I. The unfolding Covid-19 pandemic

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Milestones of the pandemic in 2020

On 31 December 2019, the Country Office of the World Health Organization (WHO) in China picked up a media statement on the Wuhan Municipal Health Commission website reporting cases of 'viral pneumonia' in Wuhan. The Country Office notified the International Health Regulations (IHR) focal point in the WHO Western Pacific Regional Office about the media statement. On the same day, the WHO's Epidemic Intelligence from Open Sources (EIOS) platform also picked up a media report on ProMED (a programme of the International Society for Infectious Diseases) about the same cluster of cases in Wuhan. Several health authorities from around the world contacted the WHO seeking additional information. The following day, the WHO requested information on the reported cluster of atypical pneumonia cases from the Chinese authorities. On 2 January 2020, the WHO representative in China wrote to the National Health Commission of China, offering WHO support and repeating the request for further information on the cluster of cases. The WHO also informed its sister United Nations agencies, international organizations, major public health agencies and laboratories, which are all part of its Global Outbreak Alert and Response Network (GOARN), about the atypical pneumonia cases.[1]

On 3 January 2020, Chinese officials confirmed to the WHO that a cluster of cases of 'viral pneumonia of unknown cause' had been identified in Wuhan. The WHO notified its member states about the cluster through the IHR Event Information System and advised them to take precautions to reduce the risk of acute respiratory infections. The WHO issued a web-based Disease Outbreak News report on 5 January 2020 to notify the scientific and public health communities, as well as global media. The report contained information about the number of cases and their clinical status; details about the Wuhan national authority's response measures; and the WHO's risk assessment and advice on public health measures.[2]

On 9 January 2020, the WHO reported that the Chinese authorities had determined the outbreak was caused by a novel coronavirus, and, two days later, the WHO received the genetic sequences of the new virus from the Chinese authorities.[3] The first death from the novel coronavirus was

[1] World Health Organization (WHO), 'Listings of WHO's response to Covid-19', News, 29 June 2020, entries 31 Dec. 2019, 1 Jan. 2020 and 2 Jan. 2020.

[2] WHO (note 1), entries 3, 4 and 5 Jan. 2020.

[3] WHO, 'WHO statement regarding cluster of pneumonia cases in Wuhan, China', News, 9 Jan. 2020; and WHO (@WHO), Twitter, 11 Jan. 2020, <https://twitter.com/WHO/status/1216108498188230657>.

reported on 11 January 2020 by Chinese media. The first recorded case of lab-confirmed novel coronavirus from Wuhan outside of China was reported by the Ministry of Public Health in Thailand on 13 January 2020.[4] Human-to-human transmission had initially been denied by Chinese officials, but on 19 January 2020 the WHO Western Pacific Regional Office tweeted that, according to the latest information received and WHO analysis, there was evidence of limited human-to-human transmission.[5]

On 20–21 January 2020, the WHO conducted its first mission to Wuhan. The team met with officials to learn about the public health response to the novel coronavirus cases and visited sites like the Wuhan Tianhe Airport and the Hubei provincial Center for Disease Control in Wuhan (Wuhan CDC). The team concluded that the evidence suggested human-to-human transmission in Wuhan, but that more investigation was needed to understand the full extent of transmission.[6] Chinese authorities placed Wuhan under quarantine on 23 January 2020 and started construction on two new hospitals.[7]

Shortly after, the WHO director-general convened an IHR Emergency Committee comprising 15 independent experts from around the world. The committee was charged with advising the director-general on whether the outbreak constituted a public health emergency of international concern (PHEIC), the WHO's highest level of alarm. When the committee met, on 22 January 2020, it was unable to reach a unanimous conclusion. Several members considered there was simply not enough information available to decide whether the outbreak constituted a PHEIC. The director-general asked the committee to continue its deliberations the next day but it remained equally divided on 23 January 2020, and recommended reconvening within 10 days.[8]

On 27–28 January 2020, a senior WHO delegation led by the director-general arrived in Beijing to meet Chinese leaders, including President Xi Jinping, to learn more about the response in China and to offer technical assistance. The director-general and the Chinese president agreed that an international team of leading scientists should travel to China to better understand the context and the overall response, as well as to exchange information and experiences.[9]

[4] WHO, 'WHO statement on novel coronavirus in Thailand', News, 13 Jan. 2020.

