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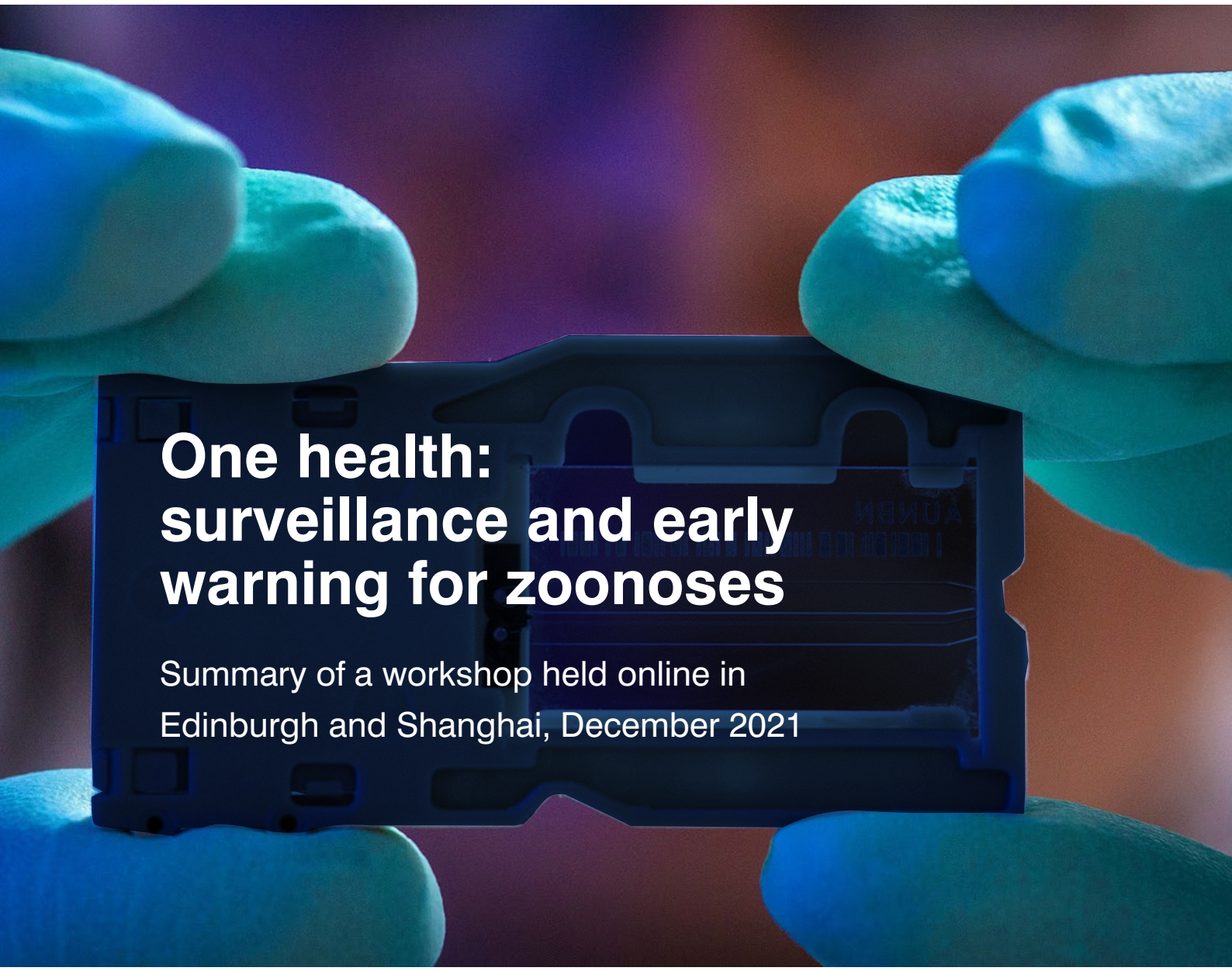

One health: surveillance and early warning for zoonoses

Summary of a workshop held online in Edinburgh and Shanghai, December 2021

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国家热带病研究中心 CHINESE CENTER FOR TROPICAL DISEASES RESEARCH

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***Cover page** – Enteric Diseases Laboratory Branch (EDLB) public health scientist, holding up a glass slide used for a run on a sequencing machine – source: https://unsplash.com/photos/UBJJuAOv9os; CDC*

***Page 2** – Digitally-colorized transmission electron microscopic (TEM) image of Avian Influenza A H5N1 viruses – source: https://unsplash.com/photos/Hu2yPu0vFQ8; CDC*

Summary

This report summarizes findings of a workshop for Early Career Researchers (ECRs) – *One Health: Surveillance and Early Warning for Zoonoses* – which was held online on the 9th and 10th of December 2021. The workshop was the result of a Researcher Link Award to the University of Edinburgh (UoE) and the National Institute of Parasitic Diseases (NIPD) at the Chinese Center for Disease Control and Prevention (China CDC), Shanghai, supported by The British Council / Newton Fund and the National Natural Science Foundation of China. The workshop was intended to be held face-to-face in Shanghai, but travel restrictions due to the COVID-19 pandemic required a shift to an online format. This report gives background information on One Health, and summarizes key findings from the workshop. The full workshop programme is shown in Appendix 1. A list of attendees is given in Appendix 2.

