HIGH-RISK PATHOGEN RESEARCH NETWORKS IN CHINA: HISTORICAL ORIGINS, CURRENT DYNAMICS AND NEAR-TERM DIRECTIONS

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Executive Summary

1. Following the 2003 SARS pandemic, the Chinese leadership made it a top national priority for the country to be adequately prepared for the next major outbreak by building more advanced public health-relevant scientific infrastructure.

2. In China, the Wuhan Institute of Virology (WIV) and Harbin Veterinary Research Institute (HVRI) have become more pathogen-specific and specialised with the WIV being increasingly driven by work on coronaviruses and the HVRI focusing heavily on avian influenza viruses.

3. WIV and HVRI are amongst the most well-known in the world in their respective fields in terms of research output, international partnerships and deep integration into China's larger public health ecosystem (civilian and military).

4. WIV's formal domestic links include the Chinese Academy of Sciences, Chinese Communist Party (CCP - which has representation on the WIV Board of Directors), provincial and city governments, and various other bodies.

5. HVRI has established itself as the 'go-to' institute for animal pathogens that pose critical threats to livestock and/or humans. It has quickly developed internationally recognised expertise in Avian influenza viruses and is officially under the supervision of the Chinese Academy of Agricultural Sciences.

6. In May 2020, China's National Development and Reform Commission (NDRC) issued a plan for every Chinese province to have at least one Biosafety Level 3 (BSL3) lab. The NDRC cited the recent COVID-19 outbreak as the key driver of this new initiative. If executed in line with NDRC directives, it will fundamentally alter the scale, scope and structure of high-risk pathogen research in China.

7. Available evidence suggests that China now possesses world-class expertise and is capable of training its own future generations of virologists onshore without sending them to the West as was the case with previous generations.

8. However, key Chinese labs at institutes such as the WIV and HVRI will likely seek to maintain strategic relationships with specific Western lab groups. This is driven by the desire to remain close to cutting edge developments outside of China, ensure that China's own ecosystem remains competitive and identify virological sub-fields where China can be a world leader.

9. Chinese virologists are unlikely to have open and free access to research and educational opportunities in key Western countries, in the United States in particular, as in the past. This will likely have the effect of driving domestic Chinese virological research down a new and unique pathway.

10. Chinese virology labs could be characterised by the military and CCP control at the management level and in other key scientific positions. They may seek to leverage all of China's recent pandemic experiences to position themselves as world leaders.

11. With such developments, nominally civilian labs will likely be treated as strategic national assets as opposed to purely public health/clinical assets.

HIGH-RISK PATHOGEN RESEARCH NETWORKS IN CHINA: HISTORICAL ORIGINS, CURRENT DYNAMICS AND NEAR-TERM DIRECTIONS

Ryan CLARKE, LI Yao & LAM Peng Er*

Historical Origins

1.1 Chinese virologists and other related biomedical scientists received training in advanced techniques and established subsequent scientific partnerships with Western institutions as early as the 1930s. For example, Professor Gao Shangyin who is widely considered to be the founder of modern virology in China went to the Rollins College in the United States for his undergraduate education in 1930 and earned his PhD from Yale in 1935. In 1956 Professor Gao also founded the Wuhan Microbiology Laboratory under the administration of the Chinese Academy of Sciences (CAS). This was the antecedent institute of the Wuhan Institute of Virology (WIV) which eventually established the first Biosafety Level 4 (BSL4) lab in China in 2015 in cooperation with the French government.[1]

1.2 Initial progress in the field was incremental and further slowed by the loss of Soviet technical assistance and the domestic chaos experienced during the Great Leap Forward (1958-1962) and Cultural Revolution (1966-1976). There was no record of publications from China before 1982 in Biomedical Sciences in the Web of Science (WS) database which has covered the majority of publications in this field since 1900.

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[1] 'China flaunts French connection to Wuhan lab; Ambivalent on WHO probe into origin of coronavirus', *Economic Times*, 7 May 2020, https://economictimes.indiatimes.com/news/international/world-news/china-flaunts-french-connection-to-wuhan-lab-ambivalent-on-who-probe-into-origin-of-coronavirus/articleshow/75600806.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst, accessed 7 May 2020. For more details, please refer to https://yswk.csdl.ac.cn/search/search_nianpucontent.action?nianpuid=773032, accessed 9 October 2020.

