim Health Assoc*, 1986, 86-91.

King L. J. - The National Health Monitoring System : fulfilling a commitment. *Prev Vet Med*, 1990, **8**, 89-95.

McCallon W. R., Beal V. C. - Historical aspects of animal disease reporting and the development of a national animal disease surveillance system. Proc 86th Annu Meet U.S. *Anim Health Assoc*, 1982, 341-349.

Martin F. B., Diesch S. L. - Animal Disease Report in Minnesota - a review of 1980. Proc 84th Annu Meeting U.S. *Anim Health Assoc*, 1980, 10-14.

Orenstein W. A., Bernier R. H. - Surveillance information for action. *Pediat Clinics Nth Amer*, 1990, **37**, 709-734.

Poppensiek G. C., Budd D. E. - Part I : A Review of Animal-Disease Morbidity and Mortality Reporting. National Research Council, A Report of the Committee on Animal Health. A Historical Survey of Animal-Disease Morbidity and Mortality Reporting. *National Academy of Sciences*, 1966, Publ 1346.

Poppensiek G. C., Combs G. P. - Report of the committee on morbidity and mortality diseases of food-producing animals. Proc 85th Annu Meet U.S. *Anim Health Assoc*, 1981, 1-6.

Poppensiek G. C. - The National Animal Disease Surveillance Program : a new concept. *J Vet Med Educ*, 1985, **2**, 104-106.

Schwabe C. W., Riemann H. P., Franti C. E. - Epidemiology in Veterinary Practice. Philadelphia : Lea & Febiger, 1977.

Simpson B. H., Talbot L., Davidson R. M., Wright D. F. - The use of sentinel farms as a source of information on the epidemiology of clinical diseases. *Proc Second Int Symp Vet Epidemiol Econ*, 1980, 87-92.

Simpson B. H, Wright D. F. - The use of questionnaires to assess the importance of clinical diseases in sheep. *Proc Second Int Symp Vet Epidemiol Econ*, 1980, 97-101.

Thacker S. B., Keewhan C., Brachman P. S. - The surveillance of infectious diseases. *JAMA*, 1983, **249**, 1181-1185.

Thrusfield M. V. - Veterinary disease information systems. *Proc Forth Int Symp Vet Epidemiol Econ*, 1986, 89.

Vaillancourt J. P., Stein T. E., Marsh W.E., Leman A.D., Dial G. D. - Validation of producer-recorded causes of preweaning mortality in swine. *Prev Vet Med*, 1990, **10**, 119-130.

Valleron A. J., Bouvet E., Garnerin P. et al - A computer network for the surveillance of communicable diseases : the French experiment. *Am J Public Health*, 1986, **76**, 1289-1292.