



Workshop 2 report

April 2025

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Executive Summary

The enormous impact of livestock disease outbreaks on both animals and humans makes them a key ‘one health’¹ challenge. A rapid, effective and well-planned response to such epidemics is a priority for governments. This workshop was designed to contribute to this effort by exploring the critical role that modelling plays in modern epidemic preparedness, and how this can be made clearer, more effective and more transparent.

The workshop brought together project participants and representatives of the modelling, science/policy brokerage, policymaking and farming communities as well as third sector organisations to explore views on model development and use.

A narrative literature review on design, communication and use of models at the science policy interface provided a summary of the social sciences literature on models and modelling in policy making for the members of the ELUCIDATE project.

In addition, six research interest groups (RIGs) were developed to encourage people with similar interests to meet and discuss themes within the modelling context. Following a presentation by each RIG, participants were invited to comment and offer suggestions on strengths or opportunities, what could potentially limit the research outcomes, how could the proposal be modified, expanded or improved and what additional expertise or resource could enhance this RIG.

There were several similarities between RIGs, and some linked well with others. The workshop highlighted that it is necessary for policy makers and modellers to engender greater trust and understanding around policy requirements and what is realistic to expect from models.

There is a requirement for further investment to bring in new expertise and specialists as we move into an era of artificial intelligence and novel technology. Democratising the production of models through for instance, participatory modelling is an option. Engaging more with potential audiences, via tailoring messages and language specifically for each audience, including new ways of communication such as cartoons, gaming, artists, and AI experts, could lead to better understanding and enhance the credibility of models.

A proposal has been submitted to UKRI for the next stage ELUCIDATE, to build on the research questions and ideas project partners would like to consider and explore further.

¹ One Health is defined as an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals, and ecosystems.

Acronyms/ terminology used in this report

Acronyms/ terminology used in this report	Meaning
AHRC	Arts and Humanities Research Council
AHWD	Animal Health and Welfare Division within the Scottish Government
AI	Artificial Intelligence
APHA	Animal and Plant Health Agency
ASF	African Swine Fever
BioSS	Biomathematics and Statistics Scotland
BTB	Bovine Tuberculosis
BTV	Bluetongue virus
CHECS	the body that certifies and quality-controls CHECS licensed cattle health schemes in the UK and Ireland
CISAP	Construction Industry Substance Abuse Program
EPSRC	Engineering & Physical Sciences Research Council
EuFMD	European Commission for the Control of Foot-and-Mouth Disease
FMD	Foot and Mouth Disease
NERC	Natural Environment Research Council
Nudge Unit	also known as the Behavioural Insights Team, is a UK-based organisation that applies behavioural science to influence people's decisions and choices
QUADS project	Members of the Quadrilateral Group of countries (QUADS: Australia, Canada, New Zealand, USA) were involved in a study comparing foot-and-mouth (FMD) simulation models
RIG	Research interest group
SPI-M	Scientific Pandemic Infections group on Modelling

Introduction to ELUCIDATE and the workshop

The enormous impact of livestock disease outbreaks on both animals and humans makes them a key ‘one health’ challenge. A rapid, effective and well-planned response to such epidemics is a priority for governments. This workshop was designed to contribute to this effort by exploring the critical role that modelling plays in modern epidemic preparedness, and how this can be made clearer, more effective and more transparent.

This was the second workshop² of the ELUCIDATE project. At this workshop we took forward research ideas developed in the first workshop, and subsequent project work, to work towards developing one or more research proposals to address the second stage of the UKRI call on tackling epidemic threats.

The workshop brought together 13 project participants and 7 stakeholders, representatives of the modelling, science/policy brokerage, policymaking and farming communities as well as third sector organisations (Annex 1). The remit was to explore views on model development and use. and to help frame transdisciplinary research to enhance epidemic preparedness by improving use of these models at the science-policy interface. As part of the ELUCIDATE project's responsible research and innovation framework the workshop aimed to ensure those affected by decisions on animal disease policy assist in developing research approaches.

The workshop was funded by UK Research and Innovation (UKRI), and facilitated by Dialogue Matters: experts in stakeholder participation, process design and facilitation: <https://dialoguematters.co.uk/>

The workshop plan, which was reviewed by The James Hutton Institute Research Ethics Committee, was designed to enable and encourage participants to share knowledge and ideas openly and freely by working through a series of participatory exercises, which included facilitated discussions and self-writing comments.

Data was collected through note taking at the workshop. The extensive amount of data collected has been condensed to highlight common themes for this report and the responses below represent many of the view's participants expressed during the workshops. We have attempted to present a plurality of views rather than produce a single narrative about the workshop participants' perspectives.

² The report from the first workshop can be obtained by contacting the authors.

Narrative literature review on design, communication and use of models at the science policy interface

The rationale for the literature review was to provide a summary of the social sciences literature on models and modelling in policy making for the members of the ELUCIDATE project. It aimed to identify gaps in the literature that could be used to develop research questions for the next stage of the project, focusing on social sciences literature on the design and development of models, the use of models and model results by policy makers and the communication and representation of models.

Results from the review found that using Litmaps³ generated a certain amount of randomness in the paper selection, and a mix of disciplines and perspectives. There was a lot of coverage of modelling in the FMD outbreak. There were papers covering animal health but also modelling in hydrology, ecology, climate change, public health and risk.

Results on the use of models and model results by policy makers highlighted different model functions, different challenges and considerations around trust and legitimacy of models.

Reflections on the review highlighted that we didn't include much of the work on climate change modelling and there is further scope to explore democratising processes like participatory modelling. Literature suggests participatory modelling is slow and labour intensive. Feedback was invited on the literature review. To read the full review contact Orla.shortall@hutton.ac.uk or Niamh.Mahon@hutton.ac.uk

The literature review presentation can be found in Annex 2

Research Interest Groups (RIGs)

Following the literature review, we moved on to presentations from the six RIGs, which were developed to encourage people with similar interests to meet and discuss themes within the modelling context. Following the presentations, workshop participants could choose one of these RIGs to discuss in further detail, in a small, facilitated group.

Copies of the full presentations can be found in Annex 3

Discussion outputs captured by the facilitator are included below.

³ Litmaps is an AI tool that helps you discover, visualize, share, and monitor academic papers.