[5] WHO Western Pacific Regional Office (@WHOWPRO), Twitter, 19 Jan. 2020, <https://twitter.com/WHOWPRO/status/1218741294291308545>.

[6] WHO, 'Mission summary: WHO field visit to Wuhan, China 20–21 Jan. 2020', News, 22 Jan. 2020.

[7] Chinese National Health Commission, 'Wuhan pulls through the worst, with a tough lockdown', Media release, 24 Mar. 2020; and 'Coronavirus: The hospital built in a matter of days', BBC News, 2 Feb. 2020.

[8] WHO (note 1), entry 22–23 Jan. 2020.

[9] WHO (note 1), entry 27–28 Jan. 2020.

On 30 January 2020, the director-general reconvened the IHR Emergency Committee, which advised the director-general that the outbreak now met the criteria for a PHEIC. The director-general accepted the committee's advice and declared the novel coronavirus outbreak a PHEIC.[10] At that time, there were 98 recorded cases in 18 countries outside China, but no recorded deaths. Four countries (Germany, Japan, the United States and Viet Nam) had evidence (eight cases) of human-to-human transmission outside China.[11]

As the recorded death toll in China surpassed that of the 2002–2003 epidemic of severe acute respiratory syndrome (SARS), and the infections spread to 24 countries, the WHO received final sign-off from China on 9 February 2020 for a WHO–China Joint Mission, and deployed an advance team. The team completed five days of preparation, working with China's National Health Commission, the Chinese Center for Disease Control and Prevention, local partners and related entities, and the WHO China Country Office.[12]

The disease is named Covid-19

The WHO announced on 11 February 2020 that the disease caused by the novel coronavirus would be named coronavirus disease 2019 (Covid-19).[13] The name of the disease was chosen to avoid inaccuracy and stigma, and therefore did not refer to a geographical location, an animal, an individual or a group of people, in accordance with best practice. On the same day, the International Committee on Taxonomy of Viruses announced the name of the new virus to be 'severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)' to reflect its close genetic relationship to the coronavirus responsible for the SARS outbreak of 2002–2003.[14]

Highlighting the unprecedented prevalence of information—including misinformation and disinformation—surrounding the unfolding pandemic, at the Munich Security Conference on 15 February 2020 the WHO director-general declared: 'We're not just fighting an epidemic; we're fighting an infodemic.'[15] In response the WHO launched a new information platform called WHO Information Network for Epidemics (EPI-WIN), which uses an 'amplification network' to share tailored information with specific target groups.[16]

[10] Ghebreyesus, T. A., 'WHO director-general's statement on IHR emergency committee on novel coronavirus', Speech, 30 Jan. 2020.

[11] WHO (note 1), entry 30 Jan. 2020.

[12] WHO (note 1), entry 9 Feb. 2020.

[13] WHO (@WHO), Twitter, 11 Feb. 2020, <https://twitter.com/WHO/status/1227248333871173632>.

[14] WHO, 'Naming the coronavirus disease (Covid-19) and the virus that causes it', WHO Technical Guidance, [n.d.].

[15] WHO Director-General, Speech to the Munich Security Conference, 15 Feb. 2020.

[16] WHO, 'About EPI-WIN', [n.d.].

Teams from the WHO–China Joint Mission initiated on 16 February 2020 completed field visits to Beijing, Guangdong, Sichuan and Wuhan to assess the seriousness of the new disease, its transmission dynamics, and the nature and impact of China's control measures.[17]

On 7 March 2020, the number of confirmed Covid-19 cases surpassed 100 000 globally.[18] On 8 March 2020, Italy placed its 60 million citizens on lockdown. Many more countries followed suit. In April 2020, more than half of the world's population resided in countries enforcing a lockdown, resulting in hugely disruptive impacts on individuals, businesses and entire sectors of society.[19]

The international response: Dealing with a pandemic and an infodemic

On 11 March 2020, the WHO characterized the Covid-19 outbreak as a pandemic.[20] By that time the epicentre of the pandemic was Europe, which had more reported cases and deaths 'than the rest of the world combined, apart from China'.[21] On 13 March 2020, the WHO, the UN Foundation and partners launched the Covid-19 Solidarity Response Fund, raising more than US$70 million in 10 days to assist health workers on the pandemic's frontlines, treat patients, and advance research for treatments and vaccines.[22]

