

<b>Institution:</b> University College London		
<b>Unit of Assessment:</b> 5 - Biological Sciences		
<b>Title of case study:</b> Understanding disease spill-over from wildlife to improve public health outcomes in a changing world		
<b>Period when the underpinning research was undertaken:</b> 2000 - 2020		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>	<b>Role(s) (e.g. job title):</b>	<b>Period(s) employed by submitting HEI:</b>
Andrew Cunningham	Professor Wildlife Epidemiology	1988 - present
Kate Jones	Professor Ecology & Biodiversity	2005 - present
David Redding	Sir Henry Dale Royal Society Research Fellow	2012 - present
<b>Period when the claimed impact occurred:</b> 2013 - 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> No		
<b>1. Summary of the impact</b>		
<p>As exemplified by the current COVID-19 global pandemic, the health and economic consequences of spill-overs of wildlife diseases into human populations can be devastating. Research carried out by scientists at the University College London (UCL) and the Institute of Zoology (IoZ) has improved the understanding of how ecological, epidemiological and socioeconomic factors interact to drive spill-overs of these 'zoonotic' diseases into humans. The research has informed global zoonotic disease research funding priorities, for example guiding wildlife disease surveillance efforts (USAID's PREDICT programme); international policy priorities through the United Nations (UN), Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), and World Wide Fund for Nature (WWF); and public health responses to disease outbreaks through the Foreign Commonwealth and Development Office (FCDO), as well as improving public understanding of links between the extinction and climate crises on zoonotic disease spill-over risk.</p>		
<b>2. Underpinning research</b>		
<p>Animal-borne (zoonotic) diseases are a major global human health and economic burden but, for many diseases, little is known about the underlying drivers of spill-overs, severely hindering effective public health responses to prevent and manage future outbreaks. UCL and IoZ researchers have made seminal contributions to understand zoonotic spill-over risk by identifying and quantifying what drives transfer of diseases from wildlife to people, predicting emerging disease hotspots, and developing a unifying interdisciplinary framework to inform disease management in a changing world.</p>		
<b>Drivers of zoonotic spill-over and identification of disease hotspots</b>		
<p>In 2000, IoZ research (undertaken by Cunningham, now a professor at IoZ) co-developed a new paradigm for the links between ecology and human health in a seminal synthesis where infectious agents (or pathogens) harboured by wildlife were highlighted as the source of a series of high-impact, human diseases (zoonoses), for example Ebola, Nipah and HIV/AIDS [R1]. The synthesis identified that the emergence of these diseases was driven by human activities, such as changes in hunting practices, encroachment into remaining wildlife habitats and a growing international trade in wildlife. This paper provided a scientific rationale for what is now known as 'One Health' – an approach to designing and implementing programmes, policies, legislation and research in which multiple sectors communicate and work together to achieve better public health outcomes. At IoZ, this idea</p>		

was further developed by Jones in 2008 (first funded by a UKRI research fellowship at IoZ from 2005 to 2012 and now a professor at UCL), with the first quantitative analysis of global patterns of human disease emergence [R2]. This research demonstrated that the rate of disease emergence was increasing, that the majority of human infectious diseases were from wildlife, and that areas of high biodiversity and increased human population densities correlated with past emergence of zoonotic disease [R2]. Additionally, Jones' analyses identified 'emerging disease hotspots': regions where new emerging infectious diseases are most likely to originate. Jones concluded that global resources to counter disease emergence are poorly allocated, with the majority of the scientific and surveillance effort currently focussed on countries where the next important emerging infectious disease is least likely to originate. Synthesising these global results with existing experimental studies in 2010 [R3], Jones importantly highlighted growing evidence of the negative impact of the Anthropocene on infectious disease risk through biodiversity loss.

