



# Final Report: EPIC Achievements 2011-2016

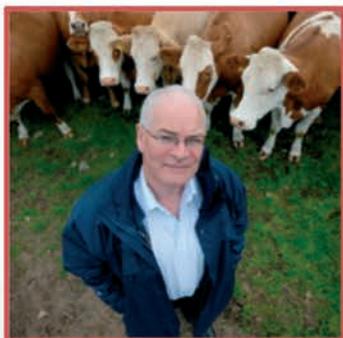


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# Foreword



**Professor  
George J Gunn,  
Director of EPIC  
2008-2016**

I am delighted to present this overview of the EPIC Centre of Expertise on Animal Disease Outbreaks and our achievements over the period 2011 to 2016. Our report is based upon views of the scientists, staff and stakeholders engaged with EPIC and so complements the more formal reports submitted to our sponsors: Scottish Government. I have received many positive comments about EPIC from around the world and it is clear that it is seen as a ground-breaking project. The fact that the follow-up project, EPIC III has already been launched is testament to the value placed upon our work by Scottish Government and other stakeholders. We would like to take this opportunity to thank Scottish Government for their financial support and their vision in working with us to create such a unique, world-leading policy-linked research facility.

## The Context of EPIC

The establishment of EPIC II should be seen in the context of a number of exotic disease outbreak challenges faced by Scotland and the United Kingdom over the past 15 years. These include Foot-and-Mouth Disease (FMD), Classical Swine Fever, VTEC O157, Bluetongue, Bovine Spongiform Encephalopathy and diseases of bees.

Disease threats have also changed significantly during this period. Political unrest and breakdown in veterinary services overseas have facilitated disease spread; African Swine Fever, Lumpy Skin Disease, and FMD continue to pose risks to European livestock. Avian Influenza, Bluetongue and Schmallenberg viruses all currently circulate close to Scottish boundaries. Schmallenberg virus is an example of how quickly new threats to livestock health can emerge and Avian Influenza illustrates the potential for linked human and livestock risks.

## About EPIC

The EPIC projects have evolved over the last 10 years. The name EPIC is derived from the longer title **E**pidemiology, **P**opulation Health and **I**nfectious **D**isease **C**ontrol. This consortium of Scottish Institutions first formed to investigate the epidemiology of zoonotic infections associated with VTEC O157.

The first EPIC project (EPIC I, 2006-2012) was funded by Scottish Government to investigate the area of disease surveillance. The Centre of Excellence was initiated by Dr Chris Low, (Scotland's Rural College (SRUC)) and led by Professor Woolhouse (University of Edinburgh) and subsequently Professor Gunn (SRUC). Repeated requests were made for EPIC I to help resolve active UK-level FMD and Bluetongue disease outbreaks. It became obvious that the best course of future action would be to focus on anticipation / preparation for threatening livestock disease outbreaks before they could occur. This realisation led to the establishment of the EPIC II Centre of Expertise on Animal Disease Outbreaks.

Establishing a Centre of Expertise involves much more than science. The challenges in developing EPIC II were greater than had been anticipated by any party at inception. EPIC has been a success because it has produced so many creative solutions to those challenges. We created a centre that uniquely harmonises world-leading academic research with practical disease policy and decision-making. EPIC balanced short term policy requests against our Mission:

**“To provide access to high quality advice and analyses on the epidemiology of animal diseases that are important to Scotland and to best prepare Scotland for the next major disease incursion”.**

Ultimately, EPIC provides a structure that delivers the best available decision-support information to Scottish Government in the face of the threats to our livestock population.

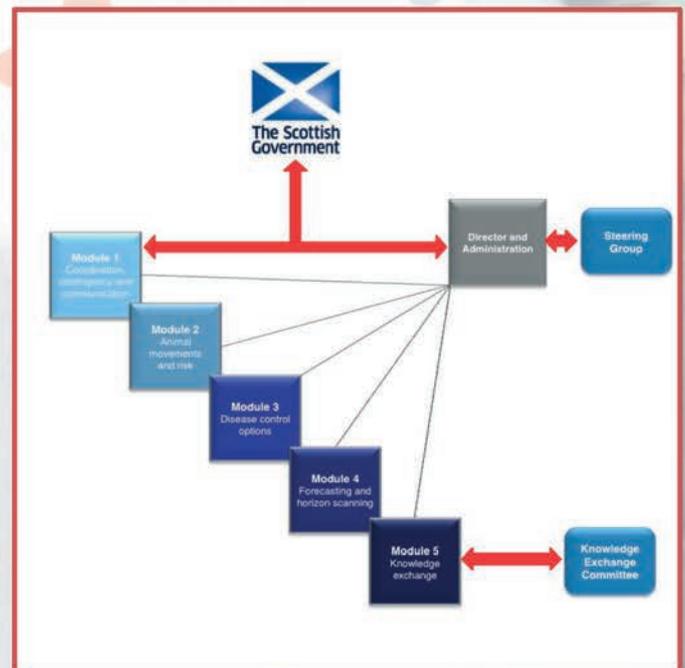
# Creating Teams within Teams

EPIC has turned competition into collaboration drawing together multi-disciplinary partnerships across seven Scottish research institutions and universities.

## Innovative Design

The modular structure of the consortium cultivated successful interdisciplinary relationships between scientists and policy-makers. This model enables multi-institutional research collaboration focused on providing policy-linked research but with inbuilt capacity to move immediately to emergency response mode in the face of a livestock disease epidemic. EPIC's multidisciplinary team include veterinarians, mathematical modellers, environment scientists, social scientists and economists working together to ensure disease control is considered in a holistic way.

The EPIC Directorate, led by Director George Gunn was responsible for the scientific direction of the consortium. Independent guidance was provided by a Steering Group composed of key academic and industry stakeholders.



