MODEL APPLICATIONS OF DECISION SUPPORT SYSTEMS IN MEAT HYGIENE PROGRAMS

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ABSTRACT

Current systems to ensure safety of meat are to a large degree based on a "procedural" approach which specifies what inspection actions will be taken to protect human health. Both knowledge and disease priorities have changed substantially over recent decades, and moreover the scale of the problems created by any breakdowns in protection has escalated greatly, as food trading and consumption patterns have changed. It is now recognized that meat hygiene needs to focus primarily on ways by which the risk that product will represent a hazard to human health can be effectively reduced, rather than merely ensuring compliance with a defined set of procedures. In addition to human food safety, meat inspection has the potential to contribute information to improve animal health on a national and a local scale. This thesis examines example issues in order to identify possible approaches to the development of decision support systems which assist in protecting meat consumers and improving the health of livestock on farms. The main areas which were explored for this purpose were respiratory disease in lambs and chemical residues in slaughter animals.

A literature review of pneumonia and pleurisy in lambs showed that numerous factors have been proposed as predisposing causes for these diseases, but there was surprisingly little valid experimental or observational research evidence to support such statements. A hazard analysis was performed for the micro-organisms which have been isolated from pneumonic lungs. The major commonly detected organisms did not appear to cause a risk to healthy people. However there were a number of micro-organisms which are isolated on occasion from pneumonic and sometimes from healthy sheep lungs that might cause human disease.

A case-control study was carried out as an exploratory means to identify risk factors and to generate hypotheses about causal processes. A number of risk factors were initially identified at univariate level. At the second stage the importance of some of these risk factors was quantified in a logistic regression model. Finally a third stage analysis showed the interactions between the factors in a logistic path model, which consisted of three clusters. One cluster included characteristics of the farm and paddocks, one cluster included the yards and practices in the yards, and a third cluster included the types and number of animals on the farm.

Two intervention studies were subsequently carried out to evaluate the effect of making various management modifications on the prevalence of pneumonia and pleurisy at slaughter. One intervention study evaluated the time lambs spent in the yards after weaning and the use or oral or injectable drenches. The second intervention study evaluated the use of oral versus injectable drenches and the use of a shower dip versus a wand. The intervention studies showed an effect of time in the yards on pneumonia. There was some association between time in the yards and acute localised pleurisy but none between the other measures tested and respiratory disease. The studies showed clear temporal patterns with regard to pleurisy and pneumonia and enabled comparisons to be made between farms.

A study of inspection for pleurisy at slaughterhouses was analysed. The analysis identified the

temporal patterns of certain types of pleurisy. Comparisons were made between four participating premises. The sensitivity and specificity of meat inspection for the various types of pleurisy was analysed. The pleurisy data over an eleven year period of the entire country were analysed. Differences were shown between islands and regions.

The potential for development of components of a decision support system for pneumonia and pleurisy was illustrated with a number of examples. An important component was to determine how farmers could be assisted in improving the health of their lambs with regard to pleurisy. Ideas to improve farmer involvement were developed. The principles of a decision support system which evaluated the issue of cross-contamination due to handling of product by the inspector were developed.

Epidemiological principles of chemical residues in slaughter animals were investigated. A number of statistical quality control tests were applied to known data sets to evaluate what sample sizes would be required to detect changing trends or spatial paterns. Temporal simulations were performed to determine how well clusters in time could be detected. The Moving Average approach was used and it appeared that with the given data set sample sizes well beyond those feasible to achieve would be required. Spatial analyses with a number of different statistics were performed. In this case also, large sample sizes were required for reliable results.

It was concluded that use of a risk analysis model to define a risk-reduction strategy targeted to avoid any significant risk to the consumer offered a much more effective tool than a fixed sampling system. This model combines a range of possible risk reduction measures in various mixes, and determines whether or not each of the tested strategies achieves the goal of making it very improbable that a consumer would be exposed to sufficient levels of chemical residues in food to even constitute some minimal public health risk.

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CHAPTER 1

INTRODUCTION

Aim of Food Safety Programs

The aim of food safety programmes is to provide food which has a minimal risk of producing diseases or other adverse effects on the consumer, at a reasonable price.