The global response to the COVID-19 pandemic highlights the importance of international collaboration and strengthening of multi/ transdisciplinary capacity and expertise to address emerging and novel disease threats. Complex biosocial determinants of disease, including population growth, urbanization, climate change and resultant biodiversity loss and translocation of zoonotic disease vectors, create opportunities for virus spillover between animal and human populations. Combined with other socio-economic and environmental drivers such as increased movements of people, animals and products, this places unprecedented pressure on global health systems, global food systems, and on natural environmental systems on which we all ultimately depend, and creates multi-dimensional fragilities at the nexus of global health security and sustainable development agendas.

This China-UK Workshop on *One Health: Surveillance and Early Warning for Zoonoses*, brought together, online, ECRs and experienced scientists to consider innovative approaches to emerging zoonotic disease contingency planning, to help them to be better able to predict, prevent, evaluate and respond to future One Health emergencies.

The workshop included keynote presentations from leading One Health practitioners from the UK and China, spanning contributions of One Health approaches to sustainable development, advances in surveillance and response to zoonoses, the challenges of both emerging and endemic zoonoses, opportunities afforded by developments in 'omic' technologies and modelling for pandemic preparedness. Poster sessions augmented and complemented these themes and highlighted the contribution of new molecular and data science methods.

The workshop also provided mentoring for early career researchers in career development, interdisciplinary research skills, publication skills, communication skills, science-policy interactions and business interactions/ entrepreneurship.

The workshop has helped develop a shared understanding of – and highlighted some excellent case studies on – the power of One Health approaches in preventing, predicting, preparing for and responding to zoonotic disease outbreaks (e.g. presentations by Cleaveland *et al.*, Zhou *et al.*). Also, it has strengthened collaboration between the organizing institutions in China – NIPD at China CDC; School of Global Health, Chinese Center for Tropical Diseases Research, Shanghai Jiao Tong University (SJTU) School of Medicine; the SJTU-UoE One Health Center – and UoE, and with partner institutions in both countries. A more detailed report on the workshop follows.

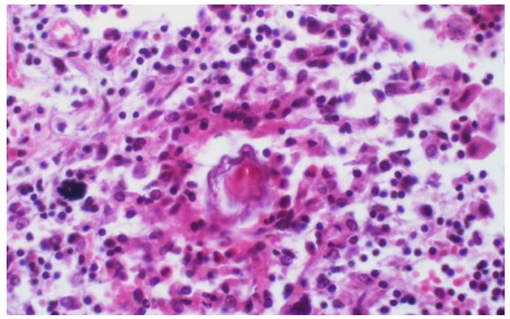
Workshop report

One health in context

Emerging and endemic zoonotic diseases pose critical threats to global health security[1], evidenced by the estimated 60-75% of emerging infectious diseases that are defined as zoonotic.[2,3] Zoonotic diseases are caused by a wide range of bacteria, viruses, fungi or parasites that can be transmitted from animals to humans[4]. Zoonoses include both classic infectious diseases such as rabies and schistosomiasis, and "new" emerging infectious diseases such as bird flu and Ebola.[5,6] Over 2.5 billion cases of human illness and 2.7 million human deaths are caused by these diseases worldwide each year[7]. Complex biosocial determinants of disease, including population growth, urbanization, climate change and resultant biodiversity loss and translocation of zoonotic disease vectors, create opportunities for disease agent spillover between animal and human populations.[8,9,10] Recent emerging zoonoses have illustrated the interdependence of human health, animal health, and ecosystem health worldwide.[11] Facing the increasing risk and impact of zoonotic pandemics, the One Health approach is increasingly recognized as a useful avenue for addressing these challenges.[12,13,14] It is defined by the One Health High Level Expert Panel (OHHLEP) as follows: "One Health is an integrated, unifying approach that aims to sustainably balance and optimize the health of people, animals and ecosystems.[15]" It mobilizes multiple sectors, disciplines and communities at varying levels of society to work together to foster well-being and tackle threats to health and ecosystems. The approach has been widely welcomed by several resolutions of UN, G20, G7, FAO,[16] WHO and other stakeholders.[17] Some countries have also applied a One Health approach in their disease control strategies, to promote interdepartmental collaboration, communication, coordination and capacity building.[18]

The One Health concept is reflected in the Sustainable Development Goals — healthy people living on a habitable planet.[19] Countries at different stages of development can solve their own or common public health problems by strengthening their One Health approach, by sharing knowledge and experience, and through cooperation.

Due to its interdisciplinary characteristics, One Health can promote the co-development of contributing disciplines and technologies.



