

**CHINA'S BIOSAFETY LEVEL 4
LABORATORIES AND THEIR
INTERNATIONAL LINKAGES
IN PATHOGEN RESEARCH**

Ryan CLARKE, LI Yao & LAM Peng Er

EAI Background Brief No. 1570

Executive Summary

1. A fundamental trend in the origins and diffusion of high-risk virology research is clear. This frontier work began in key Western countries and gradually diffused to China with the most high-risk components being ‘outsourced’ to Chinese Biosafety Level 3 and 4 (BSL3/BSL4) labs.
2. This trend broadly mirrors other highly dangerous industrial processes that were shifted from their initial production zones in the West to China. In this context, high-risk bat coronavirus Gain of Function (GoF) research in China (while still highly dangerous) is not as unique or isolated as what it may initially appear.
3. Given the current COVID-19 outbreak, public attention regarding bat coronavirus GoF research is currently being paid to Dr Shi Zheng-Li and her team at the Wuhan Institute of Virology (WIV). However, this overly narrow focus misses the critical bigger strategic picture and inhibits current and future decision-making.
4. Under the radar of many responsible bodies and sometimes independent of national governments, a transnational high-risk pathogen research network has been architected under official civilian cover.
5. Whether wittingly or unwittingly, some international researchers have been engaging in dual-use bioengineering research and development with their Chinese counterparts. The line between pure scientific research for clear public health benefit and research and development for a whole different set of strategic applications was crossed years ago.
6. There is an apparent lack of strategic cooperation and research partnerships between China’s two BSL4-capable institutes, WIV and Harbin Veterinary Research Institute (HVRI), that handle some of the world’s most dangerous pathogens.
7. While WIV and HVRI do not appear to have extensive institutional linkages between them, both have extensive international linkages to institutions in the

United States, Canada, Australia, France, India and Holland amongst others. The drivers of the formation and sustainment of these international networks appear to be more oriented towards GoF experiments as opposed to conventional clinical/scientific tasks.

8. In the event that the COVID-19 virus is reliably assessed to have been engineered in a laboratory environment/s, this poses a series of challenges. The technologies, techniques, data and other tools that have ‘powered’ this research are now widely available through open-source publications.
9. As such, they are also likely to be diffused across multiple advanced / rapidly emerging laboratory environments, many of which are in the Asia Pacific (and China in particular). Mapping and understanding the core mechanics of these diffusion processes will be critical for developing, validating and maintaining a clear picture and enabling optimal critical strategic decisions to be made.
10. COVID-19 could also be determined to be natural in origin and to have possibly emerged from a live animal market that conducted its own natural evolutionary GoF experiment. This would pose another distinct set of challenges as China and multiple Southeast Asian countries are home to thousands (reliable and more precise estimates are difficult to obtain) of such markets.

CHINA'S BIOSAFETY LEVEL 4 LABORATORIES AND THEIR INTERNATIONAL LINKAGES IN PATHOGEN RESEARCH

Ryan CLARKE, LI Yao & LAM Peng Er*

Key Drivers of International Partnerships

- 1.1 High-risk virological research began in key Western countries, with the most high-risk components gradually being 'outsourced' to Chinese Biosafety Level 4 (BSL4) labs and related BSL3 labs.¹ Apparently, the various Western lab groups that are engaged in these activities believed that they could actively control the development of this previously obscure but rapidly growing field within China. This has not been the case.
- 1.2 The network ecosystems of BSL4 labs and related BSL3 labs² have highly dense connections and almost daily (if not daily) interactions with other peer labs within China and across the world. This is due to the finite number of these labs as well as the highly specialised research that only a select group of scientists is capable of conducting.
- 1.3 Many of the international scientific partnerships in coronaviruses (especially bat-borne) and avian influenza research (as well as research on other rare but dangerous pathogens) are driven by a combination of self-interest mixed with pragmatic

* Ryan Clarke is Visiting Senior Research Fellow, Li Yao is Research Fellow and Lam Peng Er is Senior Research Fellow at the East Asian Institute.

¹ For example, please see Christina Lin, 'Why US outsourced bat virus research to Wuhan', *Asia Times*, 22 April 2020.

² BSL4 adopts the highest level of biosafety precautions and facilities are specifically designed for work with pathogens that could easily be transmitted within the laboratory and cause severe to fatal disease in humans for which there are no available vaccines or treatments. Biosafety level 3 is appropriate for work involving microbes which can cause serious and potentially lethal diseases via the inhalation route. Many of the protocols and other control measures in BSL4 and BSL3 labs are similar. For a more detailed technical overview, please see *Biosafety in Microbiological and Biomedical Laboratories – fifth edition*, US Centres for Disease Control and Prevention, Atlanta, December 2009.

scientific considerations. Research on bat coronaviruses was not previously considered to be a high priority scientific field.

- 1.4 Many working in the field around the world faced challenges such as finding tenured positions themselves, obtaining consistent access to funding and overall scientific recognition. Airtight international partnerships were essential to collectively obtain the research funds, data, scientific journal editorial board connections, and physical samples required for their field to survive, attract talent and grow. However, these dynamics have been fundamentally different in China.³
- 1.5 A small number of lab groups distributed throughout China (and a cluster of Western countries) became highly prominent.⁴ Scientists who want to work in these fields have a highly constrained set of options even globally that involve working under a handful of prominent scientific personalities. This characteristic is particularly pronounced in China.

Strategic Rationale of this Assessment

- 2.1 There is an apparent lack of strategic cooperation and research partnerships between China's two BSL4-capable institutes, namely, the Wuhan Institute of Virology (WIV) and Harbin Veterinary Research Institute (HVRI), that handle some of the world's most dangerous pathogens. These two BSL4 labs serve the entire country (in principle), with fragmented and often mutually exclusive ecosystems.⁵
- 2.2 While WIV and HVRI do not appear to have extensive institutional linkages between each other, both have extensive international linkages to institutions in the United States, Canada, Australia, France, India and Holland amongst others. Interestingly, the driver of these international networks appears to be more oriented

³ This is based on the professional experience and direct observations of Dr Ryan Clarke during his time working in a range of bio-defence/public health roles throughout the Asia Pacific, the United States and the United Kingdom.

⁴ See footnote 3.

⁵ For a more in-depth analysis, please see Ryan Clarke, Li Yao and Lam Peng Er, 'High-Risk Pathogen Research Networks in China: Historical Origins, Current Dynamics and Near-Term Directions', *EAI Background Brief*, No. 1569, East Asian Institute, 3 December 2020.

towards Gain of Function (GoF) experiments, unlike traditional international research networks that focus on conventional clinical/scientific tasks such as virus classification/analysis and data sharing for diagnostic/therapeutic development.

