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Impact of changes in cattle movement regulations on the risks of bovine tuberculosis for Scottish farms

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ABSTRACT

Legislation requiring the pre- and post-movement testing of cattle imported to Scotland from regions with high bovine tuberculosis (bTB) incidence was phased in between September 2005 and May 2006 as part of efforts to maintain Officially Tuberculosis Free (OTF) status. In this analysis, we used centralized cattle movement records to investigate the influence of the legislative change on import movement patterns and the movement-based risk factors associated with new bTB herd breakdowns identified through routine testing or slaughter surveillance. The immediate reduction in the number of import movements from high incidence regions of England and Wales into Scotland suggests that pre- and post-movement testing legislation has had a strong deterrent effect on cattle import trade. Combined with the direct benefits of a more stringent testing regime, this likely explains the observed decrease in the odds of imported cattle subsequently being identified as reactors in herd breakdowns detected through routine surveillance compared to Scottish cattle. However, at the farm-level, herds that recently imported cattle from high incidence regions were still at increased risk of experiencing bTB breakdowns, which highlights the delay between the introduction of disease control measures and detectable changes in incidence. With the relative infrequency of routine herd tests and the insidious nature of clinical signs, past import movements were likely still important in determining the present farm-level risk for bTB breakdown. However, the possibility of low-level transmission between Scottish cattle herds cannot be ruled out given the known issues with test sensitivity, changes in import animal demographics, and the potential for on-farm transmission. Findings from this analysis emphasize the importance of considering how farmer behavioural change in response to policy interventions may influence disease transmission dynamics.

1. Introduction

The incidence of bovine tuberculosis (bTB) varies across the European Union with certain countries recognized as Officially Tuberculosis Free (OTF) under the provisions of Council Directive 64/432/EEC. This includes Scotland since September 2009. OTF status does not imply that *Mycobacterium bovis* is absent from the domestic herd, but is instead awarded to a territory where both the incidence and prevalence of bTB amongst cattle herds has remained below 0.1% per year for six consecutive years and appropriate surveillance programmes are in place to detect new herd breakdowns. Although Scotland has successfully maintained bTB incidence below 0.1%, new breakdowns continue to be identified through routine surveillance each year and, as with other OTF countries, the import of infected cattle from bTB endemic regions is believed to be the leading risk factor (Gilbert et al., 2005; Green and Cornell, 2005; van Asseldonk et al., 2005; Schiller et al., 2011).

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Recognizing the importance of cattle movements in spreading bTB, the Scottish government introduced legislation in September 2005 that required all cattle imported from high incidence parishes of England and Wales to be tested for bTB within 60–120 days of arriving in Scotland at the receiving farmer's expense. Surveys have estimated the direct veterinary costs of testing range from £5.50 to £9.00 per animal, although the actual costs may be higher due to labour expenses, disruptions in farm business practices, and missed marketing opportunities (Anonymous, 2006; Bennett, 2009). The legislation includes exceptions for cattle that were subject to *post-mortem* examination for lesions consistent with bTB at slaughterhouses within 120 days of arrival and for cattle that were subject to *ante-mortem* testing as part of a routinely scheduled herd test in the receiving herd within 120 days of arrival. Similar post-movement testing of cattle imported from Northern Ireland and the Republic of Ireland was required throughout the time period leading up to OTF recognition.

The main objective of post-movement testing was to ensure that infected cattle were quickly identified and removed before disease could spread to other Scottish animals or herds. However, any legislation that imposes financial or logistical barriers to cattle trade also has the potential to change farmer behaviour and movement patterns (Vernon and Keeling, 2012). For example, when complementary pre-movement testing was introduced in May 2006 for all cattle over six weeks of age moving off farms in high incidence parishes of England and Wales, Christley and co-workers (Christley et al., 2011) found evidence that farmers in these regions reduced the size and frequency of cattle batch movements to minimize testing costs. These indirect deterrent effects on cattle import trade may have an equally important role in limiting the opportunities for bTB to be introduced into Scotland and subsequently the risk of detecting new breakdowns through routine herd surveillance.

In this analysis, we use longitudinal surveillance data and movement records to investigate the influence of post-movement testing legislation on import patterns and associated risks for bTB breakdowns in Scotland from 2002 to 2009. First, we compare the frequency and demographic characteristics of individual cattle imported into Scotland in the four-year periods immediately before (2002–2005) and after (2006–2009) the introduction of post-movement testing legislation to identify changes in the types of cattle farmers are willing to import. Next, we quantify changes in farm-level import patterns between the two study time periods to document the deterrent effects of testing legislation on cattle import trade. Finally, we use logistic regression analyses to determine whether the farm-level risk of being identified as a breakdown through routine testing or slaughter surveillance and the animal-level risk of being identified as a reactor in a breakdown herd associated with import movement history have also correspondingly changed between time periods through the direct and indirect protective effects of movement testing legislation.

2. Materials and methods

2.1. Routine surveillance for bTB in Scotland

In the period leading up to OTF recognition in Scotland, routine surveillance for bTB in cattle was conducted using three methods: (1) *post-mortem* examination of all bovine carcasses at abattoirs for visible pathognomic lesions of bTB, (2) routine herd tests (RHT) to monitor the infection status of individual herds, and (3) targeted post-movement testing of cattle imported from regions with high bTB incidence. An RHT is normally conducted once every 4 years and includes all female cattle that have previously calved, bulls greater than 12 months old unless exempted by a veterinarian, any cattle greater than 6 weeks old which could be used for breeding, and any cattle purchased since the last RHT. A small number of herds considered to be at increased risk of acquiring and transmitting bTB, including those with regular intake of cattle from the Republic of Ireland or Northern Ireland and those that retail raw milk, are subject to a greater frequency and intensity of testing.

The single intradermal comparative cervical tuberculin sensitivity test (SICCT) used for both RHT and movement-associated testing compares the sensitivity of individual cattle to bovine and avian mycobacterial antigens injected intradermally at separate sites on the neck. Depending on the relative degree of reaction to the antigens after 72 h and the perceived herd-level risk for bTB, animals may be classified as positive reactors, inconclusive reactors, or negatives (Green and Cornell, 2005). The sensitivity of SICCT for detecting infected cattle ranges from 68% to 99% and the specificity ranges from 79% to 99% (de la Rua-Domenech et al., 2006; Clegg et al., 2011). For that reason, a new bTB herd breakdown is only considered "confirmed" if either visible pathognomic lesions of infection with *M. bovis* are observed during *post-mortem* examination of positive reactors or *M. bovis* is cultured from tissue samples. Cattle with an inconclusive SICCT may be re-tested up to two times or slaughtered to examine for visible lesions. The sensitivity of *post-mortem* examination for identifying cattle with visible lesions ranges from 86% to 95% (Byrne, 1992; Corner, 1994; Whipple et al., 1996; Norby et al., 2004).

Results of all *ante-mortem* bTB tests in Great Britain and information on suspected and confirmed cases identified through slaughter surveillance have been collated in the VETNET database maintained by the Department for Environment, Food and Rural Affairs (DEFRA) since the 1990s. Negative RHT results for a herd are reported *en masse* with the following summary information: number of cattle tested, total number of animals in the herd, date and type of test, herd production type, and administrative information for the farm including its unique county-parish-holding (CPH) identifier. When a positive or inconclusive reactor is identified, the passport number of the animal is entered along with any follow-up test results or actions taken. For herds with multiple reactors, the information on whether lesions were observed at *post-mortem* examination or positive cultures for *M. bovis* were obtained from tissue samples is aggregated at the herd level.