MACROEPIDEMIOLOGY AS IT AFFECTS DECISION MAKING IN ANIMAL HEALTH

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Introduction

Practitioners in bovine veterinary medicine have long recognized the need for applied epidemiology. In fact, epidemiology made its entrance into veterinary medicine through food animal, particularly bovine, medicine[1]. Herd health or population medicine is becoming a critical part of most progressive practices. The essential definition of epidemiology is the consideration of the distribution and determinants of disease in populations in order to control disease outbreaks.

The purpose of this paper is to present the new concept of *macroepidemiology*, to draw parallels with herd health and clinical epidemiology, and to provide examples of macroepidemiology in action.

Herd health and clinical epidemiology

In the herd health application of epidemiology, more than disease is considered. Deviations from health and productivity are equally important outcome variables. Distributions considered include the age distribution of the herd, the number of animals affected, herd size, and production deviations. Determinants of disease or impaired productivity include management related risk factors, such as housing or feeding, and other herd level effects, such as weather[2]. The population under consideration is generally the herd. The control measures, or actions taken, are those aimed at preventing clinical or subclinical disease, or improving herd production. However, findings may not be easily extrapolated to other herds [2].

Clinical epidemiology focuses on the individual animal as opposed to the herd. Distributions are described as case-series[3]. Determinants of disease are considered at the animal level. The control action employed is geared toward diagnosis and treatment of the individual animal. For example[4], clinical epidemiology was applied in developing recommendations for the interpretation of diagnostic tests for Bovine Leukemia Virus. The population to which the results of these analyses is applied is the client base.

Macroepidemiology

As the world changes, so must epidemiology. There are new demands being placed on food animal agriculture. Political and economic alliances are in a state of flux. New countries are seemingly being created daily. New trading alliances, such as the European Economic Community will rewrite the rules on agricultural imports and exports. Consumers are demanding that the government and producers supply new products that are convenient, healthy, free of residues, and produced in a manner sensitive to the welfare of the animal. Rapid progress in information technology and communications will make knowledge of important disease occurrences instantaneously accessible around the world. Changes in animal production have resulted in new pressures on livestock production systems. Larger herd sizes increase the likelihood of rapid disease transmission and major economic impacts. Consolidation of production and processing capabilities continues. Increased efficiency and excess levels of production reduce profit margins for all producers. These changes continue to produce an agricultural economy very sensitive to alterations in the global economic or health environment.

Macroepidemiology is the broad application of the same basic epidemiologic principles used in clinical epidemiology and herd health[5]. However, the distributions, determinants, populations, and actions considered are different. The distributions considered in macroepidemiology are national disease statistics on clinical disease, national or regional seroprevalence estimates, geographic distribution and densities of food animal groups, (eg. dairy, beef, sheep) national productivity information, or import/export quantities. The determinants germane to macroepidemiology include such issues as national policies, trade restrictions, and veterinary/health care infrastructure. Populations important to macroepidemiology include all food animal groups in the host country as well as those in other countries. Actions implemented in the context of macroepidemiology may include establishment of specific or general monitoring and surveillance systems, trade regulations, or the establishment of government or industry control, eradication and education programs[6]. The results of macroepidemiologic decisions may impact a majority of foreign and domestic producers.

Examples of macroepidemiology

U.S. Death Loss Estimate

Macroepidemiology can address industry-wide problems such as the cost of beef production and its effect on demand. U.S. beef producers are in an extremely competitive environment. They compete with domestic producers of poultry and pork along with foreign producers of beef. The U.S. market share of beef products has decreased from 42% in 1970 to 30.5% in 1990[7]. The biggest reason for this decrease in market share is the relative cost of beef. In 1990 retail beef sold for 3.2 times the price of poultry and 1.4 times the price of pork. Macroepidemiology can be used to direct efforts to reduce the cost of production to make the national beef industry more competitive.

Lost economic opportunities in beef cattle production increase the cost of retail beef. Death loss is estimated to contribute 15.6% of the lost economic opportunities in beef cattle. A survey by the National Animal Health Monitoring System (NAHMS) and the National Agricultural Statistics Service (NASS) estimated that 4.37 million head of dairy and beef cattle were lost due to premature death in 1991[8]. The resulting cost was estimated at $2.1 billion annually. Respiratory diseases contributed to 31.1% of these deaths; digestive diseases 20.6%. The value of these losses was $624 million and $395 million, respectively. The majority (63%) of the death losses occurred in calves[8].

U.S. Dairy Calf Management

With these large losses occurring in the industry due to death in calves, we must ask what are the determinants that may be contributing to these losses. A prospective study of 1,200 randomly selected dairy farms is currently being conducted by USDA:APHIS. A study in the beef cow-calf segment will be initiated in January 1993. Preliminary results on a partial data set regarding quarantine practices in the dairy industry are shown in Table 1. Only 19.6% of farms quarantined bred heifers before bringing them in contact with calves; 11.1% quarantined lactating cows. The amount of time the animals are quarantined is generally not sufficient to prevent spread of infectious diseases. After separation from the dam, 26% of newborn calves have contact with calves over 4 months of age; 10.5% have contact with adult cows. Less that 50% of the dairy farms provide maternity facilities separate from the dry cows. These preliminary results suggest that national dairy calf herd management, to reduce death loss, could be improved.

