A Model of the Relationship of Skin Increase using the Single Intradermal Comparative Tuberculin Test (SICTT) and the Disclosure of a Visible Tuberculous-like Lesion in Cattle

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Introduction
A large volume of data is stored on District Veterinary Office (DVO) computer systems in relation to animals removed as tuberculin reactors under the Bovine Tuberculosis Eradication scheme. The data for individual animals include test dates, test types, tuberculin test results and slaughter plant records of the results of post-mortem examination results. A preliminary analysis of these animal data over the period 1989-1994 was completed in 1995 (O’Keeffe and Crowley, 1995). Following on from this analysis, it was decided to maintain a database at the Tuberculosis Investigation Unit (TIU) of both animal and test data stored on the Department of Agriculture and Food’s (DAF) computer system. Data are downloaded quarterly, three months in arrears, from the DVO systems using a customised extraction programme. These data are stored in the TIU as an Access® database.

Materials and Methods
Data are available on 308,856 animals removed as “reactors” during the years 1989 to 1997. A “reactor” is any animal deemed so by a Veterinary Inspector by a test or otherwise and compulsorily removed for slaughter. Included among “reactors” in these data are animals which were positive, inconclusive and negative to the standard interpretation of the single intradermal comparative tuberculin test (SICTT). Positive animals have a skin change of 5 mm or more at the site of infection of bovine tuberculosis at 72 hours, inconclusive animals have a skin change greater than 0 mm but less than 5 mm and negative animals have a skin change less than 0 mm., but are deemed to be reactors on epidemiological or other grounds. The skin change is the difference in skin thickness in response to the bovine and avian antigens, having adjusted for the initial skin thickness (bovine 72 h response mm – bovine 0 h mm) minus (avian 72 h mm – avian 0 h mm)). The previous analysis (O’Keeffe and Crowley 1995) demonstrated that the major predictor of lesions was the degree of skin change recorded at the most recent SICTT. The refinement in this paper is that data from 1995, 1996 and 1997 are included and also the relationship between skin change and lesion rate is modeled. It is worth reiterating that, if a confirmed lesion is detected, then tuberculosis is deemed to be confirmed, but if such a lesion is not found, one cannot be certain the animal was not infected with M. bovis.

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For the purposes of this study a tuberculous lesion is either a circumscribed lesion consistent with tuberculosis, or lymphadenopathy resembling tuberculosis. In one study, approximately 92% of these were confirmed at the Central Veterinary Research Laboratory, Abbotstown.

The SICTT is a screening test and it has both false negative and false positive reactions. In general the rates of these are estimated to be approximately 20-30% and 0.1% respectively. Thus, not all tuberculin reactors have been exposed to M. bovis and not all clear animals are unexposed to M. bovis. The proportion of standard reactors that are in fact infected depends on both the efficiency of performance of the SICTT and the true prevalence of M. bovis infection. The proportion of reactors (known as the positive predictive value) that actually are infected decreases directly with the true prevalence (Martin et al., 1987). Of course it also depends on the completeness of the examination for lesions at slaughter. Analysis of reactor cattle in Australia (Corner et al., 1990) demonstrated that about 8% of lesioned reactors are missed without a detailed examination. Corner et al., (1990) also compared a thorough gross post-mortem examination to the ‘usual’ examination cattle receive in the slaughter plant. Based on 113 reactors from one herd, the detailed examination found lesions in 13/25 (52%) of cattle and the routine examination found lesions in only 17/88 (19%). The authors of this report acknowledge that the thoroughness of examination at slaughter will affect the observed lesion rate. Other factors, such as the types of animal slaughtered and the proportion of each animal type in the national kill, also have to be taken into account (Collins, 1996). The modelling was carried out using SAS® software.