1.3 Following the normalisation of China-US relations in 1978 and Deng Xiaoping's economic reforms, a large wave of Chinese students across multiple disciplines (including virology) was sent to the West for scientific training. As a result, the share of biomedical publications from China in this field recorded by WS has also gradually increased since 1982 (Figure 1). The initial groups of Chinese sent to the United States were mature scholars with families and strong links to China to ensure their return.[2]

1.4 Between 1978 and 2000, over 200,000 Chinese students were sent to the United States, 57,000 of whom were directly funded by the Chinese government while another 102,000 were funded by government-related entities and companies. Some of these students returned upon completion of their studies while others chose to work abroad before returning to China to train the next generation of scientists. Notably, the 1989 Tiananmen Square incident did not materially impact the outward flow of Chinese students.[3]

1.5 This trend was particularly pronounced in the field of virology, epidemiology and other related clinical/scientific fields. For example, the current head of the Chinese Centre for Disease Control and Prevention, Dr Gao Fu (also known as George Gao), did his doctoral training at Oxford (1991) and 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).[4]

1.6 The 2003 SARS pandemic served as the major impetus for China to rapidly enhance and expand its biomedical research and BSL3 and BSL4-related domestic capabilities. The Chinese leadership made it a top national priority for the country to be adequately prepared for the next major outbreak by building more domestic infrastructure and enhancing specific transnational scientific partnerships. This

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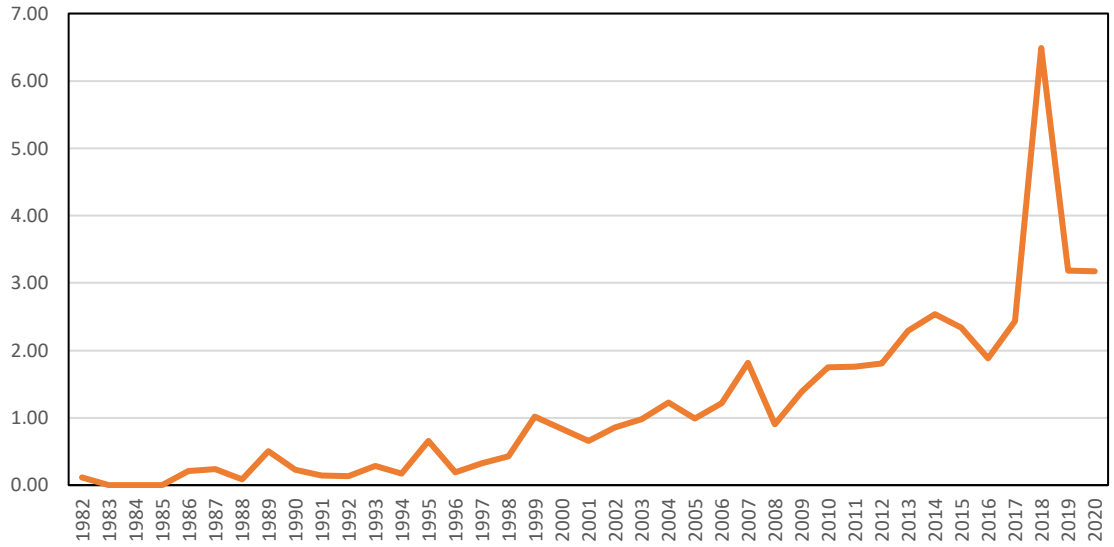
2 William Wei, 'China's Brain Drain to the United States: Views of Overseas Chinese Students and Scholars in the 1990s', *China Review International*, Vol. 4, No. 1, 1997.

3 Yabin Zhang and Xiaoqing Ma, '65 Years of Study Abroad History: From Soviet Union to the US, From Paid by Government to Paid by Family', Edited by Xiaoyi Wang, Data.163, 28 September 2014.