Quarantine Methods Employed in the
Past 12 Months on U.S. Dairy Farms
(Partial Data Set)

Percentage of Operations Who Brought Animals onto Farm	Percentage Quarantined	Average # of Days
11.1% young calves	23.4	51.0
9.3% weaned heifers	35.5	39.0
21.9% bred heifers	19.6	17.0
20.8% lactating cows	11.1	12.0
8.2% dry cows	12.2	17.0
27.3% bulls	16.1	30.0

Bovine Spongiform Encephalopathy

Another example of macroepidemiologic analysis involves a problem of international significance. Bovine Spongiform Encephalopathy (BSE) is a new disease resulting from major changes in animal production and feeding[9,10,11]. It has caused significant consumer and industry concern in Great Britain[12,13]. In the United States cattle producers became very concerned about the implications of this disease. Three questions were raised in U.S. macroepidemiologic risk assessment. Does BSE exist in the United States? If it does exist, in what parts of the country is it expected to be found? If it occurs in the U.S., will the epidemic be of the same magnitude as observed in Great Britain? In answering the above questions, analysis of the distribution, and determinants of the disease in various populations was employed. Certain national policies and actions have been implemented as a result.

The distribution of the disease in Great Britain shows an epidemic beginning in 1985. It has the characteristic of an extended common source exposure. The distribution of cases led investigators to suspect a single national event may have precipitated the outbreak[14]. Changes in the manufacturing process of rendered protein products have been implicated. These same changes occurred in the U.S approximately 10 years before those in Great Britain. The age distribution of BSE shows it to be a disease of the adult animal. The average age of onset is 4 to 5 years. The disease is distributed largely in the dairy population, with 97% of the cases occurring in dairy or dairy crossbreeds[15].

The necessary determinants of disease, as identified in Great Britain, also exist in the U.S. The source of BSE seems to have been scrapie infected sheep. Scrapie is found in both countries. Scrapie infected sheep entered the cattle food chain as meat and bone meal, a byproduct of the rendering process used as a protein supplement. Meat and bone meal is fed to cattle in the U.S., however, the amount fed is relatively less than that used in Great Britain.

The populations considered in the risk assessment include sheep, beef and dairy cattle populations in Great Britain and the U.S.[15]. This demographic analysis showed substantial difference between the two countries. The sheep population in Great Britain has increased by 33% since 1980 to 40.2 million in 1989. In the U.S. the sheep population has decreased from 47 million in 1942 to 10.9 million in 1989. The sheep farms in Great Britain are more concentrated, and more dynamic than in the U.S. There are more farms in Great Britain that have sheep and cattle on the same premise.

Cattle populations and management are different between the two countries. The U.S has 9 times as many total cattle as Great Britain (99 million versus just over 10 million). In Great Britain many cattle are used for dairy and beef purposes. The U.S. has 10 million dairy cattle compared to Great Britain's 2.6 million. Comparison of the sheep and cattle populations between the two countries shows that are many more sheep than cattle in Great Britain. The ratio of total dairy concentrates to mature sheep meat and bone meal is 34760 lbs.: 1 lbs. in the U.S. vs 778 lbs.: 1 lb. in the U.K., a difference of 45:1[15]. Therefore, BSE is not likely to occur in the U.S. If it does, the magnitude of the epidemic will be small when compared to Great Britain.

National level actions have been taken in response to this BSE risk analysis[16,17]. Surveillance systems have been initiated[12], but BSE has not been diagnosed in the U.S. to date. Diagnostic laboratories are encouraged to submit brains of cattle with undiagnosed Central Nervous System (CNS) disease. Brains submitted to state public health laboratories for rabies diagnosis are being screened for BSE lesions. Data from existing systems, such as meat inspection and veterinary teaching hospitals, are being screened for changes in frequencies of CNS disease. Much of the rendering industry has voluntarily changed policies regarding acceptance of sheep offal. The importation of meat and bone meal from Great Britain was stopped, and port surveillance has been increased. Education of veterinary practitioners, animal health officials, and diagnostic laboratories has been increased, and new research priorities have been set[18].

Residue Avoidance

Education of producers and practitioners has been increased in response to macroepidemiologic analysis by the American Veterinary Medical Association, the Association of Bovine Practitioners, and the National Milk Producers Federation. The Ten Point Plan for Milk Quality Assurance is an education program based on the analysis of distributions and determinants of residues in the national dairy population. Analysis of U.S. management and treatment practices has revealed important determinants for milk residues. Based on this analysis, control and education programs have been implemented.

Summary

To appreciate macroepidemiology, herd health practitioners may need a slight paradigm shift. Distributions considered must move from the herd to the nation. Geographic data on animal types becomes significant. Probability based, national sampling becomes more critical. Data on the national prevalence of various management and feeding practices are needed. This information may open or close important international trade routes. National health policies and regulations become consequential determinants of disease or production deviations. The impact of trade restrictions on the prevalence or risk of a disease becomes an important variable. Data on populations of food animal groups in foreign countries may become as important as they are in the U.S.

Future initiatives call for fusion of macro and herd health epidemiology[5]. Practitioners should consider merging data from individual herds with those collected as a part of national monitoring systems. This type of analysis might include a comparison of herd level production parameters with those of other herds in the same region. Another analysis might include comparison of data from diagnostic labs, with practitioner data. Analysis of new import regulations, such as the North American Free Trade Agreement, would give practitioners perspective on future health risks in their client herds. These types of analyses would give producers and practitioners new fuel for decision making and strengthen the entire food animal production system.

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