Schistosomal egg within a granuloma – source: https://commons.wikimedia.org/wiki/File: Schistosomiasis_(5416517863).jpg; CC BY-SA 2.0; Yale Rosen

Early warning of zoonotic pathogens through enhanced laboratory capacity and surveillance, and response functions at the human–animal–ecosystem interface is a crucial step towards controlling and preventing zoonoses.[20,21,22] It is also considered as a core public health capacity in the revised WHO International Health Regulations (2005), which require Member States to develop and maintain surveillance and response at points of entry, including early detection, assessment, notification and reporting to WHO.[23] A One Health approach requires shared surveillance, detection and control efforts among partners from the human health, animal health and environmental sectors. The effectiveness and cost-effectiveness of zoonoses control and prevention should be significantly improved as a result.[24]

One health workshop: surveillance and early warning for zoonoses

The *One Health Workshop: Surveillance and Early Warning for Zoonoses* was held online on the 9th and 10th of December 2021. It was hosted by NIPD at the China CDC (Chinese Center for Tropical Disease Research; cofounder of the School of Global Health with SJTU) and UoE. SJTU and UoE recently created a China-UK One Health Centre, to collaborate on world-class academic activity and translations to real-world impact at scale, through research, education, capacity building and engagement with policy, business and 'third' sectors. The workshop was a flagship event of the new Centre.

The workshop aimed to help equip a new generation of One Health professionals to be better able to prevent, predict, evaluate and respond to future One Health threats and disease emergencies. The objectives were to: **1)** develop a shared understanding of key One Health challenges; **2)** identify priority areas for collaborative research, education and capacity-building activity in One Health; and **3)** identify key cross-sectoral partnerships (involving inter-governmental, governmental, industrial, third sector, public, academic partners), that will be key to translating academic activity into a One Health approach to respond to the challenges in global public health, global food systems and related environment systems, in practice.

The workshop was attended by a total of 61 participants from both China (32) and UK (29) – principally from UoE, University of Glasgow and the Moredun Research Institute in the UK, as well as NIPD at China CDC (Chinese Center for Tropical Disease Research), SJTU, Hainan University and Hainan Medical College of China. Participants included a wide variety of expertise, including: infectious disease, epidemiology, mathematical modeling, parasitology, immunology, pathology, pharmacology, public health, veterinary medicine, agriculture and food systems, environmental health, socio-economics, law and political science. The target audience for the workshop was early-career researchers (ECRs), from interdisciplinary settings in China and UK, with an interest in One Health. The workshop was also attended by other research stakeholders and potential 'end users' (including policy-makers and funders) who contributed to workshop discussions about the translation of One Health research into practice.

The workshop included oral and poster presentations focused on the new research findings, followed by discussions of topics in working groups.

Key themes discussed during the workshop

The current coronavirus pandemic, and recent SARS, Ebola, and swine flu epidemics, illustrate the massive global impact that emerging and novel zoonotic disease can have on human health and wellbeing, animal health and food production, and economic security. The workshop covered the following three cross-cutting interdisciplinary themes:

- Global socio-economic determinants and inequalities – the impacts of (re)emerging, novel zoonotic disease and accompanying interventions on human health and wellbeing, animal health and food production, socio-economics, environmental and food security, social stability and trust.
- Global health governance and health systems strengthening to address syndemic challenges – with a focus on the importance of governance in (re-)emerging zoonosis control, and syndemic disease control, supported by integrated health systems.
- Improving scientific capacity and technological preparedness for novel and emerging zoonotic infectious disease – including capacity in surveillance, diagnostic testing, design of biomedical models and disease control options.

Summary of themed sessions at the workshop

1. Epidemiology of zoonotic disease

Wang *et al.* provided a situational analysis on the spatial prevalence of echinococcus in China, which has the highest global burden of the disease. Echinococcus is important because of the severe impact it has on human as well as animal health, but also because of the economic implications of medical treatment, lost labour and a drop in livestock productivity. Cases were mainly concentrated in northern Tibet, western Qinghai, and Ganzi in the Tibetan Autonomous Region and in Sichuan. In addition, spatial scanning analysis revealed two spatial clusters.

One type of spatial clusters included 71 counties in Tibet Autonomous Region, 22 counties in Qinghai, 11 counties in Sichuan, three counties in Xinjiang Uygur Autonomous Region, two counties in Yunnan, and one county in Gansu. In the second category, six types of spatial clusters were observed in the counties of Xinjiang Uygur Autonomous Region, and the Qinghai, Gansu, and Sichuan Provinces.[26]

Lisulo *et al.* highlighted the importance of considering companion animals, such as domestic dogs, as reservoirs of zoonotic disease.

Vaccinating against rabies – source: https://www.flickr.com/photos/ilri/51751803804; CC BY-NC-ND 2.0; ILRI/Geoffrey Njenga

Dogs are reservoirs of many zoonoses including, rabies, dirofilariasis, leishmaniasis and Chagas disease,[27] and considered sentinels in tsetse transmitted African trypanosomiasis (AT) or sleeping sickness.[28] A cross-sectional survey was conducted involving 237 indigenous dogs from tsetse-infested Mambwe district, eastern Zambia. Loop mediated isothermal amplification (LAMP) detected 8.4% AT prevalence. Over 50% of the infections were zoonotic T. *b. rhodesiense.* Most carriers did not manifest clinical illness, except for three dogs that developed corneal opacity. These results indicate that dogs carrying zoonotic T. *b. rhodesiense* might play a role in the sporadic human cases being reported in Mambwe district. These results further suggests that indigenous dogs of Mambwe district are somewhat resilient to the pathological effects of AT.[29]

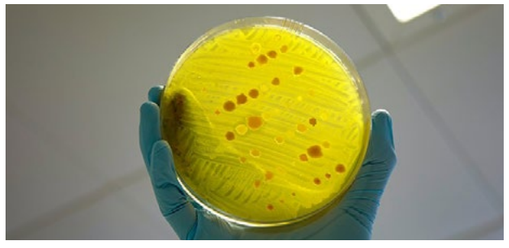
Schistosomiasis japonicum is a zoonotic disease in China. In addition to humans, more than 40 species of mammals can serve as potential zoonotic reservoirs,[30] though little is known about *S. japonicum* infection in wild animals, especially field rats. Early results from a study by Chao *et al.* in two villages of Dongzhi county, Anhui Province, show that S. japonicum infection in field rats is a potential risk factor for schistosomiasis elimination in China. Liver homogenate detection proved a sensitive method of detection.

