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Farm characteristics and farmer perceptions associated with bovine tuberculosis incidents in areas of emerging endemic spread

J.M. Broughan[a,*], D. Maye[c], P. Carmody[f], L.A. Brunton[a], A. Ashton[a], W. Wint[g], N. Alexander[g], R. Naylor[d], K. Ward[b], A.V. Goodchild[a], S. Hinchliffe[e], R.D. Eglin[a], P. Upton[a], R. Nicholson[a], G. Enticott[b]

[a] Animal and Plant Health Agency, Weybridge, Woodham Road, New Haw, Surrey KT15 3NB, UK
[b] School of Planning and Geography, Cardiff University, King Edward VII Avenue, Cardiff CF10 3WA, UK
[c] Countryside and Community Research Institute, University of Gloucestershire, Gloucester, Gloucestershire GL2 9HW, UK
[d] Royal Agricultural University, Stroud Road, Cirencester, Gloucestershire GL7 6JS, UK
[e] Department of Geography, Exeter University, Rennes Drive Exeter EX4 4RJ, UK
[f] Agile Information, London, UK
[g] Environmental Research Group Oxford, Oxford University, South Parks Road, Oxford OX1 3PS, UK

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ABSTRACT

While much is known about the risk factors for bovine tuberculosis (bTB) in herds located in high incidence areas, the drivers of bTB spread in areas of emerging endemicity are less well established. Epidemiological analysis and intensive social research identified natural and social risk factors that may prevent or encourage the spread of disease. These were investigated using a case–control study design to survey farmers in areas defined as recently having become endemic for bTB (from or after 2006). Telephone surveys were conducted for 113 farms with a recent history of a bTB incident where their officially tuberculosis free status had been withdrawn (OTFW) (cases) and 224 controls with no history of a bTB incident, matched on location, production type and the rate of endemic bTB spread. Farmers were questioned about a range of farm management strategies, farm characteristics, herd health, wildlife and biosecurity measures with a focus on farmer attitudes and behaviours such as farmers' perception of endemicity and feelings of control, openness and social cohesion. Data generated in the telephone surveys was supplemented with existing herd-level data and analysed using conditional logistic regression. Overall, herd size (OR 1.07), purchasing an animal at a cattle market compared to purchasing outside of markets (OR 2.6), the number of contiguous bTB incidents (2.30) and the number of inconclusive reactors detected in the 2 years prior to the case incident (OR 1.95) significantly increased the odds of a bTB incident. Beef herds using a field parcel more than 3.2 km away from the main farm and dairy herds reporting Johne's disease in the previous 12 months were 3.0 and 4.7 times more likely to have a recent history of a bTB incident, respectively. Beef herds reporting maize growing near, but not on, their farm were less likely to be case herds. Operating a closed farm in the two years prior to the case breakdown did not reduce the odds of a bTB incident. Farmers that had recently experienced a bTB incident were more likely to have implemented badger biosecurity in the previous year, but no more likely than control farms to have implemented cattle biosecurity. Case farmers felt significantly less likely to be influenced by government, vets or other farmers compared to those with no history of bTB. This suggests that alternative methods of engaging with farmers who have recently had a breakdown may need to be developed.

1. Introduction

Despite increasing efforts and controls to slow the spread of bovine tuberculosis (bTB), the area affected by endemic bTB in England and Wales continues to expand (Broughan et al., 2015) though the increasing trend in the incidence of bTB in England (Abernethy et al., 2013) is not uniform. The lack of uniformity has been recognised by Defra who have divided England into three distinct spatial units, each associated with different disease management strategies, in an attempt to stem the east- and northward spread of bTB. These areas are the High Risk Area (HRA) where incidence has been historically high, the Low Risk Area (LRA) that represents the major-

* Corresponding author.
E-mail address: jennifer.broughan@apha.gsi.gov.uk (J.M. Broughan).

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ity of herds in the north and east of the country and the space in between called the Edge Area (Defra, 2014).

There is considerable interest in the drivers of the spread of bTB north- and eastward from the traditional endemic core areas of south west Wales & England and western England. While herd-level risk factors have been relatively well studied for herds in the high incidence areas of England and Wales (Johnston et al., 2005; Reilly and Courtenay, 2007; Carrique-Mas et al., 2008; Ramírez-Villaescusa et al., 2010; Johnston et al., 2011; Karolemeas et al., 2011; Vial et al., 2011; Mill et al., 2012), Northern Ireland (Denny and Wilesmith, 1999), Ireland (Griffin et al., 1993; Griffin et al., 1996), Europe (Marangon et al., 1998; Garro et al., 2010; Humblet et al., 2010) and further afield (Kaneene et al., 2002; Porphyre et al., 2008; Javed et al., 2011), the factors that predispose or protect a herd against bTB are less well defined in areas of emerging endemicity. There are often inconsistencies in the risk factors that different studies identify, and most are based in long-standing endemic areas. Different risk factors may operate regionally in accordance with varying bTB incidence (Johnston et al., 2011)

This research forms part of a larger multidisciplinary approach combining GIS, epidemiological and social research expertise to characterise the spread of endemic bTB and to identify relevant farm practices, attitudes and behaviours that may prevent or encourage the spread of disease. Previous work has defined and measured endemic spread (Brunton et al., 2015). To identify herd level risk factors that may be operating in areas recently endemic for bTB, we deployed a telephone questionnaire exploring a range of farm management, general farm characteristics, herd health, wildlife and cattle biosecurity measures.

