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Title of case study: D: Foot and mouth disease in Scotland: Improving preparedness and outbreak responses

1. Summary of the impact

Underpinning Research: We have developed veterinary risk assessments (VRAs) on recreational access to the countryside and on animal movements during outbreaks of foot and mouth disease (FMD), highlighting the risks associated with movements of people and animals during an outbreak. We also conducted epidemiological and economic modelling of FMD vaccination to optimise the efficiency of potential control strategies.

Significance and Reach of Impact: The Land Reform (Scotland) Act (December 2013) was amended based on our research to better regulate recreational access to the countryside during future outbreaks of exotic disease. The VRAs have significantly improved Scottish Government and UK contingency plans for management of future FMD outbreaks, including a new suite of licences for animal movements. Our research outputs have been used as models for disease preparedness in the UK and in all 27 EU countries as well as Australia. These ensure the continuity of low-risk countryside activities; this is important for economic resilience and continued high standards of animal welfare during an outbreak, and so help to future-proof farming communities against further FMD outbreaks.

Preparedness for future outbreaks is predicted to lead to substantial reductions in economic losses if the countryside can remain open for low-risk activities (in 2001, the estimated cost of countryside closure due to the FMD outbreak for the UK was GBP3,000,000,000). Based on our research, optimised vaccination strategies are estimated to save up to GBP490,000,000 in Scotland, more than halving the impact of severe FMD outbreaks for the future economy (which are estimated at GBP950,000,000 when optimal vaccine stocks are used).

2. Underpinning research

The Challenge: Foot and mouth disease outbreaks need advance preparation

Foot and mouth disease (FMD) is a highly infectious, notifiable viral disease that affects cloven-hoofed animals, e.g. cattle, sheep and pigs. Outbreaks of FMD have significant economic, socio-economic, animal and human welfare consequences, and are an important policy priority for the UK and international Governments wishing to access international export markets. Our veterinary epidemiologists have conducted epidemiological and economic primary research to improve FMD contingency planning as part of the Scottish Government's Centre of Expertise on Animal Disease Outbreaks, known as Epidemiology, Population health and Infectious disease Control ("EPIC") since 2006.

Access to the countryside during an outbreak

During the FMD outbreak in the UK in 2001, an estimated GBP3,000,000,000 was lost through the collapse of rural economies and tourism, due to lack of access to countryside for disease control purposes. We developed and conducted qualitative veterinary risk assessments (VRAs) to assess the risks of 12 different recreational activities requiring access to the countryside, including walking, cycling, fishing, stalking deer and shooting birds, during an FMD outbreak [3.1]. This helped to determine whether countryside closures were proportional to the risk. The findings indicated that for most activities, "the likelihood of causing new outbreaks of FMD is considered to be *medium* (occurs regularly) in the Protection Zone (PZ; a minimum radius of 3km, or more if necessary, from the infected premises), *low* (rare but could occur) in the Surveillance Zone (SZ; a minimum radius of 10km from the infected premises), and *very low* (very rare but cannot be excluded) in the Restriction Zone (from outside the PZ and extending as far as necessary to prevent disease spread) if risk reduction measures were in place" [3.1]. Higher-risk activities such as hunting, shooting, stalking, and equestrian events, particularly in locations at greatest risk (such as within a PZ or SZ) increased the risk of FMD [3.1].

Animal movement and disease control

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EPIC's epidemiological models of FMD transmission, designed for use during disease outbreaks, highlighted the importance of accurately identifying the date of disease incursion in predicting disease spread and informing targeted surveillance [3.2]. Movements of animals between premises can lead to disease spread but extended movement restrictions have significant impacts on business and animal welfare. We analysed animal movements and identified high-risk areas in Scotland for prioritisation of surveillance, as well as low-risk areas in which restrictions could be lifted during the 2007 FMD outbreak [3.3]. In 2012, we built on this work to produce VRAs to assess risks associated with specific animal movements during an outbreak. Movements to slaughterhouses, between Scottish islands, and for the purposes of collecting fallen stock were shown to present a low level of risk outside specific disease control zones [3.1].