### Preventing and managing disease spill-overs in a changing world

In 2012, a joint IoZ-UCL NERC-funded research project within the Ecosystem Services for Poverty Alleviation (ESPA) programme, Jones and Cunningham (also funded by the Royal Society) co-led the development of a novel framework to operationalise the ecological, social and economic conditions that facilitate zoonotic disease emergence and transmission. This framework would inform appropriate interdisciplinary responses for prevention and management of such diseases [R4]. This holistic, interdisciplinary framework which put into operation the 'One Health' approach, brought together natural and social sciences perspectives to provide an effective framework for understanding the management and mitigation of the risks of emerging infectious diseases. This framework was used in research led by Redding (from 2012 to 2020, initially as a PDRA at UCL on the NERC project and then funded from a MRC research fellowship, and subsequently on a Sir Henry Dale Royal Society fellowship at IoZ from 2020 onwards), and supported by Jones and Cunningham (funded by MRC GCRF and EC FP7). Their research quantified how socio-ecological changes in biodiversity, habitat, land use, poverty and climate affect risk of animal-to-human disease spill-over in a number of high impact disease systems, such as Lassa fever [R5] and Ebola [R6]. These disease-forecasting models have improved knowledge of how spill-over dynamics are affected by present and future global changes, such as climate, land use and urbanisation.

### 3. References to the research

IoZ/UCL staff contributions in bold.

[R1] Daszak, P., **Cunningham, A.A.** and Hyatt, A.D. (2000). 'Emerging infectious diseases of wildlife: threats to biodiversity and human health'. *Science* **287**, 443 - 449. DOI: <http://doi.org/10.1126/science.287.5452.443> (Altmetric Citations: 2524, Altmetric Score: 63 - 97<sup>th</sup> percentile of 16,763,248 research outputs).

[R2] **Jones, K.E.**, Patel, N.G., Levy, W.A., Storeygard, A., Balk, D., Gittleman, J.L. and Daszak, P. (2008). 'Global trends in emerging infectious diseases'. *Nature* **451**, 990-993. DOI: <http://doi.org/10.1038/nature06536> (Altmetric Citations: 3415, Altmetric Score: 2048 - 99<sup>th</sup> percentile of 16,888,555 research outputs,).

[R3] Keesing, F., Belden, L.K., Daszak, P., Dobson, A., Harvell, C.D., Holt, R.D., Hudson, P., Jolles, A., **Jones, K.E.**, Mitchell, C.E., Myers, S.S., Bogich, T. and Ostfeld, R.S. (2010). 'Impacts of biodiversity on the emergence and transmission of infectious diseases'. *Nature* **468**, 647-652. DOI: <https://doi.org/10.1038/nature09575> (Altmetric Citations: 920, Altmetric Score: 410 - 99<sup>th</sup> percentile of 16,697,177 research outputs).

[R4] Wood, J.L.N., Leach, M., Waldman, L., MacGregor, H., Fooks, A.R., **Jones, K.E.**, Restif, O., Dechmann, D., Hayman, D.T.S., Baker, K.S., Peel, A.J., Kamins, A.O., Fahr, J., Ntiemoa-Baidu, Y., Suu-Ire, R., Breiman, R.F., Epstein J. and **Cunningham, A.A.** (2012). 'A

framework for the study of zoonotic disease emergence and its drivers: spill-over of bat pathogens as a case study'. *Philosophical Transactions of the Royal Society, Series B.* **367**, 2881-2892. DOI: [http://doi.org/ 10.1098/rstb.2012.0228](http://doi.org/10.1098/rstb.2012.0228) (Altmetric Citations: 124, Altmetric Score: 57 - 97<sup>th</sup> percentile of 16,641,846 research outputs).

[R5] **Redding, D.W.**, Moses, L.M., **Cunningham, A.A.**, Wood, J.L.N., and **Jones, K.E.** (2016). 'Environmental-mechanistic modelling of the impact of global change on human zoonotic disease emergence: a case study of Lassa fever.' *Methods in Ecology and Evolution.* **7**, 646-655. DOI: <https://doi.org/10.1111/2041-210X.12549> (Altmetric Citations: 38, Altmetric Score: 757 - 99<sup>th</sup> percentile of 16,538,578 research outputs).