On 23 March 2020, the UN secretary-general appealed for an immediate global ceasefire, in an attempt to reduce the effect of conflict on the pandemic.[23] His call was supported by over 100 governments, as well as regional organizations, leaders, civil society groups and some armed groups.[24]

The UN Global Humanitarian Response Plan was launched on 25 March 2020 by the WHO director-general, the UN secretary-general, the UN under-secretary-general for humanitarian affairs and the executive director of the United Nations International Children's Emergency Fund (UNICEF).[25] By 4 April 2020, over 1 million cases of Covid-19 had been confirmed worldwide, a more than tenfold increase in less than a month.[26] The WHO soon after

[17] WHO–China Joint Mission, *Report of the WHO–China Joint Mission on Coronavirus Disease 2019 (Covid-19)* (WHO: Geneva, 16–24 Feb. 2020).

[18] WHO, 'WHO statement on cases of Covid-19 surpassing 100 000', News, 7 Mar. 2020.

[19] Committee for the Coordination of Statistical Activities (CCSA), *How Covid-19 Is Changing the World: A Statistical Perspective* (CCSA: 13 May 2020).

[20] WHO Director-General, 'WHO director-general's opening remarks at the media briefing on Covid-19', Speech, 11 Mar. 2020.

[21] WHO Director-General, 'WHO director-general's opening remarks at the media briefing on Covid-19', Speech, 13 Mar. 2020.

[22] WHO, 'Covid-19 solidarity response fund', [n.d.].

[23] UN Secretary-General, 'Secretary-general's appeal for global ceasefire', Statement, 23 Mar. 2020.

[24] On the call for a global ceasefire see chapter 2, section I, in this volume.

[25] United Nations, Office for the Coordination of Humanitarian Affairs (OCHA), *Global Humanitarian Response Plan: Covid-19* (OCHA: Geneva, 28 Mar. 2020).

[26] WHO, 'Coronavirus disease 2019 (Covid-19)', Situation Report no. 75, 4 Apr. 2020.

convened an ad hoc technical consultation on managing the Covid-19 infodemic, with over 1300 field experts participating in the online webinars held on 7–8 April.[27]

The 73rd World Health Assembly, the first ever to be held virtually, took place on 18–19 May 2020. It generated significant attention, with 14 heads of state participating in the opening and closing sessions. The meeting adopted by consensus a landmark resolution—co-sponsored by more than 130 countries, the largest number on record—to fight the pandemic.[28] Among other actions, the resolution requested the WHO director-general, working with other organizations and countries, 'to identify the zoonotic source of the virus and the route of introduction to the human population'.[29] By the end of June 2020, over 10 million confirmed Covid-19 cases, including over 500 000 deaths, had been reported to the WHO.[30]

On 30 June to 16 July, the WHO hosted its first infodemiology conference, with four objectives: understanding the multidisciplinary nature of infodemic management; identifying current examples and tools to understand, measure and control infodemics; building a public health research agenda to direct focus and investment; and establishing a community of practice and research.[31]

At a side event of the 75th UN General Assembly, held virtually from 15 September to 2 October 2020, the WHO emphasized the need for mitigating the impact of Covid-19 on future generations, stopping the spread of harmful misinformation, and better emergency preparedness.[32] The WHO, the UN, UNICEF, the UN Development Programme, the UN Educational, Scientific and Cultural Organization (UNESCO) and others issued a joint statement on 23 September 2020 that highlighted the Covid-19 infodemic and the need to promote healthy behaviours and mitigate harm from misinformation and disinformation.[33]

By the end of September 2020, global deaths reported to the WHO had passed 1 million.[34]

[27] WHO, 'WHO ad-hoc online consultation on managing the Covid-19 infodemic', [n.d.]; and WHO, *Managing the Covid-19 Infodemic: Call for Action* (WHO: Geneva, 15 Sep. 2020).

[28] WHO, 'Historic health assembly ends with global commitment to Covid-19 response', News, 19 May 2020; and 73rd World Health Assembly, 'Covid-19 response', WHA73.1, 19 May 2020.

