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Livestock Health and Food Chain Risk Assessment

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Abstract

The EUFORA fellowship programme 'Livestock Health and Food Chain Risk Assessment' was proposed by the Animal and Plant Health Agency (APHA), a British governmental institution responsible for safeguarding animal and plant health in the UK. The working programme, which was organised into four different modules, covered a wide range of aspects related to risk assessment including identification of emerging risks, risk prioritisation methods, scanning surveillance, food production exposure assessment and import risk assessment of animal and human infectious diseases. Over the course of the year, the Fellow had the opportunity to work for international projects with experts in these disciplines. This allowed for significant opportunities to 'learn-by-doing' the methods and the techniques that are employed to assess animal health and food safety risks. Moreover, he consolidated his knowledge by attending several training courses and academic lessons, submitting scientific papers to peer-reviewed journals and conferences, giving presentations and using modelling software.

Keywords: livestock health, food chain, risk assessment

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1. Introduction

The working programme 'Livestock Health and Food Chain Risk Assessment' was proposed for the EUFORA fellowship programme by the Animal and Plant Health Agency (APHA). APHA is a UK government agency that is responsible for 'safeguarding animal and plant health for the benefit of people, the environment and the economy' at the national level (APHA, 2018). To meet this goal, the Agency carries out numerous activities such as providing high-level laboratory services for private and public bodies, and support and technical advice for UK institutions and scientific research. Among these activities, animal health and food safety risk assessment represent two of the most important/strategic areas, as shown by the fact that many projects at APHA within these disciplines are regularly funded by national or European Union (EU) institutions. The Department of Epidemiological Sciences (DES), and in particular, its Biomathematics and Risk Research workgroup (BRR), is the core area within the agency for risk assessment activities, which are routinely performed over the year. The Fellow was part of the BRR group over the duration of the fellowship. He had the opportunity to collaborate with the staff (around 14 staff skilled in the disciplines of statistics, modelling and risk assessment) as well as to attend several events such as presentations, training courses and project-related meetings.

The working programme covered a wide range of aspects related to risk assessment and was organised into four different modules. A main supervisor was responsible for the general monitoring of the programme, while a specialist supervisor tutored the Fellow for each module. Some of the programme activities were conducted with the support of other organisations such as the Department of Environment, Food and Rural Affairs (DEFRA) and the Royal Veterinary College (RVC).

Module 1 was titled 'Principles and Terminology of Quantitative and Qualitative Risk Assessment'. It can be considered the foundational part of the whole project and it had the scope to consolidate the knowledge of the Fellow regarding the aims, structure and basic methodologies of animal health and food risk assessment.

The second module mainly focused on the different risk ranking methods ('Hazard Identification and Risk Prioritisation Methods'). Using evidence-based and objective criteria, risk ranking techniques are frequently employed to identify and prioritise those animal diseases or food hazards that merit specific and timely attention from the risk manager and consequently help them decide how best to allocate the resources available to prevent and/or control interventions. In the UK, several tools that prioritise those pathogens of highest risk have been designed and are regularly updated and maintained. The outputs feed into specific contingency plans within the Outbreak National Response (Del Rio Vilas et al., 2013; Gibbens et al., 2016). Some of the Fellow's tasks were exploring and understanding the criteria and applying these models in practice, giving him a good basis for the subsequent development of his own model. A further part of the module programme consisted of investigating the horizon-scanning methods routinely undertaken to ensure emerging issues are captured.

Module 3, 'Food Production Exposure Assessment', was devoted to studying the behaviour of food-borne pathogens along the food chain. For this purpose, a 'farm-to-fork' simulation developed for EFSA by a consortium led by APHA was used by the Fellow to acquire and analyse knowledge regarding the methods and basic processes that determine the exposure modelling.

Finally, module 4, 'Food Import Risk Assessment', included both qualitative and quantitative methodologies frequently used by risk assessors to estimate the risk of importing a livestock or zoonotic pathogen along with foodstuffs from foreign countries.