4 'Gao Fu', University of Chinese Academy of Sciences, http://people.ucas.ac.cn/~GeorgeGao?language=en, accessed 16 September 2020.

strategy also brought in leading Western scientists who obtained unique and career-enhancing access to Chinese clinical/scientific networks, viral samples (SARS, avian influenza, swine flu and so on) and datasets. Figure 1 saw the share of biomedical publications from China after 2003 increase significantly.

FIGURE SHARE OF PUBLICATIONS FROM CHINA IN THE FIELD OF BIOMEDICAL SCIENCE



Source: Authors' calculation based on search results from Web of Science.

1.7 The 2008-2019 period witnessed a major increase in the number of Chinese students in the United States. The academic year of 2008/2009 saw 98,235 Chinese students, but a decade later in the academic year of 2018/2019, the number more than tripled to 369,548. The most popular course is business and management with engineering coming in a close second followed by computer science and mathematics. Interesting, the majority of these students appear to be self-funded.[5] This rapid increase in the representation of a specific nationality is unprecedented in American history.

[5] This data has been retrieved from, 'Number of college and university students from China in the United States from academic year 2008/09 to 2018/19', Statista, https://www.statista.com/statistics/372900/number-of-chinese-students-that-study-in-the-us/, accessed 16 September 2020.

How Do BSL4 Labs Operate? Core Mechanical Principles

2.1 BSL4 labs are specifically designed to handle a range of analytical tasks and experiments with the world's most dangerous pathogens. In principle, a BSL4 lab has globally consistent standards, protocols and training regimes regardless of which country the facility is in.

2.2 The network ecosystems of BSL4 (and some specialised BSL3 labs) 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 are capable of conducting.

2.3 Flows between these labs include (but are not limited to) datasets, scientific/clinical opinions, new technological methods and parameters for experiments, personnel,[6] physical samples, reagents and even temporary loaning of spare capacity. For example, one common practice is to allow peer labs to utilise polymerase chain reaction machines and other hardware that are underutilised in its current environment.

2.4 Internationally, the overall mode of interaction between BSL4 labs is collegiate with little competitive friction between groups due to international funding bodies' clear strategic preference for multi-institutional and even multi-country research. As such, barriers to the aforementioned flows are minimal.

2.5 In China, WIV and Harbin Veterinary Research Institute (HVRI) publications show that these two institutions have become more pathogen-specific and specialised with the WIV being increasingly driven by work on coronaviruses. HVRI appears to do relatively little work on coronaviruses and instead focuses heavily on avian influenza viruses. This single 'centre of excellence' approach poses several structural problems, namely, that the WIV and/or the HVRI represent a single point of failure in the highly dangerous pathogen research ecosystem.

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[6] Visiting research positions are common between peer labs.

2.6 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 scientific considerations.

2.7 Many working in the field around the world faced challenges such as finding permanent positions, consistent access to funding and overall scientific recognition. Airtight international partnerships were essential to collectively obtain 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.

2.8 A small number of lab groups throughout China (and a cluster of Western countries) became highly prominent in a manner uncharacteristic of many other branches of science. Chinese scientists who want to work in these fields have a highly constrained set of options within China (and even globally) that involve working under a handful of prominent scientific personalities.

2.9 This configuration gives rise to a 'mutual echo chamber' that does not tolerate dissenting views on the safety or even the necessity of the research. This is potentially problematic in a scientific field that poses global risks inherent in bat coronavirus, avian influenza and other dangerous pathogen research. Many other scientific fields are characterised by a more diverse range of lab groups with competing approaches and methods which could minimise the risk of the blind pursuit of a scientific end-goal without adequate consideration being given to potential negative consequences, including catastrophic ones.

2.10 During this critical formation process, China made strategic and sustained investments. This involved scholarships for Chinese students to study in top international universities (especially in the United States), domestic scientific training (to seed the next generation) and laboratory/other related facility construction. China also established multiple programmes (such as the Thousand Talents Programme, with WIV as one of the core components) for international scientists to serve as advisers and/or visiting research scientists in China.

