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Quantitative risk assessment and cost-effectiveness: two important requirements for meat inspection programmes

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ABSTRACT

The need to determine the scientific base and cost-effectiveness of traditional inspection methods is particularly important in New Zealand, a major exporter of sheep meat. Risk assessment as applied to potential human health hazards in a broad sphere can also be adapted to risk associated with a meat inspection programme. Risk associated with an export inspection programme aimed at maintaining market access must include human health, animal health and aesthetic defects.

A quantitative risk assessment model is described for 2 different inspection methods for liver fluke *(Fasciola hepatica)* in adult sheep. Unless sensitivity and specificity data are produced, quantitative risk assessments are statistically invalid. Determination of specificity also allows cost-benefit analyses to be correctly performed.

Keywords Meat inspection; quantitative risk assessment; sensitivity; specificity; *Fasciola hepatica*.

INTRODUCTION

Meat inspection programmes are primarily designed to ensure the safety and wholesomeness of the product, however they must also contribute to the economic viability of the production systems they service. A number of countries are beginning to evaluate the scientific validity and cost-effectiveness of their inspection systems (Dubbert, 1984, Anon, 1985; Royal, 1985; Murray, 1986), and national codes that are appropriate to the type and health status of the particular slaughter population will be the eventual outcome of such investigations.

The need to determine the scientific basis and cost-effectiveness of traditional inspection methods is particularly important in New Zealand, being a major exporter of sheep meat. European inspection programmes that evolved when animal husbandry was poor with considerable infectious disease in domestic animals have not only been transposed geographically, but have also been transported across species and age boundaries. Thus inspection programmes currently applied to lambs in New Zealand are inappropriate to the spectrum and prevalence of disease present in this country.

METHODOLOGY

Risk assessment, which has been defined as:— "the qualitative estimation of the likelihood of adverse effects from exposure to specified health hazards or from the absence of beneficial influences", (Anon, 1986) can be divided into four components (Anon, 1986):

1. Hazard identification; the qualitative indication that a condition or substance may adversely affect human health.

2. Hazard characterisation; the qualitative and quantitative evaluation of the nature of the adverse effects, including their expression as functions of the amount of exposure or dose.

3. Exposure characterisation; the qualitative and quantitative evaluation of the degree of human exposure likely to occur.

4. Risk determination; which integrates the above into a scientific determination of the level of risk as a basis for policy consideration.

Risk assessment is an emerging multidisciplinary science. Quantitative risk assessments are difficult to determine for many potential human health hazards and risks associated with meat that has been inspected using a particular programme are no exception. Defining and measuring exposure is a problem in many epidemiological studies (Kranz, 1983) and presents particular difficulties. Risk associated with an export inspection programme aimed at maintaining market access must also include animal health risk and aesthetic defects. A successful programme must not exceed an acceptable level for any of these risks while still operating within a cost-effective framework.

Methodology for developing a quantitative risk assessment can be modelled using ovine liver fluke *(Fasciola hepatica),* an aesthetic risk to the consumer. The New Zealand (observation and palpation) and European Community (gastric surface incision) inspection procedures are in marked contrast. The results of a comparative study of the 2 methods in adult sheep (Petrey, Baddeley and Kissling, unpublished) are presented in Table 1. An

TABLE 1 An analysis of inspection for liver fluke *(Fasciola hepatica)* in adult sheep using 2 different inspection methods.

| Inspection method | Apparent prevalence (%) | Inspection outcome | Actual infection[1] | | | True prevalence[1] (%) | Sensitivity[2] | Specificity[3] | Non-detection rate/1000 animals |
			Infected	Non-infected	Total				
A Observation and palpation	5.3	+	457[a]	40[b]	497				
		−	49[c]	8776[d]	8825	5.4	0.903	0.995	5.3
B Gastric surface incision	5.2	+	480[a]	0[b]	480				
		−	26[c]	8816[d]	8842	5.4	0.949	1.000	2.8

[1] Determined by multiple slicing of whole liver

[2] Sensitivity $= \dfrac{a}{a+c}$

[3] Specificity $= \dfrac{d}{d+b}$

analysis of the apparent prevalence data indicated that method A (observation and palpation) was not significantly different from method B (gastric surface incision). However, actual infection data from the trial demonstrates that method B is more sensitive than method A due to a higher specificity for method B. As a result, although method A detected less truly-infected liver, misdiagnosis gave more false positives. By relating sensitivity data to the true prevalence of infection, the difference in non-detection rate per 1000 livers examined by the 2 methods was 2.5.

The exposure assessment is not modified by preservation method (freezing or chilling), as the presence of liver flukes constitutes a visible aesthetic risk. However, end-use may be important as if livers are destined for pet food, no inspection for liver fluke should be necessary.

The possibility of cross-contamination with *Salmonella* spp., a significant public health risk, is an important consideration in viscera table procedures. It has been shown that meat inspectors' knives are commonly contaminated with these organisms, and routine incision of the liver would undoubtedly cause cross-contamination (Smetlzer and Thomas, 1981). Although there is no quantitative data available on the level of risk to the consumer, general principals of hygenic processing dictate that any potential risk be avoided. A quantitative risk assessment would therefore ignore the extremely small difference in exposure to liver fluke using the 2 inspection methods and recommend observation and palpation as the inspection method of choice.

Specificity is an important parameter in the determination of a quantitative risk assessment, but it is equally as important as a determinant of wastage. In the liver fluke study, observation and palpation falsely downgraded one in 200 livers from adult sheep, whereas no false positives resulted from gastric incision. A cost-benefit analysis of different inspection procedures must therefore take into account the level of wastage as well as differences in workloads. In some cases, there may be a conflict of interest between achieving an acceptable level of risk and introducing procedures with a decreased workload.

DISCUSSION

Epidemiologists regularly assess the accuracy of their test methods before comparing population statistics, however meat hygienists have been reluctant to establish valid quantitative parameters for equivalent comparison of meat inspection procedures. The sensitivity and specificity of a procedure are powerful analytical tools that do not change with prevalence and can be used to determine the true prevalence of a disease or defect in a population, thus;-

$$\text{True prevalence} = \frac{\text{Apparent prevalence} + \text{Specificity} - 1}{\text{Specificity} + \text{Sensitivity} - 1}$$

Quantitative risk assessment is a new concept in meat hygiene. To date, investigators have compared the outcome of different inspection methods without considering the accuracy of the tests themselves (Anon, 1985). A statistical comparison of the outcome of tests of unknown accuracy is scientifically invalid, especially in the case of diseases of very low prevalence.

A baseline methodology for developing a quantitative risk assessment has been described in this paper. Confidence limits for sensitivity and specificity can also be established, as can bounds for systematic variation in prevalence such as seasonal effects. Weightings for inspection procedures that concentrate on predilection sites can also be built into a quantitative risk assessment. Thus a national code of meat inspection for a particular slaughter population can be developed to incorporate an acceptable level of risk while minimising labour costs and wastage.

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