## Public Engagement

As a Scottish Government funded consortium, EPIC recognises its responsibility to communicate effectively to policy-makers, stakeholders and the public in a manner which makes the science accessible. EPIC's Annual Meetings fostered knowledge exchange and a closer working relationship with our policy colleagues and other scientists.

The EPIC website has been an important part of this engagement. EpicScotland.org was launched in December 2013 and is supported by a social media presence on Twitter (@EpicScotland). This website contains information on Scotland's cattle, sheep, pig, horse and poultry industries and details about important exotic and endemic diseases affecting these species. Visit these pages to discover more detail about EPIC's work.

## Novel Communication Tools

EPIC has been innovative in developing new tools and modes of interaction to promote success. Bi-annual interface meetings were introduced to facilitate co-construction of EPIC's action plan with a focus on policy-maker's needs. The EPIC work programme was improved through utilisation of an online business management tool known as 'Smartsheet'. This tool enabled principal investigators and policy-makers to undertake real-time tracking of objectives and actions. Management of internal communication within EPIC has been significantly enhanced through the use of NationalField, a secure web based project communication platform. Originally instigated to co-ordinate communication during disease exercises and emergencies, NationalField has been subsequently exploited by EPIC teams to promote transparent dialogue and overcome the natural communication challenges inherent in a multi-site and multi-disciplinary programme.

# Developing a Novel Science-Policy Interface

EPIC has built bridges with policy-makers to coordinate and communicate timely, robust policy-relevant and highly impactful scientific research.

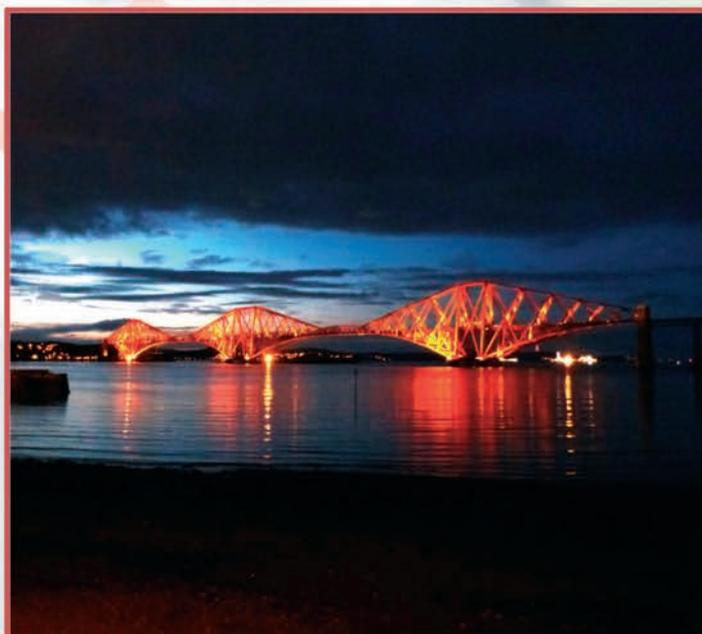
## Knowledge Brokers

Knowledge brokers connect people to share and exchange information. They are fluent in the language of both scientists and policy-makers and help scientists avoid 'solving the wrong problem'. EPIC scientists are embedded at Scottish Government Animal Health and Welfare Division and meet regularly with policy-makers to discuss and refine ongoing scientific work and to coordinate EPIC's response to any emerging policy issues. EPIC's knowledge brokering activities have promoted greater inclusiveness and proximity of EPIC scientists to policy-makers and have made it possible to inform specific policy questions that arise at different stages of an outbreak.

## Collaboration with Policy-makers

EPIC has maintained a presence at meetings of the Scottish Government's general stakeholder group. Such interactions with policy-makers and industry stakeholders provide benefits in increasing the profile and reputation of EPIC with the Scottish livestock industry. This forum provides opportunities for EPIC to identify upcoming important issues and review research priorities.

EPIC scientists have been included in workshops and training days for colleagues in the Animal and Plant Health Agency and the National Epidemiology Emergency Group. This has provided opportunities to gain further training in applied outbreak epidemiology. EPIC scientists and government epidemiologists have been able to share expertise and experience, and to better understand each other's roles in a disease outbreak emergency. The insight gained by this training has helped EPIC to further develop its strategy of how to provide the best advice and epidemiological support to Scottish Government in a disease outbreak emergency.



**“Standing and working together as scientists, policy-makers and stakeholders, we capitalise on our shared knowledge and expertise and ensure that decisions for local action are based on robust evidence which is fundamental to improving further the resilience of our livestock industries.”**

**Sheila Voas,  
Scottish Government  
Chief Veterinary Officer,  
2014**

## Policy Impact

EPIC scientists have produced a great number of highly impactful policy-relevant publications. A list of these is included at the end of this report and includes contributions to policy on Foot-and-Mouth Disease, Bluetongue virus, Bovine Tuberculosis, Avian Influenza, Bovine Viral Diarrhoea, sheep scab and others. EPIC scientists contribute to public consultations and are involved in national expert groups.

# Improving 'Big Data' for Animal Health

EPIC scientists have enabled rapid access to high quality, high volume and high resolution data through the curation of improved data resources.

## Pig Sector Movements

Data from ScotEID and other sources have been used to characterise pig movement patterns. Analyses examined distances moved, connections between different types of farms, markets and slaughterhouses. EPIC has worked in collaboration with industry partners including Quality Meat Scotland, the Agricultural and Horticultural Development Board – Pork and the Animal and Plant Health Agency to identify and subsequently close important gaps in data recording systems. These analyses have provided a detailed picture of the structure and connections between farms within the Scottish pig industry. These data have also been used in EPIC to simulate the spread of diseases (e.g. Classical Swine Fever, African Swine Fever and Porcine Epidemic Diarrhoea) between farms.

