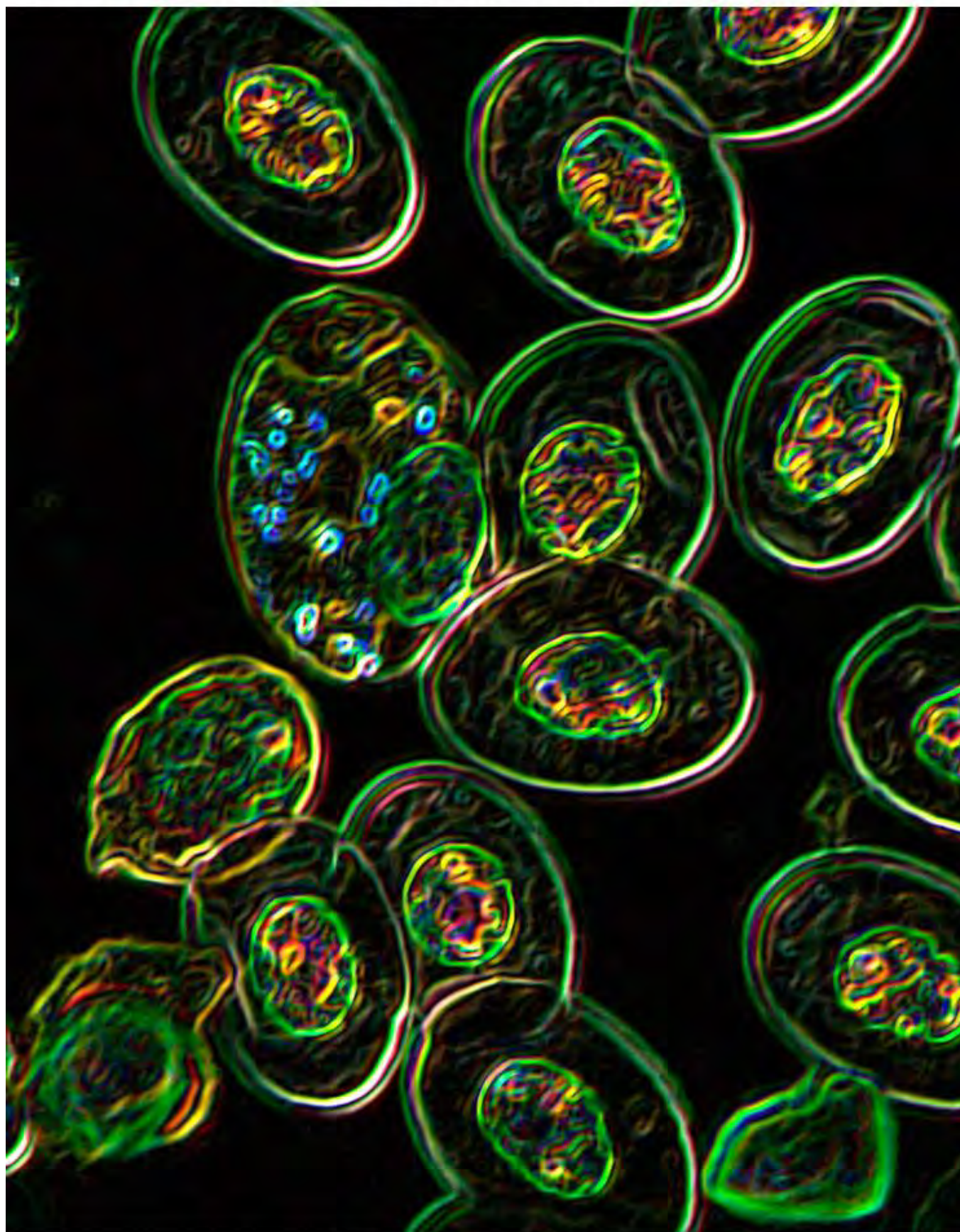

Edinburgh *Infectious* Diseases

Leading infectious disease research and training



Annual report 2018/19

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EXECUTIVE SUMMARY

WHAT IS EDINBURGH INFECTIOUS DISEASES

We are the Network of researchers across the University of Edinburgh and associated organisations with an interest in infectious diseases.

OUR MAJOR ACTIVITIES AND ACHIEVEMENTS IN 2018/19

- We have seen continued expansion of membership of *Edinburgh Infectious Diseases* to over **185** principal investigators.
- Our members were awarded over **£64.1M** supporting infectious disease research in FY 2017/18, including **£8.6M** from the Wellcome Trust and **£24.5M** from UKRI.
- We published over **470** research papers in 2018.
- We are building flourishing partnerships with external partners, through leadership of the Fleming Fund Fellowship scheme at the University of Edinburgh, and establishment of joint doctoral training programmes with the Universities of Glasgow and Leiden.
- We support the continued progress of the Wellcome Trust Four Year PhD Programme in Hosts, Pathogens and Global Health.
- We have developed a new doctoral training programme in One Health Models of Diseases.
- We supported the development of the new UKRI Centre for Doctoral Training in Biomedical Artificial Intelligence, which starts in October 2019.
- We continue to facilitate increased communication and collaboration between social scientists and basic and clinical researchers, contributing to other University initiatives, such as the Beyond Resistance network addressing antimicrobial resistance.
- We are working with Edinburgh Innovations to support engagement of researchers with industrial collaborators.
- We have expanded our communication activities through our events, website, newsletters and social media presence, to effectively connect with both our members within Edinburgh, and our global audience.
- We have supported engagement with a variety of external audiences through expert responses to policy consultations, and dialogue with public audiences at lectures, performances and workshops.

DIRECTORS REPORT

2018-19 has been an extremely busy and productive year for EID involving a wide array of activities designed to promote excellence in research and training in infectious diseases. We are one of the largest groupings of infectious disease scientists in Europe and make a major contribution to cutting-edge scientific discovery and the development of innovative training approaches.

Cutting Edge Science. A major driving force for EID is the establishment of Edinburgh as a world-class hub for research in ID and we have continued to support our community towards this goal through organisation of workshops on selected topics of strategic importance including diagnostics, One Health, and vesicles in Infectious Disease, in addition to showcasing the diversity and quality of our research at the annual symposium. In 2018-19, EID members published over 470 papers and University of Edinburgh members were awarded >£64 M in research funding relative to £400 M by UoE as a whole.

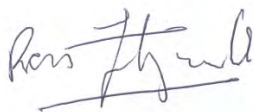
Delivering innovative training. A commitment to excellence in training the next generation of scientists in Edinburgh is a major priority area for EID as highlighted by the activity in this area in 2018-19. EID continues its central role in administering the Wellcome Trust Doctoral training programme (DTP) *Hosts, Pathogens and Global Health*, and has developed the concept for a new DTP in *One Health Models of Disease: Science, Ethics, and Society*, which has been through the preliminary application stage at Wellcome with the full application currently in preparation. We are also delighted that a new *UKRI Centre for Doctoral Training in Biomedical Artificial Intelligence* has been awarded to UoE led by Guido Sanguinetti and EID member Meriem El Karoui. The concept for this DTP emerged directly from an EID workshop and we are pleased to have played a key role in its genesis and development. EID has also led the development of new joint PhD partnerships with Leiden University (One Health Solutions for Infectious Diseases) and University of Glasgow (One Health Interventions for Infectious Diseases) with the first cohorts of students starting in September 2019.

Developing external partnerships. The development of PhD partnerships with Leiden, and Glasgow and the establishment of a memorandum of Agreement with University College Dublin highlights a University strategy to develop stronger relationships with other Universities, in the EU and One Health is an area of great potential for partnerships based on Edinburgh's strengths

in human and veterinary medical research. Furthermore, in addition to the partnership with Glasgow, EID is also actively exploring further strategic alliances with other Scottish Universities.

Promoting Global Health. An important achievement for EID in the last year has been the successful application to the Fleming Fund for Host Institute Status for the Fleming Fund fellowship scheme. The scheme provides funding for the bespoke training of fellows from low- and middle-income countries (LMIC) in methods relevant to AMR surveillance and for a collaborative research project to be carried out in-country. To date we have taken on 6 fellows from Uganda with an additional 2 to be included in due course. We also expect additional opportunities for fellowships from Zimbabwe (October) and Malawi (August) with a combined value of >£1.5 M income to the University. EID is delighted to have this opportunity to contribute to capacity building in LMICs while developing new and strengthening existing international research collaborations.

We are grateful to CMVM and CSE for increasing the annual funding for EID to allow us to continue our array of activities in support of the ID community in Edinburgh. As EID is now in receipt of external grant funding (for the Fleming fellowships) which can be used to recover administrative costs, we plan to increase the time of our admin assistant Jennifer Hurst, releasing Hilary for more strategic activities. We look forward to the next year with enthusiasm as our latest EID initiatives take shape and with a renewed outward-facing approach, we continue to help drive Edinburgh's reputation as a world-class centre for infectious disease research and training.



Ross Fitzgerald, Director, EID

EDINBURGH INFECTIOUS DISEASES

REMIT

As set out in 2011 when the network was established, the remit of Edinburgh Infectious Diseases (EID) is broad and far reaching.

- To represent the strengths of infectious disease science in Edinburgh through our symposia, workshops, outreach activity and internet profile;
- To maintain a strategic overview of infectious disease research in Edinburgh, to maximise synergy between established activities and promote new avenues for investigation;
- To foster infectious disease teaching and training at all levels within the University, including the development of new postgraduate initiatives.

DIRECTOR AND MANAGEMENT TEAM

Edinburgh Infectious Disease is led by its director Professor Ross Fitzgerald, Chair of Molecular Bacteriology at the Roslin Institute, alongside an executive committee. Members of the committee are drawn from across the University of Edinburgh and associated organisations, and are supported by the executive manager, Dr Hilary Snaith, and an administrative assistant, Jennifer Hurst. Current members of the committee are:

Member	Institute/School	Responsibility
Prof. Rosalind Allen	School of Physics and Astronomy, King's Buildings	AMR Theme Leader
Dr. Lisa Boden	Global Academy of Agriculture and Food Security, Easter Bush	
Dr. Till Bachmann	Division of Infection and Pathway Medicine, Edinburgh BioQuarter	AMR Theme leader
Dr. Amy Buck	Centre for Immunity Infection and Evolution, King's Buildings	
Ms. Catherine Burns	Head of Strategic Research Development, Research Support Office	Strategic research development advisor
Prof. Harry Campbell	Usher Institute for Population Health Sciences and Informatics	
Prof. David Dockrell	Centre for Inflammation Research, Edinburgh BioQuarter	Clinical medicine, AMR Theme Leader
Dr. Emma Elliott#	Business Development Manager, Edinburgh Innovations	Engagement with industry
Prof. Gary Entrican	The Moredun Research Institute	Related interest groups
Prof. Ross Fitzgerald	The Roslin Institute, Easter Bush	Director
Prof. Keith Matthews	Centre for Immunity Infection and Evolution, King's Buildings	
Prof. Harish Nair	Usher Institute for Population Health Sciences and Informatics	GCRF funding
Dr. Hilary Snaith	Edinburgh Infectious Diseases, King's Buildings	Executive manager
Prof. Mark Stevens	The Roslin Institute, Easter Bush	
Dr. Alice Street	School of Social and Political Science, George Square	Social science

Dr. Kate Templeton	Division of Laboratory Medicine, Royal Infirmary of Edinburgh	
Prof. Mark Woolhouse	Usher Institute for Population Health Sciences and Informatics	AMR champion, Theme Leader

We are very pleased to welcome two new members onto the committee this year, Lisa Boden and Rosalind Allen, as four long-standing members, Profs. Clifford Leen, Jürgen Schwarze, Sue Welburn and Bernadette Dutia, step down. We are indebted to the enthusiasm, insight and support of all the committee members, for driving forward new initiatives and activities through the past year.

In 2018 committee members took on responsibility for specific aspects of our activities. This has given impetus to initiatives in particular areas. In future the committee will be co-opting ad hoc members to provide guidance in undergraduate teaching (Drs. Matt Taylor and Douglas Roy, Honours Programme Organisers in Immunology and Infectious Diseases) and research translation and innovation (Dr. Andrew McBride, CMVM Translator in Residence), to ensure EID can continue to provide effective leadership across its remit.