This definition conveys the concept that the safety of food should be seen in the context of product price, ie additional safety can be bought at the cost of an increased price for the product. There should be an appreciation that there is a balance between the desire to eat various foods and the risk that is inherently taken in the process of eating each type of food. The definition is intended to express the idea that few human activities are risk-free, and that actions taken to reduce or eliminate risks must balance the additional benefit from safety programmes against the additional costs.

The critical components which should form the basis for designing meat safety programmes are explained below. They consist of process control, data collection, analysis/feedback, and risk assessment. In contrast, conventional food safety programmes rely on inspection of the carcasses of individual animals and are commonly called meat inspection systems.

Conventional Meat Inspection Systems

As an established concept 'meat inspection' has been central to efforts aimed at guaranteeing protection of the consumer. This term may have become counterproductive, because it emphasises what should be a component only of a more comprehensive food safety programme which includes process control and protection against chemical residues.

Inspection of animals in slaughterhouses is intended to protect the public health, but current inspection procedures support past disease priorities and outdated epidemiological understanding. They do not accurately reflect current concepts of product safety, and how it should be achieved. In New Zealand the vast majority of sheep, cattle, pigs, deer, goats and horses that are slaughtered for human consumption are subjected to an ante mortem and a post mortem inspection which are clinical and pathological evaluations. Usually both evaluations are carried out rapidly. However in case of abnormalities there is scope to detain live animals or carcasses and tissues for a thorough inspection, with laboratory backup if necessary. Those animals or parts of animals which are deemed unfit for human consumption will be condemned. Although the

intention is to remove product from the food chain which presents a public health hazard, in reality only tissues which display abnormalities are condemned. Many conditions of public health significance cannot be detected by current procedures. Only some of the animal diseases that are used to determine carcass disposition at meat inspection have public health significance.

Generally meat inspection systems in the Western world are 'procedure' driven. A product is inspected at the end of the production process. The systems are very occupied with compliance with their rules rather than with their more fundamental aims. These meat inspection systems are frequently based on the systems that were developed late last century. Many of the conditions that were considered to be significant at the time are no longer considered to be important. This is to some degree because the prevalence of a number of diseases in livestock has decreased. However there is an increasing awareness that some of the conditions which cannot be detected by conventional meat inspection are of great human health importance. These conditions include the presence of pathogenic micro-organisms and residues of chemicals.

There are other important functions which meat inspection already performs to some degree and which can be strengthened in new food safety programmes. They include surveillance of animal health and production, and defects of processing and marketing importance. These components are not concerned with food safety. Where these issues are addressed successfully farmers and meat processors will benefit from them. The ability to carry out post mortem examinations of large numbers of animals is a strong point of meat inspection. The role of meat inspection regarding animal health surveillance is explored below. This type of surveillance should not be considered as a stand-alone system. There are inherent weaknesses in the collection of the data, and it is biased in various respects. However an appreciation of the scope of these deficiencies will facilitate the incorporation of slaughterhouse data with other systems, ultimately leading to an overall animal disease surveillance system that will give a sufficiently accurate 'picture' of the situation. The removal of defects such as pleurisy, arthritic joints, and abnormally pigmented meat from carcasses is a cost to meat processing. Meat inspection systems can assist in quantifying the cost of labour and discarded product thereby providing valuable feedback to both farmers and meat processors. Such feedback is essential where diseases can be prevented on the farm, while the only remedy available to meat processors is trimming.

Process Control

The main tasks facing food safety programmes in relation to infectious diseases are to exclude pathogens from the food chain to a reasonable degree and to limit the opportunities for these pathogens to multiply during processing and storage. The phrases that have been coined to describe these concepts are 'pre-harvest food safety' and HACCP (Hazard Analysis Critical Control Point). In the case of pre-harvest food safety, risk factors which contribute to the existence of pathogens in farm animals are identified. Subsequently farmers can be encouraged to raise livestock in such a manner that the prevalence of pathogens in the livestock population is reduced. The HACCP principles can be applied to both farming and the meat processing industry. In the meat processing industry it focuses on the areas where processing can go wrong,

resulting in contamination of product and the multiplication of pathogens. Examples of such critical points are contact between skin, ingesta or faeces and the carcass, contact between meat and food handlers, and temperature abuse.