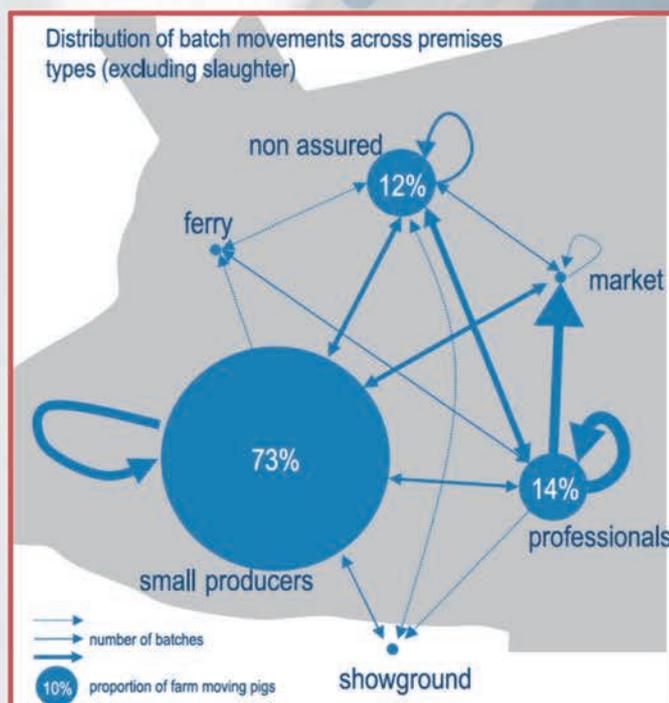
## Modelling Uncertainty

EPIC scientists have created a resilient computational framework to respond to emerging diseases and/or changes in industry structure. The 'SOHO' framework is a flexible tool that considers transmission of pathogens within and between herds, network models and the impact of different control strategies. The framework also forensically estimates disease transmission characteristics for particular outbreaks.

In small outbreaks uncertainty is high. However, even in these circumstances, EPIC scientists have now made it possible to quantify the spread of disease between farms and improve model choice. This is critical to accurately assess risks associated with future disease incursions. For example, with as few as 6 or 7 premises identified as positive, we can quantify key characteristics of disease spread and predict risks associated with future disease incursion events, including the total number and likely position of infected farms.

## EPIC Data Resources

EPIC, in close cooperation with collaborators in government, the livestock industry, and other researchers and stakeholders, has developed an extensive collection of information that describes Scotland's livestock and poultry, as well as key risk factors for the spread of disease. These data have underpinned considerable subsequent research conducted by EPIC.



**“Scotland is at the forefront of improved animal traceability through this type of data provision because of the implementation the ScotEID (electronic identification) database system covering electronic sheep movements, a pre-notified pig movement system and Scottish cattle movement data which facilitates the Bovine Viral Diarrhoea eradication programme.”**

**Sheila Voas, Chief Veterinary Officer, 2014**

# Responding to Disease Emergencies

EPIC has become a trusted and valued source of epidemiological, social science and economic advice for Scottish Government in emergency disease outbreaks.

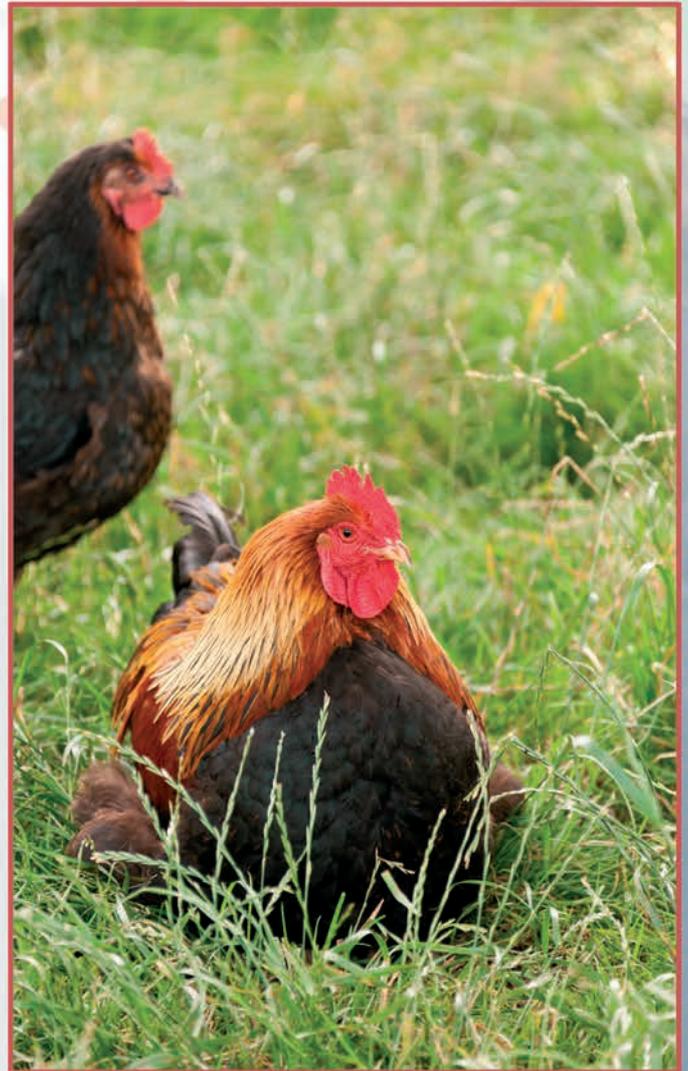
## Disease Exercises

EPIC scientists have made valuable contributions to UK and Scottish-led disease exercises on Foot-and-Mouth Disease, Avian Influenza and Classical Swine Fever including:

- Emergency analysis of movement and demography data
- Rapid risk assessments on rural access and the role of wildlife and wild birds in disease transmission
- The use of sequence data in outbreak analyses
- Assessment of surveillance strategies for disease detection
- Assessment of the effectiveness of communication structures between EPIC, Scottish Government and partner organisations.