2.11 China has continuously hosted high-profile international conferences (including a pipeline of 2021 conferences)[7] and funded spin-off companies in China to inspire scientists by demonstrating the 'real world impact' of the research they do in partnership with Chinese researchers.[8]

WIV – Home of China's First BSL4 Lab

3.1 China's two BSL4 labs are amongst the most well-known in the world in terms of research output, international partnerships and deep integration into China's larger public health ecosystem (civilian and military). WIV's BSL4 lab has extensive transnational and domestic links, both formal and informal. Formal domestic links include CAS, Chinese Communist Party (CCP – which has representation on the WIV Board of Directors), provincial and city governments, and various other bodies.

3.2 Dr Wang Yanyi is concurrently the director general of WIV and the deputy chair of a United Front political party in Wuhan. She is married to Dr Shu Hongbin, a fellow immunologist who has held several senior positions at the Wuhan University College of Life Sciences (dean) and Wuhan University (vice president). The two have a well-established track record of joint publications.[9] This represents a material dynamic between the WIV, CAS, CCP and other research institutes in Wuhan working in key areas of virology.

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[7] For example, please see The fourth China International BioPharma Conference and Exhibition, Bioexpo – China 2021, 19-21 September 2021, http://www.cajc-china.com/?_l=en, accessed 5 October 2020.

[8] For example, please see Mark Terry, 'China Has Big Presence in Top 10 Biotech IPOs this Year', BioSpace, 17 July 2019, https://www.biospace.com/article/top-10-biopharma-ipos-in-the-first-half-of-2019/, accessed 5 October 2020.

'Top Virologists of the Global Virus Network (GVN) Meet in China to Address Threats', Business Wire, 12 May 2015, https://www.businesswire.com/news/home/20150512006108/en/Top-Virologists-Global-Virus-Network-GVN-Meet, accessed 5 October 2020.

[9] For example, please see Wang (YY), Shu (HB), et. al, 'VISA is an adapter protein required for virus-triggered IFN-beta signalling', *Molecular Cell*, Vol. 19, Issue 6, 16 September 2005; and Wang (YY), Shu (HB), et. al, 'A20 is a potent inhibitor of TLR3- and Sendai virus-induced activation of NF-kappa B and ISRE and IFN-beta promoter ', *FEBS Letters*, Vol. 576, Issue 1-2, 8 October 2004.

3.3 The various lab groups in WIV (as well as HVRI)[10] have played leading roles across the full spectrum of virology research pertaining to every major highly dangerous pathogen that has emerged or impacted China in recent history. Despite establishing its BSL4 facilities only in 2015, WIV is already known as a centre of excellence for pathogens ranging from the Middle East Respiratory Syndrome (MERS), Zika, SARS and SARS-like viruses, Nipah, Ebola, HIV and various insect-borne viruses such as Malaria.

3.4 The People's Liberation Army (PLA), led by PLA Major General Dr Chen Wei, went in and temporarily assumed operational control of the WIV during one of the most acute phases of the COVID-19 outbreak.[11] Major General Wei is credited with being one of the key strategic leaders who eventually contained SARS in 2003.

3.5 It is unclear how this decision, which looks potentially outside of official CCP protocol during a crisis event, was made. There is also a near complete lack of presence of Chinese Vice President Wang Qishan despite the leading role he played alongside Major General Chen Wei during the 2003 SARS outbreak. He is also known throughout China as the leader who took decisive action to bring the deadly viral outbreak under control. This dynamic can be assessed to be also quite anomalous with no clear credible explanation.

3.6 Currently, there are 65 in-house scholars listed on WIV's official website, including 36 senior research fellows, five junior research fellows and 24 associate research fellows. Among them are 28 senior research fellows, one junior research fellow and six associate research fellows who have education, working or academic visiting experience abroad. The domestic and education experiences of WIV scholars are related to 44 universities and institutions all over 17 provinces and municipalities.

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[10] For example, Dr Shi Zheng-Li's bat coronavirus bioengineering team at WIV and Dr Chen Hualen's avian influenza bioengineering team at HVRI.

[11] 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-line, accessed 3 March 2020.