Previous work has recognised that the ability to come up with solutions for complex problems can benefit from integrating between several analytical approaches and knowledge generated by different scientific disciplines (Kristensen and Jakobsen, 2011; Wentholt et al., 2012). Studies from participatory epidemiology have highlighted the importance of capturing and including farmers' understandings of disease in scientific analyses of disease transmission (Catley et al., 2012; Leach and Scoones, 2013). This is particularly relevant for diseases such as bTB where trust in science and/or the institutions that produce scientific knowledge has proved to be an important limitation to bTB policy (Enticott, 2008). Our approach to defining potential risk factors has therefore included exploring traditional risk factors such as farm characteristics and management, but also included exploring factors relating to farmers' perceptions, attitudes and behaviours in relation to bTB.

This paper aims to investigate the differences between farms in recently endemic areas with a recent history of bTB with those in similar areas that have no experience of bTB and identify risk factors operating under this level of infection. It also aims to explore how farmers' behaviour, attitudes and farming practices are likely to be informed by different disease experience.

2. Materials and methods

2.1. Study population

The sampling frame was derived from maps of the spread of endemic bTB. In other work associated with this study a mathematical definition of endemicity was developed from which the expansion of the area affected by endemic bTB through time using data from bTB testing was mapped. Hexagonal cells with an area of 6.25 km^2 were overlaid on a map of England and Wales and gained endemic status based on the proximity and recurrence of bTB incidents on a two yearly basis between 2002 and 2012 (Brunton et al., 2015). Analysis focussed only on herds classified as Officially Tuberculosis Free Status Withdrawn (OTFW), which at that time period in GB was defined as a bTB incident which was confirmed at post mortem by the presence of visible lesions or bacterial confirmation of *Mycobacterium bovis*. Briefly, a cell was defined as endemic for bTB if there were three OTF-W incidents within 7 km of a farm within that hexagon over the time period assessed. Maps of the endemic areas were produced for nine overlapping 24 month intervals between 1st September 2001 and 31st August 2011, and the temporal spread rate of endemic bTB was estimated by overlaying the endemic areas from each time period and creating a contour-like map displaying the spread of endemic bTB over the two-year periods, from which a rate of spread was calculated. The target population was defined as all herds within hexagons defined as newly endemic. To achieve the appropriate number of cases for a statistically adequate sample size, newly endemic was defined as a hexagon through which the endemic front passed since 2006. A case was defined as herd that was located in a newly endemic hexagon, in which at least one reactor to the Single Intradermal Comparative Cervical Tuberculin (SICCT) at standard interpretation was identified and post mortem confirmation of infection was obtained, between 1st January 2011 and the 17th January 2014. Controls were defined as herds that had no record of a bTB incident in the database. As production types are managed differently and location is known risk factor for a bTB incident (White et al., 2013), cases were matched to controls within the same hexagon if possible or within a maximum of 25 km from each other (in one case this was extended to 70 km) and matched to the same main production type (beef/dairy).

2.2. Sample size and selection

Allowing for two controls for every case, 224 controls and 112 cases were required to detect a 2 fold increase in the odds at 80% statistical power and 5% statistical significance level for a risk factor that is present on 25% of control farms (WinEpiscope 2.0).

Cases were matched to up to five selected controls to improve the probability of attaining a 1:2 ratio of cases to controls. Randomisation was conducted using an MS Access VBA script interrogating the APHA SAM database. Once one control was found for a case it moved on to the next case, so as to allocate controls to cases evenly. A herd could not be a control for more than one case. Controls were ranked according to the distance from the case, with nearer herds being given lower ranks. Interviewers were encouraged to contact the control farm with the lowest rank, until they had two controls. A flow diagram describing the inclusion of farms to the study is presented in Fig. 1.

2.3. Questionnaire design

The survey design and implementation has been described in detail by (Enticott et al., 2015). The survey was thus designed to build on and extend work completed in previous epidemiological and social science research phases, combining social risk factors with farm practice and physical factors. To summarise, information on farmer attitudes, behaviours, practices and environmental conditions that may influence their disease status was generated based on a large-scale review of the existing scientific literature and was further refined during nine focus groups held with vets and farmers in different locations within the Edge Area (including, Cheshire, Leicestershire and Nottinghamshire). Focus group participants rated the significance of risk factors identified in a previous spatial analysis that affect the rate of spread, as well as other factors based on their own opinion. Other questions related to risk factors for farm-level endemic spread were identified by assessing the recent literature and prioritised using expert opinion. The survey included items on social factors such as farmer's perceived control of bTB and knowledge of bTB in their local area, as well as farm-