Risk Analysis

There is a need to develop risk analysis tools which will be able to assess the risk which pathogens, procedures and their interaction, pose to public health. This may be performed in a qualitative or a quantitative sense. There is a need to generate a greater appreciation among the general public and decision makers that with the present production and processing methods a nil-risk policy is not feasible. In fact it has never existed. The perception in the past that meat was "safe" if inspected and handled properly, was based on incomplete knowledge. New understanding which has become available over recent decades demonstrates the limitation of the inspection approach.

Risk analysis will need to be tied in with economic models. If unequivocally "safe" meat cannot be produced, then questions need to be asked about what are the economic options for producing meat of different degrees of "safety", to satisfy different market needs.

Animal Health Surveillance

Over the years the importance of disease surveillance has shifted from easily identifiable animal diseases to endemic diseases which are not clearly defined and which are strongly multifactorial. Monitoring for exotic diseases such as foot and mouth disease (FMD) through food safety programmes that are based at slaughterhouses is an important part of the overall national FMD surveillance programme. Most livestock will finally be slaughtered in a slaughterhouse. This provides an opportunity to assess the health of the national flock and individual farm flocks. The data for certain diseases can be acquired more easily and cheaply in a slaughterhouse than anywhere else. These data can then be used to assess the health status of the national herd and to monitor the effect of control or eradication campaigns. Especially in the case of endemic diseases such as pneumonia in sheep, and Johne's disease, slaughterhouse data will be invaluable to individual farmers.

Data Collection, Analysis and Feedback

The objectives of data collection have to be clearly defined before the actual data collection is started. It would need to be considered whether food safety, animal health or product quality

issues are considered.The success of process control, risk analysis and animal health surveillance depends heavily on the availability of data. These data need to be comprehensive and of good quality. Systems need to be in place to collect relevant data and to retrieve them on-line. In addition there is a need to analyse the data in a consistent, statistically sound manner. Computer hardware has reached the stage where it is able to perform the above functions in such a manner that data can be used for practical purposes. There is a need now to develop the appropriate software. Major problems still exist such as identifying geographical areas where animals have been raised before they were slaughtered. This problem may be of more importance in the cattle and sheep industry than in the pig industry.

Future Developments

There is a growing appreciation in the meat processing industry that control of the process of food production at all stages is as appropriate for them as it is for other industries. Issues such as human infections with *Salmonella* ssp., *Campylobacter* ssp., *Listeria monocytogenes*, verotoxigenic *E. coli* and *Toxoplasma gondii* in food of animal origin continue to make headlines in the media. They will not go away and the food processing industry is acutely aware of this. Bovine spongiform encephalopathy (BSE) has brought this subject even more clearly into focus at the worldwide level. Consumer rights have been clearly defined in law and are likely to be applied to instances of food poisoning more often in the future than is currently happening. In the case of *Salmonella* in eggs corrective action was taken by the poultry industry overseas. An increased awareness among farmers regarding their responsibility to supply healthy stock may seem desirable. However risk factors are usually poorly defined or not defined at all. Therefore the practices that farmers should comply with to supply animals carrying fewer pathogens are not very obvious. Improved identification systems of stock are currently being considered, especially for cattle. This will enhance systems such as AgriBase which is close to full implementation. In the near future the identification of stock may be less troublesome.

The ratification of GATT will have two major implications. Certification based on freedom of certain diseases on defined farms or in certain areas rather than in the whole of a country has become an accepted practice. Disease will be considered in relation to zones of varying size, rather than only in relation to a whole country. This will especially have an effect on the use of geographical information systems and statistical analysis. Any restrictions in trade will need to be scientifically based. This will especially have an effect on the development of risk analysis techniques.

Projects in the Thesis

This thesis takes two quite different issues as examples to explore how meat safety programs can adapt to the new priorities. First it explores how existing inspection findings could be used to

provide information to producers, based on the example of pleurisy in lambs.
Second, it examines the issue of chemical residue control, considering how a more effective surveillance system for preventing human health risks from such residues could be developed.