RIG A/B- Development and use of models and modelling as evidence at the science – policy interface

The RIG is about the production, communication, legitimisation and use of models (and modellers) for preparing for animal disease outbreaks at the science-policy interface. The presentation described the potential to develop a repository for model cards and models, and the potential for next stage of the project to develop participatory modelling methods.

What strengths or opportunities does RIG A/B present?

This RIG links with other RIGs, e.g. types of models feeding into policy. It is necessary for policymakers to be on board and can be seen as an opportunity to build trust in models and modellers. There is a requirement for a better understanding of models, and participatory modelling can enable people to see the impact and processes involved. This RIG can improve the use of models, can consider the use of models in a new way and may be an opportunity to speed up and make easier modelling in the future.

Maintaining a repository is resource intensive but could make access to validated models from different countries available and could be used as part of an epidemic protocol or during a disease incursion. It would be important to consider types of models and context.

What could potentially limit the research outcomes?

Cabinet office / policy makers will go to groups that they trust. Participants questioned how we can show trustworthiness and engage with them to highlight the research that is happening.

Some policy makers are already using models, so there is a need to articulate the benefits of the RIG proposal. This would include highlighting efficiency, using the right model, communication to the wider public and the advantages of a repository to the wider public, research and policy.

There is existing competition in epidemiology – ‘Epiverse⁴’ groups that do modelling may not see this proposal as useful. As there is a lot of interest in modelling, e.g. plant health modelling, modellers do not want to be dependent on one single research group.

How could the proposal be modified, expanded or improved?

Information flow, often relying on personal contacts, is key to improving situation explored by the RIG. For example, FMD modellers could look at information networks. As there are many levels to understanding models: impact, outputs, etc, we need to

⁴Epiverse - a global collaborative led by data.org to co-create distributed data analysis tools that will get ahead of the next global health crisis. Its inclusive, open-source software ecosystem is led by an interdisciplinary community of experts driving equitable innovation in infectious disease response

identify pipelines / routes to mitigating and controlling an outbreak. There could be an opportunity to build a relationship with human health modellers e.g. CISAP (Construction Industry Substance Abuse Program). By doing stakeholder mapping we could ascertain who should be involved in each stage and what models should be used to inform each stakeholder.

People assume that models give ‘evidence’. A game could be used as a tool for decision making, with a similar tool for communication, which might help people understand uncertainty and what models are. Although this may not relate to policy makers, as they want evidence and are not generally interested in method, it may help public perception which is also important.

What additional expertise or resource could enhance this RIG?

We need to talk to policymakers, to understand what they want. There is an assumption among policy makers (and modellers) that policy makers won’t understand models, but there may be people who want to understand. We need the expertise to map out what happens in an outbreak. Do we have the contacts, who do we involve in the discussions? We have contacts in human health and central people can lead to further contacts. The information across the UK varies and data is stringently protected. This area is very political and needs to be handled carefully to manage relationships.

Additional comments

A participant stated that this RIG has the potential to encourage more public sharing of models used by policy – which currently is not always the case

A participant queried whether the production of modelling cards is a one-off process, or could it also be iterative. Is it expected that modellers fill in all the details, or could it be a group/participatory process, involving multiple types of expertise?

RIG E-1 Develop use of models for qualitative support for policy

This RIG is about trying to better understand how we use models in different ways for different purposes and exploring the apparent contradiction that modelling is an inherently quantitative activity but there are diminishing returns in thinking too quantitatively about outputs.

E-2 Thinking about the Modelling Process, Models and their Outputs from an Epistemological Perspective

This RIG is interested in exploring the consequences for modelling practice, our understanding of models as entities and how we interpret model outputs from a perspective informed by the philosophy of knowledge, epistemology.

What strengths or opportunities does this RIG present?

Participants thought that exponential models may have a place in this RIG. There is an opportunity to scrutinise terminology and think about artificial intelligence (AI) and how AI models can help in the future. This RIG could consider what's going to be new and innovative within modelling. There is scope to integrate work within the philosophy of modelling with policy and modeller perspectives.

This RIG offers the opportunity to do systematic reviews and do interdisciplinary work and include philosophy to make models useful to modellers. But how to carry this out needs further consideration. A participant stated that while policy may want predictions and forecast, it may be the last thing modellers want to give.

What could potentially limit the research outcomes?

There is a limitation to quantitative presentations of models. There needs to be push back against the simplified view of models taking credence for social behaviour (e.g. the use of models within a nudge theory framework which holds that people just need to be nudged to change behaviour).

We need to make use of quantitative support and have discussions with policy makers about how models are placed. This involves considering how we could or should make best use of models and developing specific questions to help in the choice or development of models which can be quickly adapted for specific situations.

How could the proposal be modified, expanded or improved?

There may be two separate different themes within this RIG, and it may be worth investing a bit in separating them as they ask different questions. RIG E considers the contribution of quantitative models to qualitative questions in /for policy. Here the technical approaches are very important, i.e. what do policy makers need, how do we translate and communicate that and build belief?

A participant stated that policy makers need to make an 'effort' to understand models too. They need to understand them as tools but not use them as a shield to remove responsibility for politically difficult decisions, e.g. during Covid 19. Participatory modelling is the cement that brings it all together, along with using an approach more aligned with one health perspectives, taking people and the environment into consideration, and not using models in isolation.

What additional expertise or resource could enhance this RIG?

Models of engagement need a convincing interdisciplinary narrative and a strong steer on how transdisciplinary modelling will work, bringing in others, not only philosophers. This could be achieved through workshops looking at the methodological question. We need broad engagement and diversity, policy engagement and collaboration with other groups doing different models.

There is scope for participatory approaches – e.g. translating existing models and data parameters from other situations and working with farmers/livestock keepers. As so much modelling is produced in anticipation of and during outbreaks it may be better to think about endemic disease and look at other pathogens, not just the core 3- African swine fever, bluetongue disease and foot and mouth disease.

RIG F Overcoming barriers to the use of advanced modelling methodologies

For a given problem, modellers can apply many different models. If a model is to be used, then it needs to be within the domain of expertise of the modeller. The RIG presentation posed the question to what extent should other stakeholders be able to understand the model and is there more that modellers can do to translate ‘advanced’ models?

What strengths or opportunities does this RIG present?