- 2.3 WIV officially acknowledges international research partnerships with institutions as diverse as the University of Alabama (United States), Harvard University (United States), University of Southampton (United Kingdom), Biological Research Centre – Defence Science and Technology Organisation (Pakistan), and Jomo Kenyatta University of Agriculture and Technology (Kenya) amongst multiple others.⁶
- 2.4 However, there is no strong observed correlation between these official partners and WIV’s actual research output. Some of WIV’s more consistent scientific collaborators, such as the University of North Carolina at Chapel Hill, are not even listed as official WIV partners. Dr Shi Zheng-Li, one of WIV’s lead scientists in the field of bat coronavirus GoF experiments, is the lead on many of these studies with the University of North Carolina at Chapel Hill.
- 2.5 A similar dynamic is seen with HVRI which is said to have laboratory-oriented partnerships with multiple international organisations such as the Michigan State University (United States) and the National Veterinary Institute of Sweden but with no additional details or strong evidence of linkages in the publication record.⁷
- 2.6 There is no direct reference to Erasmus University (Holland) or the University of Wisconsin at Madison (United States) even though one of HVRI’s leading scientists, Dr Chen Hualan, has continuous partnerships in the field of avian influenza GoF experiments with both of these institutions. Scientific publications are clear evidence of this. It is not clear as to why this scientifically significant partnership is not officially mentioned on HVRI’s website while other partnerships ranging from Harvard University in the United States to the Defence Science and Technology Organisation in Pakistan are.

⁶ Partnerships, Wuhan Institute of Virology, http://english.whiov.cas.cn/International_Cooperation_2016/Partnerships/, accessed 24 September 2020.

⁷ International Cooperation, Harbin Veterinary Research Institute – Chinese Academy of Agricultural Sciences. <http://www.hvri.ac.cn/en/intlcooperation/index.htm>, accessed 24 September 2020.

Are GoF Experiments Required for Major Scientific Advances?

- 3.1 GoF experiments are a controversial domain within biomedical science, defence and security, and other related fields. They are separate and distinct from other scientific methods and approaches. GoF experiments are deliberately designed to enable pathogens to develop new properties (i.e. increased transmissibility, increased lethality, drug resistance and so on) for them to generate predictive information, knowledge and insight, and enable reliable capabilities to effectively anticipate how viruses could leap from one species to another.⁸ This would then drive rapid early detection, containment and local/regional/international pandemic prevention. However, this also makes viruses even more dangerous than the form in which they were initially discovered in nature.
- 3.2 As evidenced by the COVID-19 outbreak as well as other recent coronavirus outbreaks such as the Middle East Respiratory Syndrome (MERS), GoF has yet to fulfil these promises of enhanced early pandemic detection and control. MERS was first reported in Saudi Arabia in 2012 and spread in an irregular manner globally with cases being detected in countries such as South Korea, Thailand, and multiple others with severe disease and fatalities being reported. Similar events and shortcomings had also been witnessed during recent avian influenza virus outbreaks, such as Highly Pathogenic Avian Influenza H5N1 (2003 -HPAI H5N1) and Highly Pathogenic Avian Influenza H7N9 (2013 – HPAI H7N9), both of which originated in China.
- 3.3 GoF experiments have been funded by major bodies such as the National Institutes of Health (United States) and the Bill and Melinda Gates Foundation (United States) amongst others. Aside from coronaviruses, GoF experiments have encompassed a variety of other highly dangerous pathogens ranging from influenza viruses to HPAI H5N1.

⁸ GoF studies are not limited to the field of virology. For example, there are GoF experiments on proteins that have applications for cancer treatment. These types of GoF studies do not carry the same types of risks and are not subject to the same controversies as their counterparts in the virology domain. For one example, please see Moshe Oren and Varda Rotter, "Mutant p53 Gain-of-Function in Cancer", *Cold Spring Harb Perspect Biol*, 2(2), February 2010.

- 3.4 Before the COVID-19 outbreak, GoF research on H5N1 was considered to be the most high-risk and controversial. Numerous scientists voiced outright opposition to this work being done without first exploring all other scientific avenues.⁹ Scientists have also pointed out that no major vaccine has been developed in relation to any GoF research on H5N1, Severe Acute Respiratory Syndrome (SARS), MERS, or any other highly dangerous pathogens. This is despite GoF marketing itself as being the highest probability set of methods to achieve this endpoint.
- 3.5 Funding streams, data sharing, joint publications and other related outputs on GoF research on H5N1 have spanned the globe with Western scientists working directly in partnership with counterparts in China. Similar international linkages can be directly observed in relation to the previously obscure but now highly consequential GoF research on bat coronaviruses.

WIV in Critical International Context – Not an Isolated Set of Domestic GoF Experiments

- 4.1 The research group led by the Head of the Centre for Emerging Infectious Diseases at WIV, Dr Shi Zheng-Li, has been pioneering experiments on bat coronaviruses that could directly infect humans without the traditional need for an intermediate host (such as a civet cat, pangolin, pig and so on). These studies were openly published and Dr Shi gave many presentations around the GoF work that she and her team had done. A substantial portion of this research was originally done with scientists from the University of North Carolina at Chapel Hill.¹⁰
- 4.2 In the midst of some of the most intense phases of the COVID-19 outbreak in the United States, several other American lab groups, such as the Galveston National Laboratory (another BSL4 facility which is part of the University of Texas at Austin

⁹ For example, please see Felix Rey, Olivier Schwartz and Simon Wain-Hobson, ‘Gain-of-function research: unknown risks’, *Science*, 342(6156):311, 18 October 2013.

¹⁰ For example, please see Vineet Menachery et. al, ‘SARS-like cluster of circulating bat coronavirus pose threat for human emergence’, *Nature Medicine*, 2015 December; 21(12): 1508–1513. doi:10.1038/nm.3985.