[29] 73rd World Health Assembly (note 28), para. 9(6).

[30] WHO, 'WHO coronavirus disease (Covid-19) dashboard', [n.d.].

[31] WHO, '1st WHO infodemiology conference', [n.d.].

[32] WHO, 'UNGA virtual high-level side event on mitigating the impact of Covid-19', News, 23 Sep. 2020; WHO, 'Covid-19 pandemic: Countries urged to take stronger action to stop spread of harmful information', News, 23 Sep. 2020; and WHO, 'The best time to prevent the next pandemic is now: Countries join voices for better emergency preparedness', News, 1 Oct. 2020.

[33] WHO et al., 'Managing the Covid-19 infodemic: Promoting healthy behaviours and mitigating the harm from misinformation and disinformation', Joint Statement, 23 Sep. 2020.

[34] WHO (note 30).

Development of a vaccine for Covid-19 began early in 2020, and by the second half of the year, several vaccines were in different stages of clinical trials. By year's end, several countries had started inoculation programmes including Canada, China, Israel, Russia, the United Kingdom, the USA and several European countries.

The worst global crisis since World War II

Health and mortality impacts

By the end of 2020, the WHO had received reports of over 82 million cases of Covid-19 worldwide, with the actual number of infections likely to be considerably higher from undiagnosed cases and generally poor Covid-19-related data. As of 31 December 2020, there were over 35 million reported cases in the Americas, over 27 million in Europe, nearly 12 million in South East Asia, nearly 5 million in the Eastern Mediterranean, nearly 2 million in Africa, and just over 1 million in the Western Pacific. The five countries with the highest cumulative number of cases were, in descending order, the USA, India, Brazil, France and the UK.[35]

As of 31 December 2020, Covid-19 had caused over 1.8 million recorded deaths, with many hundreds of thousands likely to have gone unrecorded. Deaths reported in the Americas numbered over 855 000, in Europe over 579 000, in South East Asia over 183 000, in the Eastern Mediterranean over 120 000, in Africa over 42 000 and in the Western Pacific over 20 000. The five countries with the highest cumulative number of deaths were, again in descending order, the USA, Brazil, India, Mexico and Italy.[36] In the USA, by April 2020 the number of recorded deaths had already outstripped the number of names on the Vietnam War Memorial in Washington, DC.[37] By December, the average daily number of Americans dying of Covid-19 was 2379—comparable to the 2403 who died in Pearl Harbor on 7 December 1941 and the 2977 who died in the terrorist attacks on 11 September 2001.[38]

The impact of Covid-19 goes beyond its high fatality rates: many survivors of the disease have continued to suffer significant health consequences. These lasting health effects, referred to as 'long Covid', are so far poorly understood.[39]

[35] WHO (note 30).
[36] WHO (note 30).
[37] 'The origin of Covid-19: The pieces of the puzzle of Covid-19's origin are coming to light', *The Economist*, 29 Apr. 2020.
[38] Yong, E., 'Where year two of the pandemic will take us', *The Atlantic*, 29 Dec. 2020.
[39] Yong, E., 'Covid-19 can last for several months', *The Atlantic*, 4 June 2020.

Political, social and economic impacts

The pandemic's global socio-economic impacts are at levels unprecedented since the World War II. World economic output was at least 7 per cent lower than it would otherwise have been—the biggest slump since the 1940s.[40] At least 225 million full-time jobs disappeared worldwide because of the pandemic, losses not only significantly worse than those of the global financial crisis in 2009 but also worse than those of the great depression of the 1930s.[41] Among industries, aviation and tourism have been the biggest losers with border closures and quarantine restricting travel. But there were also economic winners. The combined wealth of the world's 10 richest people grew by 57 per cent, to $1.14 trillion, and the MSCI index of world stock markets rose by 11 per cent.[42] The pandemic also exposed and exacerbated long-standing economic, racial and gender divides.[43] Many of these socio-economic effects are highly likely to generate further health effects beyond the direct impacts of Covid-19.