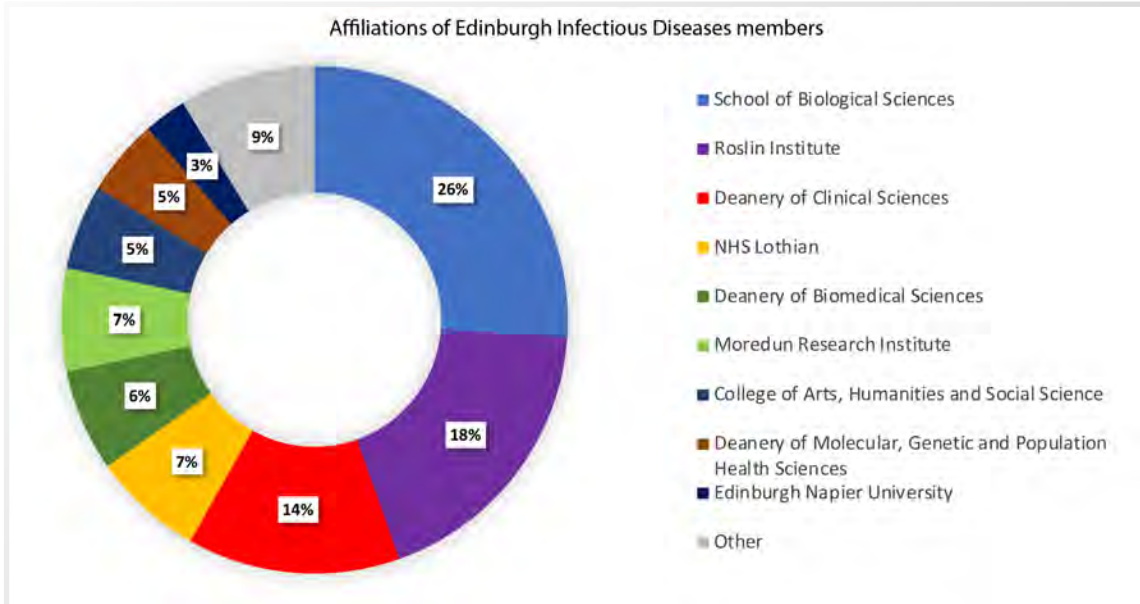
STRATEGY BOARD

In addition to the executive committee we are fortunate to have high-level input from a Strategy Board which meets once a year to provide strategic feedback on our activities and outputs. Current members of the board are:

Member	Organisation
Prof. David Argyle	Dean of Royal (Dick) School of Veterinary Studies, University of Edinburgh
Mr. Jake Broadhurst	Head of Global Academies Directorate, University of Edinburgh
Prof. Julie Fitzpatrick	Scientific Director of the Moredun Research Institute and Chief Executive of the Moredun Foundation
Prof. Charles ffrench Constant	Dean of Research, College of Medicine and Veterinary Medicine, University of Edinburgh
Prof. David Gray	Head of School of Biological Sciences, University of Edinburgh
Prof. Linda McKie	Head of School of Social and Political Science, University of Edinburgh
Prof. Dave Robertson	Head of the College of Science and Engineering, University of Edinburgh
Prof. Susan Rosser	Director of Mammalian Centre for Synthetic Biology, University of Edinburgh
Prof. Jonathan Seckl	Vice Principal Planning, Resources and Research Policy, and Professor of Molecular Medicine, University of Edinburgh
Prof. Mike Shipston	Head of School of Biomedical Sciences, University of Edinburgh
Prof. Geoff Sim	Director of the Global Academy for Agriculture and Food Security, University of Edinburgh
Prof. James Smith	Vice Principal International, University of Edinburgh
Prof. Tim Walsh	Director of Research, Development and Innovation for NHS Lothian
Prof. Moira Whyte	Head of College of Medicine and Veterinary Medicine, University of Edinburgh

MEMBERSHIP

The membership of EID is drawn from across the University of Edinburgh and related organisations across the city, including NHS Lothian, the Moredun Research Institute, and Edinburgh Napier University. The network currently has 185 academic members from across the University of Edinburgh and related institutions, representing over 250 PhD students and 300 research staff.

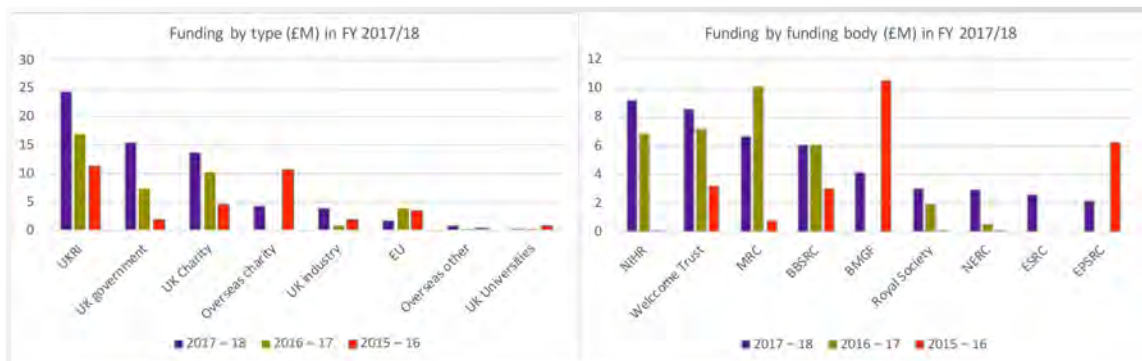


As shown in the chart above, many of our members are in the School of Biological Sciences, the Roslin Institute and in the deaneries of the School of Medicine. There are also significant numbers in the College of Arts, Humanities and Social Science, the Moredun Research Institute and clinicians working within NHS Lothian.

RESEARCH INCOME FOR INFECTIOUS DISEASES AT THE UNIVERSITY OF EDINBURGH IN FY 2017/18

The past year has been a highly successful one for members of EID obtaining research funding.

During financial year 2017/18, members were awarded over **£64.1 million** in research grants, out of a total of £400 million awarded to the University of Edinburgh as a whole (data provided by Edinburgh Innovations).



UKRI remains the largest funder of our research (£M), with the UK government and UK charities providing £24.5 million and £13.7 million respectively. Over the past two years members of EID have been recipients of large awards by the National Institute of Health Research for Global Health Research Units: £6.6 million to the Tackling Infection to Benefit Africa Programme, led by Prof Mark Woolhouse, and £6.9 million for the RESPIRE Programme addressing respiratory health in Asia, led by Profs Aziz Sheikh, Harry Campbell and Debby Bogaert.

Major UKRI awards were made by the EPSRC to Prof Mark Bradley and colleagues in the School of Chemistry by EPSRC who are continuing to support the successful PROTEUS project. Other notable awards were to Dr Sander Granneman in the School of Biological Sciences received £2.4 million for his research programme into RNA dynamics in pathogenic *Staphylococcus aureus* from the MRC, Dr Christine Tait Burkard was awarded £984K from the BBSRC for her work on porcine reproductive and respiratory syndrome virus, and Drs Till Bachmann and Alice Street, and Prof Dominic Moran, received £1.9 million from the ESRC to develop diagnostics for one health and user-driven solutions for antimicrobial resistance.

The Wellcome Trust were also a major source of funding, awarding EID members over £8.3M in FY 2017/18, including three principal fellowships to Profs Andrew Rambaut and Keith Matthews (School of Biological Sciences) and Prof Sarah Walmsley (Centre for Inflammation Research). Members are also fortunate to receive support from overseas charities, the Bill and Melinda Gates Foundation which awarded £3.8 million to the Center for Tropical Livestock Genetics and Health.

Details of research grants of over £500K awarded in FY 2017/18 are presented in the Appendix 1.

A summary for the operating costs for EID in FY 2017/18 is presented in Appendix 2.

RESEARCH WITH IMPACT

PEER-REVIEWED PUBLICATIONS

In 2018 over 465 papers published by our members, including papers in *Cell*, *Science*, *Nature*, *Nature Communications*, *Nature Ecology and Evolution*, *eLife*, *PLoS Pathogens*, *PNAS*, *The Lancet* and many others.

A selection of these publications is given below, highlighting the diverse topics of research across the EID network.

Burkard C, Opriessnig T, Mileham AJ, Stadejek T, Ait-Ali T, Lillico SG, Whitelaw CBA, Archibald AL: **Pigs lacking the scavenger receptor cysteine-rich domain 5 of CD163 are resistant to PRRSV-1 infection.** *J Virol* 2018, **7**:e01221-01218.



Chen J, Quiles-Puchalt N, Chiang YN, Bacigalupe R, Fillol-Salom A, Chee MSJ, Fitzgerald JR, Penades JR: **Genome hypermobility by lateral transduction.** *Science* 2018, **362**:207-212.

Dudas G, Carvalho LM, Rambaut A, Bedford T: **MERS-CoV spillover at the camel-human interface.** *Elife* 2018, **7**.



Felton JM, Duffin R, Robb CT, Crittenden S, Anderton SM, Howie SEM, Whyte MKB, Rossi AG, Yao C: **Facilitation of IL-22 production from innate lymphoid cells by prostaglandin E2 prevents experimental lung neutrophilic inflammation.** *Thorax* 2018, **73**:1081-1084.



Furniss JJ, Grey H, Wang Z, Nomoto M, Jackson L, Tada Y, Spoel SH: **Proteasome-associated HECT-type ubiquitin ligase activity is required for plant immunity.** *PLoS Pathog* 2018, **14**:e1007447.

Holmes EC, Rambaut A, Andersen KG: **Pandemics: spend on surveillance, not prediction.** *Nature* 2018, **558**:180-182.



Hussain S, Turnbull ML, Wise HM, Jagger BW, Beard PM, Kovacicova K, Taubenberger JK, Vervelde L, Engelhardt OG, Digard P: **Mutation of influenza A virus PA-X decreases pathogenicity in chicken embryos and can increase the yield of reassortant candidate vaccine viruses.** *J Virol* 2018:2.

Osakunor DNM, Woolhouse MEJ, Mutapi F: **Paediatric schistosomiasis: What we know and what we need to know.** *PLoS Negl Trop Dis* 2018, **12**:e0006144.



Palmer WH, Medd NC, Beard PM, Obbard DJ: **Isolation of a natural DNA virus of *Drosophila melanogaster*, and characterisation of host resistance and immune responses.** *PLoS Pathog* 2018, **14**:e1007050.

Prior KF, van der Veen DR, O'Donnell AJ, Cumnock K, Schneider D, Pain A, Subudhi A, Ramaprasad A, Rund SSC, Savill NJ, et al.: **Timing of host feeding drives rhythms in parasite replication.** *PLoS Pathog* 2018, **14**:e1006900.

Rochford C, Sridhar D, Woods N, Saleh Z, Hartenstein L, Ahlawat H, Whiting E, Dybul M, Cars O, Goosby E, et al.: **Global governance of antimicrobial resistance.** *Lancet* 2018, **391**:1976-1978.





Rojas F, Silvester E, Young J, Milne R, Tettey M, Houston DR, Walkinshaw MD, Perez-Pi I, Auer M, Denton H, et al.: **Oligopeptide Signaling through TbGPR89 Drives Trypanosome Quorum Sensing.** *Cell* 2018, **176**:306-317.

Wahl B, O'Brien KL, Greenbaum A, Majumder A, Liu L, Chu Y, Luksic I, Nair H, McAllister DA, Campbell H, et al.: **Burden of Streptococcus pneumoniae and Haemophilus influenzae type b disease in children in the era of conjugate vaccines: global, regional, and national estimates for 2000-15.** *Lancet Glob Health* 2018, **6**:e744-e757.

Whiteley D, Whittaker A, Elliott L, Cunningham-Burley S: **Hepatitis C in a new therapeutic era: Recontextualising the lived experience.** *J Clin Nurs* 2018, **27**:2729-2739.



Wilson M, Gathorne-Hardy A, Alexander P, Boden L: **Why "Culture" matters for planetary health.** *Lancet Planet Health* 2018, **2**:e467-e468.

A complete list of all publications is given in Appendix 3.

RESEARCH IN THE MEDIA

Many of the research outputs from EID have been picked up by the media and reached a wider audience through the mainstream press. In particular stories describing work from Christine Tait-Burkard on the breeding pigs resistant to the porcine reproductive and respiratory virus, from Helen Sang on the production of therapeutic proteins in chickens, and from Debby Bogaert on the nasal microbiome in infants, received extensive coverage in print and electronic news media around the world.

A summary of all press coverage is presented in Appendix 4.

IMPACTING SOCIETY

Key to making an impact from research is the translation of results into improvements in the health and wellbeing of societies and the environment. Research by EID members is having significant effects on societies across the globe. For example, during the past year our research is assisting in control of neglected tropical diseases, breeding farmed fish with increased disease resistance, informing clinical treatment of infant respiratory infections and responses to pandemic viruses, and improving the health of Scottish pine forests. We have highlighted some of this work in the summaries presented on the following pages.

- **Eliminating Schistosomiasis infection in Africa** – Prof. Francisca Mutapi (School of Biol. Sciences)
- **Vaccination programmes to eliminate rabies and dogs and humans** – Profs. Mark Bronsvoort and Richard Mellanby (Royal Dick) School of Veterinary Studies)
- **Improving the health and wellbeing of farmed salmon** – Prof. Ross Houston (Roslin Institute)
- **Informing health interventions to tackle viral disease epidemics** – Prof. Andrew Rambaut (School of Biol. Sciences)
- **Oxygen saturation targets in Bronchiolitis** – Prof. Steve Cunningham (Centre for Inflammation Research)
- **Protecting Scotland's native pine woodlands** – Prof. Richard Ennos (School of Biol. Sciences)



THE UNIVERSITY of EDINBURGH

ELIMINATING SCHISTOSOMIASIS INFECTION IN AFRICA

Schistosomiasis and soil transmitted helminthiasis (STH) are endemic diseases in Zimbabwe and are on the list of neglected tropical diseases (NTD) considered for control by WHO.

In 2010-11, there were no nationwide control programmes in place and before these could be considered, Prof Mutapi and colleagues from University of Zimbabwe carried out a national survey to understand the distribution and burden of the diseases.

This study provided comprehensive baseline data on the distribution of schistosomiasis and STH, and has formed the basis for initiating a national control and elimination programme for schistosomiasis and STH in Zimbabwe.



Due to the success of the Zimbabwe National NTD programme, other countries in Africa have adopted the mapping strategy and subsequent implementation of control programmes for schistosomiasis, STH and also other NTDs.

Mapping of NTDs is now complete in 41 out of 47 countries in Africa, covering an estimated 620 Million people at risk of disease by NTDs.

The survey data for NTDs across Africa is expected to result in the acceleration of regional elimination programmes and improved accuracy of the incidence of NTDs.

There will be cost savings through safe and integrated mass drug administration, and through cessation of unnecessary treatments.



ENSURING PRE-SCHOOL CHILDREN ARE TREATED

Work by Prof Mutapi and her team has demonstrated that children carry the heaviest burden of Schistosomiasis and that PZQ is efficacious in treating infection.

The WHO has recommended that pre-school children should be treated against schistosomiasis. However, PZQ is currently formulated as a large, extremely bitter tablet, which is inappropriate for paediatric administration.

Working with Prof Mutapi, Merck, as part of the Pediatric Praziquantel Consortium, is now working with Prof Mutapi to developing a PZQ formulation specifically for children. Phase I and II clinical trials have shown the new formulation is safe in adult subjects.