This RIG is the closest to methodological development and advanced methods are going to become more important e.g. AI. Removing barriers is something we, as modellers, need to consider, e.g. barriers connecting modellers to non-modellers and vice versa, leading to better disease control.

This is an opportunity for modellers and end users to engage with and explore why models are not being used or should be being used and better understand the shifting perceptions around risk, loss and change.

What could potentially limit the research outcomes?

A lack of focus or struggling to work out what the focus should be, a lack of definition of what advanced methodologies is and means and a lack of expertise in advanced methodologies could all have potential to limit the research outcomes. A participant stated that the appetite for road testing of models may lead to resistance to adopting them.

We can invest time in trying to explain advanced models, but people may not necessarily be convinced, and this may not overcome resistance or caution. The more different (advanced) the model the bigger the risk that it will not be accepted, and some methodologies are just inappropriate (or turn out to be).

How could the proposal be modified, expanded or improved?

Participants thought that better defining the scope of the proposal would improve it e.g. reframing as ‘the barriers to the implementation of advanced methodologies.’ They suggested seeking models from other disciplines e.g. financial, and considering all the potential audiences, tailoring messages and language for the audience. The use of an ‘interpreter’ between the modellers and the audience – a science / policy interface and

/or a master course in science / policy interfacing, as a route into the civil service perhaps, could aid understanding.

What additional expertise or resource could enhance this RIG?

Improved funding would enable bringing in additional expertise, e.g. advanced methodologies, AI and software development specialists. Seeking additional input from policy makers and other end users and including psychologists to understand how to communicate and graphic artists to explore presentation of data and information would help to enhance communication of outputs. In relation to models in other areas, it could be useful to involve someone working with financial models.

RIG C - Understanding the needs of users within the policy cycle/epidemic response cycle

This RIG explores questions that policy makers may have at different phases of disease incursions. It considers what tools could be used to meet the needs of policy makers and requirements at different points of epidemic cycle by anticipating use cases, and via communication, translation and brokering.

What strengths or opportunities does this RIG present?

One of the strengths here is that there is not much work published around the challenges of meeting potential user's needs in relation to modelling and disease. There is a lot of collective knowledge on this topic, but not much has been published. It is essential to understand end-user's requirements and the time scales involved. This relates to the outbreak cycle and can involve work during 'peacetime', i.e. when there is no disease incursion, which can be adjusted if an outbreak occurs. Incorporating more participatory approaches in peacetime, allows others to gain understanding and trust in the process and outcomes of models and modellers can better understand production systems and 'sense check' outputs.

What could potentially limit the research outcomes?

Not knowing where we are in the epidemic response cycle / policy cycle and the fact that policy makers are very busy, could limit outcomes. The definition of 'users in this context is very broad so who users are needs to be pinned down to make progress. We must reach out to the right stakeholders, farmers and policy people.

How could the proposal be modified, expanded or improved?

Conversation with other RIGs and more links between RIGs and between modellers and impacted interest groups would improve the proposal. We need to access input from the right people who are currently missing and understand the needs of end users and how to communicate effectively with them. Incorporating a one health aspect, thinking

of other ministries and the crossover to human health and the environment would be advantageous.

How do we define an outbreak cycle? An epidemic outbreak cycle is more of a policy concept; it may be different for other users. Could assessing how policy makers react to models link with disease exercises? Useability assessments exist for other methods, e.g. apps.

What additional expertise or resource could enhance this RIG?

Understanding the drivers that policy is interested in and incorporating new ways of communication, like, cartoons, gaming, artists, and AI experts, could lead to better understanding and enhance the RIG.

RIG A/D Understanding past development and use of models in epidemic management

This RIG explores whether and how historical analyses of the development of modelling methodologies and the use of models in epidemic response, especially in major outbreaks, could best inform epidemic preparedness. In particular, why did some models gain traction in the scientific or policy communities or why not? What are the most salient drivers of these trajectories? And are the drivers specific to time and place, or more general? Have they changed over time? How do models evolve and how much cross-pollination of ideas is involved (e.g. plant disease models are often very distinct from human/animal disease models)? How do models move across different country and disease contexts and what risks are involved in this process?

What strengths or opportunities does this RIG present?

There are opportunities here to learn from the past. The questions may be the same, but we can look at them from a different perspective as there is more accessibility and openness now. Looking to the past offers cases to evaluate what worked or did not work. We can consider what was not obvious or is less straightforward and how perspective has changed over time, e.g. through interviews. Modelling and implementation are only the beginning. There is further opportunity around prevention, what can be learnt from wider considerations other than modelling and where to put resources and controls.

What could potentially limit the research outcomes?

Accessing insights from policy makers about epidemics may be difficult, anonymity could be used to facilitate this. While there is a risk of focussing on spectacular cases, there is much to learn from mundane cases. Historically an enormous amount of resource was needed for modelling and there was a lack of computing power which will limit what can be learned from the past e.g. what data exists around animal movements? What timescale in the past can be explored?

How could the proposal be modified, expanded or improved?

The purpose of considering the past is to imagine the future. Looking at the wider context of how models were used rather than just the detail of how they worked, and learning from past mistakes could lead to an improved proposal.

Mathematical language may be difficult to translate into narrative form. The language of maths is a barrier to understanding, making models opaque. Is there an opportunity to connect models and mental processes? Would a move towards agent-based modelling be more intuitive?

What additional expertise or resource could enhance this RIG?

The inclusion of historians, social scientists, policy brokers and people with agricultural perspectives, would add additional expertise.

RIG G - What can we learn from other outbreaks?

This RIG focusses on updating models. Models from other outbreaks are likely to be wrong (and maybe not even useful), in part due to incorrect parameter values, transmission mechanisms and / or animal management structures. Potential solutions could include the use of a Bayesian updater⁵ or ensemble models⁶, but these bring challenges such as considerations of early data that could be used to evidence the inaccuracies in the model. Can data ever be used to evidence that the model is right? And is there a place for multiple models with increasing complexity as data becomes available, or should we just use the best guess model "off the shelf" as it is most likely to best demonstrate the consequences of infection and control?

What strengths or opportunities does this RIG present?

This RIG connects with other RIGs about what makes good modelling practise and the idea for a repository of all models to support decisions. This explores the actions necessary when there is a new outbreak. Historical outbreak data could be used to explore scenarios. There is potential for historic input such as interviews with people who were involved in responding to previous outbreaks to explore how events unfolded during an entire outbreak.