WIV also conducts research on MERS, Zika, SARS and SARS-like viruses, Nipah, Ebola, HIV and various insect-borne viruses such as Malaria.

system) openly claimed that WIV had impeccable standards and that the COVID-19 virus could not have emerged from the facility.¹¹

4.3 However, whether or not the COVID-19 virus was natural in origin is still widely contested across multiple international scientific communities. So is the claim by the team at the Galveston National Laboratory. The US Department of Education is currently investigating the nature of the links between the University of Texas and various Chinese labs (WIV in particular) as well as the Chinese state-owned telecommunications giant Huawei.¹²

4.4 Another key member of Dr Shi's team who is also an internationally recognised bat coronavirus expert and Head of the Bat Virus Infection and Immunity Project at WIV is Dr Zhou Peng. Prior to joining Dr Shi's team at WIV, Dr Zhou completed his PhD training at the Australian Centre for Disease Preparedness (formerly known as the Australian Animal Health Laboratory) in Geelong, Australia. Dr Zhou's placement was jointly funded by the Chinese and Australian governments.¹³ He subsequently completed a post-doctoral fellowship at the Duke-NUS Medical School.¹⁴

4.5 These dangerous experiments are widely assessed to have very little or no real scientific value. No current consequential therapeutic, diagnostic, vaccine, or any other relevant breakthrough on the coronaviruses (bat or otherwise) has been directly attributed to this work. In fact, the University of North Carolina researchers eventually terminated their side of the collaboration in October 2014 after the US government banned federal funding on all GoF studies on influenza, MERS and SARS. However, Dr Shi and her team continued with their work at WIV after being

¹¹ Hollie McKay, "Prominent university bio lab urged to reveal extent of relationship with Wuhan lab at center of coronavirus outbreak", Fox News, 1 May 2020.

¹² For example, please see Kate O'Keefe, 'U.S. Probes University of Texas Links to Chinese Lab Scrutinized Over Coronavirus', *The Wall Street Journal*, 1 May 2020.

¹³ Kelly Burke, 'Australian CSIRO in Geelong linked to coronavirus 'bat laboratory' theory', 7 News, 28 April 2020.

¹⁴ For example, please see Zhou Peng, Shi Zheng-Li, et. al, 'IFNAR2-dependent gene expression profile induced by IFN-alpha in Pteropus alecto bat cells and impact of IFNAR2 knockout on virus infection', PLOS ONE, 17 January 2018.

officially licensed in 2015 by the NIH to both continue bat coronavirus GoF research and receive American funds despite the ban and funding moratorium within the United States itself.¹⁵

- 4.6 WIV was designed with substantial French technical assistance¹⁶ followed by a scientific exchange programme. However, only one French researcher (from the intended 50) spent time at WIV. These developments generated concern within French intelligence and security circles¹⁷ as the WIV has had a ‘Military Management Division’ with a possible People’s Liberation Army (PLA) presence in WIV.¹⁸ In the middle of the COVID-19 outbreak in Wuhan, the PLA, led by Major General Dr Chen Wei, went in and assumed operational control of WIV.¹⁹
- 4.7 The entire city of Harbin was also forced into a full lockdown around the same time as Wuhan though specific details regarding activities at HVRI are more difficult to obtain. Regardless, HVRI operations would have necessarily been materially impacted if the entire city of Harbin and surrounding areas were fully locked down.
- 4.8 In aggregate, it appears that China’s two leading virology research institutes, HVRI and WIV, were both substantially impaired in the midst of the most acute phases of the COVID-19 outbreak in China.

¹⁵ Christina Lin, ‘Why US outsourced bat virus research to Wuhan’, *Asia Times*, 22 April 2020.

¹⁶ Both Institut Pasteur and Institut Merieux were heavily involved in the physical design and development of key management and scientific protocols. Notably, Dr Shi Zheng-Li completed her doctorate at Montpellier 2 University in Montpellier, France.

¹⁷ Glen Owen, ‘Wuhan virus lab was signed off by EU Brexit chief Michel Barnier in 2004’.

¹⁸ Ibid.

¹⁹ For example, please see Minnie Chan and William Zheng, ‘Meet the major general on China’s coronavirus scientific front line’, *South China Morning Post*, 3 March 2020, <https://www.scmp.com/news/china/military/article/3064677/meet-major-general-chinas-coronavirus-scientific-front-lin>, accessed 3 March 2020.

Synthetic Bat Coronavirus GoF ‘Breakthroughs’ in 2010, 2013 and 2015 – A Rare Example of True International Cooperation

- 5.1 Several GoF studies were published by joint Sino-American-Australian²⁰ teams in leading scientific journals such as *Nature* and *Archives of Virology* in 2010, 2013 and 2015. These studies demonstrated ways (for the first time in history) that a bat coronavirus could directly infect human beings without the need for an intermediate mammalian host. For example, the 2003 SARS coronavirus originated from bats and is believed to have infected humans via another mammal species, possibly pigs or civet cats.²¹
- 5.2 Not satisfied with this ‘breakthrough’ alone, the researchers went further and experimented with increasing the transmissibility of this new synthetic bat coronavirus. Dr Shi Zheng-Li at WIV was one of those scientists.²²
- 5.3 Although the experiments sparked major debates within the scientific and security/defence communities, the bat coronavirus GoF researchers continued with their work at various institutions in China, Australia and the United States amongst others.
- 5.4 As the scientific infrastructure required to securely store bat coronaviruses for fundamental analysis is different from the type of infrastructure required to conduct the types of experiments described in these publications, the difference should have instantly alerted relevant personnel in these immediate environments. These are not the type of experiments that can be conducted ‘in the background’.²³ The fact that

²⁰ The Australian Centre for Disease Preparedness, Australia’s BSL4 lab in Geelong (outside of Melbourne), has refrained from making comments so far even though extensive research was conducted on bat coronaviruses in this facility with Dr Shi even spending time there as a visiting scientist in 2006.

²¹ Please see, Shi Zheng-Li, Ralph Baric, et. al, ‘A SARS-like cluster of circulating bat coronaviruses shows potential for human emergence’, *Nature Medicine*, Vol. 21, No. 12, December 2015; Jonna Mazet, Peter Daszak, Shi Zheng-Li, et. al, ‘Isolation and characterization of a bat SARS-like coronavirus that uses the ACE2 receptor’, *Nature*, Vol. 503, 28 November 2013; and Fang Li, Linfa Wang, Shi Zheng-Li, et. al, ‘Angiotensin-converting enzyme 2 (ACE2) proteins of different bat species confer variable susceptibility to SARS-CoV entry’, *Archive of Virology*, Vol. 155, 22 June 2010.

²² Please see, Shi Zheng-Li, Ralph Baric, et. al, op.cit; Jonna Mazet, Peter Daszak, Shi Zheng-Li, et. al, op.cit; and Fang Li, Linfa Wang, Shi Zheng-Li, et. al, ‘Angiotensin-converting enzyme 2 (ACE2) proteins of different bat species confer variable susceptibility to SARS-CoV entry’.

²³ See footnote 3.

these researchers actually published these studies is an additional irrefutable case in point. All of this was done in the open.