3.7 Some scholars who are not listed on WIV's official website have claimed affiliation with WIV. For example, four scholars are listed on the official website of the State Key Laboratory of Virology at Wuhan University (WHUKLV) but not on WIV's official website even though the WHUKLV's official website indicates their affiliation with WIV.

3.8 Perhaps the most currently well-known researcher at WIV is Dr Shi Zheng-Li, a French-trained and internationally recognised bat coronavirus expert with expertise in bioengineering. Dr Shi and several colleagues (both domestically and internationally based) have several landmark publications in leading scientific journals such as *Nature* and *Archives of Virology* in 2010, 2013 and 2015.[12]

3.9 In aggregate, 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 that originated from bats was believed to have infected humans via another mammal species, possibly pigs or civet cats. Additional experiments show that this new synthetic bat coronavirus could be more transmissible than even the most dangerous bat coronaviruses found in nature.[13]

3.10 WIV has capabilities across a range of 'wet lab' environments that deal with physical biological materials as well as 'dry lab' environments that utilise advanced computational methods, including artificial intelligence and machine learning. This 'end-to-end' capability enables WIV to carry out virtually any advanced scientific task and/or architect and execute any state-of-the-art experiment across multiple

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[12] 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.

[13] Please see, Shi Zheng-Li, Ralph Baric, et. al, 'A SARS-like cluster of circulating bat coronaviruses shows potential for human emergence'; Jonna Mazet, Peter Daszak, Shi Zheng-Li, et. al, 'Isolation and characterization of a bat SARS-like coronavirus that uses the ACE2 receptor'; 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'.

domains within the field of virology. Much of this multi-domain infrastructure focuses on bat coronaviruses.[14]

3.11 WIV also previously acknowledged housing a Military Management Division, something that generated some concern around the potential dual-use nature of some of the research being done at WIV.[15] There is currently no direct reference to the Military Management Division on the WIV website since Major General Chen Wei took over the institute. Information regarding previous official US State Department visits to WIV has also been removed.[16]

3.12 WIV also has dense connections with other institutions in Wuhan, such as the Wuhan Institute of Technology, Wuhan University (specifically the Medical School), Wuhan University of Science and Technology and Wuhan branch of the China CDC. The facilities of China CDC in Wuhan are located several hundred metres from the Huanan Seafood Market, the initial claimed point of origin of the COVID-19 virus.

3.13 From 1981 to 2020, WIV produced 2,288 publications co-authored with scientists from 1,728 institutions across 80 countries and within China. Before 1981, there was no record. According to this publication record, scientific cooperation between WIV is particularly consistent with 138 institutions across 23 countries (measured by a track record of at least five joint publications).[17]

3.14 Domestically, WIV researchers have relatively more active cooperation with colleagues from 119 other institutions (have five or more than five joint publications). WIV has the most productive scientific partnerships with the University of Chinese Academy of Sciences (709 joint publications), Wuhan

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[14] For a full organisational chart, please see Administration, Wuhan Institute of Virology CAS, http://english.whiov.cas.cn/About_Us2016/Administration2016/, accessed 16 September 2020.

[15] Glen Owen, 'Wuhan virus lab was signed off by EU Brexit chief Michel Barnier in 2004 – despite French intelligence warnings that China's poor bio-security reputation could lead to a catastrophic leak', *The Guardian*, 23 May 2020.

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

[17] Information retrieved from Web of Science by authors.

University (358 joint publications) and Institute of Biophysics Chinese Academy of Sciences (162 joint publications). It also has very active cooperation with the Academy of Military Medical Sciences China (24 joint publications) and Second Military Medical University (eight joint publications).[18] These joint publications show HVRI's close relationship with both China's academy and military.

HVRI – China's Unlikely BSL4-Capable Avian Influenza Research Institute

4.1 Despite its location in north-eastern China, HVRI has established itself as the 'go-to' institute for various animal pathogens (known as zoonoses) that pose critical threats to livestock and/or humans. In a short period of time, HVRI has developed internationally recognised expertise in avian influenza viruses, namely, the recent H5N1 and H7N9 viruses. HVRI is officially under the supervision of the Chinese Academy of Agricultural Sciences which can directly grant doctoral degrees. HVRI established China's second official BSL4 lab in 2018.

