Institution: Royal Veterinary College
Unit of Assessment: A 6 Agriculture, Veterinary and Food Science
Title of case study: **Driving the Worldwide One Health Response to the Threat of Avian Influenza**

1. Summary of the impact (indicative maximum 100 words)

Pioneering interdisciplinary research at the Royal Veterinary College (RVC) has enabled governments internationally and global health authorities to respond swiftly to the outbreak of a disease that causes huge economic losses, threatens the livelihoods of vulnerable populations in the developing world and endangers human lives. Supported by proactive dissemination, it has shaped the control policies and risk management strategies of the United Nations and governments across Asia, Africa and Europe, as well as a national contingency plan for the UK. And it has demonstrated that costly vaccination campaigns and mass culling programmes can be avoided in efforts to bring the disease under control.

2. Underpinning research (indicative maximum 500 words)

Highly pathogenic avian influenza (HPAI) is a highly transmissible disease of poultry with a flock mortality approaching 100% in vulnerable species. Since its emergence in 2003, 63 countries have reported outbreaks of HPAI subtype H5N1 in domestic and wild birds. The virus constitutes a major public health risk; nearly 600 human infections have been reported, with a mortality of 60%.

In 2003, the RVC's Veterinary Epidemiology and Public Health (VEPH) team, headed by Dirk Pfeiffer, Professor of Veterinary Epidemiology (since 1999), embarked on a series of epidemiological field studies, theoretical research and data analysis to inform global policy recommendations to fight the disease, resulting in more than 30 journal papers in the last five years. Since its founding in 1999, the VEPH team (since 2010 VEEPH, to additionally include Economics) has expanded to 11 academic staff and more than 30 PhD students, research assistants and postdoctoral researchers. The team's diverse skill sets, covering economics, risk analysis and surveillance, enable their research to be responsive to policy needs.

The VEPH team has undertaken, as lead group and/or in collaboration with colleagues overseas and other UK HEIs, research to determine the demographic, spatial and socio-economic characteristics of poultry systems and risks associated with H5N1 outbreaks in Asia, Africa and Europe. They showed that farming systems in Asia's Mekong delta, involving domestic water birds and rice production, represented ideal conditions for the spread of infection. Analysis suggested that vaccination campaigns in countries such as Vietnam contributed to transmission of infection [1], either through ineffective vaccination or via the people administering the vaccinations, and that disease incidence peaked before holiday periods.

Based on the second epidemic wave in Thailand, Pfeiffer was a major contributor to a statistical risk model, developed in an international collaborative effort led by Université Libre de Bruxelles which is applicable to countries with similar agro-ecological conditions such as Vietnam, Laos and Cambodia [2]. With Javier Guitian, (appointed Lecturer in 2002 and progressing to Professor of Veterinary Public Health in 2010), as PI, VEPH, in collaboration with Imperial College, demonstrated that HPAI H5N1 could be sustained silently within live bird markets, but that frequent rest days were an effective means to reduce transmission, negating the need to close the market [3]. In Europe, as part of an international research team, RVC academics, led by Katharina Staerk, (Professor of Veterinary Public Health since 2007), demonstrated the effectiveness of ducks as sentinels for avian influenza virus infections [4].

Collaborative work, again with Imperial, in the UK showed that planned interventions based on movement restrictions would control the majority of outbreaks; neither localized reactive vaccination nor culling were likely to have a substantial impact [5]. Globally, the RVC team, including Jonathan Rushton, (from 2009, Senior Lecturer and since 2013, Professor of Animal

Health Economics), demonstrated that confined food animal production systems can increase animal and public health risks and geographical variations in poultry density and production systems must be taken into account to inform preventative measures [6]. In addition, a region's socio-economic conditions, including human behaviour, and incentives for bioexclusion and biocontainment, give a full understanding of the circumstances in which the virus circulates [7,8]

Other Quality and Relevance Indicators

Pfeiffer, D. Various grants for HPAI research over REF research period from Food and Agriculture Organization of the United Nations (UNFAO), UK Departments for International Development (DfID) and for Environment, Food and Rural Affairs (DEFRA) £1.5m.