2. Description of work programme

2.1. Aims

The work programme for the Fellow comprised four modules, each with different aims:

- Module 1: To obtain an understanding of the basic principles of both qualitative and quantitative risk assessment and how to go about implementing some of the methods in practice.
- Module 2: To acquire a full understanding of the tools available to rank risks that threaten animal and public health, and knowledge of how they can be incorporated into a working schedule at a national level. As a deliverable, it was expected to build an own-risk ranking tool and submit a scientific manuscript to a scientific journal.
- Module 3: To gain an appreciation of the different risk assessment models and techniques available to assess various risk questions that occur in the political area associated with food-

borne risks and evaluation of the efficiency of control measures. As a deliverable, a country-specific risk assessment for *Salmonella* based on data from each member state was expected to be created.

- Module 4: Food import risk assessment: to gain a substantial understanding of the tools that can be developed to assess spatial risks and threats, learn spatial risk assessment techniques and determine the availability of public data sets that aid European risk assessments.

2.2. Activities/methods

Module 1: Principles and Terminology of Quantitative and Qualitative Risk Assessment

As an initial task, this preliminary module planned a literature review of the most important documents regarding the standard methodologies internationally adopted for animal health and safety food risk assessment. In particular, important international guidance and widely recognised books were selected and became the object of study for the Fellow (OIE, 2004; Codex Alimentarius, 2007; Vose, 2008). Over the year, the Fellow had periodic opportunities to discuss the different components of the risk assessment process with the supervisors and the other risk analysts from the BRR staff (e.g. aim/question, framework, modelling techniques, biomathematics, probability distributions, etc.).

The working programme included attendance at the risk assessment lectures organised during the MSc in Veterinary Epidemiology at the Royal Veterinary College. The training, concerning both qualitative and quantitative risk assessment, consisted of an initial theoretical part followed by a group practical session. The first practical session (about qualitative risk) requested attendees to estimate the annual risk of introduction of Crimean Congo haemorrhagic fever virus (CCHFV) into the UK from Spain and the eventual risk of human infection. The second practical consisted of a series of case studies for which the Fellow was asked to quantify the risk of importing an exotic animal disease and explore potential mitigation measures using quantitative techniques.

Over the fellowship period, the Fellow also participated in several training courses and presentations at APHA headquarters related to risk assessment. In particular, he attended the National Emergency Epidemiology Group (NEEG) Annual Meeting during which, together with other APHA operators, he acquired knowledge regarding the application of risk assessment and management procedures during an ongoing veterinary emergency. The Fellow was also invited to be an observer at meetings of the Human–Animal Infections and Risk Surveillance Group (HAIRS) and the Veterinary Risk Group (VRG) from DEFRA. The two groups include members of the most important health, agricultural and environmental agencies in the UK, and meet periodically to identify, discuss and assess potential emerging zoonotic diseases (HAIRS) and new animal health threats (VRG). For these reasons, the meetings were an excellent opportunity for the Fellow to see risk assessment methodologies applied to real situations.

Finally, as suggested by the Fellow, a part of the module was dedicated to training him in the use of R software, which is widely employed to create quantitative simulations. Since several members of the BRR group are able to code in R, many risk analysts contributed to the training and communicated their experiences of previous risk assessment projects.

Module 2: Hazard Identification and Risk Prioritisation Methods

The first part of the module was dedicated to an extensive literature review of risk ranking methods and tools used in the field of food and animal health risk assessment. In this respect, the European Food Safety Authority (EFSA) has published two comprehensive opinions regarding the development of a risk ranking framework on biological hazards, the performance of the most common tools, and assessment of uncertainty in this context (EFSA BIOHAZ Panel, 2012, 2015). Some tools such as Risk Ranger, iRisk and the ECDC Burden of Communicable Diseases in Europe toolkit were studied in detail and their application simulated through case studies based on data from the Fellow's country of origin.

Furthermore, beyond the food safety aspects, the working programme also included aspects related to animal health. In this regard, the EFSA web seminar on rapid risk assessment tools for animal disease outbreaks was particularly useful. This gave the Fellow an overview of some models used in different EU countries to evaluate the importance of potential exotic diseases (EFSA, 2017).

Nevertheless, the module was mainly focused on the exploration of the several tools/frameworks that are routinely used to prioritise the impact of endemic or non-endemic disease on the UK. One of those, D2R2, aims to rank several endemic pathogens based on the available evidence and data. Five different areas are assessed (public health, welfare of animals, interests of the wider economy, environment and society, and international trade) and an additional module regarding potential

post-mitigation measures. D2R2 includes a long list of diseases (endemic and exotic) that are ranked separately for each of the potential animal species involved (Gibbens et al., 2016).