What could potentially limit the research outcomes?

Access to historical data and models could prove problematic, if not near impossible. In addition, there may not always be good version control when updating models during an

⁵ Using Bayes' theorem to update a hypothesis when new evidence comes to light

⁶ Ensemble models combine multiple individual models to improve prediction accuracy and reduce errors, leveraging the strengths of diverse algorithms.

outbreak. People may be unwilling to talk about the mistakes they made (disclosure bias), and we run the risk of having people question why the model is changing.

How could the proposal be modified, expanded or improved?

Building in a Quad, like the QUADS project for FMD, which shared models across the country for comparing / contrasting approaches and learning from the ASF Challenge (simulated outbreak), data from Europe and then globally (as an exemplar) could improve the proposal. Might we learn from the approaches used in climate models regarding an ensemble approach, and should we look at AI / statistical models, machine learning models and phylodynamic models?

What additional expertise or resource could enhance this RIG?

Accessing modellers, policy people and farmers involved in previous outbreaks (UK and abroad) and involving social scientists (maintaining trust in a volatile world) could enhance this RIG. Having pre-emptive data sharing agreements, developing QUADs and consulting climate modellers to support the idea of an ensemble approach would also be advantageous.

Phase II

Lukas Engelmann gave a presentation on the scope and logistics of the proposed next stage of ELUCIDATE, UKRI Call for Interdisciplinary Research to tackle epidemic threats. (Annex 4). The following points describe the scope of the call.

- To improve our understanding of factors that influence the risk and severity of infectious disease threats
- Explore the role of economic factors, culture and other humanities using social and behavioural research perspectives,
- To inform new ways to manage and respond to infectious disease threats
- Funding for research in key areas where there is a clear epidemic threat
- Funded projects are expected to become national or international focal points for epidemic-relevant interdisciplinary research in their chosen area, incl. positive and tangible impact
- Ambitiously interdisciplinary and cross the distinct disciplinary remits of at least three UKRI research councils.
- Working together with communities, people with lived experience, practitioners and policy makers and other stakeholders is encouraged
- ‘One Health’ and ‘Planetary Health’ framing are encouraged where appropriate.

IMPACT: “Taking into consideration the criteria shared by Lukas, which research ideas would you like to consider and explore further?”

Participants (in 3 groups) were asked to respond individually on 2 post it notes. Each participant then placed their responses on a Reach/Significance graph, which were given individual letters by the facilitator to enable further discussion. ‘Reach’ refers to who is involved in the research idea, e.g. is it single discipline, multi-discipline, or multi-discipline plus all stakeholders. ‘Significance’ refers to whether the idea has a local, national or international focus. Post its were placed by individuals to prompt discussion.

The ideas in black were put forward by people who identify as being ‘primarily involved in research’. The ideas in orange were put forward by people who identify as not being primarily involved in research. The ideas will be assessed and considered further by the project proposal team.

Research ideas - Reach/ Significance graphs

Group 1

High Reach, Low Significance	– History of outbreak linked with farming scenario, animal movements, trade, consumption and production. To highlight the risk factors of disease threats and recommend prevention (F)	High Reach, High Significance	– Modelling following the holistic approach of one health and promoting / facilitating on prevention measurements (H)
	– Is it enough to include policy and scenario perspectives? <ul style="list-style-type: none"> ○ General Public ○ Farmers 		– NERC – Climate vectors, wildlife disease – different timescales for energies with policy makers (D)
	– Multidisciplinary enough? [E]		– Development of modular models of livestock, wildlife, and human pathogens which can be linked and encourage cross-disciplinary collaboration in their creation and maintenance (J)
	– More representation from policy makers... or, if not policy makers, then professional policy informing / lobbying pros / free brokers (A)		– Using novel methodologies to explore the understanding of diverse user groups of infectious disease threats and explore appropriate mitigations (I)
	– More discussion on communications. If a model is used how is communicated to government. You could bring in Comms experts or thrash around ideas yourselves (B)		– A study of government interventions and their (known/likely) impact on infectious disease threats, with a link to the soon-to-

			<p>be-officially-adopted Global Pandemic Agreement. One Health framework (G)</p> <p>– Stories / games / art to explain models better [C]</p>
Low Reach, Low Significance		Low Reach, High Significance	

Group 2

High Reach, Low Significance	– Working with communities focussing on the use of participatory approaches / trialling different methods and / or degrees of participatory and transdisciplinary working. PROPERLY RENUMERATE PARTICIPANTS! (A)	High Reach, High Significance	– Pipeline of model card / repository in response to outbreak (D)
	– To align NERC: 1) Vector-borne disease eg TSTV with strong environmental rationale and output. ie not predicting BTV risk for its own sake, but instead focus on eg re-wilding / climate change effect [E]		– Need flow diagram of how the key themes to each other w.r.t. our key aims of models – policy – helping epidemic (F)
	– Various RIGs are thinking about how models relate to each other and to the world – these can be usefully combined (J)		– A more detailed exploration of how relationships between people and other species are approached differently in modelling / how this has been done in the past (K)
	– Interactions between models and policy (two-way impact) Model ---> policy (need modeller, translations) Policy ---> model (need commission, data, infrastructure, expert) (C)		
	– Climate and vectors (H)		
	– Engaging wider communities into the modelling process (L)		
	– Need clarity on split between work on modelling methods and modelling practice (I)		
	– One Health - is it possible to de-centre the 'human' in the questions we ask? Possibility via artistic practice? (more than human perspective?) (B)		

Low Reach, Low Significance	– Art / Story for model Comms (C)	Low Reach, High Significance	

Additional comments

-
- Link between stories and model cards
- Actively thinking about methods in modelling is important