## Disease Outbreaks: Avian Influenza

Starting in December 2014, a number of Avian Influenza outbreaks have occurred in the United Kingdom, the most recent being in Scotland in January 2016. Communication between EPIC and Scottish Government, industry and other partners was facilitated by EPIC scientists who were embedded within Scottish Government and attended Disease Strategy Group meetings. In addition to assisting the Scottish response, EPIC scientists were invited to visit the National Epidemiology Emergency Group and join meetings in London. EPIC's work during this outbreak contributed to Scottish Government intelligence on the complex structure of the Scottish commercial poultry sector, susceptibility of the industry to exotic disease and the value of existing data that was available for forensic contact tracing, enabling policy-makers to make more informed decisions.



## External Partnerships

EPIC cannot successfully support Scottish Government without collaboration with Scottish Government's external partners (i.e. the Animal and Plant Health Agency, Department for Environment Food and Rural Affairs and the National Epidemiology Emergency Group). These groups participated in Exercise Mercury, a bespoke disease exercise co-constructed by EPIC, the Animal and Plant Health Agency and Scottish Government.

# Contingency Planning for Exotic Disease

EPIC has developed innovative approaches (such as risk-based surveillance) to facilitate the rapid return to 'disease-freedom' after an outbreak.

## Veterinary Risk Assessments

EPIC has created a generic veterinary risk assessment (VRA) framework to improve long-term contingency planning for different exotic diseases. One of EPIC's first achievements was to produce a library of 25 qualitative VRAs to underpin movement licenses and to enable access to the countryside in the event of a Foot-and-Mouth disease outbreak. These VRAs have been adopted by Scottish Government and were made available to the Animal and Plant Health Agency and the Department for Environment, Food and Rural Affairs (DEFRA) for national use. VRAs have subsequently been produced by EPIC scientists to support decision making in the event of Avian Influenza and Classical Swine Fever outbreaks. EPIC scientists have provided critical input into DEFRA's 2016 VRA on the risks of incursion of Bluetongue virus into the United Kingdom.



## Assessing Risks of Porcine Epidemic Diarrhoea Introduction to Scotland

Between 2014 and 2015, Porcine Epidemic Diarrhoea (PED) virus and other swine delta coronaviruses spread in North America, Germany and the Ukraine. Although poorly understood, these viruses appear to spread easily through both livestock and vehicle movements, posing a threat to Scotland's swine industry. In anticipation of further spread, EPIC scientists produced a qualitative risk assessment of the risks of disease incursion into Scotland. The risks were estimated to be very low to low, but a number of possibilities for mitigation have been identified. EPIC continues to monitor the situation elsewhere in Europe.

## Surveillance Policy for Classical Swine Fever

EPIC evaluated the consequences of failing border controls for the spread of Classical Swine Fever (CSF) in the British swine industry. Based on historical data from CSF in East Anglia, EPIC demonstrated that CSF may not spread from primary infection sites beyond 5 kilometres. Temporal and spatial variations of the risk of CSF has been further investigated within Great Britain, highlighting spatial and temporal features upon which cost-efficient surveillance strategies may be designed.

# Improving Disease Traceability

EPIC has harnessed technology to improve traceability throughout the lifespan of cows, sheep and pigs in Scotland.

## Cattle Tracing System (CTS) Links and Standstills

The Cattle Tracing System (CTS) records cattle movements, but CTS-links allow keepers to move animals between linked holdings without reporting these moves. Groups of farms joined by CTS-links have grown dramatically; the largest of these contained 86 holdings in 2009, but 334 in 2013. EPIC analyses showed that, if CTS-links present a risk similar to movements, they could double the rate of spread of disease. While subject to limiting assumptions (e.g. the frequency of use of these links remains unknown), EPIC's analyses highlight the potential risks posed by CTS-links: they compromise the ability to predict and trace disease and have an impact upon the inferences of mathematical models that depend on CTS data.

In Scotland, the movement of cattle, sheep and goats trigger a 13 day movement ban or standstill whenever an animal is moved onto a holding. Unreported movements within linked cattle holdings confound compliance and enforcement of standstills. EPIC scientists are exploring the effectiveness of standstills at reducing the risk disease transmission during a disease outbreak.

**“The analysis of CTS Links carried out by EPIC has highlighted the disease risks to Scottish Government; the data and graphics have been used in discussions within Scottish Government and with the livestock sector to stimulate thinking about possible solutions.”**

**Dr Nick Ambrose,  
Scottish Government, 2015**



## Maintaining Scotland's Official Tuberculosis Free Status

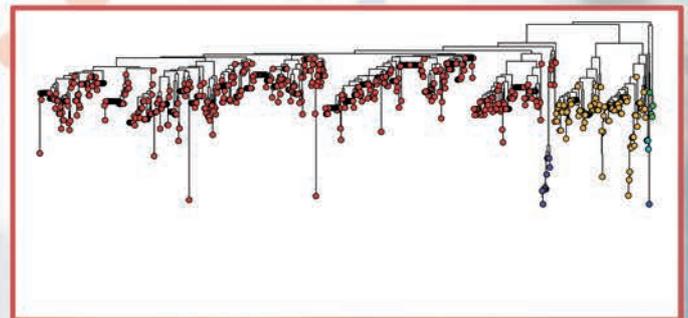
EPIC has used statistical and mathematical modelling to help Scotland maintain its Official Tuberculosis (TB) Free status within the European Union. Although there is some transmission of bovine TB in Scotland, this can usually be traced back to cattle imported from elsewhere in the United Kingdom or Ireland. Additional testing requirements appear to have led to a decrease in imports from high-risk areas. Using machine learning tools, EPIC scientists have also refined risk-based surveillance strategies; the best approach to TB surveillance is to continue annual testing for cattle imported from historically high TB incidence areas in England and Wales.

# Pioneering New Technologies

EPIC's expertise in whole genome sequencing of pathogens has advanced the science of forensic epidemiology, improved efforts to eradicate Bovine Viral Diarrhoea (BVD) and improved knowledge of future risks of bovine Tuberculosis reintroduction.