2. Transmission dynamics of zoonoses

Phlebotomine sandflies (Diptera: Phlebotomidae) are vectors of the zoonotic disease leishmaniasis.[31] A study by Zhou *et al.* of inter- and intra-specific differences among populations of *Phlebotomus chinensis* in different areas provided valuable insight on vector dynamics.

Livestock movements play an important role in the spread of zoonoses through the contact network connecting the populations.[32] Sulaiman *et al.* designed a model to simulate Rift-Valley Fever (RVF) emergence risk to contribute to intervention strategies for infectious livestock disease control, especially where missing data on livestock movement limits opportunities for targeted interventions.

A confirmatory serological test is required for clinical diagnosis of *Echinococcus* infection, and it is also an important method for epidemiological surveys and surveillance.[34] Zhang *et al.* reported that high-throughput proteomic screening offers promising point of care technology for real-time diagnosis of echinococcosis.



Testing for antimicrobial resistance – source: https://commons.wikimedia.org/wiki/File:Antimicrobial_resistance.jpg; CC BY 2.0; DFID/ Will Crowne

Foodborne zoonotic pathogens are the major global causes of gastroenteritis and diarrheal disease. Moreover, antimicrobial resistance (AMR) genes that circulate in some pathogen strains are a threat to both human and animal health worldwide. Keegan and Brien *et al.* demonstrated the value of genomic technologies such as nanopore sequencing to allow a One Health approach in surveillance for zoonoses and AMR in wildlife species.

Poultry market in Dhaka – source: https://commons.wikimedia.org/wiki/File:Poultry_Market_(212452085).jpeg; CC BY 3.0; Francisco Anzola

3. Innovation at the one health interface

The COVID-19 pandemic has affected both human health and wellbeing.[35,36,37] This has led to a redoubling of effort by public health and research administrators in thinking about how we might detect and possibly mitigate future pandemics. A collection of 386 animal, 451 human, and 109 archived bioaerosol samples were tested by Xiu *et al.* using a new pan-species coronavirus molecular assay. Thirty-eight (4%) of 946 specimens yielded evidence of human or animal coronaviruses. These results demonstrated the utility of employing the pan-CoV RT-PCR assay in detecting varied coronavirus among human, animal, and environmental specimens. This RT-PCR assay could be employed as a screening diagnostic for early detection of coronaviruses incursions or prepandemic coronavirus emergence in animal or human populations.[38]

Wastewater analysis can provide early warning of environmental risks and allow tracking of emerging infections. Hu *et al.* developed a rapid, functional membrane-based approach to molecular diagnosis of infectious pathogens present al trace levels in wastewater.

Current diagnostic methods for *Schistosoma japonicum* infection are insensitive for low-density infections.[39] Early results from Deng *et al.* on a simple and rapid basic recombinase polymerase amplification (RPA) assay show good potential for rapid and early detection of S. japonicum infection in low endemic areas.

Water sample collection – source: https://commons.wikimedia.org/wiki/File:River_water_sample_collection_get_sample.jpg; CC BY-SA 4.0; Cirosantilli2

Cancers impose the largest burden of diseases worldwide.[40] Early results of Hu suggest RNA-cleaving DNA probes offer the simple, rapid, sensitive diagnostics required in human medicine.

4. Predicting one health challenges

Mathematical models are widely used in health and One Health research and to support policy formulation. Xia *et al.* presented a conceptual approach to developing complex systems models for One Health research – spanning problem-driven

conceptual modeling, data-orientated real world grounding, goal-directed analytical inference and evidence-based practice.

Following implementation of integrated malaria control and elimination programmes, the disease burden of malaria has sharply declined with no indigenous cases reported since 2017 in China. Based on the historical malaria incidence data in the Guantang area from that period, a mathematical model was established by Bi *et al.* to explore the efficacy of a range of interventions, alone and in combination.

Schistosomiasis haematobia, caused by the parasite *Schistosoma haematobium*, is the most common form of schistosomiasis in Africa.[42] *S. haematobium* produces urological problems and leads to a high disease burden. Early results were presented by Li *et al.* from an epidemiological model to help locate high-risk areas and accurately predict disease risk, to improve the disease control and prevention in field.[43]

5. One health approach and strategy for zoonoses

Dogs play a key role in *Echinococcus granulosus sensu lato* (s.l.) and *E. multilocularis* transmission; dual infection also occurs in dogs in co-endemic regions in China.[44] A smart Internet of Things (IoT)-based deworming collar which can deliver pranziquantel (PZQ) baits for dogs was developed by Yang *et al.* Compared to manual deworming, the dogs' risk of infection with Echinococcus with smart-collar deworming was down to 0.182 times (95% CI: 0.049, 0.684) in the Seni district and 0.355 (95%CI: 0.178, 0.706) in Hezuo city. Hence, the smart collar had a significant protective effect.