- 5.5 Evidently, Dr Shi was conducting high-risk bat coronavirus GoF experiments only as a single member of a large international network. This work was done openly with the knowledge and awareness of possibly thousands of peers, and continued with the most high-risk components being progressively ‘outsourced’²⁴ to China in response to various pressures in the United States.
- 5.6 However, the links between the United States and the WIV extended well beyond scientific collaboration. A total of US\$3.7 million of US-taxpayer funds was transferred to WIV from NIH to specifically fund bat coronavirus GoF research projects despite identical work being shut down in the United States itself.²⁵
- 5.7 This link and flow of American public funds has led many to question if this grant was an erroneous one-off or if it was an iceberg phenomenon indicating much broader links between Chinese and American labs. These studies could generate unpredictable and rapid onset global public health emergencies in the event of even minor errors (or intentional releases). Dr Simon Wain-Hobson, a leading virologist at Institut Pasteur in Paris, openly made such warnings.²⁶

The USAID PREDICT Project – A ‘Global’ Programme with an Unexplained Strong Southwestern China Focus

- 6.1 Beginning in 2009, the United States Agency for International Development (USAID) directly funded the PREDICT project (US\$200 million total funding) as part of its Emerging Pandemic Threats (EPT) programme. This programme was shut down by the Trump administration in March 2020. The mandate of PREDICT was

²⁴ Christina Lin, ‘Why US outsourced bat virus research to Wuhan’, *Asia Times*, 22 April 2020.

²⁵ Shawna Williams, ‘NIH Cancels Funding for Bat Coronavirus Research Project’, *The Scientist*, 28 April 2020.

²⁶ Jef Akst, ‘Lab-Made Coronavirus Triggers Debate’, *The Scientist*, 16 November 2015.

officially to strengthen global surveillance capability, which includes novel sample collection in nature and subsequent physical sample distribution and data sharing.²⁷

- 6.2 These activities were meant to enable the more rapid and accurate detection of ‘zoonotic spill over events’ (i.e. animal viruses making a species jump and infecting humans for the first time). The majority of the work done by PREDICT was heavily focused on bat coronaviruses in tropical Asia, especially in the Chinese province of Yunnan and several states in Northeast India near the Chinese border.²⁸
- 6.3 Despite this strong geographic focus, the PREDICT programme failed to detect and/or control the geographic spread of the current COVID-19 outbreak. COVID-19 is in fact a bat coronavirus that some scientists believe has its initial point of origin in the exact same geography of PREDICT’s own surveillance and monitoring operations. Some of those involved in PREDICT have attributed this to general factors such as inadequate funding and support.²⁹
- 6.4 There is a wide range of globally distributed zoonotic spillover events that are occurring in tropical environments (and others), often in very resource-poor settings. It can be assessed to be anomalous that PREDICT had such a narrow domain focus (bat coronavirus surveillance) in a finite geography (Southwest China/Northeast India).³⁰ China also already has one of the most domestically well-funded and capable national infectious disease control systems in the world. This brings into question the rationale behind this programme.
- 6.5 A major recipient of PREDICT funds (as well as NIH funds³¹) and other material support is the EcoHealth Alliance, a New York City-headquartered non-profit

²⁷ For example, please see USAID PREDICT Semi-Annual 2019 Report, <https://ohi.sf.ucdavis.edu/sites/g/files/dgvnsk5251/files/files/page/SAR2019-draft-final-compressed.pdf>, accessed 24 August 2020.

²⁸ Ibid.

²⁹ For example, please see Charles Smith, ‘Why the Coronavirus Slipped Past Disease Detectives’, *Scientific American*, 3 April 2020.

³⁰ For example, please see USAID PREDICT Semi-Annual 2019 Report, <https://ohi.sf.ucdavis.edu/sites/g/files/dgvnsk5251/files/files/page/SAR2019-draft-final-compressed.pdf>, accessed 24 August 2020.

³¹ For example, please see Peter Daszak, ‘Understanding the Risk of Bat Coronavirus Emergence’, NIH Grant Database, <https://grantome.com/grant/NIH/R01-AI110964-06>, accessed 24 August 2020.

organisation. EcoHealth Alliance also has a strong focus on tropical Asia, including Southeast Asia, and has been openly endorsed by USAID. The Head of EcoHealth Alliance, Dr Peter Daszak, was previously invited to speak at US Embassy forums in locations such as Kuala Lumpur, Malaysia. Dr Daszak was featured prominently in multiple documentaries, such as ‘Coronavirus, Explained’, where he openly discussed his work in bat caves in Yunnan and his strong ties to the Chinese government.³²

- 6.6 Why the USAID-funded EcoHealth Alliance is doing high-risk and potentially strategically sensitive fieldwork in a country that already has advanced domestic capabilities is unclear. China also has a clear preference for self-reliance and minimal (and temporary) dependence on foreign expertise.
- 6.7 Dr Daszak has continuously supported the Chinese scientific establishment (including publicly calling Dr Shi a ‘hero’) which is involved in the full spectrum of COVID-19 projects. He and his team have also provided a blueprint strategy to prevent a repeat of the ‘2019-nCoV outbreak’. However, despite marketing itself as the expert team in the field, the EcoHealth Alliance clearly missed this outbreak. Why they continued to receive funding from the PREDICT programme prior to its official termination remains unknown.³³
- 6.8 EcoHealth Alliance also has a strong relationship with the University of California at Davis, which itself was the other major partner of USAID’s PREDICT

³² For a recent mainstream American media example, please see Julie Zaugg, ‘The virus hunters who search bat caves to predict the next pandemic’, CNN, 27 April 2020. Please see also Simon Anthony, Peter Daszak, et. al, ‘Global patterns in Coronavirus diversity’, *Virus Evolution*, 2017, 3(1): vex012; Michael Letko et. al, ‘Bat-borne virus diversity, spillover, and emergence’, *Nature Reviews Microbiology*, 18, 2020, pp. 461–471; Li, W, Shi, Z, Yu, M, Ren, W, Smith, C, Epstein, JH, Wang, H, Cramer, G, Hu, Z, Zhang, H, Zhang, J, McEachern, J, Field, H, Daszak, P, Eaton, BT, Zhang, S and Wang, L, 2005. Bats Are Natural Reservoirs of SARS-Like Coronaviruses. Science DOI: 10.1126/science.1118391; Peter Daszak et. al, ‘Global hotspots and correlates of emerging zoonotic diseases’, *Nature Communications*, 8:1124, 24 October 2017; Shi, Zheng-Li, Zhou Peng, Peter Daszak, et. al, ‘Fatal swine acute diarrhea syndrome caused by an HKU2-related coronavirus of bat origin’, *Nature*, 2018 Apr;556(7700):255-258; and Shi Zheng-Li, Peter Daszak, et. al, ‘Discovery of a rich gene pool of bat SARS-related coronaviruses provides new insights into the origin of SARS coronavirus’, *PLOS Pathogens*, 30 November 2017.

³³ For example, please see Peter Daszak et. al, ‘A strategy to prevent future epidemics similar to the 2019-nCoV outbreak’, *Biosafety and Health*, Vol. 2, Issue 1, March 2020, pp. 6-8.