Vaccination in FMD Control

The use of vaccination in FMD control is a potentially valuable tool, but its implementation remains a contentious issue. We successfully developed epidemiological, direct-cost and indirect-cost models to assess the impact of severe outbreaks of FMD in the future and the cost-benefits of a reactive vaccination policy targeting cattle in Scotland. The likelihood of severe epidemics, in which more than 100 premises are infected, lasting for more than 60 days, is lower if vaccination is implemented, reducing the number of infected premises, duration of the outbreak and number of animals culled for disease control [3.4]. Both direct and indirect costs are significantly reduced in a large outbreak when vaccination is used (although not in smaller outbreaks) [3.5]. Our economic analyses, which incorporated restrictions on national and international markets and limitations in vaccine supply chains, indicated that maintaining a vaccine stock of 200,000 doses, sufficient to vaccinate 12% of the Scottish cattle population, would maximise relative epidemiological and economic benefits of vaccination strategies without having to vaccinate the whole animal population. This would save an average of GBP490,000,000 in direct and indirect costs compared with a scenario where no vaccination is used [3.5; 3.6].

Attribution

EPIC is a GBP10,000,000 multi-partner, multi-disciplinary research consortium of expertise between universities and other research provider funded by the Scottish Government to provide epidemiological intelligence to inform animal health policy and improve animal disease preparedness. The FMD research has been led by Principal Investigators at our unit. [Partners: University of Edinburgh, University of Glasgow, Scotland's Rural College, Moredun Research Institute, The James Hutton Institute and Biomathematics and Statistics Scotland.]

3. References to the research

- [3.1] Auty H, Mellor D, Gunn G, Boden L, The risk of foot and mouth disease transmission posed by public access to the countryside during an outbreak, *Front Vet Sci* 2019; 6:381 [doi: 10.3389/fvets.2019.00381](https://doi.org/10.3389/fvets.2019.00381)
- [3.2] Porphyre T, Boden L, Correia-Gomes C, Auty H, Woolhouse M Using national livestock movement databases to help inform responses to animal disease outbreaks: the impact of temporal uncertainty around incursion time. *Nature Scientific Reports* 2016; 6:20258 [doi: 10.1038/srep20258](https://doi.org/10.1038/srep20258)
- [3.3] Volkova VV, Bessell PR, Woolhouse MEJ, Savill NJ Evaluation of risks of foot-and-mouth disease in Scotland to assist with decision making during the 2007 outbreak in the UK. *Veterinary Record* 2011; 169:124 [doi: 10.1136/vr.d2715](https://doi.org/10.1136/vr.d2715)
- [3.4] Porphyre T, Auty H, Tildesley M, Gunn G, Woolhouse M Vaccination against foot-and-mouth disease: do initial conditions affect its benefit? *PLOS One* 2013; 8:e77616. [doi: 10.1371/journal.pone.0077616](https://doi.org/10.1371/journal.pone.0077616)
- [3.5] Porphyre T, Rich K, Auty H. Assessing the economic impact of vaccine availability when controlling foot and mouth disease outbreaks, *Frontiers in Veterinary Science* 2018; 5:47. [doi: 10.3389/fvets.2018.00047](https://doi.org/10.3389/fvets.2018.00047)
- [3.6] Barratt AS, Rich KM, Eze JI, Porphyre T, Gunn GJ, Stott AW. Framework for estimating indirect costs in animal health using time series analysis. *Frontiers in Veterinary Sciences* 2019; 6:190 [doi: 10.3389/fvets.2019.00190](https://doi.org/10.3389/fvets.2019.00190)

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4. Details of the impact

Impact on government legislation: rural access policy

The VRAs we developed were the first to provide a scientifically rigorous evidence base to refine FMD contingency planning and outbreak preparedness anywhere [5.1]. The Scottish Government (SG) Animal Health and Welfare Division (AHWD) used the library of VRAs to underpin a change in rural access policy so that the countryside could remain open for business, with restrictions remaining only in the Protection Zone [5.2a]. This policy change resulted in a legislative amendment to the Land Reform (Scotland) Act (modification in December 2013) to allow closure of paths in a Protection Zone during an outbreak [5.3]. This Scottish policy is also used to inform decisions in England and Wales about access to the countryside [5.2b]. In addition, animal movement analyses were used to reduce the impacts of outbreak; the policy manager from AHWD's disease control branch confirmed: "*SG also used EPIC analysis to [be able to] free some Scottish islands (Hebrides, Orkney and Shetland) from FMD National Movement Ban restrictions earlier than other areas.*" [5.2a]

Impact on FMD contingency planning in the United Kingdom

The VRAs have been incorporated into the UK's FMD contingency planning since they were signed off by the Outbreak Readiness Board and Animal Disease Policy Group in early 2013 [5.1; 5.2a; 5.4]. Since then, EPIC's research has been key to overall UK decision-making for FMD outbreak preparedness [5.2b]. The research is highly valued by SG and the UK Government's Department for Environment, Food and Rural Affairs (Defra) as: "*A good model of how to secure the best available scientific advice to inform government policy on reducing the impact of animal disease outbreaks.*" [5.5]. Scotland's Chief Veterinary Officer (CVO) similarly states: "*It provides SG, both Ministers and Civil Servants, with a sense of security that our investment in EPIC has resulted in the preparation of a range of pretested tools, plans and documentation that can be immediately available when we are next faced with a FMD outbreak*" [5.2b].