4.2 HVRI is a large operation (covers an area of more than 69,600 square metres) and has a 1,532,900-square metre laboratory animal breeding farm in suburban Harbin. The institute is in the process of being relocated to a 271,800-square metre new site, near quadrupling the size and associated capacity of HVRI's main production site.[19]

4.3 From 1987 to 2020, HVRI produced 1,814 publications co-authored with scientists from 809 institutions across 52 countries, including China. Before 1987, there was no record. According to these publication records, the cooperation between HVRI and 50 international institutions across 12 countries were especially active (with at least five joint publications).[20]

4.4 Domestically, HVRI researchers have relatively more active cooperation with colleagues from 74 other institutions (as measured by five or more joint

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[18] Information retrieved from Web of Science by authors.

[19] For more information, please see About Us, Harbin Veterinary Research Institute – Chinese Academy of Agricultural Sciences, http://www.hvri.ac.cn/en/aboutus/athvri/index.htm, accessed 21 September 2020.

[20] Information retrieved from Web of Science by authors.

publications). HVRI has the most productive scientific partnerships with the Northeast Agricultural University China (232 joint publications), Harbin Medical University (80 joint publications) and Northeast Forestry University China (70 joint publications). It also has very active cooperation with the Academy of Military Medical Sciences China (42 joint publications), Air Force Military Medical University (seven joint publications), China Ministry of Agriculture (18 joint publications) and WIV (10 joint publications).[21] These joint institutional publications show HVRI's close relationship with both China's academy and military, as well as the domestic government.

4.5 HVRI has multiple international partnerships, including an industry partnership with leading animal health company Boehringer Ingelheim. The 'industry-academia-research' exchange platform was established in May 2019, the first of its kind in China. The partnership encompasses training (classroom and lab-based), joint research and development, and student exchanges that enable HVRI postgraduate students to conduct research within the broader Boehringer Ingelheim corporate scientific infrastructure.[22]

4.6 One of the most well-known researchers at HVRI is Dr Chen Hualen, a leading veterinary virologist who worked at the US Centres for Disease Control and Prevention from 1999 to 2002. Dr Chen's recent work focuses on avian influenza viruses and, similar to Dr Shi at the WIV, some of her experiments have generated controversy, especially those on bioengineering avian influenza viruses.[23]

4.7 One of Dr Chen's most controversial studies was published in June 2013. It demonstrates how the H5N1 avian influenza virus could develop pandemic potential by picking up entire genes from H1N1, a highly virulent human influenza virus that caused a global epidemic in 2009. By combining segments of H5N1 and H1N1

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21 Information retrieved from Web of Science by authors.

22 'Boehringer Ingelheim and Harbin Veterinary Research Institute set up 'industry-academia-research' exchange platform', Boehringer Ingelheim corporate website, 10 May 2019, https://www.boehringer-ingelheim.com/press-release/new-exchange-platform-harbin-research-institute, accessed 30 October 2020.

23 Martin Enserink, 'Single Gene Swap Helps Bird Flu Virus Switch Hosts', *Science*, 2 May 2013, https://www.sciencemag.org/news/2013/05/single-gene-swap-helps-bird-flu-virus-switch-hosts, accessed 30 October 2020.

viruses in her lab, Dr Chen developed a new hybrid virus that can transmit between mammals through the air and without direct contact. Such a synthetic virus with these properties had not been previously detected in nature.[24]

China's New Frontier – Advanced BSL3 Lab Infrastructure in Every Province

5.1 In May 2020, China's National Development and Reform Commission (NDRC) issued a plan for every Chinese province to have at least one Biosafety Level 3 (BSL3) lab. The NDRC cited the recent COVID-19 outbreak as the key driver of this new initiative.[25] For some of the more sensitive, high-risk analytical tasks and experiments, there is often an unclear line between BSL3 and BSL4 labs. For example, Dr Shi Zhengli is believed to have conducted some of her bat coronavirus bioengineering experiments in a BSL3 lab within WIV.