Programme. UC Davis hosts the One Health Institute, which received a new US\$85 million grant from USAID in October 2019 to build capacity in Southeast Asia.³⁴

- 6.9 The One Health Initiative has a declared mandate and mission that virtually overlaps with that of EcoHealth Alliance. Several of the ‘godfathers’ of bat coronavirus research completed doctoral and other relevant training at UC Davis. The executive director of the One Health Initiative (and scientific collaborator with Dr Daszak) is Dr Jonna Mazet.
- 6.10 The One Health Initiative is housed in UC Davis’ School of Veterinary Medicine with associated laboratory and other physical clinical research infrastructure. Conversely, the work of EcoHealth Alliance appears to be highly ‘field-based’. All openly available evidence suggests that the contributions from EcoHealth Alliance primarily derive from its operational flexibility that is not inhibited by traditional academic commitments such as teaching, student supervision, clinical trial/lab-based research project management and so on.
- 6.11 EcoHealth Alliance has a relatively flat management structure and is not officially tethered to an established formal academic institution. This very likely results in the EcoHealth Alliance having the ability to serve as the ‘tip of the spear’ for much of the more dynamic bat coronavirus surveillance work in Southwest China/Northeast India. This fieldwork likely represents activities that groups like the One Health Initiative and/or PREDICT programme personnel either cannot or will not carry out themselves.
- 6.12 Dr Daszak and his team also have a well-established track record of joint publications with Dr Shi Zheng-Li (as well as prominent members of her lab such as Dr Zhou Peng) at WIV. Dr Mazet also has similar linkages with Dr Shi as well as Dr Daszak.³⁵

³⁴ Kat Kerlin, ‘\$85M to Develop a One Health Workforce for the Next Generation - USAID Award Supports New Project Led by UC Davis One Health Institute’, University of California at Davis website, 9 October 2019, <https://www.ucdavis.edu/climate-science/news/85m-develop-one-health-workforce-next-generation/>, accessed 24 August 2020.

³⁵ For example, please see Peter Daszak, Jonna Mazet, Shi Zheng-Li, et. al, ‘Joint China-US Call for Employing a Transdisciplinary Approach to Emerging Infectious Diseases’, *Ecohealth*, 2015; 12(4): 555–559.

The Global Virome Project: A Privatised Transnational Enterprise

- 7.1 Dr Mazet, Dr Daszak and Dr Dennis Carrol all serve on the Global Leadership Team of the Global Virome Project. This is a somewhat undefined organisation that markets itself as a strategic advisory firm for structuring infectious disease control programmes and ‘managing partner investment and optimizing return on investment’. Dr Dennis Carrol is the now-retired former head of USAID’s Emerging Pandemic Threats Programme that provided critical support to PREDICT (and by extension, to Dr Daszak and Dr Mazet) in its early phases.³⁶
- 7.2 Dr Gao Fu (George Gao), now the director of the Chinese Centre for Disease Control and Prevention in Beijing (China CDC), published a letter of support for the Global Virome Project in 2018.³⁷ It is unclear why Dr Gao would openly endorse a private-sector enterprise while serving in an official governmental capacity. Dr Gao was at the Institute of Microbiology of the Chinese Academy of Sciences at the time.
- 7.3 Dr Gao did his doctoral training at Oxford (1991), spent time at the University of Calgary before returning to Oxford as a post-doctoral researcher. Dr Gao then worked at Harvard Medical School in 1999 (funded by the UK’s Wellcome Trust) and eventually became a lecturer at Oxford (2001-2004).³⁸ As the director of the China CDC, Dr Gao is as central, if not more so, to China’s international linkages in virological research as prominent research scientists at WIV, HVRI and other research institutes. China CDC is the central bureaucratic organisation that is tasked with managing pandemics and has laboratory infrastructure in Wuhan.
- 7.4 Another key member of the Global Virome Project team is Dr Jennifer Gardy. She is concurrently on the Leadership Board and the deputy director of the Malaria Team at the Bill and Melinda Gates Foundation. Prior to assuming these roles, Dr Gardy spent a decade at the British Columbia Centre for Disease Control and the University

³⁶ For more information, please see <http://www.globalviromeproject.org/who-we-are>, accessed 16 September 2020

³⁷ For example, please see George Gao, Joanna Mazet, Peter Daszak, et. al, ‘The Global Virome Project’, *Science*, Vol. 359, Issue 6378, pp. 872-874, 23 February 2018.

³⁸ ‘Gao Fu’, University of Chinese Academy of Sciences, accessed 16 September 2020.

of British Columbia's School of Population and Public Health where she held the Canada research chair in Public Health Genomics. Her research focused on the use of genomics as a tool to understand pathogen transmission, and incorporated techniques drawn from genomics, bioinformatics, modelling, information visualisation and the social sciences.³⁹

Key French Technical Assistance: From Initial Lead Architect to Obscurity in Wuhan

- 8.1 Both Institut Pasteur and Institut Merieux were heavily involved in the physical design and development of key management and scientific protocols of WIV in its initial development phases. The completion of construction of the WIV building was meant to be followed by a scientific exchange programme that saw only one French researcher (from the maximum 50) spend time at WIV.⁴⁰ These developments generated concern within French intelligence and security circles⁴¹ given the nature of the experiments and the presence of a 'Military Management Division' at WIV.
- 8.2 Many believed that the Military Management Division represented an official PLA presence in WIV. However, there is currently no direct reference to the Military Management Division on the WIV website and information regarding previous official US State Department visits to WIV has also been removed.⁴²
- 8.3 French biomedical research institutes, such as Institut Pasteur, have a uniquely long-term successful track record in establishing infrastructure within mainland China. Institut Pasteur of Shanghai has a formal partnership with the Chinese Academy of

³⁹ For more information, please see Jennifer Gardy, 'Leadership – Global Virome Project', Global Virome Project, <http://www.globalviromeproject.org/who-we-are/leadership/jennifer-gardy>, accessed 8 October 2020.

Jennifer Gardy, 'What We Do – Malaria', Bill and Melinda Gates Foundation. <https://www.gatesfoundation.org/What-We-Do/Global-Health/Malaria/Strategy-Leadership/Jennifer-Gardy>, accessed 8 October 2020.

⁴⁰ Glen Owen, 'Wuhan virus lab was signed off by EU Brexit chief Michel Barnier in 2004'.

⁴¹ Ibid.

⁴² Josh Rogin, 'State Department cables warned of safety issues at Wuhan lab studying bat coronaviruses', *New York Times*, 14 April 2020.