Group 3

High Reach, Low Significance	– Art as a method to communicate Models (& outputs) eg graphic artist (B)	High Reach, High Significance	– Develop a robust and resilient communication between modellers, social scientists and community. Same model in One Health (L)
	– How models / modelling should be tailored to different outbreak types (e.g. vector-borne or not) under environmental / social change [E]		– Mental model of disease in farmers, policy makers and community and how these relate to mathematical models (H)
	– Translation of complex models into something that policy makers can understand (G)		– Modelling consequences on farming community – financial & Social (D)
	– Refine how modelling informs policy (on animal health) (M)		– Something about re-wilding (A)
Low Reach, Low Significance	– None		– Participating approaches to disease modelling (including translation) (+ multi-stakeholders) (F)
			– Intersection of Livestock and wildlife health and disease (L)
			– Include wildlife, landscape vectors aspect (J)
		– Cross-border spread of disease (K)	
Low Reach, Low Significance	– None	Low Reach, High Significance	– More interpretation of different data types e.g. satellite imagery, and/or Sero surveillance / metagenomics for underlying changing risk factors (I)
			– Modelling focused disease exercises to explore user needs and use of outputs and dialogue / co-construction [C]

Additional comments

- Including international links with researchers can move everything → top right
- C – modelling exercises and guides to model exercises
- D – including unexpected consequences
- F links to B
- G links to B
- H could include biosecurity
- J links with A+L – needs to be full w/pack just tacked on – hard to do
- L links to A
- M guiding for policy – ways of talking about models
- not convinced NERC or EPSRC the way to go – others in group agreed
- If include more wildlife rewilding enough makes this a completely different grant
- Increase AHRC arts as communication tool

Conclusion and going forward

The work of ELUCIDATE established that there would be value in a deeper, more systematic exploration of modelling practice and the science/policy interface via ethnographic methods. Exploring why users come to trust the outputs from some models, and, perhaps not others, and whether there are changes to the practice of modelling which would support the generation of justified trust, will be valuable. Democratising the production of models through for instance, participatory modelling will support many of the wider objectives identified in ELUCIDATE, as well as being valuable in its own terms. Some technical aspects of modelling practice would benefit from further research into methodological and technical approaches: addressing issues such as transferability and explainability of models. This work will benefit by being reframed via a Science and Technology Studies perspective. Engaging more with potential audiences, via tailoring messages and language specifically for each audience, including new ways of communication such as cartoons, gaming, artists, and AI experts, could lead to better understanding and enhance the credibility of models. In general, most of the insights of the ELUCIDATE RIGs have been integrated into the ELUCIDATE II proposal, subject only to budget constraints and the need to formulate a cohesive workplan.

A proposal has been submitted to UKRI for the next stage ELUCIDATE, to build on the research questions and ideas discussed here that project partners would like to consider and explore further.

Who would like to be involved in taking these ideas further?

Offer	Your name or badge number	Definite commitment	In principle	Don't hesitate to ask
(D) Cannot dedicate time but work with wildlife modellers so could feed in	1, 34		✓✓	
(D) Already doing some of this work and involved with Scottish Government	29		✓	
(D) Have interest but not sure what I can bring	22			✓
(H) have time to contribute	32		✓	
(H) interest	29		✓	
(J) have some time	1		✓	
(J) interest	29		✓	
(C+I) interested	29, 22		✓✓	
(C+I) happy to be involved	32, 1, 34			✓✓✓
(G) happy to be involved	29		✓	
(G) may have some time for this	32			✓ if the time is coming
Data infrastructure / pipeline (eg data linkage)	Ting	✓	✓	✓
One health involving human health epidemiology	Ting	✓	✓	✓
Framework protocol in responding to outbreaks	Ting	✓	✓	✓
Lessons learnt from work with policy-makers	Ting	✓	✓	✓
Social scientific expertise	Niamh			
Experience working with artistic practitioners	Niamh			
Participatory methods	Max		✓	
Multispecies in modelling (social science perspective)	Max		✓	
Expertise in Maths and computing, QA, SE, AI	Jess	✓	✓	✓
Some writing time in the next few months	Jess	✓	✓	✓
Links to humans via SPI-M, Juniper Networks	Jess	✓	✓	✓
Maths communication and outreach, link to math-sci-comm network, plus maths team	Jess	✓	✓	✓

NERC-staff (vectors / environment), Communications and translation of science > policy, coordination	Lucy	✓ (if needed)	✓	✓
Coordination helping out	Lucy			✓
Writing and EU aspects and further down this line and human health	Matt			
Involved in writing proposal but that's all	Giles			
Lead writing proposal	Lukas			
Interested in policy bits	Harriet			
Interested in being involved	Stephen			
Can't write proposal happy to be involved further down the line	David			
Interested in writing and further down the line	Sam			

Acknowledgements



We would like to thank Dialogue Matters for their help in designing and running this workshop, and all the participants for taking the time to share their knowledge and ideas, Alba Juarez-Bourke and (James Hutton Institute) for her help in facilitating and UKRI for funding this project.

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ANNEX1. List of participant affiliations

Affiliation	Male	Female
APHA	1	
BIOSS	4	
Farmers	2	
James Hutton Institute		1
Third sector organisations	1	1
University of Edinburgh	2	3
University of Glasgow		4
University of Copenhagen	1	

ANNEX 2- Literature review presentation

ELUCIDATE

Narrative literature review on design, communication and use of models at the science policy interface

Orla Shortall, Niamh Mahon, Emma Coffey



Aims of the lit review

1. Provide a **summary of the social sciences literature** on models and modelling in policy making for the members of the ELUCIDATE project
2. To aid in **identifying gaps in the literature** that could be used to develop research questions for the next stage of the project

Lit review focused on social sciences literature on:

- The **design and development** of models
- The **use of models** and model results by policy makers
- The **communication and representation** of models

Methods

Narrative literature review of **52 papers**

Literature consisted of:

- Papers considered "key" (4)
- Litmaps search to identify literature that cite/are cited by key papers (24)
- Papers by members of the ELUCIDATE consortium (10)
- Snowball sampling of references identified in papers (7)
- Literature from missing/under-represented areas (7)

EC, NM, OS analysed the literature using NVIVO and wrote summaries.