5.2 Prior to this new initiative, China launched in 2004 a national BSL programme that oversaw the accreditation of 42 BSL3s.[26] In addition, four mobile BSL-3 laboratories were imported from the Labover company (headquartered in Montpellier, France) for institutes in Beijing, Shanghai and Guangdong. These imported labs were intended to enable mobile nationwide surveillance of pathogens and to support emergency response operations.[27]

5.3 While this is a recently announced initiative, the rapid proliferation of BSL3 labs, if executed in line with NDRC directives, will fundamentally alter the scale, scope and structure of high-risk pathogen research in China.

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[24] Martin Enserink, 'Single Gene Swap Helps Bird Flu Virus Switch Hosts'. Please also see, Chen Hualan, et. al, 'H5N1 Hybrid Viruses Bearing 2009/H1N1 Virus Genes Transmit in Guinea Pigs by Respiratory Droplet', *Science*, Vol. 340, Issue 6139, 21 June 2013, pp. 1459-1463.

[25] 'All provinces in China are asked to set up P3 lab: ministries', *Global Times*, 20 May 2020, https://www.globaltimes.cn/content/1188916.shtml, accessed 30 October 2020.

[26] The majority of these BSL3 labs are located in key Chinese cities such as Beijing, Shanghai and Guangzhou.

[27] Yuan Zhiming, 'Current status and future challenges of high-level biosafety laboratories in China', *Journal of Biosafety and Biosecurity*, Vol. 1, Issue 2, September 2019.

5.4 The overall architecture is also unclear about whether some of these new provincial-level BSL3 labs fall under a WIV-led cluster while others will report up to HVRI, or if they will serve as standalone assets reporting to provincial-level/local clinical infrastructure. These key questions and others are presently open and will require continuous observation and analysis.

5.5 However, the current fragmentation of China's domestic high-risk pathogen research activities is increasing the likelihood that these new planned provincial BSL3 labs will 'fill' bureaucratic spaces controlled by either WIV or HVRI. If this occurs, domestic Chinese high-risk pathogen research networks would become considerably more complex and difficult to navigate, especially for those working inside the system.

Are Advanced Chinese Labs Going Down Their Own Unique Path? Near-Term Implications

6.1 While the current situation within China's domestic virology research ecosystem is dynamic and constantly evolving, available evidence suggests that China now possesses world-class expertise and knowhow. China is capable of training its own future generations of virologists onshore as opposed to having to send them to the West in large numbers as was the case with previous generations.

6.2 However, key Chinese labs at institutes such as the WIV and HVRI will likely seek to maintain strategic relationships with specific Western lab groups. This is driven by the desire to remain close to cutting edge developments outside of China, ensure that China's own ecosystem remains competitive and identify virological sub-fields where China can be a world leader.

6.3 While Chinese virologists have previously had open and free access to research and educational opportunities in key Western countries, in the United States in particular, current evidence suggests this trend is not likely to continue. The broader process of China-US decoupling across multiple areas of trade, technology, capital markets and other strategic matters is likely to also inhibit scientific matters. This will likely have the effect of driving domestic Chinese virological research down a new and unique pathway.

6.4 Virology labs with 'Chinese characteristics' could be characterised by PLA and CCP control at the management level and in other key scientific positions. Those working in BSL4 labs at WIV/HVRI and future teams in the rapidly proliferating BSL3 labs may seek to leverage all of China's recent experiences to position themselves as world leaders. These claims of expertise will apply across the full virological spectrum – from diagnostics to therapeutics to vaccines. China's first-to-market claims regarding COVID-19 vaccines is a key case in point.

6.5 The nature of the respective ecosystems of China's two BSL4-capable institutes, WIV and HVRI, was already fragmented prior to China-US decoupling. The CCP and PLA may begin to exert greater control of their activities, thereby taking Chinese virological research down an unprecedented pathway. This could also involve nominally civilian labs being treated as strategic national assets as opposed to purely public health/clinical assets, a move that may extend to China's rapidly proliferating BSL3 lab infrastructure across all provinces.

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