PHASE III TRIALS

Phase III clinical trials are planned in Cote d'Ivoire and Kenya during summer 2019.

Once these studies are completed, it is anticipated that more than 10 million pre-school children will receive PZQ treatment to keep them free from debilitating Schistosome infection.



CONTACT

Edinburgh Infectious Diseases
Ashworth Laboratories
Kings Buildings
University of Edinburgh
T: 0131 651 3688
E: eid@ed.ac.uk
W: <https://edin.ac/2ToSdzH>

|||| SCIENCE HAS IMPACT |||



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VACCINATION PROGRAMMES TO ELIMINATE RABIES IN DOGS AND HUMANS

Rabies is a devastating zoonotic disease which kills around 60,000 people each year. It has the highest case fatality of any infectious disease with patients almost always succumbing to the infection once clinical signs develop. The global cost of rabies has been estimated to be \$USD 8.6 billion with the loss of over 3.7 million disability-adjusted life years. The majority of cases occur in low- and middle-income countries in sub-Saharan Africa and south-east Asia, notably India.

Pioneering research started by Sarah Cleaveland at UoE in 2003 demonstrated that vaccinating 60-70% of dogs would effectively control dog rabies, leading to a significant reduction in demand for human post-exposure rabies treatment.



To address the challenges posed by upscaling pilot studies into mass vaccination programmes, researchers at the The Royal (Dick) School of Veterinary Studies (R(D)SVS) and the Roslin Institute (Richard Mellanby, Mark Bronsvoort) have developed a strategic partnership with the Mission Rabies charity (<http://www.missionrabies.com/>).

Together they have developed large scale, rapid vaccination protocols which ensure that over 70% of the canine population are vaccinated.

TACKLING RABIES IN INDIA

Implementing these programmes is particularly difficult in India where over 20,000 people die from rabies each year. The vast majority of dogs in India are free roaming which makes restraining them for vaccination challenging.

Despite these challenges, the team developed a vaccination strategy which has allowed over 70% of free roaming dogs to be vaccinated in several Indian cities. This study was the first demonstration of rapid, large scale vaccination programmes in India at a demonstrable high coverage.

RABIES VACCINATION IN AFRICA

Rabies is particularly problematic in Malawi, estimated to cost the country 13 million USD and 484 human deaths annually, one of the highest incidences of paediatric rabies in Africa.

Following on from the success seen in India, the research team demonstrated the feasibility of vaccinating over 35,000 dogs over a short time period (20 days) in Blantyre, Malawi, achieving more than 70% vaccination coverage. Continuous monitoring of the programme has allowed improvements in the vaccination throughput with 34,000 dogs vaccinated over 12 days with the same personnel numbers.

A crucial reason for this success has been the development of a bespoke data-gathering mobile phone application by University of Edinburgh PhD student Andy Gibson, which has now collected details of over 1 million dog vaccinations.

SIGNIFICANT IMPACT ON HEALTH WELFARE

Since the vaccination programmes were implemented there have been major reduction in paediatric rabies cases, in the Blantyre region of Malawi from 12 in 2012-15 to two cases in 2017 and none in 2018. In Goa the incidence of human rabies has declined from 15 human deaths in 2014 pre-campaign to zero in 2018 in Goa.

In addition the vaccination programmes run alongside an education outreach initiative, reaching over 1 million children in both India and Malawi by February 2019.

CONTACT

Edinburgh Infectious Diseases
 Ashworth Laboratories
 Kings Buildings
 University of Edinburgh
 T: 0131 651 3688
 E: eid@ed.ac.uk
 W: <https://edin.ac/2ToSdzH>

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IMPROVING THE HEALTH AND WELLBEING OF FARMED SALMON

Huge welfare burden

Sea lice are a major concern for salmon aquaculture worldwide causing hundreds of millions of dollars per year in prevention and treatment costs to the industry, together with significant health and welfare burden.

Research led by Professor Ross Houston at the Roslin Institute into the genetic basis of host resistance to sea lice, has both improved understanding of the host-parasite interaction, and has resulted in development of new methods of selective breeding for disease resistance.

WORLDWIDE IMPACT ON SALMON HEALTH



Largely via a BBSRC and Newton funded project in collaboration with researchers from Chile, the team detected three genomic regions containing loci affecting resistance to lice, explaining between 7 and 13 % of the genetic variation in lice counts.

The team also used RNA-Sequencing to compare the host response to infection between resistant and susceptible animals, observing that sets of genes related to pattern recognition, muscle activity, and iron availability were differentially expressed.



DEVELOPMENT OF LOW-COST METHODS

The previous research into cost-effective methods of improving genomic selection for resistance has resulted in a **low-cost** method of predicting breeding values for lice resistance in the fish.

Improving resistance to disease via genomic selection will reduce the disease burden, which in turn will improve fish health and welfare.

The improvement is both **direct** via reduced incidence of disease-associated pathology, and **indirect** via reducing the need for treatments which can themselves be stressful for the fish.

This new research allows genomic selection at low cost by using a technique called genotype imputation. The result is a major drop in the cost of genomic selection, allowing for a wider uptake by breeding companies, and therefore far-reaching impact on the aquaculture industry worldwide.



CONTACT

Edinburgh Infectious Diseases
 Ashworth Laboratories
 Kings Buildings
 University of Edinburgh
 T: 0131 651 3688
 E: eid@ed.ac.uk
 W: <https://edin.ac/2ToSdzH>

|||| SCIENCE HAS IMPACT |||



THE UNIVERSITY of EDINBURGH

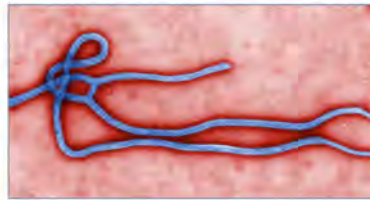
INFORMING HEALTH INTERVENTIONS TO TACKLE VIRAL DISEASE EPIDEMICS

The BEAST software was developed in Edinburgh for Bayesian analysis of molecular sequences related by an evolutionary tree. It analyses gene sequence data to investigate evolutionary and epidemiological dynamics.

Information about the timing and spatial location of epidemics can be traced and the rate of spread can be measured from a relatively small number of isolates from the population of infected individuals.

BEAST has been used by Andrew Rambaut (School of Biological Sciences) and Sam Lycett (Roslin Institute) in analysis of disease spread during two major pandemics – the West African Ebola Virus outbreak in 2013-16 and the H5N8 Avian influenza flu pandemic in 2014-15.

The resulting data has been used by global agencies to inform disease prevention and control strategies, leading to long-term impact of the research.



Ebola outbreak 2013-2016

The 2013-2016 Ebola outbreak in west Africa was of unprecedented magnitude. The WHO declared a public health emergency in August 2014. The epidemic that followed had >28,000 documented cases and >11,000 deaths in 6 countries.

Analysis of molecular sequence data was performed by Andrew Rambaut and colleagues to inform public health bodies (WHO, CDC, PHE USA) in West Africa at the time of the Ebola epidemic.

Until this outbreak, genomic studies of infectious disease outbreaks were retrospective. Use of BEAST, combined with high-throughput next-generation sequencing, now enabled rapid and in-depth viral genome surveillance while the outbreak was ongoing.

One of Andrew's collaborators sent a PhD student to Guinea to sequence viruses on the ground and then feed the data directly for analysis in Edinburgh, which allowed a 24 hour turn-around from sample collection.

The data revealed the pathways of viral spread through communities and have been used to direct intervention methods to transmission hot spots and to determine the impact of specific interventions.

This was the first time that genomic data were used directly in a real-time public health setting to inform infection control policies.

REAL TIME GENOME ANALYSIS

Avian Influenza

Avian flu poses a major threat to global poultry production and to public health, as it has the potential to cause severe disease in humans.

In 2014-15 there was an avian flu H5N8 outbreak in Asia, Europe & North America. This was the first time since 2005 that a strain had spread so far and to North America and was a serious threat to food security worldwide. Sam Lycett and her colleagues used BEAST to confirm that the H5N8 virus was not being transmitted flock-to-flock but rather via long-distance migratory birds.

The work also demonstrated it was highly unlikely that the virus was introduced via contaminated water, feed or poultry, nor was it attributable to personnel or trade in wild animals.

These findings were highly influential in informing appropriate control measures that were implemented during subsequent outbreaks of avian flu. Previously the control measures of keeping chickens indoors during an outbreak was advisory only – this work proved that such precautions should be mandatory whilst wild birds are migrating.



CONTACT

Edinburgh Infectious Diseases
 Ashworth Laboratories
 Kings Buildings
 University of Edinburgh
 T: 0131 651 3688
 E: eid@ed.ac.uk
 W: <https://edin.ac/2ToSdzH>

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THE UNIVERSITY of EDINBURGH

OXYGEN SATURATION TARGETS IN BRONCHIOLITIS

Bronchiolitis is blockage of the small airway in the lungs caused by viral infection and occurs in children less than two years of age. Bronchiolitis is usually the result of infection by respiratory syncytial virus (72% of cases) or human rhinovirus (26% of cases).

Symptoms may include fever, cough, runny nose, wheezing, and breathing problems. There is no specific treatment and supportive care at home is generally sufficient. But occasionally hospital admission for oxygen, support with feeding, or intravenous fluids is required.

In England, there were 43,617 admissions with bronchiolitis in 2016 an increase of 21% in five years, and representing 1 in 5 infant admissions to hospital.



Steve Cunningham in the Centre for Inflammation Research at the University of Edinburgh, chaired the 2005 Scottish Intercollegiate Guidelines Network (SIGN) and the 2015 National Institute of Clinical Excellence (NICE) Bronchiolitis Guidelines.

Through this work he developed an interest in testing the efficacy of using oxygen saturation levels recommended in the SIGN guidelines (94%), versus new guidelines in the US that recommended significantly lower levels of oxygen saturation (90%).

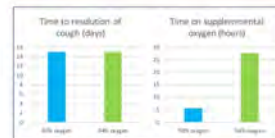


CLINICAL TRIAL OF NEW GUIDELINES

In a clinical trial with over 600 infants between the ages of 6 weeks to 12 months, treatment was randomised to either 90% or 94% oxygen saturation targets, and the time to resolve cough was measured.

The trial showed that there was no difference in the time to resolve cough between the two oxygen levels.

Importantly the trials also showed that patients spent fewer hours on supplemental oxygen, were discharged earlier, returned to normal feeding soon, and when treated at lower levels of oxygen saturation.



SIGNIFICANT COST-SAVINGS TO THE NHS

The cost-savings that could be made due to the earlier discharge of £290 per child, and a saving across the NHS from the intervention could be £14 million.

Eight leading paediatric hospital units in the UK taking part in the trial, seven are routinely using the 90% saturation threshold (1 did not respond). Paediatricians in other countries (Germany) are also known to have adopted a 90% threshold for routine care of bronchiolitis.

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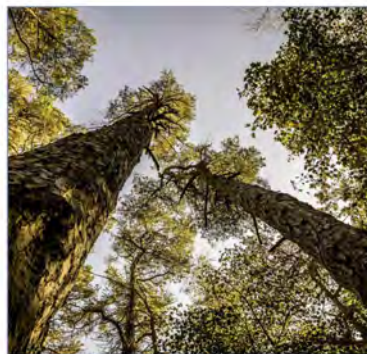


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PROTECTING SCOTLAND'S NATIVE PINE WOODLANDS

Richard Ennos in the School of Biological Sciences and colleagues at Scotland's Rural College, have been leading research to determine the origin of the emerging Dothistroma needle blight (DNB) disease on native Caledonian Scots pines.

This work has directly contributed to the development of effective strategies to control spread of the disease.



Dothistroma needle blight disease is caused by the fungal pathogen *Dothistroma* and can result in defoliation year on year.

It weakens trees and reduces timber yields very significantly, eventually causing death, with those trees being unmarketable.

There are approximately 245,000 ha of pine woodland in Scotland. Surveys have shown that *Dothistroma* needle blight disease affects 11,000 ha of pine woodland, which highlights the significant risk the disease poses to Scotland's forest resource.

Based on work from Richard and others, in 2016 the Forestry Commission has imposed restrictions on transfer of Scots pine from nurseries into Caledonian pinewoods.

It also initiated felling programmes to remove the highly susceptible Lodgepole pines from the vicinity of Caledonian pinewoods in 2017.



RESEARCH INFORMING FORESTRY POLICY

Richard's new research has found that the current outbreak of DNB disease (which started in 2000) is caused by three races of the pathogen *Dothistroma septosporum*.

The entry of *D. septosporum* into Britain has been facilitated by the widespread planting of two exotic pine species, Corsican and Lodgepole pines.

Two particular races of *D. septosporum* now present in the Caledonian pinewoods cause significant damage, and there is the possibility that these existing races will hybridise to create more damaging genotypes in the future.

These new results have important implications for future Forestry Commission policy on use of exotic tree species that are related to native tree species in British forestry.