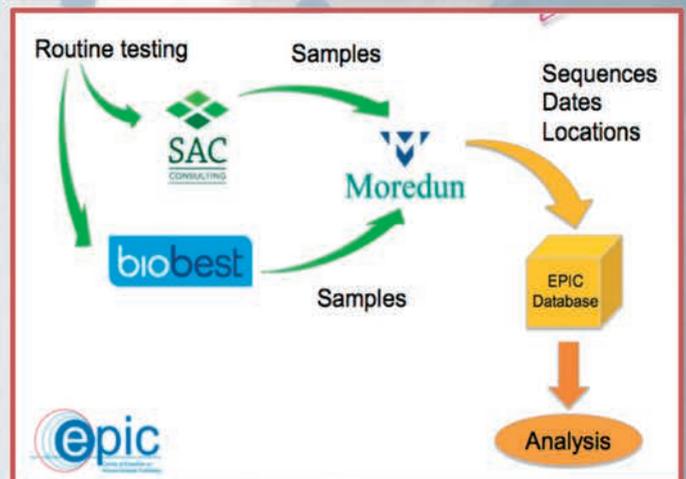
## BVD Biobank

In collaboration with stakeholders (Biobest laboratories, SAC consulting), EPIC scientists are analysing BVD virus from animal samples to inform the latter stages of the Scottish eradication campaign. Thousands of samples have been archived and genotyped, creating an important national reference database for Scotland. As of April 2016, there were over 3000 samples in the Biobank. Most samples were from holdings in Scotland with about 25% from other parts of the UK.



## Phylodynamics Uncover Outbreak Sources

EPIC scientists have used sequencing technology to uncover routes and risks of BVD transmission. Preliminary phylodynamic analysis shows that BVD virus has moved between England and Scotland on multiple occasions. This work provides an important resource to allow tracking of infection chains and can inform the final stages of Scotland's BVD eradication policy. This methodology is already a well-established tool to control disease outbreak emergencies (e.g. Avian Influenza, Foot-And-Mouth Disease) and could provide new insights into the control of other endemics (e.g. bovine Tuberculosis). After the highly pathogenic Avian Influenza outbreaks in England and elsewhere in Europe during 2014 and 2015, sequences were quickly available from UK, European, and worldwide collaborators. EPIC scientists were able to perform rapid phylodynamic analyses to infer source locations and bird species. The results suggested a single introduction into Europe in mid-2014, with possibly silent spread for between 1-4 months before first detection, transmission between wild and domestic birds and limited farm to farm spread.



## BVD Eradication

As the BVD eradication scheme progresses eliminating infection from the last few farms is likely to become increasingly difficult. A collaboration between EPIC and the Scottish Government's strategic research programme has resulted in an analysis method that can distinguish between farms with high levels of circulating antibody, as might occur if a persistently infected animal had been missed, to those with lower levels, as might occur from infection coming from a neighbouring farm. EPIC scientists can identify farms where eradication has been effective, and those where there has been reintroduction of infection.

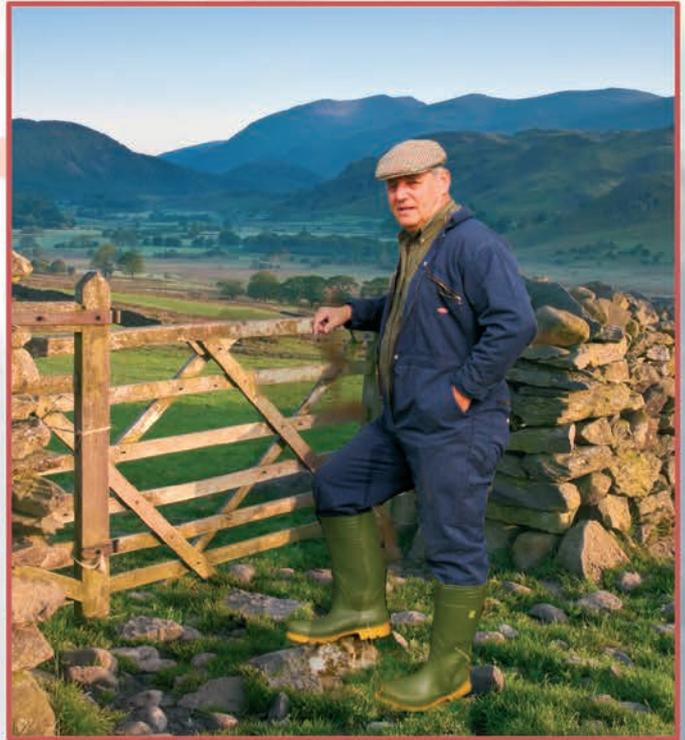
# Promoting Stakeholder Engagement

EPIC has put farmers at the forefront of our work to ensure practical, industry-informed science.

## Industry Interface Meetings

EPIC has collaborated with researchers funded by Scottish Government's Strategic Research Programme to develop their contact networks for combined livestock industry interface meetings involving sheep, pig, poultry and cattle (beef and dairy) farmers and relevant industry representatives including: veterinarians and representatives from the National Farmer's Union Scotland, Quality Meat Scotland, National Beef Association, Wholesome Pigs Scotland Group and SAC Consulting's Veterinary Service. These meetings give stakeholders opportunities to voice important industry issues, guide EPIC's future research priorities and provide specific inputs for existing EPIC models and risk assessments. Topics have covered:

- Endemic and exotic disease control
- Eradication of sheep scab from Mull
- Sheep electronic identification (EID)
- Routes for more effective knowledge exchange.



## Scenario Planning: Involving Stakeholders in Future Planning

Scenario planning workshops were organised by EPIC to discuss the future of the Scottish cattle and sheep industries and their disease resilience. These workshops were attended by approximately 50 stakeholders from a range of backgrounds, providing an opportunity for interaction between industry sectors, policy-makers, EPIC and two other Centres of Expertise (for Climate Change and Waters). This process was a novel application of scenario planning for the animal health industry and its value was evidenced in both the dialogue and solidarity formed among participants through the consideration of different plausible futures.