In 2017, EPIC was instrumental in establishing the 5-Nation Veterinary Risk Assessment forum. This brought together Government representatives from England, Scotland, Wales, Northern Ireland and the Republic of Ireland, to standardise and harmonise approaches to risk assessment across the 5 Governments. Scotland's Minister for Rural Affairs and the Natural Environment summarised EPIC's contribution to this forum in a conference speech in 2019: "*EPIC are taking a lead role in [the forum] [...]. Veterinary Risk Assessments are a key tool used to estimate the risks of disease spread associated with different practices and activities, and they are vital in informing timely policy decision in the event of an outbreak*" [5.6].

Our research has also shaped the processes within the UK Government's Animal and Plant Health Agency (APHA), as follows: "*Firstly, the drafting of a standard set of conditions for GB movement licences by Policy teams within Defra and the Devolved Administrations, and secondly, improving the quality and consistency of risk assessments drafted by APHA during an outbreak of notifiable disease, as well as the speed with which these can be delivered*" [5.2c]. In addition to providing VRAs specific to FMD, we were recently asked by APHA to further contribute to the arsenal of outbreak preparedness by creating a toolkit for reviewing VRAs for notifiable diseases, based on our approach to our generic FMD VRA template. Approved in December 2020, this toolkit will be routinely used to review the relevant VRAs during future outbreaks to "*ensure these VRAs to support licensing are as timely, robust, transparent and consistent as possible*" [5.2e].

Impact on future FMD outbreak responses

No outbreaks of FMD have occurred during the REF census period. However, the VRAs, which are reviewed every 2 years and updated after lessons learned from UK-wide disease exercises, such as Exercise Blackthorn in 2018 and Exercise Waratah in 2020, have allowed the SG to put in place strategies, protocols and a suite of licenses that will allow better and more transparent decision-making in the event of an outbreak [5.2a]. Furthermore, during the Highly Pathogenic Avian Influenza outbreak in December 2020, our new VRA review toolkit was deployed by APHA to review the pertinent VRAs and to support licencing of essential activities [5.2e].

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From an industry perspective, the benefits of these preparedness activities are clear, as described by the Director of Economic Services at Quality Meats Scotland: *“The minute something like FMD breaks [...] is the point when everyone from farmer to consumer asks questions and expects immediate answers. By having VRAs on record that are regularly reviewed, those having to take key decisions - mainly Government – have the “scientific advice” on which to make decisions readily available, probably for more questions than in the immediacy of need have been thought about e.g. public access, and publicly available to anyone who wants to follow the exercise through. [...] They [VRAs] speed up and hopefully simplify the actions to be taken to control the disease and therefore have significant economic benefit to the industry both by reducing the level of disease but also minimising disruption to export markets for example”* [5.7].

EPIC’s impact in this field is evident in the team’s inclusion and significant role in regular national FMD exercises, such as Exercise Rohan in 2015 and Exercise Blackthorn in 2018. In the UK-wide Exercise Blackthorn [5.8], the VRAs on rural access were tested by Defra, SG and APHA in decisions about movement licences and implementation of a Protection Zone, which requires closure of footpaths. Scotland’s Minister for Rural Affairs and the Natural Environment concluded: *“The ‘lessons identified’ report that EPIC produced will help ensure the support EPIC provides to us during an exotic disease outbreak continues to be of a high standard.”* [5.6] Most recently, Exercise Waratah in January 2020, a joint pilot rapid risk assessment exercise between the UK and the New South Wales Department of Primary Industries, Australia, used the format of the EPIC VRAs to inform the draft risk assessments produced [5.2a]. As stated by Scotland’s CVO, *“This is clear evidence that the EPIC team are having impact internationally for preparedness of epidemic diseases and their control”* [5.2b].

Defra use the FMD VRAs as a model for teaching and training globally. In the last 3 years, Defra has delivered risk assessment training to 450 participants from all 27 EU Member states, and Australia, including displaying the EPIC website for the VRAs and explaining that these tools can be used by others rather than *“reinventing the wheel”* [5.2d]. Such proactive risk assessment development is essential to ensure business continuity in future disease outbreaks. Defra has also successfully expanded the VRA model to responding to other exotic disease outbreaks, for example for provision of movement licences during African Swine Fever outbreaks [5.2d].