The owners' overall compliance rate in attaching the smart collars to their dogs was 89%. The smart deworming collar could effectively reduce the dogs' risk of infection with Echinococcus, significantly increase the deworming frequency and coverage, and rapidly remove worm biomass in dogs. Thus, it may be a promising alternative to manual deworming, particularly in remote areas.[45]

The level of environmental microplastics is an ever-increasing global issue and one of this generation's key environmental challenges.[46] In all biological systems, microplastic exposure may cause particle toxicity, with oxidative stress, inflammatory lesions and increased uptake or translocation.[47] Four sizes (0.1, 0.5, 1, 5μm) of polystyrene microspheres (PS-MPs) and nanospheres (PS-NPs) were selected for a study by Zhou *et al.* The effects of different sizes of polystyrene particles on human colonic epithelial cell CCD841CoN and small intestinal epithelial cell HIEC-6 within 24 h were explored. PS-NPs were found to have more potential to enter cells than micro-sized polystyrene PS-MPs, as confirmed by fluorescence microscopy; the intake amount was proportional to the exposure time. In addition, the membrane damage caused by PS-MPs was significantly higher than that by PS-NPs. This may be due to the large amount of polystyrene adhering to interstitial tissues, which has a significant negative effect on the cell membrane functions. For the first time human intestinal normal cell lines were used to study the effect of microplastic pollution, which can provide some references for the influence of microplastics on human health in the future.[48]

Conclusions

Previous and current infectious diseases caused by zoonoses have caused great harm to the health of humans, animals and the environment. (Re-)emerging zoonotic diseases are expected to continue to occur and outbreaks will have devastating effects. Whether these diseases are controlled successfully will have an important impact on achieving the United Nations Sustainable Development Goals (SDGs).

One Health is an ideal approach for control of zoonoses, with its aim of promoting sustainability via a balanced emphasis on the health of people, animals and ecosystems. The following solutions were proposed in the workshop to enhance a One Health approach to tackling zoonoses: 1) One Health should be advocated more forcefully and collectively from global to community level, by governments and their agencies, experts, communities, NGOs, industry and other key actors; 2) disease surveillance and response systems are the basis of zoonosis control and prevention; more sensitive, specific, cost-effective tools need to be developed; 3) One Health research and capacity building are vital if these goals are to be achieved; and finally 4) we need to promote the use of a One Health approach in the practice of human and animal disease prevention and control and in protection of ecosystems, as well as in research.

This workshop enabled "intergenerational" knowledge sharing with a new cohort of One Health professionals to better equip them to predict, prevent, evaluate and respond to future One Health emergencies. We hope that the workshop helped build confidence and capacity among those seeking fulfilling and impactful careers in One Health research and its translation to practice. The institutions involved will benefit from ongoing cooperation, and having a growing cadre of skilled, motivated and confident professionals, capable of interacting beyond their own domain, and who will be able to direct their research towards real-world impact. The wider international benefit will flow through mobility of ECRs via the strong, existing international partnerships of the proposers, and our plans to grow this international mobility further via our One Health Centre.

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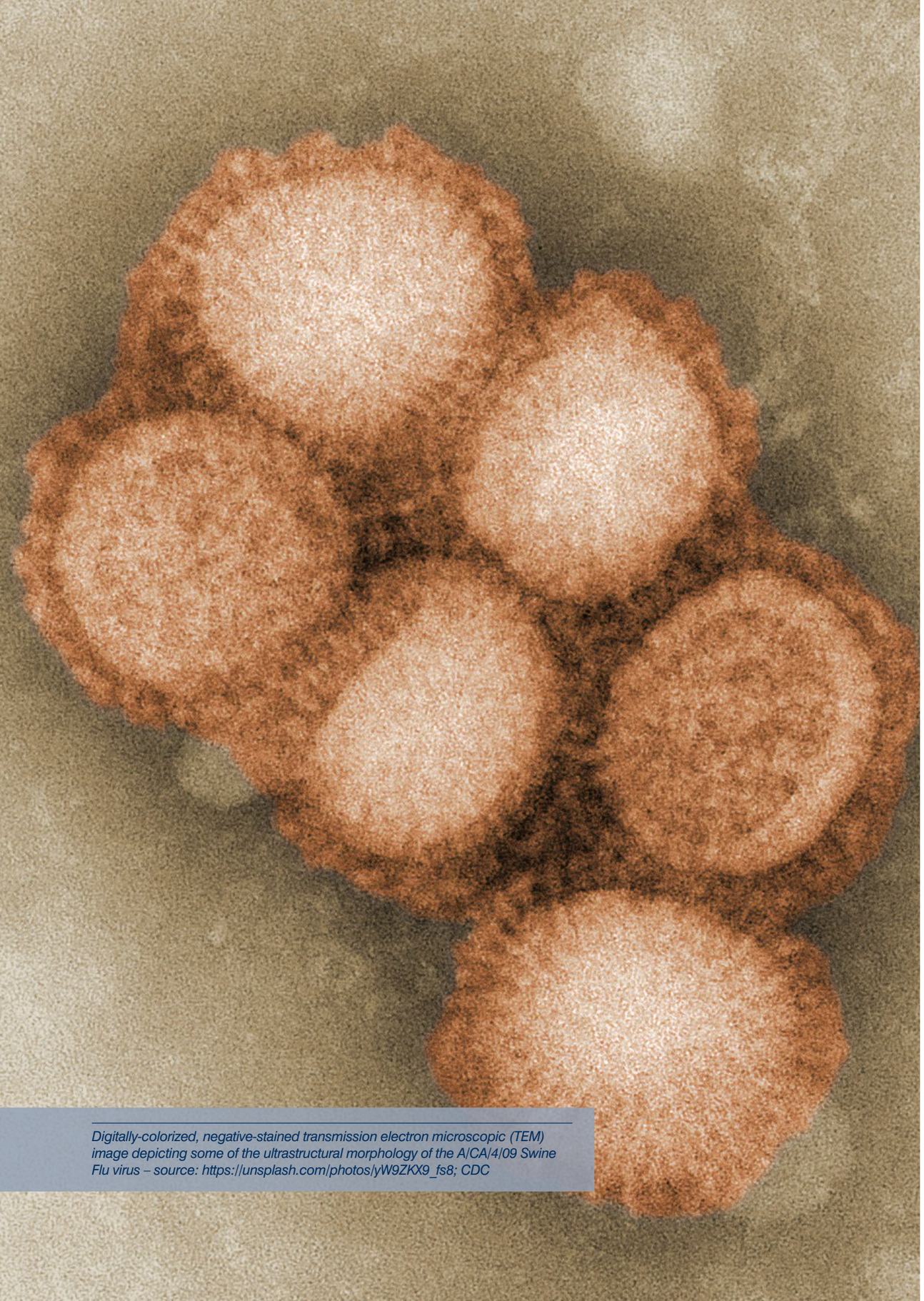