3. References to the research (indicative maximum of six references)

1. Pfeiffer, DU, Minh, PQ, Martin, V, Epprecht, M, Otte, MJ. 2007 An analysis of the spatial and temporal patterns of highly pathogenic avian influenza occurrence in Vietnam using national surveillance data. Veterinary Journal;174(2):302-9 DOI: org/10.1016/j.tvjl.2007.05.010
2. Gilbert, M, Xiao, X, Pfeiffer, DU, Epprecht, M, Boles, S, Czarnecki, C, Chaitaweesub, P, Kalpravidh, W, Minh, PQ, Otte, MJ, Martin, V, Slingenbergh, J. 2008 Mapping H5N1 highly pathogenic avian influenza risk in Southeast Asia. Proceedings of the National Academy of Sciences USA;105(12):4769-74 DOI: 10.1073/pnas.0710581105
3. Fournié, G, Guitian, FJ, Mangtani, P, Ghani, AC. 2011 Impact of the implementation of rest days in live bird markets on the dynamics of H5N1 highly pathogenic avian influenza. Journal of the Royal Society Interface; 8(61):1079-89. DOI: 10.1098/rsif.2010.0510
4. Globig, A, Baumer, A, Revilla-Fernández, S, Beer, M, Wodak, E, Fink, M, Greber, N, Harder, TC, Wilking, H, Brunhart, I, Matthes, D, Kraatz, U, Strunk, P, Fiedler, W, Fereidouni, SR, Staubach, C, Conraths, FJ, Griot, C, Mettenleiter, TC, Stärk, KD. 2009 Ducks as sentinels for avian influenza in wild birds. Emerging Infectious Diseases;15(10):1633-6 DOI: 10.3201/eid1510.090439
5. Truscott, J, Garske, T, Chis-Ster, I, Guitian, J, Pfeiffer, DU, Snow, L, Wilesmith, J, Ferguson, NM, Ghani, AC. 2007 Control of a highly pathogenic H5N1 avian influenza outbreak in the GB poultry flock. Proceedings of the Royal Society B - Biological Sciences; 22;274(1623):2287-95 doi: 10.1098/rspb.2007.0542
6. Leibler, JH, Otte, J, Roland-Holst, D, Pfeiffer, DU, Soares Magalhaes, R, Rushton J, Graham, JP, Silbergeld, EK. 2009 Industrial food animal production and global health risks: exploring the ecosystems and economics of avian influenza. Ecohealth;6(1):58-70 DOI: 10.1007/s10393-009-0226-0
7. Rushton, J, Viscarra, RV, Taylor, NM, Hoffmann, I, Schwabenbauer, K. 2010 Poultry sector development, highly pathogenic avian influenza and the smallholder production systems. Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, CABI.2010 5 No 030 DOI: org/10.1079/PAVSNNR20105030
8. Hinrichs, J, Otte, J, Rushton, J. 2010 Technical, epidemiological and financial implications of large-scale national vaccination campaigns to control HPAI H5N1. Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, CABI.2010 5 021 DOI: org/10.1079/PAVSNNR20105021

4. Details of the impact (indicative maximum 750 words)

Research at the RVC has provided global health organisations and governments with scientific evidence urgently required to manage the threat posed by one of the most high-profile viruses in recent history. Policies based directly on findings from cross-continental research into the HPAI H5N1 virus have had profound social and economic implications, enabling more efficient allocation of limited resources for disease control and reducing the devastating economic damage from the culling of domestic birds. In Southeast Asia alone, virus outbreaks have caused the destruction of 140 million birds, equating to losses of around $10bn and putting low-income families' livelihoods at risk.

To fill-in data gaps and promote science-based policy implementation, the RVC's VEPH team carried out a number of studies as part of a DfID-funded programme on Pro-Poor HPAI Risk Reduction Strategies, including risk assessments for eight governments in Asia and Africa [a]. The studies identified risk factors and geographic hot spots for infection; the advantages and

disadvantages of vaccination campaigns; and the effectiveness of rest days in live bird markets. The risk assessment exercises facilitated the formulation of existing scientific evidence into risk mitigation strategies. Programme findings were presented at the final research meeting in October 2010, held in conjunction with the Animal Production and Health Commission for Asia and the Pacific (APHCA) in Thailand, attended by senior policy makers from fourteen countries; key findings were also reflected in the ten key messages arising out of the Programme's Southeast Asia research, and presented to APHCA in November 2010 [b,c].

The VEPH team's studies were closely aligned with global disease control policy, resulting in the rapid translation of Programme findings into risk management strategies. Consequently, governments have been able to tailor control measures for high-risk areas, adapt vaccination campaigns to minimise the risk of infection and safeguard traders' livelihoods. Thailand, Vietnam and Africa have now modified their HPAI control strategies, with more focused vaccination and culling campaigns. The UNFAO Senior Animal Production and Health Officer for Asia and the Pacific commented: "*The RVC's research […] demonstrated how a number of characteristics […] contribute to disease risk in poultry systems. [It] also contributed to the understanding of the social and economic context within which poultry producers operate. The RVC's risk assessments were therefore critical in informing the Programme's ten key messages*" [d]. Recommendations to introduce market rest days as opposed to full closure are also likely to have restricted the spread of the H5N1 virus. The introduction of rest days has helped secure buy-in from local communities for disease control efforts. (Draconian moves to force market closures spawn black markets and the creation of favourable conditions for the virus.)

Research activities have been complemented by major capacity building work, with veterinary staff from over 70 countries worldwide being trained by researchers from the RVC, utilising the underpinning research findings. These UNFAO-supported activities were focused on improved surveillance for HPAI in endemic and disease-free countries and improved international coordination of national surveillance and control efforts [a]. Findings were communicated at a UNFAO-backed workshop in Thailand in 2008, attended by 80 participants, including government representatives from China, Indonesia, Lao PDR, Myanmar, Thailand and Vietnam [e]. Pfeiffer co-edited the book Health and Animal Agriculture in Developing Countries (Natural Resource Management and Policy, Vol. 36) (Springer, 2011), which has been translated into Chinese and Japanese.