CONTACT

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 Ashworth Laboratories
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 University of Edinburgh
 T: 0131 651 3688
 E: eid@ed.ac.uk
 W: <https://edin.ac/2ToSdzH>

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BUILDING CONNECTIONS WITH EXTERNAL PARTNERS

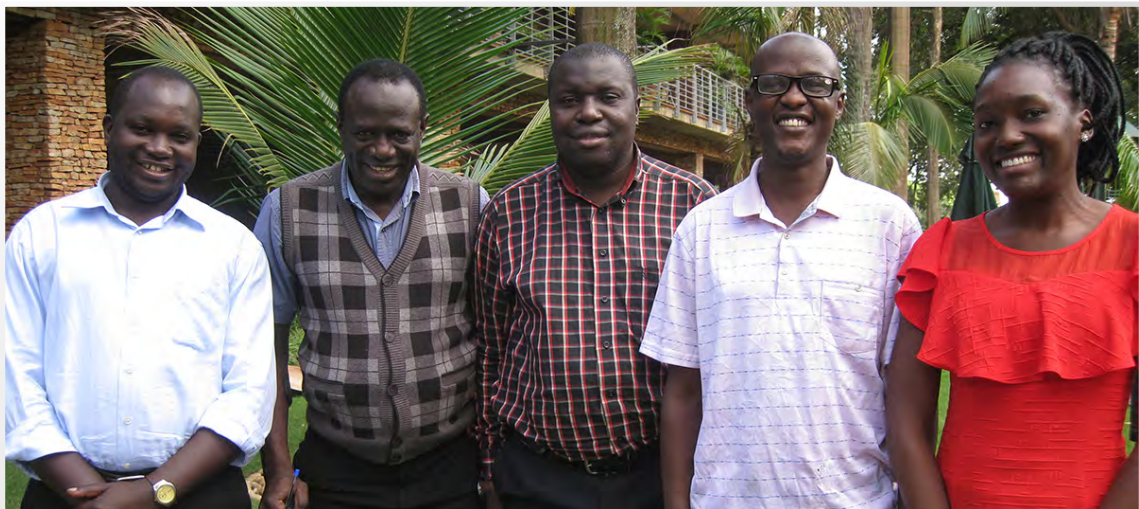
A key role for EID is looking outward to identify external partners and collaborators to enhance and complement our research and training programmes. During 2018 we led a number of initiatives that align with the University’s strategic aims in this area.

FLEMING FUND FELLOWSHIPS: ADDRESSING SURVEILLANCE OF ANTIMICROBIAL RESISTANCE IN LOW- AND MIDDLE-INCOME COUNTRIES



The Fleming Fund is a £265 million UK aid programme to help low- and middle-income countries fight antimicrobial resistance (AMR), through increasing the quantity and quality of data on antibiotic use and AMR surveillance. The Fleming Fund has several strands of activity, including making regional and country grants, and through the Fellowship scheme. This last scheme supports a global network of AMR experts and advocates for action by offering fellows an opportunity to develop key skills, benefit from expert mentorship and opportunities for peer-to-peer knowledge sharing.

In Spring 2018 EID led an application to the Fleming Fund for Host Institute status for University of Edinburgh for fellowships based in Southern and East Africa. In September 2018 we were chosen by the Fleming Fund management agent Mott MacDonald, to host six fellows from Uganda for 18-month fellowships. The fellowships bring **£480K** to the University, which covers training and research costs for the fellows, and the time mentors and administrators spend on the project.



Five of the Fleming Fund fellows in Uganda that we will be working with over the next 18 months. Left to right: Ibrahim Mugerwa (Uganda National Health Laboratory Services), William Olum (Ministry of Health, Jinja), Joel Bazira (Mbarara University of Science and Technology), Michael Omodo (Ministry of Agriculture, Animal Industry and Fisheries) and Merab Acham (National Animal Disease Diagnostics and Epidemiology Centre). The final fellow is Joseph Kungu from the College of Veterinary Medicine, Animal Resources and Biosecurity, Makerere University.

The new Fellows work in both human and animal health, with professional remits covering antibiotic use, AMR surveillance and laboratory practice. These fellowships represent enormous opportunities for the fellows to receive training that will be directly relevant to their professional roles tackling AMR in Uganda.

The Fellows will also be supported by the University of Edinburgh mentors Profs. Mark Bronsvort and Mark Woolhouse, and Drs. Gavin Paterson, Adrian Muwonge and Kate Templeton, to subsequently disseminate some of the new techniques, practices and skills within their home institutions.

EID ran an opening workshop in Kampala, Uganda in January 2019 for the fellows and their University of Edinburgh mentors. This event established the training needs of each of the Fellows, and ensured that the workplans developed by the mentors addressed those requirements. The first of the training units was delivered in Kampala in April 2019, and we are looking forward to hosting the six Fellows in Edinburgh later this summer.

The Fleming Fellowship scheme will eventually be rolled out into six further countries in Southern and East Africa – eSwatini, Kenya, Malawi Tanzania, Zambia and Zimbabwe. EID has indicated to the Fleming Fund that we would be interested in partnering with fellows in Malawi and Zimbabwe, and are looking forward to developing these collaborations further.

JOINT PHD PROGRAMMES WITH THE UNIVERSITIES OF GLASGOW AND LEIDEN

One Health is one of three joint PhD programmes, alongside Criminology and Future Cities, that were initiated with the University of Glasgow in 2018. The *One Health Interventions for Control of Infectious Diseases* programme is being led by EID director Prof. Ross Fitzgerald and Prof. Dan Haydon in Glasgow. Four students have now been recruited to work on projects in Glasgow and Edinburgh and will start their studies in October 2019.

Leiden University is one of a number of EU institutions with whom the University of Edinburgh is currently developing strategic partnerships. In the past EID has funded undergraduates from the Infectious Diseases honour programme in Edinburgh to undertake 2-month summer placements with colleagues at the Leiden University Medical Center (LUMC). Building on some of these existing links, over the past 6 months EID executive committee members Profs. David Dockrell, Mark Stevens and Ross Fitzgerald have been instrumental in the development of a new joint training partnership in *Integrated One Health Solutions* with LUMC. It is anticipated that the new programme will recruit three students at each institution to work on jointly supervised projects, with the students spending up to 1 year in the partner lab.

Discussions are also underway with colleagues at University College Dublin (UCD) and the EID Director has visited UCD to explore how productive partnerships in the areas of *One Health of Infectious Diseases* might be developed.

SUPPORTING ACADEMIC ENGAGEMENT WITH INDUSTRIAL PARTNERS

Tackling antimicrobial resistance is a major strategic priority within Edinburgh Infectious Diseases, and we recognise that our members have an important role to play in addressing this global challenge. In 2017 EID developed the Edinburgh Antimicrobial Resistance Research Strategy which highlighted expertise in at the University of Edinburgh addressing four major themes in AMR research: (1) Global and Local Epidemiology of AMR, (2) Basic Mechanisms Underpinning AMR, (3) Rapid Diagnostics for more Effective Antibiotic Use and (4) Antibiotic Alternatives and Vaccine Development. IN 2018-19 a fifth strand focusing on AMR Governance and Stewardship has been added. In the last 5 years (2014-2018) researchers in Edinburgh were awarded over £19M for projects which addressed this urgent global need.

This year we have been actively trying to support our members to engage with potential industrial partners. We believe that the most effective commercialisation support we could provide to our members at the current time is market analysis of the AMR landscape, tailored to our identified thematic research areas. We have applied for funding from impact accelerator accounts at the University to allow us to commission a technology consultancy company to carry out this work over summer 2019. Following delivery of the report will work closely with the Business Development teams within Edinburgh Innovations in the University of Edinburgh to take forward the key findings and recommendations from this report. In conjunction with the market analysis, we have also been preparing marketing material on research expertise in AMR diagnostics that can be used by colleagues in Edinburgh Innovations.

INFLUENCING POLICY

As was demonstrated in several of the impact studies above, research generated by our members is being used to inform policy across a wide spectrum of activities in global health, disease preparedness and clinical practises. Members of our executive committee serve on a number of advisory panels and expert committees.

During this year EID coordinated responses to high level policy consultations on AMR research strategy for the *Health and Social Care Parliamentary Committee* of the UK Government and the *UN Interagency Coordination Group on AMR*. We will continue to promote and support similar engagements going forward.

The submission to the *Health and Social Care Parliamentary Committee* of the UK Government, Prof Rosalind Allen and Dr. Luke McNally in June 2018. In it they gave the Edinburgh perspective on suggested actions and priorities for the next AMR strategy. Specifically, that,

- Research in AMR can be grouped into Translational AMR research, AMR Observational Science and Basic AMR research. These should be treated individually since they work quite differently.
- Translational AMR research is resource intensive and needs long term commitment; funding and initiatives should be intensified in this area.
- To address the urgent need for data to inform AMR policy we recommend targeted calls for large consortium-style grants in AMR Observational Science.
- AMR Basic Science requires sustained funding to ensure a supply of innovative ideas that will in the long term generate technological progress in AMR. We suggest that UKRI run a continuous and interdisciplinary Responsive Mode grant scheme specifically in AMR.
- We also suggest UKRI run an interdisciplinary AMR Fellowship scheme for to generate a cohort of rising star early career researchers, including clinicians, across the full breadth of AMR related disciplines.
- The need to address data access issues surrounding digitised patient records, which are of great value in AMR research, is a pressing issue following the introduction of GDPR. The government should consult with the AMR research community when considering research exemptions to GDPR requirements.
- We recommend maintenance of the existing initiatives to foster international collaborations in AMR research, under a more sustained, long-term programme of support such as that provided by a responsive mode scheme.
- We recommend incentives to strengthen UK industry-academic links in AMR.

The UK government published the new strategy in January 2019, acknowledging several of the points raised.

TRAINING IN INFECTIOUS DISEASES

One of the major remits of EID is to develop and promote teaching and training in infectious diseases at both the undergraduate and postgraduate level.

ALIGNING UNDERGRADUATE TEACHING OF INFECTIOUS DISEASES

Over the past several years progress has been made to better align delivery of infectious disease and immunology content across the Schools of Biomedical and Biological Sciences.

The Infectious Diseases Honours course is one of seven programmes delivered by the Biomedical Teaching Organisation, and Immunology Honours is taught by the Biology Teaching Organisation. Differences in course structures and timetabling currently make it difficult for students on these related programmes to take courses offered by the other teaching organisation. This has both reduced student choice and also led to duplication of teaching material by staff.

On behalf of Edinburgh Infectious Diseases, Dr. Bernadette Dutia (Roslin Institute) undertook an initiative with both the Biomedical and Biology Teaching Organisations to explore possible changes in programme delivery that would allow students on the Infectious Diseases and Immunology Honours programmes wider access to courses. Both organisations have engaged very positively with these discussions.

To inform further developments, a student questionnaire has been developed by the Honours Programme Organisers for Immunology (Dr. Matthew Taylor, School of Biological Sciences) and Infectious Diseases (Dr. Douglas Roy, Division of Infection and Pathway Medicine). This survey will be sent to all 4th year students completing these programmes in summer 2019 to determine how much interest there is among students for increasing access to additional courses, and for which courses there would be particular demand. Any changes that are mandated by the survey responses could be implemented for students commencing their Honours year in 2020, following discussion and agreement concerning resourcing, structuring, and delivery.

HOSTING UNDERGRADUATE VISITORS FROM UNIVERSITY COLLEGE OF SOUTHERN DENMARK

This year we hosted a group of 25 students from University College of Southern Denmark who were visiting the University of Edinburgh as part of their studies in biomedical education systems.



They had a very busy schedule over the three days they spent in Edinburgh, touring labs at the Kings Buildings, Edinburgh BioQuarter, the Institute for Genetics and Genomic Medicine, and the Roslin Institute. They heard talks about different courses offered by the University of Edinburgh in infectious diseases at both undergraduate and

postgraduate levels, heard about some of our research in antimicrobial resistance and had a poster session with infectious diseases Masters students.

POSTGRADUATE TRAINING

WELLCOME TRUST 4-YEAR PHD PROGRAMME IN HOSTS, PATHOGENS AND GLOBAL HEALTH

The *Hosts, Pathogens and Global Health* PhD programme welcomed its third cohort of students in October 2018. This interdisciplinary programme is led by EID executive committee members Profs Keith Matthews and Mark Woolhouse in the School of Biological Sciences and integrates training across three major themes: Immunology & Molecular Biology, Evolutionary Biology & Ecology and Molecular Phylogeny & Epidemiology. This has been a very successful programme, bringing together students from different backgrounds to continue their training in interdisciplinary approaches to tackling problems in infectious disease and global health. Students are supported to combine research in a UK and developing country setting, to understand how infectious agents are spread, cause disease, interact with the immune and other body systems, or evolve to overcome therapeutic interventions.



Students from the 2016 and 2017 cohorts with Keith Matthews at the programme retreat to Dunkeld in June 2018. Left to right: Oumie Kuyateh, Alex Morgan, Kyriaki Neophytou, James Iremonger, Frank Venter, Tasha Smith, Áine O’Toole, Flo McLean, Florian Bach, Aliz Owolabi and Prof. Keith Matthews.

There are now 17 students enrolled on the programme, and we have just recruited the fourth cohort who will start later this year. Following successful completion of their first year Masters by Research in Hosts, Pathogens and Global Health, the students from the first two cohorts are now undertaking PhD projects in a wide variety of topics:

First name	Supervisor	Project title
2016 cohort		
Florian Bach	Phil Spence	Immune responses of initially naïve human hosts to repeated infection with blood-stage Plasmodium vivax
James Iremonger	Liam Morrison and Achim Schnauffer	Mitochondrial Metabolism in Livestock Trypanosomes
Florence McLean	Alex Rowe	Conserved Epitopes in Rosetting PfEMP1 Variants: Prevalence will Inform Potential as a Therapeutic Target in Severe Malaria
Áine O’Toole	Andrew Rambaut	Exploiting nanopore sequencing technology for real time analysis of acute viral outbreaks

Natasha Smith	Graeme Cowan	Decoding adaptive immunity: high-throughput sequencing and characterisation of the immune repertoires produced during parasitic infections
Frank Venter	Keith Matthews	The Impact of mixed species infection on trypanosome virulence and spread
2017 cohort		
Oumie Kuyateh	Darren Obbard	Evolution and Functional Genetics of Drosophila Viruses
Alex Morgan	Mark Woolhouse	Understanding the dynamics of antimicrobial resistance transmission at the livestock/human interface
Kyriaki Neophytou	Amy Buck	Elucidating the function of an Argonaute protein secreted by a parasitic nematode in the mammalian gut
Alíz Owolabi	Sarah Reece	'N Sync – Evolutionary and ecological drivers of synchrony between malaria parasites
Hanne Stawarz	Ross Fitzgerald	Characterising microbiome-mediated environmental pressures on <i>S. aureus</i> within two host niches

The programme has been invited to submit a full application to the Wellcome Trust for renewed funding which will allow us to recruit further cohorts of students starting in 2020.