ETHiR is a risk ranking framework used mainly for emerging or new threats/vulnerabilities, with the goal of estimating their probability of occurrence and economic impact. It is meant for new threats, described as the 'risk resulting from a newly identified hazard to which a significant exposure may occur or from an unexpected new or increased significant exposure and/or susceptibility to a known hazard'. ETHiR uses a scoring system to assess several factors (e.g. public health impact, public concern, potential countermeasure, etc.) and it is used by the Veterinary Risk Group in the UK (Kosmider et al., 2017).

Finally, particular attention was given to the IDM risk of incursion tool (Roberts et al., 2011; EFSA, 2017). This ranks many exotic diseases (34 for the August 2017 revision) on the basis of their estimated probability of entry into the UK. To perform this, a score is attributed to each disease, weighting the potential import routes (live animals trade, food trade, etc.), using available data (e.g. volume of trade from an infected area) or expert opinions. Risk of incursion is periodically updated by DEFRA to monitor the risk of importing disease, and the reports are sent to APHA, policymakers and a wider government audience including the Cabinet Office and UK Border Agency (Roberts et al., 2011). The present version of the risk of incursion tool uses a Microsoft Excel® spreadsheet (Microsoft Corporation, Redmond, WA, USA, v. 2010). One of the tasks of the Fellow was to convert the tool to R language to simplify the updating process and make it possible in the future to download the data of interest from defined sources and automatically update the results (SPARE Project Group, 2016).

A further task of the Fellow was to develop a version of the tool (using his country as a case study) that supported the authorities in border surveillance for those pathogens with higher probabilities of entry. A selection approach, taken from the EU SPARE project (SPARE, 2016; Horigan et al., 2018), was applied to produce a list of infectious diseases that are non-endemic to Italy and subject to World Organisation for Animal Health (OIE) notification. The world was divided into different areas and OIE data used to assign a score related to the prevalence of each disease in the animal population. Several possible pathways for pathogen introduction were considered: trade in live animals, foodstuffs, and germplasm; vectors; and the movements of people and wild animals. For each pathogen, a score was calculated to estimate the probability of incursion of the pathogen through each potential pathway. The scores were based on data retrieved from EU databases or published scientific research. The volume of live animal and foodstuff imports to Italy from a particular area were retrieved from COMEXT (2018) and TRACES (European Commission, 2018) to estimate the potential likelihood of entry of the different pathogens through an associated commodity. Information regarding aircraft/ship/truck movements (EUROSTAT, 2018), certain types of commodities (COMEXT, 2018) and wind streams were used to evaluate the probability of entry of an infected vector. The tool used data from EUROSTAT regarding annual people movement in Italy and from the DG SANTE website (https://ec.europa.eu/info/departments/health-and-food-safety_en) for information on collection centres authorised to import semen and embryos. Dispersal of terrestrial wild animals and bird migration were assessed, considering, respectively, the proximity of the studied areas to Italy and the different flight paths used by migratory birds (EFSA AHAW Panel, 2005; Stroud et al., 2004). No score was attributed to a pathogen when a pathway was considered of negligible importance because it was not a biologically plausible means of transmission. Finally, an algorithm was proposed to calculate an overall risk score for each pathogen:

$$\sum_{p=1}^{n} \text{Pathway (d, p)} = \frac{\sum_{i=1}^{n} \text{Area status (i, d)} \times \text{score (i, s)}}{\text{Pathway maximum risk}}$$

where Pathway is the overall disease score of the p pathway for the given pathogen, d; Area status is the disease score for that pathogen in the area, i; Score is the value attributed to an area for the species/commodities/risk factor, s, that can potentially cause the entry of the given pathogen. The score was standardised by dividing by the *Pathway maximum risk* that was defined for each pathway as the highest score among the considered diseases. Figure 1 shows a schematic representation of the method applied.