Sciences. The initial Letter of Intent was signed in Paris in the presence of then-Chinese President Hu Jintao and then-French Prime Minister Jean-Pierre Raffarin.⁴³

- 8.4 Institut Pasteur has another operation embedded within the University of Hong Kong, the HKU-Pasteur Research Pole. The lab was originally established by Dr Malik Peiris who is credited with being one of the first scientists to fully characterise the SARS virus in 2003 and determine its transmission through droplets in the air.
- 8.5 French institutes such as Institut Pasteur could have unknowingly/inadvertently provided multi-use foundational infrastructure in WIV which could have enabled advanced experimental platforms (such as bat coronavirus GoF experiments) to be prioritised when French scientists were no longer with the WIV.
- 8.6 Institut Pasteur has played a pivotal role throughout China's history as a reference lab/s for novel virus characterisation, scientific advice, technical assistance during outbreaks and other public health challenges. It is also a major provider of biomedical education in mainland China and Hong Kong.
- 8.7 Notably, Institut Pasteur has its own institutional avoidance of GoF experiments.⁴⁴ There was/is no precedent of Institut Pasteur's institutes in China/Hong Kong (or any others spread across 25 countries) being misused for GoF experiments (of any kind), making it likely that those involved in the initial WIV project did not anticipate that risks such as these could emerge.
- 8.8 The role (if any) WIV played in the COVID-19 outbreak aside, the Institut Pasteur experience demonstrates how rapidly scientific/technological know-how can transmit in an unintended and unpredictable manner (at least for the initial source). This can occur even when such infrastructure and/or knowledge is not even explicitly related to GoF research.

⁴³ Inauguration of the Institut Pasteur of Shanghai – Chinese Academy of Sciences, Press Release, Institut Pasteur-Chinese Academy of Sciences, Shanghai, 10 October 2004, <https://www.pasteur.fr/en/inauguration-institut-pasteur-shanghai-chinese-academy-sciences>, accessed 9 June 2020.

⁴⁴ For example, please see Felix Rey, Olivier Schwartz and Simon Wain-Hobson, 'Gain-of-function research: unknown risks', *Science*, 342(6156):311, 18 October 2013.

India's National Centre for Biological Sciences and WIV

- 9.1 The Indian government's formal investigation into a bat coronavirus study carried out by researchers from India, China and the United States is ongoing in the Northeast Indian state of Nagaland. The investigation focuses specifically on scientists from India's National Centre for Biological Sciences (NCBS), WIV, Uniformed Services University of the Health Sciences (US) and the Duke-National University of Singapore Medical School (Duke-NUS). The enquiry is determining if scientists obtained both bat and/or human samples without proper permissions.⁴⁵
- 9.2 The enquiry is also seeking information on whether Indian-origin bat and/or human samples were shared with WIV. The lead on this investigation is a five-member team from the Indian Council of Medical Research who will then submit their findings to the Indian Ministry of Health.⁴⁶
- 9.3 One of the primary origins of these concerns is an October 2019 study published in *PLOS Neglected Tropical Diseases*, a new journal funded by the Bill and Melinda Gates Foundation. This study focuses on human bat hunters who had continuous exposure to bat-borne pathogens, namely, filoviruses.⁴⁷
- 9.4 The study concluded that Nagaland is witnessing the circulation of several filoviruses in bats with the accompanying possibility of filovirus transmission from bats to humans. The co-authors of this study include WIV scientists Dr Shi Zheng-Li, as well as prominent researchers from NCBS and Duke-NUS. WIV is publicly acknowledged by NCBS to have provided reagents for this study, which could be classified as biological materials. This study was funded by the US Defence Threat Reduction Agency (DTRA).⁴⁸

⁴⁵ Bindu Shajan Perappadan, 'Study on bats and bat hunters in Nagaland to be probed', *The Hindu*, 3 February 2020.

⁴⁶ Ibid.

⁴⁷ Pilot Dovih, Shi Zheng-Li, et. al, 'Filovirus-reactive antibodies in humans and bats in Northeast India imply zoonotic spillover', *PLOS Neglected Tropical Diseases*, 13(10), 31 October 2019.

⁴⁸ Pilot Dovih, Shi Zheng-Li, et. al, *ibid* and Bindu Shajan Perappadan, 'Study on bats | No rules were broken, says NCBS', *The Hindu*, 4 February 2020.

- 9.5 While the investigation is ongoing, it is evident that DTRA directly funded bat virus and human immunology research in India via Duke-NUS. Duke-NUS then simultaneously channelled funds to the NCBS in Bangalore as well as WIV in Wuhan for various forms of technical and scientific assistance.⁴⁹ This multi-dimensional relationship developed in spite of geopolitical rivalries, trade disputes and other factors that would have disrupted many other transnational network linkages.
- 9.6 The US-funded partnership between Duke-NUS, NCBS and WIV continued for years with joint publications between the three institutions being clear evidence of this. While this particular October 2019 Indian study focused on bat filoviruses as opposed to bat coronaviruses, bat filoviruses are also relevant for analysing and engineering bat coronaviruses.

Links between WIV and Canada's National Microbiology Lab

- 10.1 Canada's National Microbiology Lab in Winnipeg also has clear demonstrated links with WIV, though more in key logistical (namely, viral sample sharing) and critical knowledge transfer domains. These are strategic modes of interactions that are not always immediately apparent as they do not immediately manifest themselves in the form of joint publications, joint grant award announcements and/or other 'loud' traditional detection mechanisms. The case of cooperation between various researchers at Canada's National Microbiology Lab and the WIV highlights another amorphous dimension to the nature of this transnational network of high-risk pathogen research.
- 10.2 In July 2019 leading Ebola researcher, Dr Qiu Xiangguo, and her entire research team were escorted out of their lab and taken into custody by the Royal Canadian Mounted Police. Dr Qiu was determined to have shipped multiple dangerous pathogens, including Ebola and Henipah virus samples, to WIV. Dr Qiu was

⁴⁹ Pilot Dovih, Shi Zheng-Li, et. al, op.cit.

dismissed from her position but the National Microbiology Lab stated that her dismissal was not related to this shipment.⁵⁰

- 10.3 Dr Qiu made at least five trips to China between 2017 and 2018 to train local staff at WIV. The Canadian government openly acknowledged that the costs were being borne by third-parties and not Public Health Canada. It is also established that Dr Qiu met collaborators in Beijing during these trips. These trips generated major concern amongst Canadian colleagues at the National Microbiology Lab citing national security concerns.⁵¹
- 10.4 Dr Qiu is one of the inventors of ZMapp, the most effective therapy for Ebola virus disease. One of her key collaborators, Hualei Wang, is linked to the Academy of Military Medical Sciences, a Chinese military medical research institute in Beijing.⁵² Dr Qiu also obtained multiple scientific awards in Canada for her research and held an academic appointment at the University of Manitoba.
- 10.5 Similar to other lead scientists in this network, Dr Qiu operated openly with counterparts at WIV and even the PLA. While Dr Qiu has not been formally linked to bat coronavirus GoF research, her Ebola- and Henipah-driven interactions with WIV/PLA surfaces another network layer that shows how bold and catastrophic risk-tolerant these scientists can be.