ONE HEALTH MODELS OF DISEASE

As mentioned earlier, a key approach in health and disease studies is One Health, which recognises the interconnectedness of health in humans, animals and ecosystems. This approach involves applying a coordinated, collaborative, multidisciplinary and cross-sectoral working to address potential or existing risks that originate at the animal-human-ecosystems interface.

Major technological advances in gene editing for transgenesis and genome-scale mutagenesis are opening up opportunities for the design of new 'One Health' models of neurodegenerative, cardiovascular, developmental, and infectious diseases of humans and animals that could transform our experimental approach to understanding diseases. Although the technological advances have tremendous potential, there is currently a significant gap at a national level in graduate-level training in state-of-the-art techniques, at world-class purpose-built facilities by leading scientific experts.

To address this training need, EID has developed a new PhD programme to the Wellcome Trust ***One Health Models of Disease: Science, Ethics and Society*** for potential funding by the Wellcome Trust. Many of the new techniques addressed by the Programme, for example in gene editing, could have significant societal impact. Thus, working with colleagues in the Wellcome Trust Centre for Biomedicine, Self and Society, the proposed programme has integral training in bioethics to allow students to understand the ethical implications of these powerful new approaches and how they may be applied.

Much of the ground work for this new programme was laid out at a workshop run by EID in October 2018, that brought together many of the key contributors for informed and fruitful discussion.

If the application is successful, the new programme will be led by Prof. Ross Fitzgerald with input from Dr. Kenny Baillie; Dr. Vicky MacRae, Prof. Mark Stevens and Dr. Tom Wishart at the Roslin Institute, and Drs. Martyn Pickersgill and Sarah Chan (Wellcome Trust Centre for Biomedicine, Self & Society, Usher Institute).

EPSRC CENTRE FOR DOCTORAL TRAINING IN BIOMEDICAL ARTIFICIAL INTELLIGENCE

A new UKRI Centre for Doctoral Training in *Biomedical Artificial Intelligence* (AI) was awarded to the University of Edinburgh in March 2019. This new centre will train students to develop techniques that will extract knowledge from biomedical data sets, with potential impact for public health and the economy.

The initial concept for the new centre developed following a workshop on Quantitative Methods for Combatting Infection run by EID in November 2017. The Centre is led by Prof. Guido Sanguinetti from the School of Informatics, alongside EID member Dr. Meriem El Karoui in the School of Biological Sciences and Prof. Chris Ponting at the Institute of Genetics and Molecular Medicine.

It builds on a collaboration between several centres of excellence within the University: the School of Informatics, the School of Biological Sciences, the MRC Institute of Genetics and Molecular Medicine, the Usher Institute of Population Health Science and Informatics, and the School of Social and Political Sciences. Together, these institutes provide a unique breadth and depth of expertise, as well as state-of-the-art computational and experimental facilities, to support the CDT cohorts. It will enable students to innovate in AI while addressing problems with direct translational relevance to biomedical challenges such as the emergence of antimicrobial resistance within infection and cancer. Furthermore, it will give students understanding of the socio-ethical aspects raised by this new capacity in biomedical AI. Additionally, leading clinical, industrial and international academic partners will provide students with opportunities for hands-on application in a broad variety of contexts.

The first cohort of students is currently being recruited to start their studies in autumn 2019.

BUILDING A STRONG AND CONNECTED COMMUNITY

One of the major ways that EID brings value, is by increasing interactions between members on different campuses and promoting knowledge exchange and collaboration. We continue to implement a wider strategy promoting the continued development of internal and external links across the network and beyond.

E-COMMUNICATIONS

During 2018 we have continued to develop our new weekly newsletter, connecting recipients with information about infectious disease seminars from across the different campuses, details of relevant events in Edinburgh and further afield, and news of particular successes across the network.

We launched our new website in February 2018, which has brought a more professional interface for those seeking information about our work. Traffic is brought to our site from across the globe, augmented by our social media profile. Details of all the news stories we have highlighted on our website is presented in Appendix 5.

SYMPOSIA AND WORKSHOPS

A key aspect of our work has been the events that bring researchers physically together. A summary of the events we ran in 2018 is listed below. In particular the annual symposium and Winter Lecture attracted many of our members.

Events	When	Where
Vesicles, Extracellular RNA and Infectious Disease workshop	9 May 2018	Edinburgh City Chambers
Edinburgh Infectious Diseases 7 th Annual Symposium	23 May 2018	Informatics Forum
Respiratory Diagnostics workshop	12 September 2018	Queen's Medical Research Institute
One Health Models of Disease workshop	23 October 2018	Queen's Medical Research Institute
World Pneumonia Day Symposium	12 November 2018	Queen's Medical Research Institute
Annual Winter Lecture with Dr Tom Kariuki , African Academy of Sciences	13 November 2018	Playfair Library, Old College
Diagnostics for Infectious Diseases workshop	14 November 2018	Roslin Institute
Future events	When	Where
Parliamentary Engagement on Tuberculosis Research in Scotland	10 May 2019	Edinburgh BioQuarter
Edinburgh Infectious Diseases 8 th Annual Symposium	5 June 2019	Royal College of Physicians, Edinburgh
Nanopore Users workshop	September 2019	Kings Buildings
Annual Winter Lecture with Prof Liz Sockett FRS, University of Nottingham	19 November 2019	Playfair Library, Old College

We continue to respond to requests from our members to run symposia and other similar events to continue integrating researchers from across the University and the city, promoting collaboration and innovation.

SEVENTH ANNUAL SYMPOSIUM

As in previous years, the annual symposium was the highlight event. Held this year in the Informatics Forum, the symposium was a celebration of the huge range of infectious disease research in Edinburgh.

The programme showcased research from across the network, including presentations from Prof. Eleanor Riley (Director of the Roslin Institute), discussing malaria and salmonella confections in Africa; Dr. Darren Obbard (School of Biological Sciences) describing identification of novel viruses from *Drosophila*; Prof. Mark Stevens (Roslin Institute) on *Salmonella* pathogenesis in cattle and Dr. Thamarai Schneiders (Division of Infection and Pathway Medicine) dissecting antimicrobial resistance in *Klebsiella* bacteria.



Left: EID director Prof. Ross Fitzgerald with Ker Memorial lecturer Prof, Sir Mike Ferguson and Ker Memorial Prize winner Dr. Rodrigo Bacigalupe. Right: Poster prize winners and judges at the Annual Symposium. Left to right: Prof. Gary Entrican, Prof. Ross Fitzgerald, Omar Altifuri, Prof. Clifford Leen, Dr. Bernadette Dutia and Dr. Spring Tan.

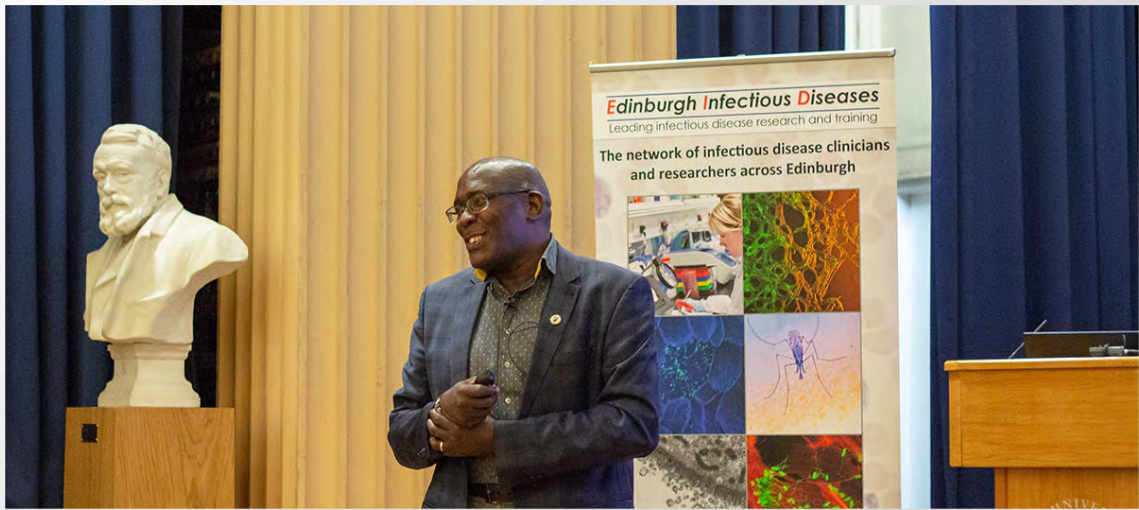
We were delighted to award the Ker Memorial Prize for the most outstanding thesis on infectious disease submitted to the University of Edinburgh during 2017 to Dr. Rodrigo Bacigalupe. Rodrigo carried out his PhD in Ross Fitzgerald's lab (Roslin Institute) on population genomic analysis of the niche adaptation of bacterial pathogens and presented his work to the symposium audience. This year the Ker Memorial Lecture was given by Sir Mike Ferguson, Regius Professor of Life Sciences and Academic Lead for Research Strategy at the University of Dundee. Mike gave a very insightful and inspiring talk about the collective endeavour he has been involved in for many years to develop drugs against neglected tropical neglected diseases.

There were also very lively poster sessions during the coffee breaks and lunch time. Dr. Spring Tan from Dr. Bob Dalziel's lab (Roslin Institute) won the prize for best poster by a postdoc for her work to develop a genome wide CRISPR knockout library to study host pathogen interactions in cattle, and Omar Altifuri from Dr. Liam Morrison's lab (Roslin Institute), was awarded the student prize for his studies on the effect of pre-disposed local skin inflammatory response on African trypanosome infection.

WINTER LECTURE 2018

For our public winter lecture in November 2018 we were very pleased to host Dr. Tom Kariuki, Director of Programmes at the African Academy of Sciences and head of the Alliance for Accelerating Excellence in Science in Africa. In a packed Playfair Library he spoke compellingly about the huge developments that are

being made in African science across the continent, the continued need for support from external partners to continue building knowledge and expertise, and his optimism for the future.



Dr. Kariuki explained how the African Academy of Sciences is currently working to support research, development and commercialisation of novel, high-impact solutions. This is being achieved through global strategic partnerships, crucially helping to shift the centre of gravity for African science into Africa.

He eloquently described how the 17 Sustainable Development Goals of the United Nations paint an optimistic picture of what the world can look like in 2030. But on many targets, especially those related to poverty and disease, it is clear that African countries still have the far to go. In human terms, this means that the quality of life for more than a billion people on the fastest-growing continent on earth still hangs in the balance.



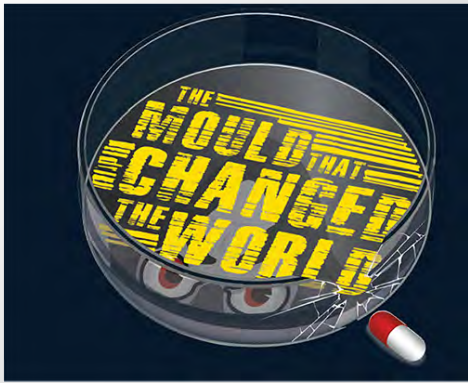
Earlier in the day Dr. Kariuki met with PhD students Hosts, Pathogens and Global Health programme, who are supported by the University of Edinburgh's Darwin Trust and Mastercard Scholar Programmes.

PUBLIC ENGAGEMENT

EID has been involved in a number of events that help the public to engage with the key issues some of our research addresses.

THE MOULD THAT CHANGED THE WORLD

One major project was the production of a musical “The Mould that Changed the World”, based around the discovery of penicillin and the subsequent emergence of antibiotic resistance.



The new musical is a collaboration between composer Robin Hiley and Edinburgh clinician scientist Dr. Meghan Perry. It seeks to immerse both the performers and audience in the evocative story of antibiotics, and the real dangers of antimicrobial resistance.

There are two versions of the musical – a version for professional actors with a chorus of health care professionals and scientists, and a schools’ version for upper primary/lower secondary students. The schools’ version has already had two very successful premieres in Edinburgh and

London, which were favourably reviewed by both the British Medical Journal¹ and the Lancet Infectious Diseases².



The cast during a performance of The Mould That Changed the World during the Edinburgh Fringe in August 2018.

Assessment of the impact of the musical on the children taking part in the school performances has demonstrated increased knowledge of AMR and important behavioural change in relation to antibiotics.

¹ <https://doi.org/10.1136/bmj.k3038>

² [https://doi.org/10.1016/S1473-3099\(18\)30472-9](https://doi.org/10.1016/S1473-3099(18)30472-9)

With the support of all four UK Chief Medical Officers, free online resources will go live on 1 May 2019, enabling any primary school in the UK to perform the musical independently.

In summer 2018 the professional version of the musical had a very successful run in the Edinburgh Fringe with over 98% of tickets sold, high profile attendees and high impact media coverage including on the BBC news. Evaluation of audience responses showed that over 95% of attendees agreed that the musical was an effective way to spread the urgent message of AMR.

The future of the *Mould* includes a model of week-long community residencies of the Professional version in Scottish cities using local choirs of healthcare professionals and scientists in each area. The residencies engage communities at many levels, with workshops for children during the day to facilitate school uptake, and performances in a local theatre in the evenings, as well as science outreach activities. The university's widening participation program will help to facilitate outreach to target low income schools. The project has been funded by the British Society of Antimicrobial Chemotherapy.

EXPLORING BUGS AND BONES

The Bugs and Bones project is an ongoing activity designed to bring the Ashworth Natural History Collection to wider public audiences, facilitating engagement with current research in infectious disease research.

During 2018 EID continued to build resources for primary school pupils, developing a Science, Art and Writing workshop based around the Bugs and Bones treasure chest. The new workshop gives children hands-on interaction with the bones and parasite samples, explores concepts common to both language and infection, including spread, evolution, and adaptation, and helps participants to create a piece of artwork inspired by the specimens.