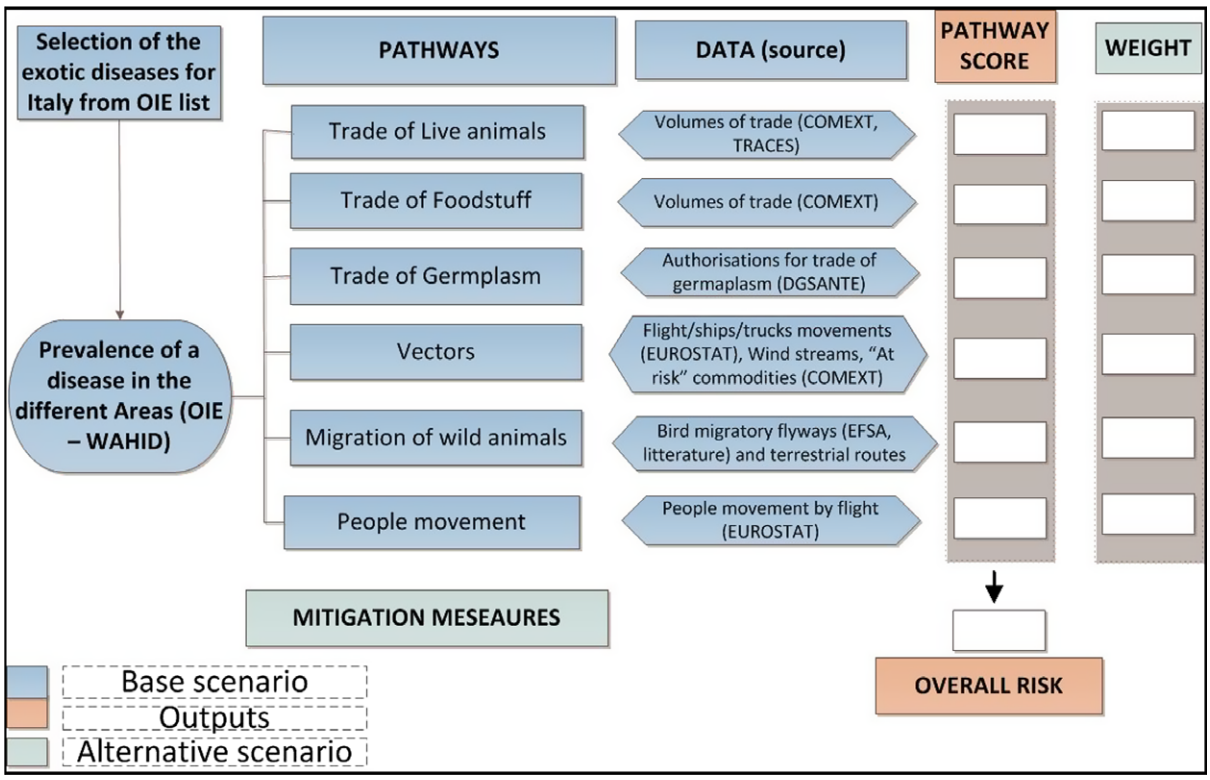

Figure 1: Schematic representation of risk ranking approach

The last part of module 2 was dedicated to exploring horizon scanning methods. Horizon scanning is a routine activity that aims to improve the situational awareness of decision-makers across the government, thus allowing governments to be more anticipatory in their responses to natural hazards and reduce the impacts of future disasters. In the UK, in addition to APHA, three further agencies (Met Office, British Geological Survey and Public Health England) work in coordination to produce periodic reports on new, emerging or deteriorating situations regarding global natural/climate disasters, animal health and human public health issues. The Fellow was instructed on the structure and layout of the report, the information sources usually consulted by APHA and the methodology used by them to complete all parts of the report. He gave a presentation on 'Identification of animal health emerging risks in the UK' during a summer school organised by EFSA and the University of Parma (16 May 2018, Parma, Italy).

Module 3: Food Production Exposure Assessment

The third module 'Food Production Exposure Assessment' involved studying and properly running a 'farm-to-consumption' simulation to understand how the different basic processes of a quantitative microbiological risk assessment (QMRA) could be applied to modelling the variations in prevalence and concentration of a pathogen (Nauta, 2002). To this purpose, a QMRA was employed on '*Salmonella* in Slaughter and Breeder Pigs' developed for EFSA by a European Consortium led by APHA (Hill et al., 2016a,b; Simons et al., 2016; Snary et al., 2016a,b; Swart et al., 2016a,b; Vigre et al., 2016a,b). The model deals with four European countries and, as main output, it calculates the risk of human salmonellosis associated with the consumption of fresh pork cuts, minced meat and fermented sausage. The first task of the Fellow was to understand the workings of the simulation and the technical solutions that were adopted to model the exposures. The second task was to find specific information for the country-specific parameters of the simulation to generate an alternative scenario concerning Italy. Whenever possible, the retrieved data were manipulated to generate probability distributions. For this reason, the Fellow learnt what distributions are usually adopted to model certain type of biological events/phenomena in a risk assessment process and how to select them based on data availability and widely accepted scientific criteria. In addition, several tools were applied to fit the data (e.g. R software, Matlab scripts). Finally, the simulation was implemented using the new data and the results compared with those of the other countries.

