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Analysis of Epidemiology Reports on Selected Herd Breakdowns of Tuberculosis, 1996 - 1997

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Introduction

The Epidemiology Report Form (ER76) investigation methodology and reporting format have been in use since January 1995 and are applied by Veterinary Officers of the Department of Agriculture and Food (DAF) on all breakdowns investigated. Details of the investigation format were published by Griffin, O'Keeffe and Dolan (1994). This paper is an update of the database and includes further analysis on data relating to herds reported on previously by O'Keeffe and O'Driscoll (1997).

Materials

The database contains 601 ER76 reports. The breakdowns reported on were not randomly chosen and are not a representative sample of herds identified with tuberculosis since 1995. Episodes analysed had a minimum of two standard reactors identified with at least one lesion on gross examination. This resulted in 488 herds of the total of 601 reports going to the analysis stage. Herds from the Cavan DVO area comprise 18.9% of the final sample used for analysis (Table 1). These limitations should be borne in mind when evaluating the results. Based on the date when herds were de-restricted, of the 488 herds analysed, 9 outbreaks were in 1994, 188 were in 1995, 257 were in 1996 and 34 were in 1997.

Table 1. DVO areas of origin of reports.

DVO Area	No. of Reports Submitted	No. of Reports Analysed (%)
Carlow	6	5 (1.0)
Cavan	117	92 (18.9)
Clare	38	28 (5.7)
Cork	52	39 (8.0)
Donegal	24	23 (4.7)
Dublin	4	3 (0.6)
Galway	13	11 (2.3)
Kerry	47	35 (7.2)
Kildare	4	3 (0.6)
Kilkenny	25	22 (4.5)
Laois	41	34 (7.0)
Leitrim	6	5 (1.0)
Limerick	24	20 (4.1)
Longford	26	22 (4.5)
Louth	3	3 (0.6)
Mayo	10	10 (2.0)
Meath	11	7 (1.4)
Monaghan	22	20 (4.1)
Offaly	17	14 (2.9)
Roscommon	35	33 (6.8)
Sligo	4	4 (0.8)
Tipperary	27	24 (4.9)
Waterford	14	9 (1.8)
Westmeath	18	12 (2.5)
Wexford	8	6 (1.2)
Wicklow	5	4 (0.8)
Total	601	488 (100)

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Results and Discussion

Profile of Index Herds

Index herds had a mean size of 83.2 animals (SD ±77.9), median 63. The median size of 63 confirms the right skew in the data on size mentioned previously (O'Keeffe and O'Driscoll, 1997). Index herds had, over the episode, a mean of 7.2 standard reactors (SD ±7.6), median of 4, with a mean of 3.4 animals (SD ±3.8), median of 2, with tuberculous lesions at slaughter. Mean total reactors removed over an episode were 10.1 (SD ±11.6), median of 6. The mean number of animals per herd which had tuberculous lesions at slaughter was 4.1 (SD ±4.6), median of 2.

History of Tuberculosis in Index Herds

Of the herds analysed, 295 (60.5%) had had an earlier restriction. The distribution of these herds in relation to the time interval since a test-positive animal was last identified is presented in Table 2.

Table 2. Time to last test positive in index herd.

Time since last test positive	No. of herds (%)
0 - 1 yr	27 (9.1)
1 - 2	53 (17.9)
2 - 3	39 (13.2)
3 - 4	42 (14.2)
4 - 5	33 (11.1)
5 - 6	39 (13.2)
> 6	62 (21.3)
Total	295 (100)

The mean number of total reactors per herd at the previous breakdown episode was 4.9 (SD ±7.3), median of 2, test positive animals.

Contiguous herd information

The mean number of herds contiguous to each index herd was 7.8 (SD ±4.4), median of 6, herds. Of 488 herds analysed in detail, one had no information on contiguous herds. Of the remaining 487 herds, 102 herds had neighbouring herds which were clear when the epidemiology reports were finalised. The 385 herds with contiguous herds which were concurrently restricted had a mean of 2.5 (SD ±1.6), median of 2, restricted neighbours.

Involvement of tuberculous badgers

Information on badgers was provided in 465 of the 488 reports analysed. Badgers were excluded as being present on the farm or on contiguous farms in 49 herds (10.5%). The presence of badgers, either on the farm (201) or on contiguous farms (162), was confirmed in 363 cases (78%).

Badgers were snared as part of the investigation in 251 of the breakdowns that are analysed. Snaring was carried out at 157 licensed sites. Under licence, snaring is permitted within a 2km. radius at each site where one is granted.

A total of 1,565 badgers were removed. Of these, 209 had gross lesions indicative of tuberculosis (13.3%). Tuberculous badgers were found in 85 of the 157 areas for which licences were issued, up to the time reports were submitted. The 209 tuberculous badgers were included in a total of 1159 removed from positive licences, which is a lesion rate of 18% for the positive social groups. On average, 13.6 badgers were removed from each positive group. A further 406 badgers, which were negative, were removed under 72 other licences. This represents an average of 5.6 badgers sampled from the negative groups. The terms "positive" and "negative" as used here refer to the results of gross examinations only, and while these reflect the actual position, they do not represent as definitive a result as that following histopathology and culturing of specimens.

Involvement of Purchased Animals

Of 488 herds investigated, two had no information on purchasing. Of the remainder, 203 herds (41.8%) were reported as being self-contained, while 118 herds were reported to have purchased only calves and/or a bull. Purchased adult cattle were reported to be present in 165 (33.9%) of herds investigated. In 39 of these herds the investigation strongly implicated a purchased animal as the most likely source of *Mycobacterium bovis* infection. In a further 49 herds, a purchased source could not be discounted. Of the 165 herds that purchase adults, 88 (53.3%) were considered to have been at risk due to the practice.