These workshops were run in Sacred Heart Primary School, Penicuik and Rosewell Primary School during the Midlothian Science Festival in October 2018. Some of the comments demonstrated the power of combining the three approaches –

“I love that we saw the bugs”

“Best Science”

“I loved the art activity and all the interesting facts about the animals”



Examples of artwork inspired by the specimens in the Bugs and Bones treasure chest, created by pupils at Rosewell and Sacred Heart Primary Schools, as part of the Science-Art-Writing workshops during the Midlothian Science Festival.

EID also presented several activities on Doors Open Day in September 2018, with work on sleeping sickness, malaria and immune system disorders.



BEYOND RESISTANCE

EID has been pleased to support the Beyond Resistance network during 2018.

The intersection of arts, social, basic and clinical sciences in Edinburgh is a key strength of our research portfolio. Beyond Resistance is a new network focusing on the contributions that social science and art can make to addressing the challenges of antimicrobial resistance.

It is coordinated in the School of Social and Political Science and has input from the Edinburgh Centre for Medical Anthropology, Atelier – the creative arts and social sciences network – as well as Edinburgh Infectious Diseases. It was launched at a workshop in May 2018, and since then has gone on to run several public engagement activities during the Edinburgh Fringe (August 2018) and the Festival of Creative Learning (February 2019).



The network has also engaged with a wide spectrum of researchers and in January 2019 ran a colloquium Re-imagining AMR - Beyond the Military Metaphor exploring the language used to discuss antimicrobial resistance and the impact this has on our response to the problem. EID is working with the network to further develop these growing connections.

APPENDIX 1

SELECTED GRANTS >£500K AWARDED TO MEMBERS OF EDINBURGH INFECTIOUS DISEASES IN FY 2017-18

School	Lead researcher	Project Title	Sponsor	Award (£)
Deanery of Molecular, Genetic and Population Health Sci.	Aziz Sheikh	RESPIRE: exploiting information technology to reduce morbidity and mortality from respiratory disease in low- and middle-income countries	NIHR	£6,945,875
Royal (Dick) School of Veterinary Studies	Appolinaire Djikeng	Center for Tropical Livestock Genetics and Health	BMGF	£3,768,680
Chemistry	Mark Bradley	EPSRC IRC PROTEUS - multiplexed 'touch and tell' optical molecular sensing and imaging	EPSRC	£3,102,465
Deanery of Clinical Sciences	Kevin Dhaliwal	Optimising ablation of suspicious pulmonary lesions with flexible bronchoscope	BTG International ltd	£2,964,762
Biological Sciences	Sander Granneman	Unravelling post-transcriptional regulatory networks in pathogenic <i>S. aureus</i>	MRC	£2,366,064
Biological Sciences	Keith Matthews	Challenging trypanosome antigenic variation paradigms using natural systems	Wellcome Trust	£1,920,993
Deanery of Biomedical Sciences	Till Bachmann	Project DOSA - Diagnostics for One Health and User Driven Solutions for AMR	ESRC	£1,888,109
Biological Sciences	Andrew Rambaut	Putting genomic surveillance at the heart of viral epidemic response.	Wellcome Trust	£1,721,712
Biological Sciences	Keith Matthews	Wellcome Trust PhD Programme Hosts, Pathogens & Global Health - main award	Wellcome Trust	£1,685,740
Deanery of Clinical Sciences	Sarah Walmsley	Defining the interplay between hypoxia and metabolic adaptations of the innate immune response.	Wellcome Trust	£1,642,425
Deanery of Molecular, Genetic and Population Health Sci.	Adam Hill	Pneumonia investigation bundle to guide therapy for hospitalised community acquired pneumonia (PIB CAB study)	NIHR	£1,619,527
Biological Sciences	Edward Wallace	Dynamic regulation of mRNA processing in adapting fungi	Royal Society and Wellcome Trust	£1,337,768

Royal (Dick) School of Veterinary Studies	Barry McColl	Understanding and manipulating innate-like B cell mechanisms to prevent stroke-associated infection	MRC	£1,337,134
Royal (Dick) School of Veterinary Studies	Christine Tait-Burkard	A strategic approach to identifying and combating Porcine Reproductive and Respiratory Syndrome virus outbreaks and other porcine viral diseases	BBSRC	£983,771
Royal (Dick) School of Veterinary Studies	Fiona Houston	Comparative evaluation of the performance of proposed diagnostic tests for vCJD in preclinical blood samples	Dept of Health	£882,178
Biological Sciences	Amy B Pedersen Wilson	The impact of resource availability on parasite transmission: insights from a natural multi-parasite community	NERC	£802,127
Physics and Astronomy	Aidan Brown	The physics of bacteriophage-coated antimicrobial surfaces	EPSRC	£772,595
Biological Sciences	Josephine Pemberton	Causes and consequences of variation in maternal effects in the wild	NERC	£762,097
Deanery of Clinical Sciences	Kevin Dhaliwal	Interventional biophotonics – a UK healthcare technology accelerator facility	MRC	£708,000
Royal (Dick) School of Veterinary Studies	Christine Tait-Burkard	Understanding the CD163 - PRRS virus interaction to improve genetic engineering for resistance	BBSRC	£674,353
Biological Sciences	Paul Sharp	Adaptation and self-fertilisation: from genes to genomes	NERC	£648,049
Law	Gerard Porter	Smart regulation of antibiotic use in India- understanding, innovating and improving compliance	ESRC	£644,285
Royal (Dick) School of Veterinary Studies	Jean Manson	Strain typing of vCJD cases	DoH	£631,126
Royal (Dick) School of Veterinary Studies	Tim Connelley	International Veterinary Vaccinology Network	MRC	£600,000
Biological Sciences	Paul Sharp	Species barriers: origin, architecture, and effects	Royal Society	£598,740
Royal (Dick) School of Veterinary Studies	Eleanor Riley	The relationship between malarial anaemia, neutrophil function and susceptibility to invasive bacterial disease	MRC	£595,737
Royal (Dick) School of Veterinary Studies	Adam Balic	Exploitation of new technologies to advance understanding of avian dendritic cell biology	BBSRC	£589,932
Royal (Dick) School of Veterinary Studies	Ross Houston	Improving resistance to infectious salmon anaemia using genome editing: novel approaches to tackling viral disease in aquaculture	BBSRC	£566,191
Royal (Dick) School of Veterinary Studies	Rowland Kao	Bilateral BBSRC-sf1: tackling a multi-host pathogen problem - phylodynamic analyses of the epidemiology of M. bovis in Britain and Ireland	BBSRC	£560,091

Social and Political Science	Ann Bruce	Diagnostic Innovation and Livestock (DAIL): towards more effective and sustainable applications of antibiotics in livestock farming	ESRC	£550,836
Royal (Dick) School of Veterinary Studies	Neil Mabbott	Determining the role of CSF1r-dependent macrophages in paneth cells and the intestinal stem cell niche	MRC	£529,437

APPENDIX 2

FINANCIAL SUMMARY OF EDINBURGH INFECTIOUS DISEASES OPERATING COSTS FOR FY 2017/2018

Item	Income	Outgoing
Income from UoE (nominal)	-50000	
Income from symposium fee	-3340	
Income from event sponsorship	-1850	
Salary support		45429
Major events		6176
Office support		1751
General hospitality		1183
Edinburgh Microbiology Forum		800
Student support		62
Public engagement		21
Sub-total	-55190	55422
TOTAL		232

APPENDIX 3

PUBLICATIONS BY EDINBURGH INFECTIOUS DISEASES MEMBERS IN 2018

1. Abbas AH, Silva Pereira S, D'Archivio S, Wickstead B, Morrison LJ, Hall N, Hertz-Fowler C, Darby AC, Jackson AP: **The Structure of a Conserved Telomeric Region Associated with Variant Antigen Loci in the Blood Parasite *Trypanosoma congolense***. *Genome Biol Evol* 2018, **10**:2458-2473.
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APPENDIX 4

CITATIONS OF EDINBURGH INFECTIOUS DISEASES MEMBERS IN THE GENERAL MEDIA

News	Sources
Andrew Leigh Brown (Biological Sciences) says new HIV study reveals new group of at-risk men	THE TIMES, THE SUN, THE HERALD, THE SCOTSMAN, DAILY RECORD, EDINBURGH EVENING NEWS, HIV PLUS MAGAZINE, CBS PHILLY (USA), WASHINGTON BLADE
Andrew Leigh-Brown (Biological Sciences) comments on the case of a man who infected two former partners with HIV	IRISH INDEPENDENT (Ireland)
Anoop Shah finds that people infected with HIV are twice as likely to suffer from heart disease	US NEWS AND WORLD REPORT (USA), MONTEVIDEO PORTAL (Uruguay), THE INDEPENDENT ON SATURDAY (South Africa)
Anura Rambukkana's work (Centre for Regenerative Medicine) on leprosy and how it may unlock the secrets of stem cells	GIZMO CRAZED (USA)
Aziz Sheikh (Usher) and Sandeep Ramalingam find simple sea salt water solution could help to reduce symptoms of a cold	LA OPINION (USA), DAILYMAIL.CO.UK, DAILY MAIL, THE TIMES, THE HERALD, THE DAILY MAIL, THE SCOTSMAN, EDINBURGH EVENING NEWS, THE STAR (KENYA), NEWSTALKKIT.COM, BBC RADIO NORFOLK, IRISH DAILY MAIL (Ireland), XIN MSN (Singapore), ZHANGJIAKOU ONLINE, WORLD WIDE WEB, CHINA ECONOMIC NET (China)
Aziz Sheikh (Usher) discusses challenges for big data and AI in healthcare	CHINA ECONOMICS AND TRADE INFORMATION DATABASE
Baojun Wang (Biological Sciences) unveils smartphone test that spots poisoned water risk to millions of lives	METRO, DAILY RECORD, GLASGOW EVENING TIMES, MED INDIA (India), NEW ATLAS, NEWS MEDICAL NET (Australia), TECH DIGEST (USA), ALL AFRICA (Pan Africa)
Bruce Whitelaw (Roslin) talks about the impact of African swine fever virus	BBC WORLD SERVICE
Bruce Whitelaw (Roslin) begins survey to gauge public opinion on gene-edited meat	THE NATIONAL, THE i, THE TIMES, THE SUN, THE HERALD, EDINBURGH EVENING NEWS, EAST ANGLIAN DAILY TIMES, DUNDEE COURIER, NEWCASTLE JOURNAL, BELFAST NEWSLETTER, THE NORTHERN ECHO, YORKSHIRE POST, ABERDEEN PRESS AND JOURNAL, DUNDEE EVENING NEWS, FARMING UK, MIDLOTHIAN ADVERTISER, SCOTTISH FARMER, STV NEWS AT 6, IRISH INDEPENDENT (Ireland), BBC RADIO ORKNEY, BBC RADIO SURREY, BBC RADIO 4,
Christine Tait-Burkard (Roslin) leads research in gene-edited pigs that are resistant to billion-dollar virus	THE NEWCASTLE JOURNAL, ABERDEEN PRESS AND JOURNAL, THE OBESEVER, VET NEWS, FARMING UK, THE WEEK, BUSINESS STANDARD, FARMERS WEEKLY, NATIONAL PIG ASSOCIATION, DAILY MAIL, SCIENCE TIMES (South Korea), YAHOO INDIA (India), IRISH INDEPENDENT (Ireland), NATIONAL HOG FARMER (USA), INDO ASIAN NEWS SERVICE (India), SCIENCE ALERT (Australia), THE I, THE PRESS AND JOURNAL, VETERINARY TIMES, DOMAIN B (India), SLASHDOT (USA), I4U NEWS (USA), ATLANTICO (France), THE GUARDIAN, VETERINARY TIMES, DOMAIN B (India), SLASHDOT (USA), I4U NEWS (USA), ATLANTICO (France)
Danielle Gunn-Moore and Conor O'Halloram (Royal (Dick) School of Veterinary Studies) warn cat owners of raw diet TB risk	SUNDAY TIMES, DAILY MIRROR, DAILY RECORD