Nodes	% Nodes
Model choice and design	100%
History of modelling	100%
Anticipatory modelling	100%
Outbreak and community over model choice and design	100%
Modelers and people who do modelling	100%
Communication and representation of models	100%
Use of models and model results	100%
Benefits of models	100%
Validation of models	100%
Model calibration	100%
Test and rigour of models	100%
How MOSES can be moved out of here once everyone is happy with them	100%
What is a model	100%
Papers are chosen primarily on basis	100%

Results

- Using Litmaps generated a certain amount of randomness in the paper selection – **eclectic mix of disciplines and perspectives**
- A lot of coverage of modelling in the **FMD outbreak**
- Animal health but also modelling in hydrology, ecology, climate change, public health and risk

Results - Use of models and model results by policy makers

- **Different model functions** – Contingency planning, understand past outbreaks, deciding how to respond to an outbreak, providing “evidence”/ “certainty” in times of chaos
- **Challenges** – choices and assumptions in models can become obscured while at the same time models may promoted as producing “objective truths”
- **Trust and legitimacy of models** – models may gain greater legitimacy the more they’re used. How does this happen, how do challenges to this legitimacy take place?

Results – Design and development of models

- The design of models may be scrutinised if **model use becomes controversial**, e.g., FMD, covid, climate change
- **Participatory modelling** can democratise the design and use of models
- **FMD** is when modelling replaced veterinary risk assessment as a policy driver
- **Modeller “subjectivity”**: Cultural differences between modellers and “boots on the ground vets”
- How has modeller subjectivity changed since FMD, **how do modellers view their profession**, how do they process their ‘duty of care’?

Results – Communication and representation of models

- Communicating models is difficult because there’s **a need to establish the authority of the model and modeller** and also highlight the decision making and uncertainty involved in its design
- In Covid the public and media communicated about models like never before, modellers and models held aloft and torn down

Reflections








- We didn’t include much of the work on climate change modelling
- Scope to explore democratising processes like participatory modelling
- These are slow and labour intensive
- Feedback welcome
- Read the full lit review

ANNEX 3 – RIGs presentations

ELUCIDATE RIG A/B

Development and use of models and modelling as evidence at the science-policy interface

Harriet Auty, Lisa Boden, Lukas Englemann, Lucy Gilbert, Kari Lancaster, Sam Lycett, Kimberly Lyons, Niamh Mahon, Louise Matthews, Iain McKendrick, Sibylle Mohr, Davide Pagnossin, Orla Shortall, Tarek Soliman, Abigail Woods

What is RIG A/B about?

Development and use of models and modelling as evidence at the science-policy interface.

- RIG A/B combines:
 - **RIG A:** Understand model development and use by researchers and policymakers, and
 - **RIG B:** Models as 'evidence' at the science/policy interface.
- We combined because our interests were inter-related and for logistical reasons. History **RIG D** joined the discussions but will present separately.
- We met four times.
- The RIG is about **the production, communication, legitimisation and use of models (and modellers) for preparing for animal disease outbreaks at the science-policy interface.**

Ideas for next stage: 1.

Model Cards and Model Repository

(Lucas Englemann, Sam Lycett)

- **Model Cards** to aid transparency and trust in using models for policy questions
 - Model cards describe the model (Michel 2018)
 - Suggest include a Model ethics side as well as a technical side (Boden & McKendrick 2017)
- **Model Repository** for Epidemiological - Policy relevant models
 - Model code and example data, and Model card
 - Database would be searchable
 - Use of controlled ontologies to help with search, history and provenance of models

Model Card	
Model Details Inputs / Outputs Features Data, Testing Validation	Model Ethics Independence Transparency Beneficence Justice

Boden LA, McKendrick IJ. Model-Based Policymaking: A Framework to Promote Ethical "Good Practice" in Mathematical Modeling for Public Health Policymaking. *Front Public Health*. 2017 Apr 5;5:68. <https://pubmed.ncbi.nlm.nih.gov/28424768/>

Mitchell et al "Model Cards for Model Reporting" (2018) FAT* '19: Proceedings of the Conference on Fairness, Accountability, and Transparency <https://doi.org/10.1145/3287566.3287595> <https://arxiv.org/abs/1810.03993>

Ideas for next stage: 2.

Model (and modeller) trust & legitimacy

(Kari Lancaster, Niamh Mahon, Lucy Gilbert)

- **Explore participatory modelling** – including non-modellers in the design and use of models, possibly with a table-top exercise
- **The work of modellers** – How is authority of modellers (as individuals/groups/lineages/dynasties), of modelling (as an act), and of models (as useful objects) built and subsequently maintained? How does the legitimacy of and trust in a model/modeller change over time, what happens when this is challenged (building on Lisa and Iain's paper).
- **Communication between modellers and policy makers** – The perceived objectivity and certainty of modelling versus the acknowledgement of the uncertainties and limitations of what models and modelling can achieve. How can/do modellers communicate this nuance without undermining their work? How do they learn to do this work/acquire these skills in communication with policy makers? How do they know/understand when they are successful?
- **Use of models by policy/decision makers** – The outputs of models, especially mathematical models as providing 'a way of knowing' and legitimising certain actions (building on Kari's work)

ELUCIDATE RIG E

Develop use of models for qualitative support for policy

Iain McKendrick, Glenn Marion, Louise Matthews, Dave Ewing, Sibylle Mohr, Harriet Auty
(apologies to the rest of the RIG, who may not want to be associated with the content....)



What is the RIG about?

- Trying to better understand how we use models in different ways for different purposes
- Exploring the apparent contradiction that
 - modelling is an inherently quantitative activity
 - but there are diminishing returns in thinking too quantitatively about outputs
- The difference between forecasting/predicting and exploring scenarios

What the RIG discussed

- The unhelpful way in which 'modelling' covers so many different activities and motivations
 - 'Forecasting', empirical statistical modelling, toy models, process models
- The concept of 'generalisability' (in conflict with 'over fitting')
 - An important, often neglected, concept in statistics
 - Models need to be based on replicates drawn from the population across with we wish to generalise
 - Is there an analogous concept for modelling: across different situations, different places, near future, distant future?...
 - How does this apply to model assumptions? How does it apply to validation? Are all aspects of a model equally generalisable?
- The concept of 'richness' in the model space
 - Whether the inclusion of more 'detail' in the model makes it
 - More or less suited to some activities, such as forecasting, digital twinning
 - More generalisable?...

Ideas for next stage

- Link more strongly to Corinna's 'justified stories' research
- Explore further whether model 'richness' and 'generalisability' are useful concepts
 - Especially whether they align with concepts from other RIGs
 - When do models need to be generalisable?
 - What aspects of models are more readily generalisable?
 - (eg Qualitative Behaviours?)
 - What about emergent behaviour in models?
 - Does this link to thinking about model uncertainty?
- Use these concepts to develop strategies for when and how to use quantitative models as qualitative tools

ELUCIDATE RIG E-2

Thinking about the Modelling Process, Models and their Outputs
from a Epistemological Perspective

Corinna Elsenbroich & Iain McKendrick



What is the RIG about?