The Covid-19 pandemic also saw unparalleled policies introduced all over the globe of 'locking down' cities and even entire countries, curtailing freedom of movement for millions of people. Technologies combining computing power, algorithms and biological data were used to monitor individuals and control populations at unmatched scales and levels of invasiveness.[44] Technologies adopted by several countries included surveillance cameras with facial recognition to track quarantine evaders or to gauge elevated temperatures of potentially infected individuals in crowds; fine-grained location data transmitted from mobile phones to determine the numbers and identities of people obeying lockdown orders; algorithms to monitor social media posts for signs of disease spread; and contact-tracing apps that centrally stored user interactions to provide 'social graphs' of individuals. A key question in the post Covid-19 world will be whether governments de-escalate their powers of personalized surveillance or keep them in place for 'public protection'.

[40] 'The year when everything changed', *The Economist*, 19 Dec. 2020.

[41] International Labour Organization (ILO), ILO Monitor: COVID-19 and the World of Work, Briefing notes, 7th ed. (ILO: Geneva, 25 Jan. 2021), p. 20.

[42] Oxfam International, 'Mega-rich recoup Covid-losses in record-time yet billions will live in poverty for at least a decade', Press release, 25 Jan. 2021; and *The Economist* (note 40).

[43] See e.g. *The Economist* (note 40); Oxfam International, *The Inequality Virus: Bringing Together a World Torn Apart by Coronavirus through a Fair, Just and Sustainable Economy*, Oxfam Briefing Paper (Oxfam GB: Oxford, Jan. 2021); and UN Women, 'The shadow pandemic: Violence against women during Covid-19', [n.d.].

[44] See e.g. Lentzos, F., 'How to protect the world from ultra-targeted biological weapons', *Bulletin of the Atomic Scientists*, 7 Dec. 2020; Xinmei, S., 'Neighborhood sends drone to check people's temperature at their windows', China Tech City, 14 Feb. 2020; Rahim, A. A., 'AR smart glasses can help mitigate Covid-19 resurgence in China', Techwire Asia, 1 Apr. 2020; and Mozus, P., Zhong, R. and Krolik, A., 'In coronavirus fight, China gives citizens a color code, with red flags', *New York Times*, 1 Mar. 2020.

Theories on the origins of SARS-CoV-2

One of the critical questions of the pandemic is where the novel coronavirus came from. Identifying the source of SARS-CoV-2 is essential for ensuring it is not reintroduced to the human population and for reducing the risk of other new virus introductions in the future. However, what should have been a routine science question has instead become politically charged.[45]

The 'natural spillover' theory

At the time of writing very little was known about how, where and when SARS-CoV-2 started circulating in Wuhan. Some evidence can be found in the genetic makeup of the virus, which indicates that it is closely related to coronaviruses isolated from bat populations.[46] However, because there is usually very limited close contact between humans and bats to enable direct transmission, the leading scientific theory was that transmission happened through an intermediate animal host, such as a domestic animal, a wild animal or a domesticated wild animal. As at the end of 2020, however, this host had not been identified.

There is precedent for 'spillover' through intermediate hosts. The first known coronavirus to have caused serious illness in humans, SARS-CoV, likely also had its ecological reservoir in bats, jumping from bats to civet cats (a farmed wild animal), and from there to humans, where it started spreading. The virus caused the SARS outbreak in 2002–2003 and killed over 800 people around the world before it was brought under control.[47] Emerging in 2012, Middle Eastern respiratory syndrome (MERS) was found to be caused by a coronavirus (MERS-CoV) that spread from bats into camels and then humans.[48] By the end of 2020 MERS-CoV had killed over 880 people; it has not yet been eliminated and regularly passes from camels to humans, making it harder to eradicate, but it only spreads in conditions of close proximity, which makes it more manageable.[49]

One of the early theories for SARS-CoV-2 was that pangolins could have served as the intermediate host for the virus. Later susceptibility studies with SARS-CoV-2 showed that domestic cats, ferrets, hamsters and minks are particularly susceptible to infection, and that any one of these could have served as intermediate hosts—or that they could establish reservoirs

[45] Huang, Y., 'How the origins of Covid-19 became politicized', Think Global Health, 14 Aug. 2020.

[46] Calisher, C. et al., 'Statement in support of the scientists, public health professionals, and medical professionals of China combatting Covid-19', *The Lancet*, vol. 395, no. 10226, E42–E43 (7 Mar. 2020); and Andersen, K. G. et al., 'The proximal origin of SARS-CoV-2', *Nature Medicine*, vol. 26 (2020).