Opinion of Veterinary Officers as to the source of infection

The subjective assessment of the investigating Veterinary Officers (in the 484 reports that contained this information) as to the most likely source of the *M. bovis* infection is presented in Table 3.

Table 3. Opinion of veterinary officers as to source.

Source	No. of cases(%)
Purchased animal	34 (7.0)
Residual infection	45 (9.3)
Neighbour	74 (15.3)
Badger	138 (28.5)
Other wildlife	3 (1.2)
Unclear	190 (39.3)
Total	484 (100)

Where outbreaks of tuberculosis involve a number of adjacent herds, many investigators find evidence to sustain two or more sources of infection. Of the 190 investigations where VI's described the source as "unclear", only in 4 investigations was no source identified for the breakdown.

Weighting each source in an investigation

The ER76 methodology employs a system of 5 weights to rate the probability of each of the common sources of tuberculosis being responsible for introducing infection into a herd. The weights used are 1 to 5 (The stronger the evidence implicating a source, the lower the weight assigned). Weights were assigned in 487 reports in relation to residual infection, on 488 for badger involvement and purchasing and on 488 reports for contiguous source. A weighting of 1 is an exclusive state where very strong evidence is established during the investigation implicating a source as proven, and where at the same time it was possible to rule out all other sources as being involved. In only 13 herds out of the 488 reported on was this level of confidence established (2.7%).

More commonly, a number of possibilities are established, with no objective means available of deciding between the possibilities.

Weightings, when assessed independently for each source, are presented for (i) purchasing (confined to the 165 herds which purchased adult stock) , (ii) infected contiguous herds, (iii) residual infection and (iv) infected badgers in the environment of the herd in Tables 4 to 7.

Table 4. Weights for purchasing.

1	4 (2.4%)
2	35 (21.2%)
3	49 (29.7%)
4	76 (46.1%)
5	1 (0.6%)
Total	165 (100%)

The weightings display the degree to which an investigation was successful in establishing evidence implicating a source. Epidemiologically the converse is just as significant, i.e. where an investigation succeeds in eliminating a source. Weights of 5 are where an investigation succeeded in eliminated the source as causal. Weights of 4 are where assigning a low probability was justified by the evidence gathered. In practice, weights of 4 or 5 can be taken together and assumed to be situations where the source is "low" probability.

Weights of 3 represent situations where a source was identified as present and was possibly the cause of the problem. Weights of 1 or 2 signify situations where the investigation identified evidence sufficient to implicate a source as being causal, using principles and criteria that are accepted by a majority of the members of the scientific community.

Table 5. Weights for badgers in the environment.

1	6 (1.2%)
2	152 (31.1%)
3	286 (58.6%)
4	1 (0.2%)
5	43 (8.8%)
Total	488 (100%)

Table 6. Weights for residual infection.

1	2 (0.4%)
2	105 (21.6%)
3	67 (13.8%)
4	65 (13.3%)
5	248 (50.9%)
Total	487 (100%)

Table 7. Weights for contiguous infected herds.

1	1 (0.2%)
2	284 (58.2%)
3	42 (8.6%)
4	104 (21.3%)
5	57 (11.7%)
Total	261 (100%)

Clustering

Clustering of breakdowns create a number of difficulties. In the case of the epidemiology of tuberculosis, it frequently results in situations where good evidence is identified implicating residual, badger as well as contiguous spread as causal in the same breakdown.

For the 444 herds weighted 1, 2 or 3 for badgers, the weights for residual are presented in Table 8 while those for contiguous spread are presented in Table 9.

Table 8. Residual weights for herds weighted 1, 2 or 3 for badgers.

2	100 (22.5%)
3	62 (14%)
4	60 (13.5%)
5	222 (50.0%)
Total	444 (100%)

Table 9. Weights for contiguous herd for herds weighted 1, 2 or 3 for badgers.

2	267 (60.1%)
3	38 (8.6%)
4	88 (19.8%)
5	51 (11.5%)
Total	444 (100%)

Similarly, for the 175 herds weighted 1,2 or 3 for residual, the weights for badger are presented in Table 10, while those for contiguous spread are presented in Table 11. The same methodology is applied to the 327 herds weighted 1,2 or 3 for neighbouring spread, the results presented for badger weights in Table 12 and for residual weights in Table 13.

Table 10. Badger weights for herds weighted 1, 2 or 3 for residual.

2	65 (37.1%)
3	97 (55.4%)
5	13 (7.4%)
Total	175 (100%)

Table 11. Weights for contiguous herd spread for herds weighted 1, 2 or 3 for residual.

2	104 (59.4%)
3	18 (10.3%)
4	32 (18.3%)
5	21 (12.0%)
Total	175 (100%)

Table 12. Badger weights for herds weighted 1, 2 or 3 for spread involving a contiguous herd.

2	126 (38.5%)
3	179 (54.7%)
5	22 (6.7%)
Total	327 (100%)

Table 13. Residual weights for herds weighted 1, 2 or 3 for spread involving a contiguous herd.

2	75 (22.9%)
3	47 (14.4%)
4	44 (13.5%)
5	161 (49.2%)
Total	327 (100%)

Conclusion

These data demonstrate the large number of herds where rigorously applied conventional epidemiological criteria have failed to deliver single source attributions in relation to the cause of the tuberculosis identified in the herds investigated. This may accurately reflect the dynamic disease process that is ongoing within individual clusters of herds with tuberculosis. This observation may have implications for investigations in the future. Benefits might accrue from expanding the unit of interest of investigations from individual herds to some amalgamation, incorporating all the infected animals, of herds within the cluster.

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