Module 4: Food Import Risk Assessment

To meet the objective of module 4 'Food Import Risk Assessment', the Fellow collaborated with several members of the BRR group on two different projects. The first was a qualitative risk assessment commissioned by DEFRA. Working alongside colleagues who were performing the risk assessment for the UK, the Fellow performed a risk assessment for his own country. It focused on the risk of introduction of transmissible spongiform encephalopathies through unusual domestic animals such as camels. The second project involved collaborating on one of the tasks within COMPARE, an EU-funded Horizon 2020 project. The task in question concerned the development of a generic and spatial quantitative risk assessment framework that could estimate the risk of introduction and spread of exotic diseases into new areas that would be applicable to any disease, pathway or area. The Fellow worked with others in BRR to develop the food importation pathway and estimate the risk of importing a zoonotic or animal disease through the importation of foodstuffs, based upon pathways that had previously been developed within COMPARE. To do this, the Fellow acquired and refined skills in data extraction and comprehension, understanding of the risk assessment framework specifically within a generic setting, and modelling quantitative import risks using R software.

3. Conclusions

The working programme 'Livestock Health and Food Chain Risk Assessment' was an opportunity for the Fellow to consolidate and broaden his knowledge of risk assessment. Several aspects of qualitative risk assessment were examined in depth (e.g. identification of the pathways and consequent tree scenario definition) and practical means/tools such as risk tables, procedures and report layouts were provided and applied to simulate risk case situations (modules 1 and 4). Studying the elements of animal health risk assessment was a relevant part of the programme, and the Fellow not only acquired the theoretical bases but he also had the opportunity to apply them in practice (modules 1, 2 and 4). In particular, the different phases of import risk analysis (OIE, 2004) were examined in detail and combined with risk prioritisation methods to create a risk ranking tool (module 2). The applied methodology was presented in a poster at the 2018 EFSA Conference, while a full description of the tool and its results will be reported in a manuscript currently in preparation.

Regarding quantitative risk assessment, because the Fellow already possessed a basic understanding of the theoretical background and had practical experience in the application of quantitative risk assessment, the project aimed mainly to strengthen some specific aspects such as the different sensitivity analysis approaches (Patil and Frey, 2004), convergence testing, uncertainty assessment and modelling techniques (modules 1 and 3). In this regard, the simulation of *Salmonella* in pigs (EFSA *Salmonella* in Pigs QMRA Consortium, 2010) was shown to be a suitable case study because, in contrast with several other QMRAs, its complexity means it includes a wide range of elements/situations that can be present in a food risk assessment (module 3). Furthermore, the setting of a new alternative country-based scenario allowed the Fellow to become familiar with data gathering and application of curve fitting techniques in the field of probability distribution. To provide an exhaustive representation of the quantitative risk assessment, different frameworks were also practically applied to estimate the risk of importing zoonotic disease via food trade (module 4).

Finally, as mentioned above, some activities, such as learning a new modelling software, were not explicitly planned by the programme, but could be added because of the Fellow's pre-existing knowledge and the need to enhance the core programme. At the end of the period, the Fellow was able to use the R software functions that are commonly employed in risk simulation, and he used this software language to replicate a risk ranking tool (IDM Risk of incursion, Roberts et al., 2011) and a previously published QMRA implemented using a different language (modules 1 and 2).

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Abbreviations

APHA	Animal and Plant Health Agency
BRR	Biomathematics and Risk Research workgroup
CCHFV	Crimean Congo haemorrhagic fever virus
DEFRA	Department of Environment, Food and Rural Affairs
DES	Department of Epidemiological Sciences
HAIRS	Human–Animal Infections and Risk Surveillance Group
NEEG	National Emergency Epidemiology Group
OIE	World Organisation for Animal Health
QMRA	Quantitative Microbial Risk Assessment
RCV	Royal Veterinary College
VRG	Veterinary Risk Group