[47] WHO, 'Severe acute respiratory syndrome', [n.d.]; and WHO, 'WHO cumulative number of reported cases of SARS', [n.d.].

[48] WHO, 'Middle East respiratory syndrome coronavirus (MERS-CoV)', [n.d.].

[49] WHO, 'MERS situation update, December 2020', Dec. 2020.

for the virus and provide new sources for 'spillover' events into the human population. No source reservoir had been positively identified by the end of 2020, and there was no evidence to demonstrate the possible route of transmission from a bat reservoir to humans through one or several intermediary animals.[50]

The published genetic sequences of SARS-CoV-2 isolated from early human cases are very similar, suggesting that the start of the outbreak resulted from a single point of introduction in the human population around the time that the virus was first reported in humans in Wuhan.[51] In other words, the evidence suggests the virus jumped from an intermediate species (or, less likely, directly from a bat) only once.

The genetic sequences also indicate that SARS-CoV-2 is genetically stable and already well adapted to human cell receptors, which enables it to invade human cells and easily infect people. Researchers have found that the virus resembles SARS-CoV in the late phase of the 2003 epidemic after SARS-CoV had developed several advantageous adaptations for human transmission.[52] That the virus was already pre-adapted to human transmission was considered 'surprising', particularly since no precursors or intermediate evolutionary versions stemming from a less human-adapted SARS-CoV-2-like virus had been detected.[53] The findings, which were noted in the terms of reference for a joint WHO–China 'global study on the origins of SARS-CoV-2' (described below), suggest the virus could have circulated undetected in people for months while accumulating adaptive mutations.[54] Available evidence suggests this is unlikely, however, leaving only two other possible explanations: that the virus was already highly adept at human transmission while in bats or another animal, or that it had become adapted in human cells or humanized animals—that is, research animals carrying functioning human genes, cells, tissues or organs—in a laboratory.[55]

Epidemiological research on the initial cases of Covid-19 reported in late December 2019 and early January 2020 also provides clues to the origins of the virus. Early work indicated that a large proportion (28/41) of the cases had a direct link to the Huanan Wholesale Seafood Market in Wuhan—a large market with 653 stalls and more than 1180 employees where mainly seafood, but also fresh fruits and vegetables, meat and live animals (farmed,

[50] World Organisation for Animal Health (OIE), 'Questions and answers on Covid-19', Updated 22 Jan. 2021.

[51] WHO, 'Origins of SARS-CoV-2', 26 Mar. 2020.

[52] Zhan, S. H., Deverman, B. E. and Chan, Y. A., 'SARS-CoV-2 is well adapted for humans: What does this mean for re-emergence?' (Pre-print article), bioRxiv, 2 May 2020.

[53] Zhan et al. (note 52), p. 9.

[54] WHO, 'WHO-convened global study of the origins of SARS-CoV-2: Terms of references for the China part', 5 Nov. 2020, p. 3.

[55] Ridley, M. and Chan, A., 'Did the Covid-19 virus really escape from a Wuhan lab?', Matt Ridley Blog, 7 Feb. 2021.

wild and domestic) were sold.[56] Many of the initial patients were either stall owners, market employees or regular visitors to the market. Out of 842 environmental samples taken after the market was closed down on 1 January 2020, 69 (8 per cent) tested positive for SARS-CoV-2. Of those, 61 (88 per cent) were from the western wing of the market, with 22 samples from eight different drains and sewage systems. The virus samples collected at the market were 'virtually identical' to the patient samples collected at the same time.[57] However, none of the 336 animal samples collected from the market was positive for SARS-CoV-2. The data suggests either an animal source in the market or an infected human could have introduced the virus to the market, and the virus may then have been amplified in the market environment.[58]

A significant number (13/41, or 32 per cent) of the first cases, however, had no contact whatsoever with the market, including the first recorded person to present with the disease, indicating there might be another, unidentified, source of the outbreak.[59] Reviews by China of possible earlier cases confirmed there were 124 cases presented in December 2019, including 119 from Wuhan and 5 from Hubei or other provinces who had 'travel links to Wuhan during the period of exposure'.[60] That means it is likely these early cases were exposed through contact with other undetected cases as early as November 2019 (incubation time from exposure to symptom onset being up to 14 days). It also seems likely there were early infections which were not serious and which did not reach hospitals, before the first official cases were seen in Wuhan in December. Epidemiological studies into early, unrecognized infections were ongoing at the end of December 2020.