Laying the Transnational Foundation for Bat Coronavirus GoF Experiments: Dutch HPAI H5N1 Experiments

- 11.1 Transnational collaboration on high-risk pathogen GoF experiments can be directly traced to work on HPAI H5N1 viruses. Similar to the early formation phases of the bat coronavirus GoF scientific network, early HPAI H5N1 GoF work was

⁵⁰ Tom Blackwell, 'Dismissal and investigation by RCMP of Winnipeg co-inventor of Ebola drug stuns colleagues', *National Post*, 16 July 2019.

⁵¹ Tom Blackwell, 'In mystery investigation of two Canadian scientists, a request for Ebola, henipavirus from the Wuhan lab', *National Post*, 5 May 2020 and Karen Pauls, 'Canadian government scientist under investigation trained staff at Level 4 lab in China', *CBC News*, 3 October 2019.

⁵² Karen Pauls, *ibid* and Hualei Wang, Xiangguo Qiu, et. al, 'Equine-Origin Immunoglobulin Fragments Protect Nonhuman Primates from Ebola Virus Disease', *Journal of Virology*, Vol. 93, Issue 5, March 2019.

dominated by a select group. This group was led by Dr Ron Fouchier of the Erasmus Medical Centre in Rotterdam, Holland.

- 11.2 It appears that leading avian influenza virus specialist Dr Chen Hualan at HVRI has benefitted significantly from this foundational infrastructure. Dr Fouchier has openly cited the work done by Dr Chen and her colleagues at HVRI as a justification for his own controversial HPAI H5N1 GoF experiments in Holland.⁵³
- 11.3 However, Dr Chen’s GoF work on avian influenza viruses is not characterised by extensive international linkages like some of her WIV counterparts. Dr Chen’s international linkages are more narrowly focused and include continuous work with Dr Yoshihiro Kawaoka, a long-time collaborator of Dr Fouchier, with a joint appointment at the University of Wisconsin-Madison and University of Tokyo.⁵⁴ While this connection between Dr Fouchier and Dr Chen may have one slight degree of separation, it is significant nonetheless.
- 11.4 Dr Yoshihiro Kawaoka is a member of the leadership team of the University of Tokyo component of the Japan Initiative for Global Research Network on Infectious Diseases (J-GRID). Under the J-GRID framework, Dr Kawaoka and his University of Tokyo colleagues are responsible for Chinese partnerships. Dr Kawaoka has personally established a strong relationship with HVRI and is the chief of the Joint China-Japan Joint Research Group on Avian Influenza Virus, which is officially housed within HVRI.⁵⁵

⁵³ ‘Dutch researcher resumes H5N1 transmission studies’, Centre for Infectious Disease Research and Policy, University of Minnesota, 28 February 2013, <https://www.cidrap.umn.edu/news-perspective/2013/02/flu-news-scan-resuming-h5n1-research-h7n3-mexico-fda-flu-strain-selections>, accessed 11 June 2020.

⁵⁴ For example, please see Hualan Chen, Yoshihiro Kawaoka, et. al, ‘A Single-Amino-Acid Substitution in the NS1 Protein Changes the Pathogenicity of H5N1 Avian Influenza Viruses in Mice’, *Journal of Virology*, Vol. 82, No. 3, pp. 1146–1154, February 2008 and Hualan Chen, Yoshihiro Kawaoka, et. al, ‘A Duck Enteritis Virus-Vectored Bivalent Live Vaccine Provides Fast and Complete Protection against H5N1 Avian Influenza Virus Infection in Ducks’, *Journal of Virology*, Vol. 85, No. 21, p. 10989–10998, November 2011.

⁵⁵ Research Activities of Japan Initiative for Global Research Network on Infectious Diseases (J-GRID), Division of Infectious Diseases Research, Department of Research Promotion, Japan Agency for Medical Research and Development, July 2018.

- 11.5 Dr Fouchier openly discusses his work, including his controversial experiments that successfully engineered HPAI H5N1 viruses to transmit between ferrets without direct contact. On upper respiratory tract infections caused by HPAI H5N1, ferrets are the mammals that most closely and genetically resemble humans.⁵⁶
- 11.6 This work was highly controversial with many leading virologists and other scientists openly claiming that Dr Fouchier was directly engaging in strategic research under the guise of public health. Dr Fouchier dismissed these claims and continued with his work, again occasionally citing the work of Dr Chen at HVRI as justification.
- 11.7 The Dutch government did take notice and forced Dr Fouchier to obtain a European Union-compliant Export Licence prior to publishing any further HPAI H5N1 GoF research. This EU regulatory regime is designed specifically to prevent the unauthorised proliferation of weapons of mass destruction. It was highly unlikely that any of such Export Licences would be granted. Dr Fouchier unsuccessfully challenged this decision in Dutch courts in September 2013 thereby bringing about what many believed would be a permanent end to this type of GoF research.⁵⁷
- 11.8 However, in 2019 the US government (which had previously successfully pressured the Dutch government to shut down Dr Fouchier's research) quietly lifted the moratorium on HPAI H5N1 GoF research. Dr Yoshihiro Kawaoka publicly praised the decision while Dr Fouchier appears to have adopted a low profile and resumed his work at Erasmus.⁵⁸ No clear explanation was given for the scientific rationale behind this resumption nor the risk assessment process that preceded it.

⁵⁶ For example, please see Ron Fouchier et. al, 'Airborne transmission of influenza A/H5N1 virus between ferrets', *Science*, 22 June 2012;336(6088):1534-41 and Ron Fouchier et. al, 'The potential for respiratory droplet-transmissible A/H5N1 influenza virus to evolve in a mammalian host', *Science*, 22 June 2012, 336(6088):1541-7.

⁵⁷ Martin Enserink, 'Flu Researcher Ron Fouchier Loses Legal Fight Over H5N1 Studies', American Association for the Advancement of Science (ScienceMag), 25 September 2013.

⁵⁸ Jocelyn Kaiser, 'EXCLUSIVE: Controversial experiments that could make bird flu more risky poised to resume', American Association for the Advancement of Science (ScienceMag), 8 February 2019.

Making the ‘Species Jump’ from HPAI H5N1 to Coronaviruses: Setting an International Precedent?