The VEEPH team's work on risk assessments and surveillance has been referenced in various poultry publications and other media internationally, including a feature in the British Medical Journal in 2011, indicating the penetration of the research outcomes encapsulating the One Health approach, with broad reach to relevant stakeholders, including the human medical profession [f].

RVC research guided the formulation of guidelines issued in 2011 by OFFLU, a network established by the World Organisation for Animal Health (OIE) and the UNFAO, on avian influenza surveillance at country level [g]. The Chairman of OFFLU comments: "*In particular, the RVC's demonstration of the demographic, spatial and socio-economic characteristics of poultry systems and their associated risks […] can be evidenced in OFFLU's guidance on targeted risk-based sampling for on-farm surveillance*." [h]

In Europe, Pfeiffer has been a member of the European Food Safety Authority's Panel on Animal Health and Welfare. Risk assessments relating to HPAI involving the RVC team have shaped guidelines contained in a series of Scientific Opinions issued by the EFSA, such as the May 2008 Statement, in response to a European Commission request, on the animal health and welfare aspect of avian influenza and the risk of its introduction into the EU poultry holdings. Guidance given in these Statements has remained in force throughout the REF impact period [i].

VEEPH's work was also incorporated into risk management guidelines that incorporate value chain analysis, adopted and promoted by the UNFAO, with Rushton one of the two main authors. [j].

In July 2012 the United Nation's Food and Agriculture Organisation (FAO) awarded the RVC the status of FAO Reference Centre in Veterinary Epidemiology, a reflection of the global recognition of the RVC as a centre of excellence in veterinary epidemiology [k].

The research findings and RVC's expertise in this field continue to impact upon policy discussion in the UK and internationally: Pfeiffer was invited to make a presentation on avian flu to the UK Parliamentary Labour Party Health Group in January 2013 [l]. He was one of 30 international experts invited to an emergency meeting held under the auspices of the UNFAO's EMPRES (Emergency Prevention System) Animal Health team in April 2013 to address epidemiology, surveillance and risk management of H7N9 – the newly emergent strain of avian influenza responsible for the most recent outbreaks in China [m], which was recorded, with webcasts available from the UNFAO website [n].

5. Sources to corroborate the impact (indicative maximum of 10 references)

a. FAO, 2011. Pro-Poor HPAI Risk Reduction Strategies. Final Report. Held by RVC.
b. DfID, 2010. Research meeting: Pro-Poor HPAI Risk Reduction: Lessons from Southeast Asia and Africa. (Phuket, Thailand).
http://www.dfid.gov.uk/r4d/PDF/Outputs/HPAI/WKS101025_puket_proceedings.pdf [accessed 19 Aug 2013]
c. APHCA, 2010. Ten Key messages from the Pro-Poor HPAI Risk Reduction Project in Southeast Asia. (http://www.aphca.org/index.php?view=article&catid=87%3Aanimal--human-health&id=75%3Aten-key-messages-from-the-pro-poor-hpai-risk-reduction-project-in-southeast-asia&tmpl=component&print=1&layout=default&page=&option=com_content&Itemid=197) [accessed 19 Aug 2013]
d. Statement provided by Senior Animal Production and Health Office for Asia and the Pacific, UNFAO. Held by RVC.
e. FAO/Cirad/RVC International Workshop on 'Research Activities on Avian Flu and other Transboundary Animal Diseases in South-east Asia', Bangkok, Thailand, January 21-22, 2008. (http://www.dfid.gov.uk/r4d/PDF/Outputs/HPAI/mtg080121_abstracts.pdf) [accessed 19 Aug 2013]
f. http://www.bmj.com/content/343/bmj.d4117.full [accessed 19 Aug 2013]
g. http://www.offlu.net/fileadmin/home/en/publications/pdf/OFFLUsurveillance.pdf [accessed 19 Aug 2013; published May 2013]
h. Statement from Chairman, OFFLU Steering Committee (OIE-FAO Network of Expertise on Animal Influenza). Held by RVC.
i. http://www.efsa.europa.eu/en/efsajournal/pub/715.htm [accessed 17 Oct 2013
j. http://www.fao.org/docrep/014/i2198e/i2198e00.pdf [accessed 19 Aug 2013]
k. http://empres-i.fao.org/eipws3g/index.html?animalProdNetwork=yes [accessed 19 Aug 2013]
l. Invitation by email from the Right Honourable Frank Dobson MP, dated 3 September 2012. Held by RVC.
m. http://www.fao.org/ag/againfo/programmes/en/empres/news_190413.html [accessed 19 Aug 2013]
n. http://www.fao.org/ag/againfo/programmes/en/empres/H7N9/ [accessed 19 Aug 2013]