- To explore the consequences for modelling practice, our understanding of models as entities and how we interpret model outputs of **a perspective informed by the philosophy of knowledge** (epistemology)
- What is the nature of the knowledge resulting from a model?
 - Is it empirical (e.g. statistical models are a summary of empirical data)
 - If not empirical, what is it?
- How does the knowledge resulting from a model relate to action?
 - Can models help us understand the real world?
 - If so, what are the properties of this understanding?
 - Can models predict?

What the RIG discussed

- Knowledge as “justified true belief” (a classical definition)
- Models as exemplars of contingent truth
 - awareness of the limitations of a model should be central to practice
 - an aspect of a model may be true only in some times and places
 - some aspects of a model may be recognised as ‘not true’ but adequate for the purpose
- How do models interact with other knowledge and evidence?
 - How is “justified true belief” constructed?
 - Intrinsic strength of the assumptions and arguments in the model
 - Validation with respect to real world observations
 - But how should these be weighed, and how should they interact?

Ideas for next stage

- Seek to formalise these ideas relative to different schools of epistemology
- To consider how these ideas generalise across a wider range of models, such as
 - Agent-based models
 - Classical statistical, inferentially oriented models
 - Machine learning models
 - Multi-criteria decision analysis.
- Exemplar questions:
 - What do we learn from comparing the output from two models?
 - What do we learn when we compare model output with real world observations?
 - What do we learn from use of a model?
- To improve understanding of, and drive change in, modelling practice, based on fundamental philosophical principles.



RIG F: overcoming barriers to the use of advanced modelling methodologies

Stephen Catterall, Matt Denwood, Sam Lycett & Glenn Marion

What is this RIG about?

- Given a problem, modellers can apply many different models
- If a model is to be used then
 - It needs to be within the domain of expertise of the modeller
 - To what extent should other stakeholders be able to understand the model?
 - Is there more that modellers can do to translate 'advanced' models?

Three examples which we kept in mind

- Differential equation SIR transmission models – some aspects of the model are easy to understand
- Complex agent-based models – easy to understand the underlying processes, they produce very detailed outputs but uncertainty is hard to quantify
- AI models – not easy to understand the model itself, but focus is more on its output/predictions – but again uncertainty is hard to quantify

What we discussed

- As a modeller, we can choose something 'off-the-shelf' if time is pressing, but if less constrained by time then we can put more effort into the development of perhaps less familiar models
- These ideas led to the concept of a four (?) dimensional space of modelling approaches, with the four axes being model complexity, speed (time available for modelling), realism and available data
- Where the modeller chooses to be in this space is partly determined by external constraints e.g. at what stage we're at in a disease outbreak
- Also, has implications for the communication of the modelling to policy makers

What we'd like to focus on...

- Choose exemplar models from different regions of model space
- Consider what could be done to 'translate' these models
 - To what extent is it helpful for policymakers to understand a model?
 - Or do we only worry about understanding the model *outputs*?
 - How is modelled uncertainty and structural uncertainty managed?

ELUCIDATE RIG C

Understanding the needs of users within the policy cycle/epidemic response cycle



What did the RIG look at?

- What questions that policy makers would have at different phases, and what tools could be used
 - Needs of policy makers
 - Needs at different points of epidemic cycle
- Anticipating use cases, but also communication, translation, brokering
- EPIC has worked on some aspects of this since 2011
 - Disease exercises
 - Disease outbreaks
 - C1/C4 activity in current EPIC programme
 - Iain and Thibaud - modelling cycle, characteristics of useful models at different points in the cycle, drivers of different modelling outcomes

Between outbreaks

Advice on possible control, based on models of disease
 Advice on surveillance for disease incursion
 Monitoring and modelling spread in other countries to identify risk of incursion/high risk areas

Early outbreak

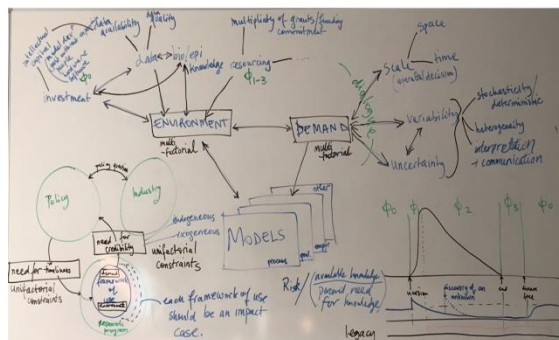
Contact tracing
 Modelling disease incursion and spread
 How fast is it spreading (geographically/ between units)
 Identifying risk free areas

During an outbreak

Inform restrictions, regionalisation
 Inform control, restrictions, licensing (risk assessment)
 How will people behave/comply
 Identify likely incursion date and routes of transmission
 Predict scale, spread, high risk areas/premises
 Quantify impacts of interventions to mitigate outbreak
 Cost/benefits of control measures/ outcomes

Late outbreak

When is the outbreak likely to finish?
 Methods for declaring disease freedom
 Surveillance strategies
 Inform lifting of regional movement controls



Where next?

- So far focused on 'what' is needed 'when'
- What does that mean for different disease and scenario contexts?
- Who needs it, who decides what the questions are?
 - Role of policy, industry/farmers, researchers
 - Co-construction of questions, understanding of policy – brokering
- What outputs/how communicated?
 - Communication, translation, directionality
- Exploring these questions with policy-makers and others

ELUCIDATE RIG A/D

Understanding past development and use of models in epidemic management

Lukas Englemann, Iain Mckendrick, Abigail Woods



What is the RIG about?

- To explore whether and how historical analyses of
 - the development of modelling methodologies
 - the use of models in epidemic response, especially in major outbreakscould best inform epidemic preparedness.
- In particular
 - Why did some models gain traction in the scientific or in the policy communities? Why not?
 - What are the most salient drivers of these trajectories?
 - Are the drivers specific to time and place, or more general? Have they changed over time?