Digitally-colorized, negative-stained transmission electron microscopic (TEM) image depicting some of the ultrastructural morphology of the A/CA/4/09 Swine Flu virus – source: https://unsplash.com/photos/yW9ZKX9_fs8; CDC

Appendix 1: Workshop Programme

Day 1 (9 December) – Part A

Time (UK GMT)	Presentation title	Speaker	Chair
10.00-10.10	Welcome	Xiao-Nong Zhou & Geoff Simm	
10.10-10.35	**Keynote:** Setting the Scene – One Health and Sustainable Development	Liz Grant	Lisa Boden
10.35-11.00	**Keynote:** Surveillance and response to zoonoses	Xiao-Nong Zhou	Lisa Boden
11.00-11.30	**Session I:** Epidemiology of zoonotic disease: Pathogen and disease biology; pathogens at the human-animal interface including the emergence of new pathogens of humans and livestock • Li-Ying Wang *et al* – Prevalence and spatial distribution characteristics of human echinococcosis in China • Malimba Lisulo *et al* – Dogs and One Health: A case of African trypanosomiasis in indigenous dogs from Mambwe District, Eastern Zambia • Chao Lv *et al* – Schistosoma japonicum infection in field rats: a potential risk factor	Rapid presentations of selected posters (3 min each + 2 min discussion)	Lisa Boden
11.30-12.00	**Mentoring workshop 1:** Career development (Co-leads: Qian Han & Geoff Simm)	All participants	

Day 1 (9 December) – Part B

Time (UK GMT)	Presentation title	Speaker	Chair
13.00-13.25	**Keynote:** Challenge of emerging zoonoses	Kassegne Kokouvi	Kun Yin
13.25-13.55	**Session II:** Transmission dynamics: Genomic epidemiology – understanding host-switching, predicting virulence, understanding emergence and global spread of pathogens • Zhengbin Zhou *et al* – Genetic Diversity of Phlebotomus chinensisin China • Tijani Sulaimon *et al* – Assessing the effectiveness and robustness of vaccination strategies for disease control • Ting Zhang *et al* – A Paper-Based Point-of-Care Diagnostic Technology for Human Echinococcosis • Karen Keegan – Evaluating the Use of Nanopore Sequencing to Investigate Zoonoses and Antimicrobial Resistance (AMR) at the Wildlife-Livestock Interface: Setting the Scene	Rapid presentations of selected posters (3 min each + 2 min discussion)	Kun Yin
13:55-14:20	**Keynote:** Omics in zoonoses control	Wei Zhang	Kun Yin
14:20-15:00	**Mentoring workshop 2:** Publication skills (Co-leads: Guojing Yang & Raf De Oliveira Silva) **OR** **Mentoring workshop 3:** Communication skills (Co-leads: Kun Yin & Inês Orfao Crespo)	All participants	

Electron microscopic image of the 1976 isolate of Ebola virus – source: https://unsplash.com/photos/7CQFCHoFL-o; CDC