Impact on the economy

Scotland’s CVO confirmed that EPIC’s work will significantly mitigate the negative economic and welfare impact of countryside restrictions felt during previous FMD outbreaks and substantially reduce the overall cost of a future outbreak [5.2b]. The 2001 FMD outbreak costs were estimated to be GBP3,000,000,000 for the UK [5.9]. Thus, if a complete closure of the countryside can be avoided and business and tourism continuity within affected rural areas ensured, this will likely lead to substantial cost savings in the event of a future FMD outbreak. In Scotland, we estimated that future severe outbreaks would result in GBP862,000,000 in direct costs [3.5] (e.g. export, culling and movement ban) and GBP88,000,000 in indirect costs [3.6] (e.g. impact on commodity markets). These represent benchmarks for cost-saving policy decisions from both government and industry stakeholders and EPIC’s FMD VRAs will lead to further cost-savings [5.2b]. Our epidemiological and economic models provide options for the SG’s FMD preparedness and vaccination control policies to comply with European Union directive 2003/85/EC, which mandates countries to have an emergency vaccination strategy in place in case of an outbreak [5.10]. Since 2018, our research has been used to inform plans on vaccine stocks after Brexit in the event that the UK can no longer access the European vaccine bank after this time [5.2b]. We have identified the conditions when vaccination is most effective, and the optimal vaccine stocks required. This knowledge could save an average of GBP490,000,000 in direct and indirect costs in severe outbreaks if vaccination is implemented optimally [3.6] and spare up to 950,000 animals from being culled [3.5].

Impact on animal welfare

The VRAs have provided a framework to ensure continued high standards of animal welfare during an outbreak. In 2001, approximately 1/3 of the 6,000,000 animals culled were slaughtered for welfare reasons [5.11]. FMD controls that restrict movements meant that animals could not be

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moved between fields when they had to cross roads or be moved to slaughterhouses. Because of the restrictions, farmers ran out of feed for animals and animals that were ready for slaughter could not be moved off farms. The VRAs we developed [3.1; 5.1] specifically address the issues around issuing movement licenses to farmers with a focus on minimising welfare impacts and allowing restricted movements to slaughterhouses and for fodder, which are used by the SG to support new suites of movement licenses [5.2b]. This distinctive contribution is expected to reduce suffering or unnecessary slaughter of animals during any future FMD outbreaks.

5. Sources to corroborate the impact

[5.1] [Scottish Government veterinary risk assessments](#) (published September 2015 but informing SG since 2011, see 5.2a)

[5.2] Testimonials for EPIC's influence on Scottish and UK Government policy and practice

- a. Testimonial from Policy manager on behalf of Lead Exotic Team AHWD
- b. Testimonial from Scotland's Chief Veterinary Officer
- c. Testimonial from International Disease Monitoring and Risk Assessment, APHA
- d. Testimonial from Defra
- e. Email from APHA re: VRA review toolkit and its use in HPAI outbreak

[5.3] Amendment to the Scottish Land Reform Act based on EPIC's risk assessments (Dec 2013)

- a. Land Reform (Scotland) Act 2003 (Modification) Order 2013
- b. Rationale behind the modification: Scottish Government (2014) [The Land Reform \(Scotland\) Act 2003 \(Modification\) Order 2013: guidance for local authorities and national park authorities](#)

[5.4] Scottish Government's Exotic Diseases of Animals Contingency Framework 2018

[5.5] Defra 2014 Animal and Plant Health in the UK: Building our science capability, p. 23; Case Study 2

[5.6] YouTube video of Minister for Rural Affairs and the Natural Environment speech at EPIC conference 2019: <https://www.youtube.com/watch?v=urL0RELRQkk&feature=youtu.be>; screenshot and transcript are provided.

[5.7] Email from Director of Economic Services at Quality Meat Scotland, June 2020

[5.8] Defra Exercise Blackthorn: National Foot and Mouth Disease Exercise Evaluation and Lessons Identified Report, October 2018

[5.9] Anderson I. (2002). – Foot and mouth disease 2001: lessons to be learned inquiry report. The Stationery Office, London, 187 pp. Available at: http://webarchive.nationalarchives.gov.uk/20100807034701/http://archive.cabinetoffice.gov.uk/fmd/fmd_report/report/index.htm

[5.10] [European Union directive 2003/85/EC](#) on FMD preparedness and vaccine control (Section 8) (Article 14, Paragraph 3)

[5.11] Mansley L.M., Donaldson A.I., Thrusfield M.V., Honhold N. [Destructive tension: mathematics versus experience – the progress and control of the 2001 foot and mouth disease epidemic](#). *Revue scientifique et technique (OIE)* 2011;30:483–498.