[R6] **Redding, D.W.**, Atkinson, P., **Cunningham, A.A.**, Lo Iacono, G., Moses, L.M., Wood, J.L.N., and **Jones, K.E.** (2019). 'Impacts of environmental and socio-economic factors on emergence and epidemic potential of Ebola in Africa'. *Nature Communications* **7**, 646–655. DOI:<https://doi.org/10.1038/s41467-019-12499-6> (Altmetric Citations: 15, Altmetric Score: 339 - 99<sup>th</sup> percentile of 16,651,648 of research outputs).

#### 4. Details of the impact

The impact of research from UCL and IoZ falls into three main areas: informing zoonotic disease research funding; influencing international policy priorities and public health responses to disease outbreaks; and improving public understanding of links between environmental change and zoonotic disease spill-over risk. As evidenced by communication from the Wellcome's Director: "*This research has had a global impact over many years, events of the last twelve months have underlined just how critical it is to all our health here in the UK, in so many countries around the world and to global health security*" [S1].

##### **Informing research funding priorities for zoonotic diseases**

UCL and IoZ research has informed funding priorities both internationally and nationally. Some key examples include:

Emerging disease hotspots information: [R2] was used as the basis for the geographical targeting of the US Government's international aid to countries at high risk of emerging diseases. From 2008 to 2019, approximately USD1.5 billion was spent through USAID's Emerging Pandemic Threats program, including the PREPARE, IDENTIFY, PREDICT, RESPOND, and One Health Workforce programmes. As evidenced by the Director of EcoHealth Alliance, a key partner in PREDICT: "*The maps from this paper ...remain a central core of the geographic targeting for all USAID pandemic prevention work to date*" [S2].

Key evidence from [R2] also contributed to the DFID (now Foreign and Commonwealth Development Office) scoping report in 2012 on the links between zoonotic disease emergence and livestock systems. This resulted in the establishment of the Zoonoses and Emerging Livestock Systems (ZELS) research programme, which allocated millions of pounds of funding to 17 projects. Updates planned on these scoping reports will inform new research programming over the next few years [S3].

Evidence from [R1], [R2] and [R3] has furthermore contributed to the 2020 IPBES report on Biodiversity & Pandemics, has influenced the establishment of the EU's PREZODE initiative to develop fundamental and operational research to prevent and manage future zoonotic disease outbreaks [S2] and [S4].

Key evidence on zoonotic spill-over [R2], [R3], has informed the 2020 Trinity Challenge (a coalition aiming to improve the world's protection against health emergencies, using data-driven research and analytics) representing millions of pounds of investment. Trinity Challenge Board Chair and former UK Chief Medical Officer Dame Professor said: "*Your*

work on identifying global hotspots and EID risk has informed a lot of our early thinking in our “Identify” category of The Trinity Challenge” [S5].

**Policy and public health responses:** Research conducted by UCL and IOZ researchers is among key evidence linking emerging zoonotic diseases with land use and climate change. As a result, it has informed international and national policy priorities and public health responses to disease outbreaks [S1]. Some key policy impact examples include:

- Providing a scientific rationale and synthesis of research [R1] for ‘One Health’ multi-sector approach to improving public health outcomes which is now a major component of pandemic prevention policy around the world [S2];
- Evidence [R1], [R2] and [R3] used for the United Nations Environment Programme (UNEP)’s rapid assessment report (2020) ‘Preventing the next Pandemic’ led to UNEP joining an alliance with the World Organisation for Animal Health (OIE), Food and Agriculture Organisation (FAO), and World Health Organisation (WHO), recognising that there was a need to strengthen the environmental dimension of One Health global efforts [S6].
- Underpinning evidence [R1], [R2], [R3] provided to the WWF ‘Beyond Boundaries’ 2020 report contributed directly to WWF’s ongoing work to influence policy and practice in a range of areas on linkages between environmental degradation, emerging infectious disease risk and human health. One example is the organisation’s work around mitigating the risk posed by the wildlife trade, particularly in East and South East Asia [S7].
- Evidence on the impact of ecosystem degradation on zoonotic risk [R2] was provided by in 2020 for The Dasgupta Review commissioned by the UK’s HM Treasury setting out how nature should be accounted for in economics and decision making. This will inform policy discussions at the Convention on Biological Diversity (CBD) COP 15, United Nations Framework Convention on Climate Change (UNFCCC) COP 26, and the G7 meeting in 2021 [S8]. In 2019, as evidenced by communication with the Chief Scientific Officer at FCDO: “*The Ebola risk map from Redding et al. provided important contextual information to inform discussions with ministers in our short and medium term thinking on our response to Ebola*” [R6].
- Finally, evidence on zoonotic disease emergence [R1], [R2], [R3] is informing current discussions within UK government and the G7 to develop a more strategic approach to understanding emerging zoonotic and biodiversity threats [S9].

### 3. Increasing public understanding of zoonotic disease risk

The research in understanding zoonotic disease spill-over processes [R1], [R2], [R3], [R4], [R5], [R6] has been communicated extensively through the international broadcast news and print media over the assessment period, thereby improving public understanding of zoonotic disease risks. Clear scientific communication has been particularly relevant during the global COVID-19 pandemic and the research team have appeared in over 150 national, specialist, and international media outlets in 2020, sharing the research with an estimated audience of over 300 million people [S11]. Highlights have included contributions to BBC Radio 4’s flagship news show the ‘Today Programme’ and its ‘Inside Science’ programme, as well as the BBC World Service. Additionally, Professor Jones gave a cross-departmental talk within the UK Government on predicting pandemics [S9] and co-wrote, with Dr Redding, a special briefing to UK Government’s Cabinet Office [S10]. This informed several of the UK prime minister’s speeches for example, to the UN Summit on Biodiversity and to the UN General Assembly in 2020 [S9], [S10]. The research also helped to provide evidence on the environmental links to the emergence of zoonotic diseases for the UK Environmental Audit Committee [S11] in 2020. Jones acted as a scientific consultant on the BBC’s Horizon programme and its ‘Extinction: the Facts’ documentary presented by David Attenborough, which covered the links between deforestation and pandemic risk.

### 5. Sources to corroborate impact

[S1] Letter from Director, Wellcome Trust, UK.

## Impact case study (REF3)

- [S2] Email from Director, EcoHealth Alliance, New York.
- [S3] Emails from International Livestock Research Institute, Kenya, and Livelihoods Advisor, Foreign, Commonwealth and Development Office, UK Government.
- [S4] Letter from Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, UN.
- [S5] Letter from former Chief Medical Officer, UK Government, Chair of the Board of Trustees, Trinity Challenge.
- [S6] Letter from World Conservation Monitoring Centre, United Nations Environmental Programme.
- [S7] Letter from Chief Advisor Wildlife, World Wildlife Fund, UK.
- [S8] Letter from Her Majesty's Treasury, UK Government.
- [S9] Email from Department of Environment, Farming and Rural Affairs, UK Government.
- [S10] Email from Head of Adaptation, Climate Change Committee, UK.
- [S11] IOZ annual report and House of Commons report.
- [https://issuu.com/zoologicalsocietyoflondon/docs/zsl\\_annual\\_report\\_2019-20?fr=sMDU1OTlwNDgxMTg](https://issuu.com/zoologicalsocietyoflondon/docs/zsl_annual_report_2019-20?fr=sMDU1OTlwNDgxMTg)
- <https://committees.parliament.uk/oralevidence/421/pdf>