Results and Discussion
While the single best predictor of lesion presence is the size of the skin change to the SICTT, in practice, the SICTT result is the initial phase in declaring cattle as “reactors” and, therefore, the relationship of the SICTT result to lesion rate is of considerable interest. We describe here how we chose to model the skin change-lesion rate association and to then ascertain to what extent the relationship holds across the other factors that affect lesion rate. An early question was what form to use for modelling this relationship. For this purpose, five different models were investigated. These included using the observed skin changes, in both linear and quadratic (curvilinear) models, using the coded skin changes (-1mm., 0mm., 1mm., 2mm., 3mm., 4mm., 5mm., 6mm., 7mm., 8mm., 9mm., 10mm., 11-12mm., 13-15mm., 16-20mm., 21-29mm., >29mm.) in both linear and quadratic models, and using the coded skin changes as a categorical variable (skin change data less than 0 mm. were coded -1). The latter essentially reproduces the data set, as it includes a coefficient for every mm of skin change. This model fitted the data almost perfectly but gave no insight into the nature of the relationship, because a parameter was estimated for every skin change category. However, a perusal of the coefficients indicated that there are no large or abrupt changes between skin change categories that would serve as ‘cutpoints’ or thresholds. Hence, a simpler modeling process using skin change as a continuous variable, could be pursued with equal confidence.
Data from 2,742 cattle in which the skin change of reactions had not actually been measured (for administrative reasons, all avian and bovine measures had been set to 1mm.) where omitted from the modelling process. A feature of the overall information available on animals removed as reactors was that it included data on 2,633 cattle that showed no skin change but were removed as in-contact animals in herd depopulations. Of these cattle, 6.3% had tuberculous lesions identified, whereas over 12% of “other” cattle having no skin increase, but which were deemed reactors, had lesions. Although their impact is small, these cattle were not included in the models.

Table 1. Skin changes in Tuberculin Reactor Results of the Linear and Quadratic Models.

<table>
<thead>
<tr>
<th>Model</th>
<th>Deviance</th>
<th>B1</th>
<th>B2</th>
<th>B1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1 Skinchange</td>
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<td>0.0538</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model 2 (Skinchange)^2</td>
<td>366775</td>
<td>0.1108</td>
<td>-0.0011</td>
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<tr>
<td>Model 3 Codedsknchg</td>
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<td></td>
<td></td>
<td>0.0856</td>
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<tr>
<td>Model 4 (Codedsknchg)^2</td>
<td>364486</td>
<td></td>
<td></td>
<td>0.1961</td>
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</tbody>
</table>

The results of four of the models are shown in Table 1. The observed skin changes are modelled in linear (Model 1) and quadratic (curvilinear) (Model 2) forms. The coded skin response are modelled in linear (Model 3) and quadratic (Model 4) forms. By examining the deviances (a smaller deviance means a better fit), it was apparent that the quadratic forms of model (i.e. Model 2 with deviance 366,775 and Model 4 with deviance 364,486) generated a better fit than either of the respective linear forms of model. Furthermore, as the graph at Figure 2 illustrates, the coded skin responses fit the data better than the observed skin responses. In essence, the coded responses brought the extremes of skin change in towards the central area of the distribution without having to use a transformation that would reduce the practical interpretation of the most frequently observed skin changes (0-10 mm.). A very good fitting model would have a deviance approximately equal to the number of cattle in the data base (i.e. 303,481 for this set of data).

The linear and quadratic models based on coded skin change are shown graphically at Figure 2.

The summary relationship of SICTT skin change to lesion rate is shown in Figure 3. The mean lesion rate was 32.5% and the mean skin change was 9.6 mm.

Conclusion
These models indicate that the odds of finding a tuberculous lesion in cattle at slaughter increase by approximately 11% for every mm. increase in skin change. This observation is relevant when risk-based decisions are contemplated.
Figure 1. Linear and Quadratic Models based on Coded Skin Increase.

Figure 2. Summary Relationship of Skin Increase (Bovine-Avian) to Lesion.
References