- 12.1 It appears that while his HPAI H5N1 GoF research was under pressure, Dr Fouchier became more deeply involved in coronaviruses, starting with MERS. MERS was first officially isolated in Saudi Arabia by Dr Ali Zaki, an Egyptian doctor working at the Dr Soliman Fakeeh Hospital in Jeddah, Saudi Arabia.⁵⁹
- 12.2 Dr Zaki claims that he sent the MERS samples to Dr Fouchier for PCR testing and virus identification/characterisation after being ignored by Saudi authorities. Dr Fouchier completed this task in June 2012 and patented several critical datasets and other intellectual property related to the virus. Meanwhile, Dr Zaki was dismissed from his position and left Saudi Arabia.⁶⁰
- 12.3 Dr Fouchier then went on to share these MERS samples with the National Microbiology Lab in Winnipeg, Canada. The then-director of the National Microbiology Lab, Dr Frank Plummer, openly criticised the Material Transfer Agreements (MTA) that governed these Saudi-origin MERS samples as being too restrictive. Dr Plummer also noted that China had shared samples of the H7N9 bird flu virus during previous pandemics.⁶¹
- 12.4 The initial link between Dr Zaki and Dr Fouchier warrants analysis. PCR testing and virus identification is an internationally standardised scientific process that can be done even in resource-poor settings. There is no clear scientific or technical reason why Dr Zaki had to send these MERS samples to Dr Fouchier’s specific lab at Erasmus. Any international standard laboratory could have completed the task. Cornell University’s Weill Cornell Medical College has a campus in nearby Doha, Qatar and the Cleveland Clinic has a large operation in Abu Dhabi, the United Arab Emirates. In 2012 Dr Fouchier was considered to be one of the world’s most

⁵⁹ Kai Kupferschmidt, ‘As Outbreak Continues, Confusion Reigns Over Virus Patents’, American Association for the Advancement of Science (ScienceMag), 28 May 2013.

⁶⁰ Ibid.

⁶¹ Kelly Crowe, ‘Saudi coronavirus work stymied at Canadian lab’, CBC News, 29 May 2013.

controversial scientists. He was known not for identifying and classifying novel pathogens, but for re-engineering them to make them more dangerous.

- 12.5 What is clear from the case of the HPAI H5N1 work done by Dr Fouchier is that lines between various viral GoF communities (i.e. HPAI H5N1 groups versus bat coronavirus GoF groups) has become blurry and porous. Physical samples can move nearly instantly around the world amongst a relatively small number but highly densely connected labs.
- 12.6 It can be reasonably argued that Dr Fouchier is one of the modern founders of highly pathogenic GoF research. His scientific methods, transnational partnership structures and modalities, and other outputs helped to form a critical foundation. This foundation has been advanced by the bat coronavirus GoF research carried out by scientists at WIV and others around the world. It has also been advanced by the avian influenza GoF research conducted by Dr Chen Hualan at HVRI and her scientific collaborators, including Dr Yoshihiro Kawaoka.

The Line between Public Health Research and Dual-Use Applications Has Been (Un)Intentionally Crossed

- 13.1 A core fundamental trend in the origins and diffusion of bat coronavirus GoF research is clear and unambiguous. This work began in key Western countries and gradually diffused to China with the most high-risk components being ‘outsourced’ to Chinese BSL3 and BSL4 labs.
- 13.2 This trend broadly mirrors other highly dangerous industrial processes that were shifted from their initial production zones in the West to China. In this context, high-risk bat coronavirus GoF research in China (while still highly dangerous) is not as unique or isolated as what it may initially appear.
- 13.3 Given the current COVID-19 outbreak, public attention regarding bat coronavirus GoF research is currently being paid to Dr Shi and her team at WIV. However, this overly narrow focus misses the critical bigger strategic picture and inhibits current and future decision-making.

- 13.4 Under the radar of many responsible bodies and sometimes independent of national governments, a transnational bat coronavirus GoF network has been architected under official civilian cover. A similar development has occurred in HPAI H5N1 GoF research though Dr Chen's international linkages appear to be more highly concentrated on a specific HPAI H5N1 GoF community in the United States, Holland and Japan.
- 13.5 This network continuously shares key data, scientific opinions, international prestige and status within certain circles and, critically, funds. The transfer of US\$3.7 million from NIH that eventually ended up funding bat coronavirus GoF research at WIV becomes less inexplicable and seems less random when this broader network context is considered.

Ongoing Point of Origin Investigations and Near-Term Implications

- 14.1 This transnational bat coronavirus GoF network represents a clear strategic-level public health issue that needs to be continually mapped, characterised and assessed given the highly dynamic nature of these networks.
- 14.2 Whether wittingly or unwittingly, these international researchers have been engaging in and continuously advising each other on high-risk dual-use bioengineering research and development. The line between pure scientific research for clear public health benefit and research and development for a whole different set of strategic applications was crossed years ago.
- 14.3 In the event that the COVID-19 virus is reliably assessed to have been engineered in a laboratory environment, this poses a series of challenges. The technologies, techniques, data and other tools that have 'powered' this research are now widely available through open-source publications.
- 14.4 As such, they are also likely to be diffused across multiple advanced / rapidly emerging laboratory environments, many of which are in the Asia Pacific (and China in particular). Mapping and understanding the core mechanics of these diffusion processes will be critical for developing, validating, and maintaining a

clear information picture and enabling optimal critical strategic decisions to be made.

- 14.5 Notably, even with all the negative media coverage around bat coronavirus GoF research, many scientists continue with their work on bats. Bats (with over 1,300 different species) harbour the most viruses out of any other mammal with none of these viruses appearing to cause any disease in bats themselves. Bat immunology is believed by many scientists as holding the key to human protection against the world's most dangerous pathogens and even non-communicable diseases, such as various types of cancer.
- 14.6 COVID-19 could also be determined to be natural in origin and to have possibly emerged from a live animal market that conducted its own natural evolutionary GoF experiment. This would pose another distinct set of challenges as China and multiple Southeast Asian countries are home to thousands (reliable more precise estimates are difficult to obtain) of such markets.
- 14.7 In these markets, various animal species (including bats and birds) are packed in close proximity to each other (something which would never occur in nature) and are under highly stressed and immunocompromised conditions.
- 14.8 The sheer scale and geographical spread of these markets pose major challenges for traditional epidemiological surveillance. A more concentrated and targeted effort on supply chains and other key flows that feed into and enable the formation and sustainment of these live animal markets is needed.
- 14.9 While these supply chains also represent a complex system, key material flows are not as numerous and/or amorphous as individual live animal markets. Supply chains are also more vulnerable to effective systems-level targeting and disruption compared to the thousands of individual live animal markets that feed off these supply chains.

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