## A Focus on Farmer Behaviour

EPIC scientists have explored farmer behaviour in relation to uptake of health-related technologies to improve disease surveillance and control measures. Behavioural economics models have been used to analyse determinants of innovative technology uptake and disease control behaviour and indicate the importance of knowledge transfer and bespoke advice. EPIC has demonstrated that negative characterisations of farmers' technological capabilities may obscure significant opportunities. Analysis of interviews capturing farmer attitudes to digital technology revealed opportunities for enhanced uptake of cattle electronic identification and other future surveillance and control systems. Improvements can be achieved through exploitation of the technological web of data provision within which farmers already operate.

# Encouraging Interdisciplinarity

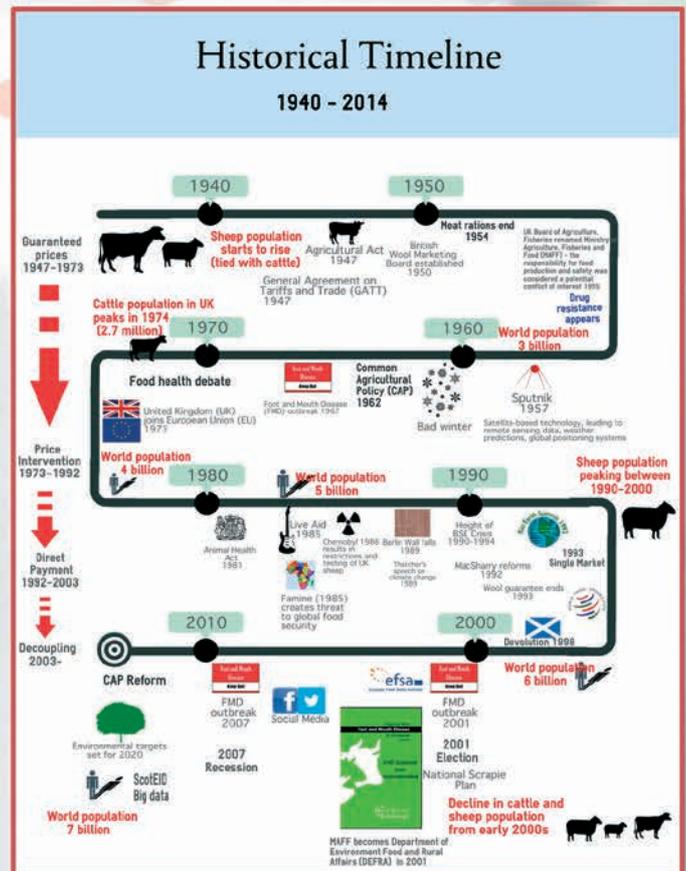
EPIC has integrated social science, economics and other expertise into epidemiological investigations of exotic and endemic disease outbreaks.

## Spotlight on Economics and Social Science

EPIC scientists have used behavioural economics models and social science to analyse the impact of determinants on farmers' behaviour towards animal disease prevention and eradication. These efforts to integrate different disciplines have made a significant contribution to Scottish Government disease control policy. One recent example was an economic analysis of the use of vaccination during a Foot-and-Mouth Disease (FMD) outbreak in which outputs from EPIC's epidemiological FMD model were combined with a novel econometric model of the effects on commodity markets to capture indirect costs. EPIC scientists have also analysed farmer incentives to use the Cattle Tracing System (CTS) and CTS-links and scenario planning workshops explored with stakeholders the resilience of Scottish cattle and sheep livestock sectors to exotic and endemic diseases in the future.

## World-Leading Collaborations

EPIC has forged a number of important international and national scientific collaborations which are likely to have a big impact on Scotland's animal health. For example: EPIC scientists at Scotland's Rural College (SRUC) are working with the European Space Agency to develop methods to measure risks of vector-mediated diseases (such as Lyme disease); EPIC personnel from The James Hutton Institute, Moredun Research Institute, the University of Glasgow and University of Stirling are working together to use economic approaches to improve sheep scab control. Members of EPIC (SRUC) are also involved in a leading role in the innovative Agri-tech Innovation Centre.



## A 'One Health' Approach

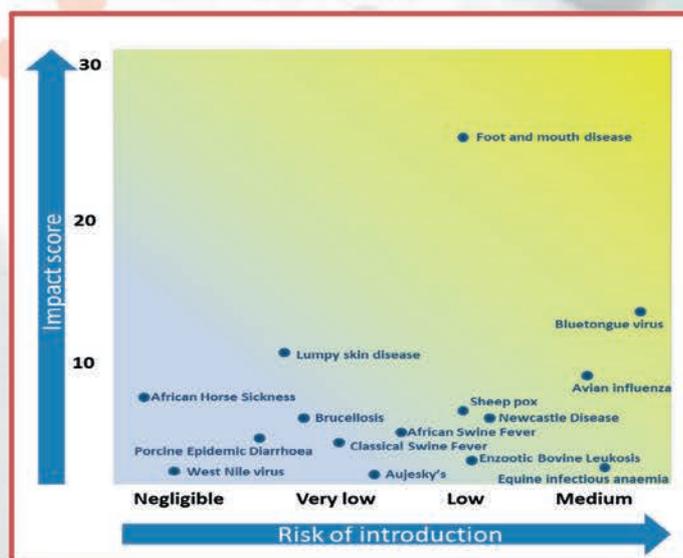
EPIC scientists have forged new collaborations with external partners in human health and wildlife sectors. In 2015, EPIC was asked to contribute to a call for evidence to underpin a future ministerial decision on the reintroduction of beavers into Scotland. A qualitative risk assessment on the public health risks associated with beavers was undertaken by EPIC and Health Protection Scotland (HPS) scientists. This work consolidated links between HPS and EPIC, improved EPIC's access to endemic disease data and have facilitated ongoing conversations about future 'One Health' approaches to resolving joint animal and human disease issues.