The research-related accident theory

A competing (if still marginal) origin theory to the 'natural spillover' theory is that the source of the initial outbreak could be related to safety lapses in the course of scientific research with coronaviruses. There was, as of December 2020, no solid evidence for this, but the genetic and epidemiological evidence collected so far did not exclude the possibility.

At least two institutions in Wuhan work on coronaviruses: the Wuhan CDC and the Wuhan Institute of Virology (WIV). The WIV houses several laboratory complexes, including the National Biosafety Laboratory, the first biosafety level four (BSL-4) laboratory in mainland China. Conceived following the 2002–2003 SARS outbreak, the laboratory was physically

[56] Huang, C. et al., 'Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China', *The Lancet*, vol. 395, no. 10223, E28–E32 (15 Feb. 2020); and WHO (note 54), p. 5.
[57] WHO (note 54), p. 5.
[58] WHO (note 54), pp. 5–6.
[59] Huang et al. (note 56).
[60] WHO (note 54), p. 5.

completed in 2015, in collaboration with the Centre International de Recherche en Infectiologie (CIRI) in France, and became operational in early 2018. The WIV has become a leading authority on bat coronaviruses, having established one of the largest strain collections, including a database of more than 20 000 pathogen samples from wild animals across China.[61] Because most coronaviruses are harmless, and the ones that infect humans generally only cause a cold, they have been classified as relatively low risk, to be studied at biosafety level two (BSL-2) laboratories. Problems arise when new, dangerous coronaviruses unexpectedly appear, as BSL-2 containment only provides minimal protection for workers and the environment. While coronaviruses were studied at BSL-2 at the Wuhan CDC, they were also studied at higher containment levels at the WIV. This work involved high-risk 'gain-of-function' work, where viruses are forced to evolve artificially, and the engineering of chimeric viruses, which contain genetic mixtures of two or more different viruses.[62] Sometimes this work can result in new viruses that are even more dangerous than the parent viruses. For example, this is what happened in 2015 when a team of USA- and WIV-based researchers combined a coronavirus circulating in Chinese horseshoe bats with SARS-CoV.[63]

Research facilities where dangerous viruses and bacteria are stored and studied are designed to protect researchers, the public and the environment from harm. But laboratory design cannot always overcome human error or poor training. With each experiment comes opportunities for accidental exposures and subsequent infections. Incidents of varying severity happen all the time in laboratories around the world.[64] There have already been several documented cases of safety lapses in the course of work specifically with coronaviruses.[65]

At the time of writing there was still no evidence demonstrating a fully natural origin of SARS-CoV-2. Natural spillover, largely based on patterns of previous zoonosis events, was only one of a number of possible origin theories, alongside the research-related accident theory.

Chinese attempts to control the origins narrative

The Chinese Government made significant attempts throughout 2020 to control the pandemic origins narrative, including efforts to stifle the

[61] Fan, Y. et al., 'Bat coronaviruses in China', *Viruses*, vol. 11, no. 3 (2019).

[62] National Institutes of Health, Research Portfolio Online Reporting Tool (RePORT), 'Understanding the risk of bat coronavirus emergence', Project Information no. 2R01AI110964-06.

[63] Menachery, V. D. et al., 'A SARS-like cluster of circulating bat coronaviruses shows potential for human emergence', *Nature Medicine*, vol. 21 (9 Nov. 2015).

[64] Furmanski, M., 'Threatened pandemics and laboratory escapes: Self-fulfilling prophecies', *Bulletin of the Atomic Scientists*, 31 Mar. 2013; and Klotz, L., 'Human error in high-biocontainment labs: A likely pandemic threat', *Bulletin of the Atomic Scientists*, 25 Feb. 2019.