<p>Debby Bogaert (Centre for Inflammation Research) says children’s noses hold clues to serious lung infections</p>	<p>SUNDAY TELEGRAPH, THE SCOTSMAN, THE HERALD, DAILY MIRROR, DAILY RECORD, THE COURIER, EDINBURGH EVENING NEWS, TELEGRAPH AND ARGUS, BBC RADIO SCOTLAND, BBC RADIO THREE COUNTIES, THE AUSTRALIAN (Australia), TAY FM, BBC.CO.UK, DAILYMAIL.COM, ITV.COM, NEWS.COM.AU, STV.TV, NEWS.YAHOO.COM, PLANETRADIO.CO.UK, AOL.CO.UK/NEWS, BELFASTTELEGRAPH.CO.UK, LABMANAGER.COM, MEDICALXPRESS.COM, EXPRESSANDSTAR.COM, EVENINGTIMES.CO.UK, EVENINGEXPRESS.CO.UK, TRIALSITENEWS.COM, THEQUINT.COM, DAIJIWORLD.COM, STHELENSSTAR.CO.UK, THEARGUS.CO.UK, BRIDPORTNEWS.CO.UK, HARWICHANDMANNINGTREESTANDARD.CO.UK, DORSETECHO.CO.UK, CHESTERSTANDARD.CO.UK, COUNTYPRESS.CO.UK, BURYTIMES.CO.UK, SWINDONADVERTISER.CO.UK, ECHO-NEWS.CO.UK, OXFORDMAIL.CO.UK, GAZETTE-NEWS.CO.UK, WESTERNTTELEGRAPH.CO.UK, CREWEGUARDIAN.CO.UK, SOUTHWALESARGUS.CO.UK, DAILECHO.CO.UK, WIRRALGLOBE.CO.UK, CHARDANDILMINSTERNEWS.CO.UK, CLACTONANDFRONTONGAZETTE.CO.UK, KEIGHLEYNEWS.CO.UK, WILTSGLOSSTANDARD.CO.UK, GUARDIAN-SERIES.CO.UK, CRAVENHERALD.CO.UK, MALVERNGAZETTE.CO.UK, THE GOLD COAST BULLETIN, NEWS.COM.AU (Australia), INDO-ASIAN NEWS SERVICE, MED INDIA, TIMES OF INDIA (India), EL PAIS (Costa Rica), IOL (South Africa)</p>
<p>Devi Sridhar (Global Health Governance) comments on West African Ebola outbreaks</p>	<p>POLITICO EUROPE (Belgium)</p>
<p>Devi Sridhar (Global Health Governance) says respiratory diseases are the biggest challenges to better World Health</p>	<p>NEW YORK TIMES, INFOBAW (Argentina)</p>
<p>Dishon Muloj and Bram van Bunnik (Usher) discuss the role of farm animals in the emergence and spread of drug-resistant bacteria to human</p>	<p>DOMAIN B (India), ALL ABOUT FEED (NETHERLANDS)</p>
<p>Edinburgh researchers (Usher) estimate the impact of antibiotics in treating of childhood pneumonia in Sub-Saharan Africa</p>	<p>GUYANA TIMES (Guyana)</p>
<p>Edinburgh researchers study genetic makeup of parasitic worms (Biological Sciences)</p>	<p>REUTERS (Spain), EL MERCURIO (Chile), NOTICIAS FINANCIERAS (USA), LA JORNADA (Mexico), ZHANGJIAKOU ONLINE, WORLD WIDE WEB (China)</p>
<p>Edinburgh team (Biological Sciences) finds plants produce nitric oxide when attacked by bacteria or viruses</p>	<p>ENVIRONMENTAL NEWS NETWORK (USA)</p>
<p>Edinburgh team (Biological Sciences) finds tsetse fly releases enzymes called peptidases that can cause sleeping sickness</p>	<p>ASIAN NEWS INTERNATIONAL (India), SCIENCE DAILY (USA)</p>
<p>Edinburgh team investigates use of antibiotic to target dangerous enzymes released by melanoma</p>	<p>STUFF.CO.NZ (New Zealand)</p>
<p>Eleanor Riley and Mark Stevens (Roslin) discuss advancements in gene editing and livestock disease</p>	<p>THE GUARDIAN, SUNDAY EXPRESS</p>
<p>Ewan Harrison (Surgery) suggests that surgical infections are linked to drug-resistant bugs</p>	<p>DAILY TELEGRAPH, DAILY MAIL, THE TIMES, AGENCE FRANCE PRESSE, LA BERRY REPUBLICAIN (France), YAHOO SINGAPORE (Singapore), VOICE OF AMERICA (USA),</p>
<p>First Minister opens Roslin Innovation Centre</p>	<p>GLASGOW EVENING TIMES, FARMERS GUARDIAN,</p>
<p>First transgenic chickens, resistant to flu, hatched at Roslin Institute</p>	<p>THE i,</p>

Francisca Mutapi (Biological Sciences) diagnoses lupus in black Africans	MEDICAL XPRESS (USA)
Francisca Mutapi & Derick Osakunor (Biological Sciences) flag up dangers of snail fever in young children	MED INDIA
Garry Blakely (Biological Sciences) finds link between autoimmune diseases gut bacteria	MEDICAL EXPRESS (USA)
Gary Loake (Biological Sciences) quantifies plants' response to disease	XINHUA NET, WANWEI READER (China)
Graham Stone (Biological Sciences) discusses parasitic vine that slowly sucks life out of wasps	THE ATLANTIC (USA), FORT MILL TIMES (USA)
Harry Campbell (Usher) comments on curable diseases that kill poor children	EL CRONISTA COMERCIAL (Argentina)
Harry Campbell (Usher) says substandard antibiotics pose risk to thousands of children	ECHO OF INDIA (India)
Helen Sang (Roslin) says chicken eggs with human proteins could be key for future therapies	THE SUN, BBC 1 BREAKFAST TV, BBC RADIO 4. STV NEWS, BBC NEWS, BBC 1 SCOTLAND EURO NEWS, STV NEWS AT 6, BBC WORLD SERVICE, BBC RADIO CAMBRIDGESHIRE, CENTRAL FM, BBC RADIO THREE COUNTIES. MERCADO DIGITAL (Argentina), YUANG GUANG.COM, CHINA PHARMACY NETWORK (China), MED PAGE TODAY, LISTVERSE (USA), TEMPO.CO (Indonesia), JOURNAL DE MONTREAL (Canada), DA KEE YUAN NEWS, GREAT DAY NEWS NETWORK (Taiwan), NOTIMEX (Mexico), MERCADO DIGITAL (Argentina), SOHU NEWS, CHINA PHARMACY NETWORK, DA KEE YUAN NEWS NETWORK, GREAT DAY NEWS NETWORK (China), BBC RADIO 4 TODAY, BBC BREAKFAST, BBC WORLD SERVICE NEWSDAY, BBC REPORTING SCOTLAND, BBC NEWS 24, STV, BBC RADIO SCOTLAND NEWSDRIVE, CENTRAL FM, BBC RADIO CAMBRIDGE, BBC RADIO 5 LIVE SCIENCE, BBC RADIO THREE COUNTIES, EURONEWS, BBC RADIO FIVE, TRT WORLD (Turkey), THE NAKED SCIENTISTS, DAILY TELEGRAPH, THE TIMES, THE SUN, THE INDEPENDENT, DAILY STAR, METRO, THE HERALD, THE SCOTSMAN, ABERDEEN PRESS & JOURNAL, DUNDEE COURIER, YORKSHIRE POST, THE NATIONAL, EDINBURGH EVENING NEWS, GLASGOW EVENING TIMES, BBC NEWS (Science), BBC NEWS (Scotland), DAILY MAIL, THE INDEPENDENT, MIRROR.CO.UK, ITV NEWS, SKY NEWS, THE SCOTSMAN, STV NEWS, ABERDEEN EVENING EXPRESS, BELFAST TELEGRAPH, JERSEY EVENING POST, EXPRESS AND STAR, THEPOULTRYSITE, SDE ENTERTAINMENT NEWS, IFLSCIENCE, DOWN TO EARTH MAGAZINE, TVNZ, DOMAIN-B, THEHEALTHSITE, ECNS, WDTV, NEWS-MEDICAL.NET, BOVINE VETERINARIAN, DROVERS MAGAZINE, THEBLAZE.COM, INFOSURHOY, NEW ATLAS, GEEK, FEEDSTUFFS, BRINKWIRE, SCIENCE CODEX, LAB MANAGER MAGAZINE, 7THSPACE INTERACTIVE, TDNEWS, SCIENCE DAILY, COSMOS, DRUG TARGET REVIEW, GULF DIGITAL NEWS, EPM MAGAZINE, SIFY NEWS, PHYS.ORG, NEWS-MEDICAL.NET, ANI NEWS, NATURE WORLD NEWS, AOL UK, GENETICS LITERACY PROJECT, FOODPROCESSING.COM, TECH TIMES, BT.COM, INTERESTING ENGINEERING, EARTH.COM, LABORATORY EQUIPMENT, EVOLVING SCIENCE, XINHUA NEWSWIRES, CHINA NEWS NETWORK, CHINA DAILY ONLINE, CHINA NET INTERNATIONAL CENTRE, CHINA INDUSTRY NETWORK, SCIENCE NETWORK, NORTH COUNTRY NETWORK, CHINA ECONOMIC NET, DRIVE HOUSE, JIANGSU NET, CHINA SCIENCE AND TECHNOLOGY NETWORK, BRAUN INFORMATION NETWORK (China), THE IRISH NEWS, THE HINDU, BUSINESS STANDARD, NEW KERALA, THE SIASAT DAILY, TIMES OF INDIA, DHAKA TRIBUNE, FNB NEWS, THE HINDU ASIAN NEWS INTERNATIONAL, PRESS TRUST OF INCIA, INDO ASIAN NEWS SERVICE, BIOTECNIKA, DOWN TO EARTH (India), TUKO (Kenya), ASHARQ AL-AWSAT (Saudi Arabia), BUSINESS INSIDER (South Africa), DE STANDAARD (Belgium), DER

	STANDARD (Austria), OUEST FRANCE, KUAM NEWS (Guam), FOCUS.IT (Italy), ANSA, BLASTING NEWS, TRT, BBC (PORTUGUESE), TVI24, SPUTNIK NEWS (Russia), JAPAN TODAY (Japan), TAIPEI TIMES (Taiwan), KOMPAS.COM, SECONDS, KORAN TEMPO (Indonesia), EUROPA PRESS (Spain), GLOBAL BUSINESS NETWORK, WEN WEI PO (Hong Kong), FUTURISM, UPI, BLAZE, GEEK.COM, WCBS.TV, CBS PHILLY, WBZ NEWS RADIO, LA OPINION, DESIGN TECHNICA, CBS NEWS, USA TODAY, 2NEWS, WBOC NEWS, WFMJ, CBS8, THE HILLTOP MONITOR, SMITHSONIAN MAGAZINE, INDIANAPOLIS TODAY, STATESMAN JOURNAL, ARIZONA CENTRAL, DETROIT FREE PRESS, GREENVILLE NEWS (USA), NEW ATLAS, COSMOS, LABONLINE.AU (Australia), TIEMPO, ALFA TECNICOS EDITORES (Mexico), TELE TRECE (Chile), GLOBOVISION (Venezuela), COLOMBIA.COM, TELEVISA NEWS, ECUAVISIA.COM, GLOBO.COM, LINEA DIRECTA, ATV.PE, BLASTING NEWS, MEIONORTE.COM
Henry McSorley (Centre for Inflammation Research) finds protein produced by intestinal worms may help asthma sufferers	DAILY RECORD, DAILY MIRROR
Jose Vazquez-Boland (Biomedical Sciences) finds that Listeria bacteria may be susceptible to treatment	SPUTNIK NEWS SERVICE (Russia), DEREDACTIE.BE (Belgium), MEDINDIA (India), FOOD SAFETY NEWS (USA)
Jose Vazquez-Boland (Biomedical Sciences) unveils superbug discovery that renews hope for antibiotic treatment	THE SCOTSMAN,
Kenneth Baillie (Roslin) unveils Sepsis treatment quest focusing on genes	THE HERALD, BBC SCOTLAND
Kev Dhaliwal (Centre for Inflammation Research) leads new test to quickly identify pneumonia	IRISH MIRROR (Ireland), WORKER CHINA, XINHUA (China), HONG KONG NEWS AGENCY (Hong Kong)
Kev Dhaliwal (Centre for Inflammation Research) talks about technology that travels inside lungs to treat infections	BBC RADIO 4, BBC WORLD SERVICE
Lindsey Plenderleith (Biological Sciences) discovers genetic diversity in parasitic monkey strains	EUROPA PRESS SALUD (Spain), HEALTH DAILY DIGEST (India), AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (USA), CHINESE ACADEMY OF SCIENCES, CHINA BIOTECH INFORMATION NETWORK, SCIENCE NETWORK (China), EUROPEAN HOSPITAL (Germany),
Lonneke Vervelde (Roslin) says vaccine shows promise against widespread chicken disease	EDINBURGH EVENING NEWS, YORKSHIRE POST, WESTERN DAILY PRESS, WESTERN MORNING NEWS
Marc Walpart (Roslin) discusses research to try to remove pig gene resistant to PPRS virus	FARMERS GUARDIAN
Mark Blaxter (Biological Sciences) comments on our understanding of genomes	FORTUNE (USA), CONTIFY LIFE SCIENCES (India)
Mark Bronsvort (Roslin) finds vaccines hidden in dog food could help curb the spread of rabies	BBC RADIO SCOTLAND, EDINBURGH EVENING NEWS, MED BULLETIN, ET HEALTH WORLD, PRESS TRUST OF INDIA (India), PHYS ORG (USA)
Mark Woolhouse (Usher) bids to beat drug resistance boosted by worldwide sewage survey	THE SUN
Mark Woolhouse (Usher) comments on government targets to produce new antibiotics	THE TIMES
Mark Woolhouse (Usher) discusses need for datasets with information about genomes of viruses	STAT (USA)
MRC Centre for Regenerative Medicine research on Hepatitis C informs efforts to tackle other viruses	SILICON REPUBLIC (Ireland)