Day 2 (10 December) – Part A

Time (UK GMT)	Presentation title	Speaker	Chair
10:00-10:30	**Session III:** Innovation at the One Health interface – including diagnostics, data platforms, analytics, data-driven innovation, in vivo sensors and engineering solutions - in disease (including food-borne disease) detection, prevention, control and eradication • Kun Yin *et al* – Functional membrane-based pathogen molecular diagnosis from wastewater • Stephanie Brien *et al* – Developing Next-Generation Sequencing Tools for Health Surveillance at the Wildlife-Livestock Interface • Qinqin Hu *et al* – Selection of RNA-cleaving DNA probes for cancer diagnostics • Stephanie Brien *et al* – Health Surveillance to Improve Understanding of Wildlife-Livestock Disease Transmission Risks in Antelope Conservation Reintroductions • Wangping Deng *et al* – A basic recombinase polymerase amplification RPA assay for rapid and early detection of Schistosoma japonicum infection	Rapid presentations of selected posters (3 min each + 2 min discussion)	Geoff Simm
10:30-10:55	**Keynote:** One Health: insights form research on endemic zoonoses	Sarah Cleaveland	Geoff Simm
10:55-11:30	**Mentoring workshop 4:** Interdisciplinary research skills (Co-leads: Joyce Tait and Yong-Zhang Zhu)	All participants	
11:30-12:00	**Session IV:** Predicting One Health challenges from a changing climate, including new pest and disease threats/ changing insect migration patterns and implications for sustainable food systems • Shang Xia *et al* – Complex Systems Modeling for One Health Research • Hongmei Li *et al* – Machine Learning Approaches for Modelling Transmission Risk of Schistosomiasis haematobia • Bo Bi *et al* – Interventions portfolio analysis of P. vivax elimination in Guantang	Rapid presentations of selected posters (3 min each + 2 min discussion)	Geoff Simm

Day 2 (10 December) – Part B

Time (UK GMT)	Presentation title	Speaker	Chair
13.00-13.35	**Mentoring workshop 5:** Science-policy interactions (Co-leads: Lisa Boden & Bin Zheng) **OR** **Mentoring workshop 6:** Business interactions / entrepreneurship (Co-leads: Shan Lv & Xiao-Nong Zhou & Siân Ringrose)	All participants	
13.35-14:00	**Keynote:** Modelling for Pandemic Preparedness: A Need for a One Health Approach	Lisa Boden	Xiao-Nong Zhou
14:00-14.30	**Session V:** One Health models; 'What works' in developing a One Health approach; Strategies for healthcare and policy • Shijie Yang *et al* – Integrated solution for intelligent control and monitoring of Echinococcosis source based on the Internet of Things • Hailong Zhou *et al* – The potential effects of microplastic pollution on human digestive tract cells • Leshan Xiu *et al* – A pan-coronavirus assay for rapid viral screening of animal, human, and environmental specimens	Rapid presentations of selected posters (3 min each + 2 min discussion)	Xiao-Nong Zhou
14:30-15:00	Panel Discussion & Concluding remarks	All participants	Xiao-Nong Zhou & Geoff Simm

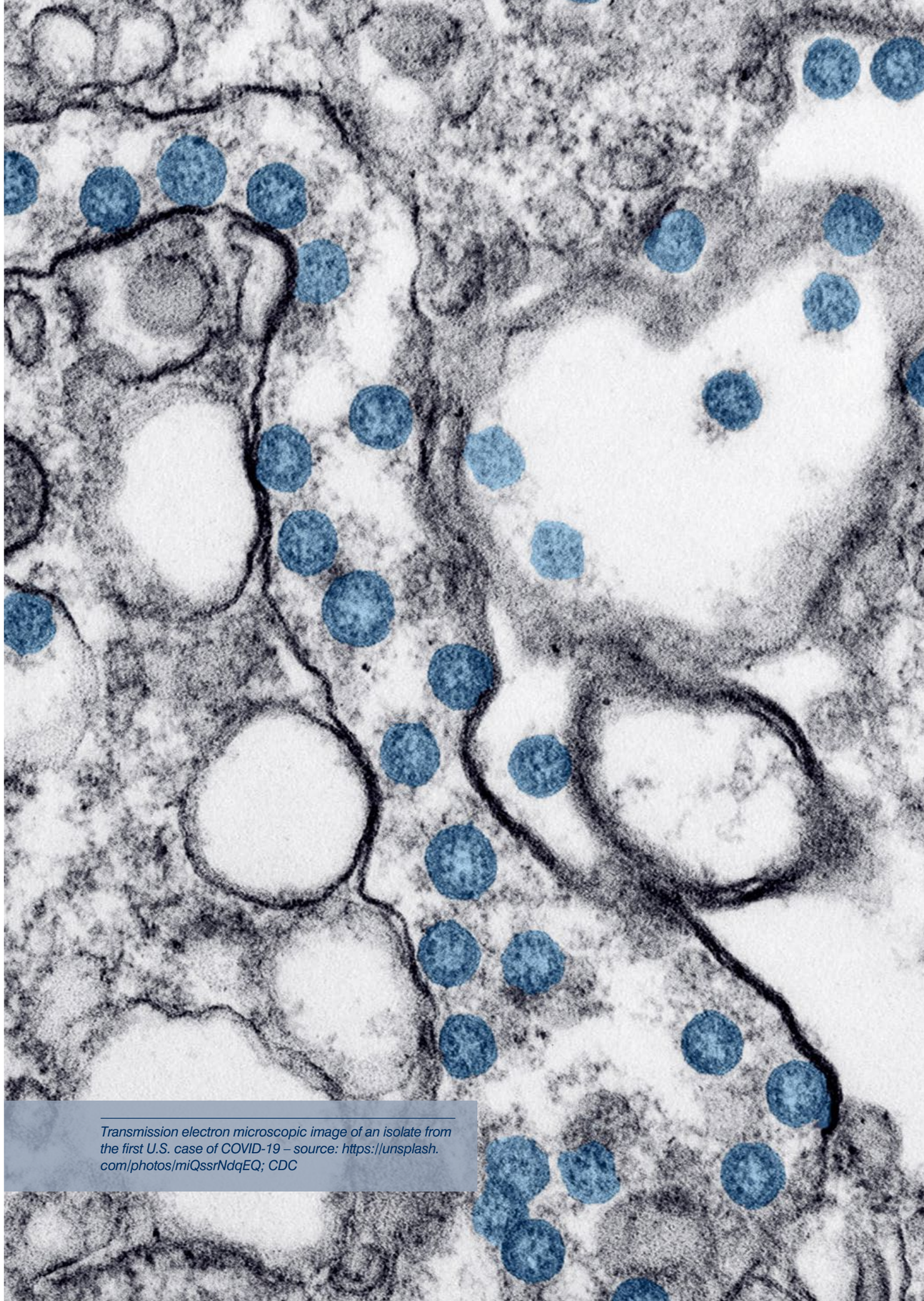
Appendix 2: Workshop Organizers, Keynote Speakers And Attendees