# Prioritising New Disease Risks

EPIC scientists have developed close links with the Animal and Plant Health Agency in order to monitor potential future disease threats, particularly those associated with vector-mediated disease and climate change.

## Horizon Scanning for Disease Threats

Working with tools developed by the Animal and Plant Health Agency and Department for Environment, Food and Rural Affairs, EPIC scientists have developed a semi-quantitative disease horizon scanning tool that combines the likelihood of incursion into and potential impact of those exotic diseases for Scotland. The tool is frequently and systematically revised, particularly when the global distribution of a disease changes. Farmers and other stakeholders are kept informed of these findings through twice yearly updates in The Scottish Farmer.



EPIC's Horizon Scanning Matrix

## Disease Risks Posed by Wild Bird Migration

EPIC scientists have evaluated potential migratory bird routes by which highly pathogenic Avian Influenza and West Nile Virus could be introduced into Great Britain and Scotland. Large numbers of water bird species migrate from Siberia and mainland Europe and in the past, their peak arrival time has coincided with the introduction of highly pathogenic Avian Influenza to Northern England. However, in contrast, a quantitative risk assessment demonstrated minimal risk of West Nile Virus introduction into Scotland via migrating birds. Indirect introduction of this disease through Southern England is possible, but unlikely due to the lack of mosquito populations which can transmit that disease. This research supports the current policy of not having a policy on West Nile Virus, but recommends monitoring of the situation in England and France and advises surveillance for presence of competent mosquito vectors.

## Novel Emerging Diseases

The emergence of Schmallenberg virus (SBV) in the UK has been an important concern for the Scottish cattle and sheep industries. Using a mathematical model, different strategies for deploying SBV vaccines have been explored to optimise use of the vaccine. As the potential for transmission of SBV is limited by climate, EPIC was able to demonstrate that targeting vaccine at cattle can lead to a 68.7% reduction in infections compared to a 79.7% reduction following vaccination of 4.29 million cattle **and** sheep. Thus, we demonstrated how vaccines can be targeted effectively to maximize impact. More generally, it would take a very warm year to trigger an extensive SBV outbreak in Scotland. Development of a model of SBV spread has benefited from collaboration with the Centre for Ecology and Hydrology in Edinburgh.

# Impact on Science and Policy

EPIC scientists and staff have made robust, timely and impactful contributions to academic research and animal health policy.

## Scientific Publications

### 2016

- O'Hare et al. (2016) Broadwick: A framework for computational epidemiology. *BMC Bioinformatics* 17:65
- Porphyre et al. (2016) Using national movement databases to help inform responses to swine disease outbreaks in Scotland: the impact of uncertainty around incursion time. *Scientific Reports Nature* 6:20258

### 2015

- Boden et al. (2015) Scenario planning for the future of the cattle and sheep industries in Scotland and their resiliency to disease. *Preventive Veterinary Medicine* doi:10.1016/j.prevetmed.2015.08.012
- Grant et al. (2015) Assessment of the rabbit as a wildlife reservoir of Bovine Viral Diarrhoeal virus: serological analysis and generation of transplacentally infected offspring. *Frontiers in Microbiology* 6:1000 doi: 10.3389/fmicb.2015.01000

### 2014

- Bachofen et al. (2014) Experimental infection with rabbits with Bovine Viral Diarrhoeal virus by a natural route of exposure. *Veterinary Research* 45:34
- Bessell et al. (2014) Impact of temperature, feeding preference and vaccination on Schmallenberg virus transmission in Scotland. *Scientific Reports* 4 doi:10.1038/srep05746
- Bessell et al. (2014). Quantifying the risk of introduction of West Nile Virus into Great Britain by migrating passerine birds. *Transboundary and Emerging Diseases* doi:10.1111/tbed.12310
- Boden et al. (2014) Working at the science policy interface. *Veterinary Record* 165-167
- Gates et al. (2014). Not all cows are epidemiologically equal: Quantifying the risks of Bovine Viral Diarrhoea virus (BVDV) transmission through cattle movements. *Veterinary Research* 45:110 (15pp)



# Impact on Science and Policy

## Scientific Publications

### 2014 contd.

- Gates and Woolhouse (2014) Suboptimal herd performance amplifies the spread of infectious disease in the cattle industry. *PLoS One* 9:e93410 (10pp)
- Kao et al. (2014) Supersize me: How whole-genome sequencing and big data are transforming epidemiology. *Trends in Microbiology* 22 (5): 282-291
- Nickbakhsh et al. (2014) A metapopulation model for highly pathogenic Avian Influenza: implications for compartmentalization as a control measure. *Epidemiology and Infection* 142 (09)1813-1825
- Porphyre et al. (2014) How commercial and non-commercial swine producers move pigs in Scotland: a detailed descriptive analysis. *BMC Veterinary Research* 10:140 (17pp)

### 2013

- Bachofen et al. (2013) Direct RT-PCR from serum enables fast and cost-effective phylogenetic analysis of Bovine Viral Diarrhoea virus. *Journal of Virological Methods* 190:1-3
- Bessell et al. (2013) Epidemic potential of an emerging vector borne disease in a marginal environment: Schmallenberg in Scotland. *Scientific Reports* 3:1178 doi:10.1038/srep01178
- Flood et al. (2013) The performance of approximations of farm contiguity compared to contiguity defined using detailed geographical information in two sample areas in Scotland: Implications for Foot-And-Mouth Disease. *BMC Veterinary Research* 9:198 (13pp)
- Gates et al. (2013) Impact of changes in cattle movement regulations on the risks of bovine Tuberculosis for Scottish farms. *Preventive Veterinary Medicine* 112 (3-4): 285-295
- Hall et al (2013) Reconstructing geographical movements and host species transitions of Foot-And-Mouth disease virus serotype SAT 2. *mBio* 4:e00591-13 (11pp)
- Nickbakhsh et al. (2013) Implications of within-farm transmission for network dynamics: Consequences for the spread of Avian Influenza. *Epidemics* 5:67-76
- Porphyre et al. (2013) Vaccination against Foot-And-Mouth disease: Do initial conditions affect its benefit? *PLoS One* 8: e77616 (14pp)
- Rich et al. (2013) Systems approaches to animal disease surveillance and resource allocation: methodological frameworks for behavioral analysis. *PLoS One* 8:e82019 doi: 10.1371/journal.pone.0082019
- Shaw et al. (2013) Transmission of Schmallenberg virus in a housed dairy herd in the UK. *Veterinary Record* 173:609 doi:10.1136/vr.101983