National reporting centre for suspected cases of Bovine TB is based at Edinburgh	SUNDAY TIMES
Neil Mabbott (Roslin) discusses recent discovery of BSE infected cattle in Aberdeen	FOREIGN AFFAIRS.CO.NZ (New Zealand)
Neil Mabbott (Roslin) says BSE case is unsettling but need not worry meat eaters	DAILY TELEGRAPH, THE INDEPENDENT, DAILY MAIL, THE HERALD, THE SCOTSMAN
Paul Digard (Roslin) comments on whether dog 'flu could be passed to humans	STAR ISLAND HEADLINE (Hong Kong), XINHUA NEWS AGENCY (China) CHINESE ECONOMIC NET, CHINA NEWS NETWORK, HONG KONG NEWS NETWORK, WIND MEDIA, CENTRAL NEWS SERVICE, MING PAO LIVE NEWS, XINMU.NET, CHINA BUSINESS NETWORK, XIAMEN NET, CENTRAL BUSINESS SERVICES, QIANLONG NET, CHINA NEWS LIAONING NEWS, OCEAN NET, FREE TIMES (Taiwan), ONCC EAST NET, CHINESE ACADEMY OF SCIENCE, SING TAO, LETTER (Hong Kong), CHINA RADIO NETWORK, STAR ISLAND NET, MING PAO TORONTO (Canada), MING PAO VANCOUVER (Canada), SIN CHU DAILY, CHINA NEWS SERVICE (China), CARE 2 (USA)
Paul Digard (Roslin) explains why getting flu jab right is hard	DAILY MAIL
Paul Digard (Roslin) explains how flu viruses spread between different animals	ORIENTAL DAILY (Hong Kong)
Paul Sharp (Biological Sciences) comments on people's susceptibility to cross-specific infection	EUROPA PRESS (Spain), CONTIFY LIFE SCIENCE (India), SCIENCE DAILY (USA)
Peter Barlow (Clinical Sciences) comments on a study that analyses the common cold	FOREIGN AFFAIRS.CO.NZ (New Zealand)
Petra Schneider (Biological Sciences) says malaria parasites most infectious when mosquitoes feed	ENVIRONMENTAL NEWS NETWORK, SCIENCE DAILY (USA)
Researchers at Roslin create chicken that does not transmit viruses to other chickens	BIOTECH NOW (USA)
Roslin hosts Bill Gates as he unveils £28m fund to fight livestock disease	THE TIMES, DAILY MIRROR, THR HERALD, THE SCOTSMAN, THE SUN, DAILY MAIL, METRO, YORKSHIRE POST, WESTERN MORNING NEWS, ABERDEEN EXPRESS, ABERDEEN PRESS & JOURNAL, DUNDEE COURIER, DAILY RECORD, EDINBURGH EVENING NEWS, THE NATIONAL, GLASGOW EVENING TIMES, SUNDAY POST, NEWCASTLE JOURNAL, WESTERN DAILY PRESS, BBC NEWS, SCOTTISH TELEVISION, FOREIGN AFFAIRS.CO.NZ (New Zealand), THE PRESS (New Zealand), ASSOCIATED PRESS NEWSWIRES, NEW YORK POST (USA), THE HERALD ZIMBABWE (Zimbabwe), EL PAIS (Uruguay), AGENCIA EFE (Spain), NF NEWS (USA), THE MONITOR (Botswana), CAPITAL.FR (France), SIN CHEW, BIOTECHNOLOGY INFORMATION NETWORK, ORIENTAL DAILY NEWS LIANHE ZAOBAO, NETEASE, XINHUA, WORKER CHINA, DALIAN NEWS, CHONGQING NEWS, PEOPLE'S NET WORLD, KAIFENG NET, CHINA ECONOMIC NET, JILIN NET, SCIENCE NET (China), LIBERTY TIMES (Taiwan)
Roslin Institute ranked top of its field	EDINBURGH EVENING NEWS
Roslin Institute shows E. coli levels in cattle has been consistent in Scotland for past decade	FOOD SAFETY NEWS (USA)

Roslin Institute trials vaccines to combat E. coli	FARMERS GUARDIAN
Roslin researchers at create chicken that does not transmit viruses to other chickens	CENTRAL NEWS CHINESE NEWS, SING TAO HEADLINE NEWS, SING TAO DAILY, SOHU NEWS, CHINA NEWS NETWORK, ZHANGJIAKAU ONLINE, CHINA TIBET NETWORK, WORLD WIDE WEB, CHINA INDUSTRY NETWORK, OCEANIC, CHINA ENTERPRISE NEWS NETWORK, CHINA NEWS.COM (China)
Roslin scientist reveals possible breakthrough in fight against E. coli	SUNDAY EXPRESS, SCOTLAND ON SUNDAY, ABERDEEN PRESS AND JOURNAL, EDINBURGH EVENING NEWS,
Ross Fitzgerald (Roslin) sheds light on how human and animal disease can jump between species	METRO, EDINBURGH EVENING NEWS
Ross Houston (Roslin) plays part in healthier seafood project	THE SUN, DAILY MAIL, THE HERALD, ABERDEEN PRESS AND JOURNAL, EDINBURGH EVENING NEWS, FISH FARMING EXPERT, MANUFACTURINGCHEMIST.COM
Royal (Dick) Veterinary School invests £35m in Global Academy of Agriculture and Food Provision	THE SCOTSMAN
Sarah Chan (Usher) comments on ethics of DIY genetic engineering	THE TIMES
Sarah Chan (Usher) condemns gene editing on human babies by Chinese scientist	DAILY TELEGRAPH, THE i, THE SUN, LONDON EVENING STANDARD, FOREIGN AFFAIRS.CO.NZ (New Zealand), L'EXPRESS, LCI.FR, LA CHARENTE LIBRE, PRESSE OCEAN, THE TELEGRAM, METRO, MIDI LIBRE, MAGIC MAMAN, RTL, LCI.FR, AGENCIE FANCE PRESSE (France), SPECTRUM OF SCIENCE (Germany), LACAPITALMDP.COM (Argentina), LA JORNADA (Mexico), AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, NOTICIAS FINANCIARAS (USA), YAHOO SINGAPORE (Singapore), SCMP.COM (Hong Kong), SOHU NEWS, EASTERN FORTUNE NETWORK, OCEAN NET, MULTIDIMENSIONAL NEWS NETWORK, WANWEI READER (China)
Sarah Chan (Usher) discusses developing global standards for governance of human genome editing	BBC RADIO SCOTLAND
Tim Palmer (Pathology) finds HPV vaccine linked to fall in early cancer warning signs	THE TIMES, DAILY MAIL, DAILY EXPRESS, THE SUN, THE METRO, THE HERALD, DAILY RECORD, THE ABERDEEN PRESS AND JOURNAL, THE COURIER, ABERDEEN EVENING EXPRESS, i ONLINE, THE i, THE GUARDIAN, INDEPENDENT, PULSE TODAY, DOWNTIME RADIO, BBC RADIO SCOTLAND, SKY NEWS, RADIO FORTH, FOREIGN AFFAIRS.CO.NZ (New Zealand), YAHOO INDIA (India), GIZMODO, SCIENCE DAILY (USA)
Tim Regan (Roslin) unveils Bee gene study that sheds light on risks to hives	THE NATIONAL, DAILY MAIL, THE SUN, EDINBURGH EVENING NEWS,
Xavier Donadeu (Roslin) explains blood test could aid cattle health and productivity	ABERDEEN PRESS AND JOURNAL, DUNDEE COURIER
You Li, PhD student, offers overview of respiratory infections and pneumococcal disease	LIFE SCIENCE WEEKLY (USA)

APPENDIX 5

NEWS STORIES FEATURING EDINBURGH INFECTIOUS DISEASES

We have published a large number of stories highlighting achievements and outputs from all our members during the past year.

- Further details about all these stories can be accessed on our website:
<http://www.ed.ac.uk/edinburgh-infectious-diseases/news/news>
- Applications now open for the 2019 Moredun Foundation Award Scheme
- University of Edinburgh part of VALUE-Dx partnership fighting antimicrobial resistance through diagnostics
- Sepsis study to focus on genes in quest for treatments
- Children's noses hold clues to serious lung infections, study shows
- Gene study at the Roslin Institute set to investigate how flu jumps species
- Prof Francisca Mutapi appointed to Strategic Advisory Group of the Global Challenge Research Fund
- Bid to beat drug resistance boosted by worldwide sewage survey



Image courtesy of Courage Kosi Setsoafia Saba, University of Development Studies, Ghana.

Efforts to monitor the spread of antibiotic resistance worldwide could be transformed with a map created using data from analysis of sewage samples.

- Many congratulations to Sarah Reece and Liz Grant, new Fellows of the Royal Society of Edinburgh
- Students at the University of Edinburgh discuss antimicrobial resistance during the Festival of Creative Learning
- University of Edinburgh to host new centre of postgraduate training in Biomedical Artificial Intelligence
- Edinburgh researchers showcase AMR research in the UK parliament

- Deforestation linked to changes in spread of infectious diseases
- African experts join forces to beat tropical diseases
- University of Edinburgh researchers lead on £2.5 million grant to support appropriate antibiotic prescribing
- International Veterinary Vaccinology Network has issued new call for funding applications
- Scottish consortiums take giant leap forward for salmon gill health
- Researchers at Edinburgh Napier University awarded £400K to combat dengue virus infection
- Edinburgh and Glasgow to offer joint research schemes for postgraduate students
- University of Edinburgh to host Fleming Fund fellows from Uganda
- New study could explain higher rates of human E. coli infection in Scotland
- Huge range of new publications in autumn 2018
- Decoding sleeping sickness signals could aid quest for treatments
- "Parasites: Battle for Survival" exhibition opens 6 December 2019 at the National Museum of Scotland
- Gene study boosts bid to keep British bees safe from disease
- University of Edinburgh researcher selected for new PhD Training Programme in AMR
- Parasite study could aid efforts to treat malaria
- Dr. Tom Kariuki presents Edinburgh Infectious Diseases 2018 Winter Lecture
- Key gene find could enable development of disease-resistant crops
- Vaccine shows promise against widespread chicken disease
- Antibiotic may selectively kill dangerous skin cancer cells
- Malaria parasites adapt to mosquito feeding times
- Managing Scab in UK Sheep Flocks: There May Be Trouble Ahead
- Lupus discovery could help manage the disease in African patients
- UK-India project combats infections threat with diagnostics



Christine Tait-Burkard and colleagues at the Roslin Institute have produced pigs that can resist one of the world's most costly animal infections, Porcine reproductive and respiratory syndrome virus, by changing their genetic code.

- Beyond Resistance - Interdisciplinary network to tackle Antimicrobial resistance
- Many congratulations to our new professors in infectious diseases!
- Superbug discovery renews hope for antibiotic treatment
- Edinburgh to host World One Health Congress in 2020.

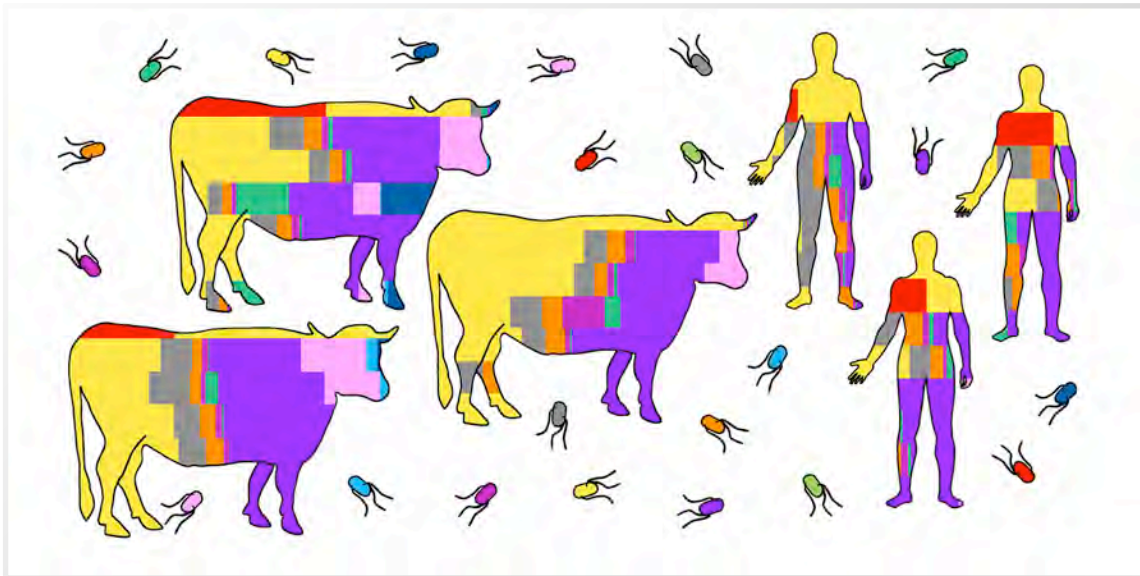
- On World Mosquito Day 2018 highlighting researchers studying malaria
- Edinburgh researchers AMR funding success with SULSA
- Snails, worms and flies have different ways to fight viral infection
- Gene study pinpoints superbug link between people and animals
- HIV infection doubles risk of heart disease, global study finds
- Many congratulations to Edinburgh scientists recognised by high-profile awards
- Inbred animals face greater threat from changes to environment
- Gene-edited pigs are resistant to billion-dollar virus, finds Roslin Institute study
- Report on the Edinburgh Infectious Diseases Annual Symposium 2018
- Study published on current uptake of best practice principles of worm control on British farms
- Lung study points to therapies for chronic coughing disease
- Experts discuss control of ovine pulmonary adenocarcinoma
- Relaunch of Comparative and Veterinary Immunology Group
- HIV study reveals new group of men at risk of infection
- Students from University College of South Denmark visit Edinburgh
- Many congratulations to 2018 Ker Memorial Prize Winner Rodrigo Bacigalupe
- UK's top doctors back school musical to inspire battle against superbugs
- Prof Keith Matthews elected to Fellowship of the Academy of Medical Sciences
- Malaria: a sticky problem at the Edinburgh International Science festival



Researchers from Alex Rowe's lab in the School of Biological Sciences went to the Edinburgh International Science Festival in April 2018 to talk about their research on severe malaria.

- Malaria study reveals gene variants linked to risk of disease
- PARAGONE Consortium Meeting Cordoba, March 2018
- New gene study highlights threat of ash dieback
- Under-fives should be priority for snail fever therapy, study finds
- Experts' chicken study may lead to improved safety in food
- Antibiotic-resistance gene goes from pig farms to patients worldwide
- Casting call for AMR musical - The Mould that Changed the World
- Applications now open for 2018 Moredun Foundation Award Scheme
- Education essential in fight against rabies, expert says
- Meal times may be key to managing malaria, parasite study shows
- DNA study of cow stomachs could aid meat and dairy production

- New insight into how the body ‘gobbles up’ asthma-inducing cells
- Surgical infections linked to drug-resistant bugs, study suggests
- Novel sequencing approach to study Salmonella survival in cattle



Researchers have developed a new sequencing method to study the survival of different Salmonella serovars simultaneously in cattle.

- Breeding quirks of head lice offer insight into effective treatments
- New funding to develop tests for the detection of redworm parasites in horses