Organisers/Keynote Speakers/Mentors

Yasmin Abdalla	University of Edinburgh
Lisa Boden	University of Edinburgh
Sarah Cleaveland	University of Glasgow
Rafael De Oliveira Silva	University of Edinburgh
Liz Grant	University of Edinburgh
Inês Orfao Crespo	University of Edinburgh
Yan Ren	University of Edinburgh
Siân Ringrose	University of Edinburgh
Geoff Simm	University of Edinburgh
Joyce Tait	University of Edinburgh
Kassegne Kokouvi	Shanghai Jiao Tong University
Yuan Fang	NIPD, China CDC, Chinese Centre for Tropical Diseases Research, SJTU
Xiao-Kui Guo	Shanghai Jiao Tong University
Qian Han	Hainan University
Shan Lv	NIPD, China CDC, Chinese Centre for Tropical Diseases Research, SJTU
Xuechen Yang	Shanghai Jiao Tong University
Guojing Yang	Hainan Medical College
Kun Yin	Shanghai Jiao Tong University
Xiao-Nong Zhou	NIPD, China CDC, Chinese Centre for Tropical Diseases Research, SJTU

Workshop Participants

Alistair Antonopoulos	University of Glasgow
Gina Bertolacci	University of Glasgow
Stephanie Brien	University of Edinburgh
Ambre Chapuis	Moredun Research Institute
Charlotte Cook	Pirbright Research Institute
Anna Formstone	University of Glasgow
Lucija Jurisic	Università degli Studi di Teramo, Italy
Karen Keegan	Moredun Research Institute
Holly Kerr	University of Edinburgh
Sarah Krumrie	University of Glasgow
Timothy Lee	University of Edinburgh
Malimba Lisulo	University of Edinburgh
Lu Lu	University of Edinburgh
Maha Mansour Shalaby	University of Glasgow
Keila Meginnis	University of Glasgow
Rossella Panarese	University of Glasgow
Alexandra Raftery	University of Glasgow
Tijani Sulaimon	University of Edinburgh
Ross Watson	University of Edinburgh
Lin Ai	National Institute of Parasitic Diseases, China CDC
Bo Bi	Hainan Medical College
Jun-Hu Chen	National Institute of Parasitic Diseases, China CDC
Wangping Deng	National Institute of Parasitic Diseases, China CDC
Xin-Yu Feng	Shanghai Jiao Tong University
Jian He	Shanghai Jiao Tong University
Qinqin Hu	Shanghai Jiao Tong University
Hongmei Li	National Institute of Parasitic Diseases, China CDC
Min Li	Shanghai Jiao Tong University
Chao Lv	Shanghai Jiao Tong University
Tianren Shen	Zhejiang University-University of Edinburgh Institute
Liying Wang	National Institute of Parasitic Diseases, China CDC
Shang Xia	National Institute of Parasitic Diseases, China CDC
Leshan Xiu	Shanghai Jiao Tong University
Jingshan Xu	Shanghai Jiao Tong University
Shijie Yang	National Institute of Parasitic Diseases, China CDC
Wei Zhang	Nanjing Agricultural University
Ting Zhang	National Institute of Parasitic Diseases, China CDC
Yi Zhang	National Institute of Parasitic Diseases, China CDC
Xiaoxi Zhang	Shanghai Jiao Tong University
Hanqing Zhao	Shanghai Jiao Tong University
Bin Zheng	National Institute of Parasitic Diseases, China CDC
Zhengbin Zhou	National Institute of Parasitic Diseases, China CDC
Hailong Zhou	Hainan University
Yong-Zhang Zhu	Shanghai Jiao Tong University
Junyang Zou	Shanghai Jiao Tong University



Transmission electron microscopic image of an isolate from the first U.S. case of COVID-19 – source: https://unsplash.com/photos/miQssrNdqEQ; CDC

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