# Impact on Science and Policy

## Selected Reports and Research Briefs for Scottish Government

### 2016

- Department for Environment, Food and Rural Affairs (DEFRA) Qualitative Risk assessment for Bluetongue Virus (BTV-8): risk assessment of entry into the United Kingdom. Available at [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/499882/qra-BTV8-UK-160212.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/499882/qra-BTV8-UK-160212.pdf)
- Interim report on the role of digital technology in influencing farm-level disease management practices.
- Update on Bovine Viral Diarrhoea Phylodynamics.

### 2015

- Analysing bovine Tuberculosis (TB) breakdowns in Scotland using a partial membership model.
- Gap analysis on risks of disease associated with backyard pigs and poultry.
- Peer-reviewed veterinary risk assessment on the public health risk of *Giardia* and *Cryptosporidium spp* posed by re-introduced beavers into Scotland. Available at <http://www.snh.gov.uk/protecting-scotlands-nature/beavers/beaver-trial-monitoring-reports/>
- Report on sheep and cattle standstills in Scotland 2011-2013.
- Summary statistics and descriptive network analysis of the ScotEID sheep movement network (2011-2014).
- Research Briefing: Assessing patterns in biosecurity risk relating to Foot-And-Mouth Disease.
- Research Briefing: Movement patterns of the PRIMO-approved swine producers and potential for disease spread.
- Research Briefing: Schmallenberg virus: Present situation and policy implications.



# Impact on Science and Policy

## Selected Reports and Research Briefs for Scottish Government

### 2014

- EPIC stakeholder reports on Scenario Planning Workshops on cattle and sheep. Available online at:  
[http://epicscotland.org/downloads/file/3/epic\\_cattle\\_industry\\_scenario\\_planning\\_report#.VaPH6y7F\\_pB](http://epicscotland.org/downloads/file/3/epic_cattle_industry_scenario_planning_report#.VaPH6y7F_pB) and  
[http://www.sruc.ac.uk/epic\\_new/download/downloads/id/7/epic\\_sheep\\_industry\\_scenario\\_planning\\_report](http://www.sruc.ac.uk/epic_new/download/downloads/id/7/epic_sheep_industry_scenario_planning_report)
- Lessons learned report – Exercise Mercury (a bespoke disease contingency planning exercise for EPIC, Scottish Government and the Animal and Plant Health Agency).
- Peer-reviewed veterinary risk assessment commissioned by Scottish Government on the risk of introduction of Avian Influenza into Scotland from England.
- Peer-reviewed veterinary risk assessment on the risks associated with traceability and sheep Electronic Identification (EID): What is the risk that using a single flock (non-EID) tag up to the point an animal leaves its CPH (or business) of birth leads to untraceable contact with other sheep (compared to the situation in which sheep are tagged with the EID double-tagging system)?
- Short report on model resilience.
- Research Briefing: What is the risk of introduction of swine enteric coronaviruses into Scottish Pig farms?
- Research Briefing: Blood testing as a tool in the control of sheep scab.
- Research Briefing: Broadwick modeling framework.
- Research Briefing: Cattle Tracing System - Links in Scotland.
- Research Briefing: Evaluating the vulnerability of the Scottish Pig Industry to Classical and African Swine Fever.
- Research Briefing: West Nile Virus: Risks of introduction from the Camargue by northward migrating passerines.

### 2013

- Report to Scottish Government on EPIC's responses to Exercise Walnut. This included a veterinary risk assessment on the risks posed by wild boar to the spread of Classical Swine Fever, an analysis of pig movement data and a lessons learned document.
- Research Briefing: Schmallenberg virus and vaccination with new replication rates.
- Research Briefing: West Nile Virus / Arbovirus.



# Impact on Science and Policy

## Selected Reports and Research Briefs for Scottish Government

### 2012

- Peer-reviewed qualitative risk assessments on the risks associated with various activities that require access to the countryside during a Foot-And-Mouth disease outbreak (12 documents).
- Peer-reviewed qualitative risk assessments on the risks associated with movements of animals and various other activities during a Foot-And-Mouth disease outbreak (12 documents).
- Peer-reviewed qualitative risk assessment on the risks associated with transport of infected carcasses during a Foot-And-Mouth disease outbreak.

### PhD Theses

#### 2016

- Hall (2016) The phylodynamics of infectious diseases of livestock: preparing for the era of large-scale sequencing. *PhD thesis*, University of Edinburgh.

#### 2015

- Flood (2015) Foot-and-Mouth Disease epidemiology in relation to the physical, social and demographic farming landscape. *PhD thesis*, University of Edinburgh.

### Selected EPIC Presentations

- Gunn (2016) Providing Government with an evidence base for disease control: beyond BVD to zoonotics and 'EPIC' epidemics. Invited Seminar on Infectious Disease Control, SVA, Uppsala, Sweden.
- Gunn (2012) Policy linked research in Veterinary Epidemiology: Combining advancing surveillance with emergency outbreak control. *International Society for Veterinary Epidemiology and Economics (ISVEE)* Maastricht, Netherlands.



# Acknowledgements



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