What the RIG discussed

- We hypothesised that 'traction' is a function of
 - Model characteristics, **and/or** perceptions of model characteristics
 - Relevance to question(s) of interest
 - Mathematical formulation
 - Breadth and 'richness' of model characterisation and outputs
 - Availability of data
 - Ease of implementation
 - Accessibility to non-specialists
 - Authority from other domains of use ('domain independence')
 - Who is proposing the model
 - Authority, and the nature of this authority
 - Access to power and resources
 - Growth and survival of (and membership or exclusion from) modelling milieus
 - Who is commissioning/needing the model
 - Characteristics/background of policy communities
 - Motivation of policy communities
 - Interaction of different aspects of authority and power

Ideas for next stage

- Collection of primary source materials: interviews with key figures in policy (eg Jim Scudamore, Leslie Gardner) and model development (eg Roy Anderson ?, Frank Ball ?, others)
- Exploration of historical processes. A parallel focus on
 - exemplar pathogens (brucellosis; FMD 1967, 2001, 2007; BSE/nv-CJD; bluetongue; bTB; avian influenza): what models were proposed and used to inform responses?
 - different modelling milieus/cultures/ lineages (the Silwood circle; Central Vet Lab / University of Reading; other groups, to be identified, who maybe tried and failed to gain traction) and how these competed and interacted and gained or lost traction with policy audiences?



RIG G: WHAT CAN WE LEARN FROM OTHER OUTBREAKS

Dave Ewing, Matt Denwood, Stephen Catterall
& Giles Innocent

UPDATING MODELS

- Models from other outbreaks likely to be wrong (and maybe not even useful):
 - Wrong parameter values
 - Wrong transmission mechanism
 - Wrong animal management structure
 - Potential solutions
 - Bayesian updater?
 - Ensemble models?
 - Challenges:
 - How early can we use data to evidence that the model is wrong?
 - Can we ever use data to evidence that the model is right?
 - Is there a place for multiple models with increasing complexity as data becomes available, or should we just use the best guess model "off the shelf" as it is most likely to best demonstrate the consequences of infection and control?
-

MODEL-HUMAN INTERACTIONS

- "All models are wrong, but some are useful" George Box, 1976; Peter McCullagh and John Nelder, 1983; M.R. Nester, 1996.
 - How do we explain that predictions are just that: predictions?
 - "The shape of things to come" Vs "Follow the yellow brick road."
 - "There are likely to be..." Vs "There will be ..."
 - Separation of variability vs modelled uncertainty (parameter values) vs structural uncertainty (maybe the model is wrong)
 - What do we do when things go wrong: we "fix" the model
 - How do policy colleagues feel?
 - Do we lose the trust of the public?
 - Conversely modellers have **more** trust in the new model.
 - Should we completely ignore previous model results?
 - Can we as modellers learn not to make the same mistakes as in other outbreaks?
-

TIMING

- Links to RIG C
 - Is the same model appropriate all the time?
 - Early in epidemic: little data
 - Simple models?
 - Use models built and parameterised on "other" outbreaks?
 - In the middle of an ongoing outbreak
 - Complex models fitted to data.
 - Do we have time for models?
 - What do policy makers want/expect from models?
 - At the end of an outbreak
 - Where should we look?
 - How hard should we look?
 - When do we stop looking?
 - All potential modelling questions.
-

ANNEX 4- Phase II – ElucidatED presentation

elucidatED

UKRI Call for Interdisciplinary Research to tackle
epidemic threats

Phase II

Scope

- Improve our understanding of factors that influence the risk and severity of infectious disease threats
- A social and behavioural research perspective is encouraged; exploring role of economic factors, culture and other humanities
- Inform new ways to manage and respond to infectious disease threats
- Must be in scope of at least three research councils
- Funding for research in key areas where there is a clear epidemic threat
- Funded projects are expected to become national or international focal points for epidemic-relevant interdisciplinary research in their chosen area, incl. positive and tangible impact
- Ambitiously interdisciplinary and cross the distinct disciplinary remits of at least three UKRI research councils.
- Working together with communities, people with lived experience, practitioners and policy makers and other stakeholders is encouraged
- 'One Health' and 'Planetary Health' framing are encouraged where appropriate

Out of Scope

- single discipline research programmes that lack interdisciplinary integration, perspectives or approaches
- applications that do not cover the disciplinary remits of at least three UKRI research councils
- projects that do not embed the research and innovation community in the process
- development or evaluation of agrochemicals, diagnostics, therapeutics and vaccines, and vaccine/diagnostic technology platforms
- projects related to antimicrobial resistance
- operationalisation of public health and social health measures
- health systems research where the project objectives are not directly relevant to the understanding, prediction or prevention of infectious disease threats
- disease surveillance; such work could only be eligible as a minor, facilitating component if critical to enable a wider holistic programme of research. In such instances we would expect evidence of sustainability through relevant government agency or ministry support
- pests and parasites that affect humans, animals or plants but do not transmit or cause disease

Logistics

- Closing date: 19 June 2025 4:00pm
- 24 April 2025 11:00am Webinar
- Total funding is 20 mil, 3.75 mil per application
- Costs for partnerships and stakeholders are permissible
- Max of five years duration
- Finalised application due on **5th June 2025** for Edinburgh Research Office

Phase I projects

- **Transforming the humble brick**, Ann Kelly, Oxford
- **BuildAir**, University of Birmingham
- **Mobilising Scotland's assets in equitable ways for epidemic control**, Paul Flowers and Dr Ruairidh Clark, University of Strathclyde
- **One health computational network**, MRC-University of Glasgow Centre for Virus Research
- **PrepSense**, Steven White at UK Centre for Ecology and Hydrology and Stephen Parnell, The University of Warwick
- **Zoonotic influenza preparedness: a transdisciplinary one health approach**, Dr Syed Abbas, Dr Ayako Ebata, UK Institute of Development Studies
- **Seeking better understanding of human interactions**, Jonathan Read, Lancaster University, Kavita Vedhara, Cardiff University
- **Wastewater**, Davey Jones, Bangor University
- **Tackling vector borne diseases in the Caribbean**, Jonathan Lines, LSHTM
- **Balancing the health, economic and social impacts of disease and our response to them**, John Edmunds, LSHTM
- **Preparing agriculture for vector-borne viral and bacterial epidemics**, James Bell at the Keele University