[65] Klotz (note 64).

research-related accident theory by diverting attention from scientific research as a possible source of the pandemic.[66] The Chinese Government ordered genomics companies doing some of the early testing of Covid-19 cases to stop releasing their test results and to destroy their samples of the virus.[67] Doctors, investigative journalists and scientists were silenced.[68] The government also placed severe restrictions on the publication of pandemic origins research.[69] Documents were taken down from websites, including from the websites of the WIV and the Wuhan CDC.[70] The WIV's virus database was taken offline at the beginning of 2020 for 'security reasons'.[71] In their publications, scientists at the WIV renamed viruses with sequences closely resembling SARS-CoV-2 in an apparent attempt to obfuscate their previous work with these viruses before the pandemic.[72] The WIV's first Covid-19 papers also failed to mention a significant feature of SARS-CoV-2 (a 'furin cleavage site') that makes the virus more capable of infecting tissues in the human body.[73] The lack of transparency about the WIV's research and the inconsistencies in the information released raised unfortunate but inevitable doubts about the credibility of any Chinese-led origins investigation.

Studies into the origins of SARS-CoV-2

The WHO's first novel coronavirus press conference on 14 January 2020 highlighted the importance of finding the animal source of SARS-CoV-2.[74] The first IHR Emergency Committee of independent scientific experts advising the WHO director-general on the pandemic recommended convening an international multidisciplinary mission, including national experts, to 'review and support efforts to investigate the animal source

[66] 'China Covid-19: How state media and censorship took on coronavirus', BBC News, 29 Dec. 2020; and McMullen, J., 'Covid-19: Five days that shaped the outbreak', BBC News, 26 Jan. 2021.

[67] Yu, G. et al., 'How early signs of the coronavirus were spotted, spread and throttled in China', *Straits Times*, 28 Feb. 2020.

[68] Buckley, C. et al., '25 days that changed the world: How Covid-19 slipped China's grasp', *New York Times*, 30 Dec. 2020.

[69] Gan, N., Hu, C. and Watson, I., 'Beijing tightens grip over coronavirus research, amid US–China row on virus origin', CNN, 16 Apr. 2020.

[70] Kang, D., Cheng, M. and McNeil, S., 'China clamps down in hidden hunt for coronavirus origins', AP News, 30 Dec. 2020.

[71] Sudworth, J., 'COVID: Wuhan scientist would "welcome" visit probing lab leak theory', BBC News, 21 Dec. 2020.

[72] Zhou, P. et al., 'A pneumonia outbreak associated with a new coronavirus of probable bat origin', *Nature*, vol. 579, no. 7798 (12 Mar. 2020). An addendum to the paper published online on 17 Nov. 2020 acknowledges the renaming, and links the WIV's pre-Covid-19 research to viruses with genetic sequences closely resembling SARS-CoV-2. Zhou, P. et al., 'Addendum: A pneumonia outbreak associated with a new coronavirus of probable bat origin', *Nature*, vol. 588, no. 7836 (3 Dec. 2020).

[73] Ridley and Chan (note 55).

[74] WHO, 'Novel coronavirus: Thailand (ex-China)', Disease Outbreak News, 14 Jan. 2020.

of the outbreak'.[75] The WHO director-general directly raised the matter of identifying the virus origins and intermediate hosts with President Xi Jinping during his visit to China in January 2020.[76]

While not its main focus, considering the source of SARS-CoV-2 formed part of the WHO–China Joint Mission in February 2020. Led by a senior adviser to the WHO director-general and the chief expert of the Chinese National Health Commission, the mission team comprised 25 experts from the WHO, China, Germany, Japan, Republic of Korea, Nigeria, Russia, Singapore and the USA.[77] Over nine days beginning on 16 February, the mission team consulted provincial governors, municipal mayors, senior scientists, public health workers and others. They visited hospitals, disease control agencies, transport hubs and emergency supply warehouses in Bejing, Guangdong and Sichuan. They also visited a wet market, though not the one in Wuhan that had been identified as the possible spillover site. Only select team members travelled to Wuhan, where they visited a hospital and a mobile cabin hospital. The mission report concluded that the novel coronavirus was a zoonotic virus, that bats appeared to be the virus reservoir, and that no intermediate hosts had yet been identified.[78] One of the report's recommendations was that 'additional effort should be made to find the animal source, including the natural reservoir and any intermediate amplification host, to prevent any new epidemic foci or resurgence of similar epidemics'.[79] To that end, and in line with the prevailing theory that the spillover event happened at a wet market, the mission report highlighted activities already underway by Chinese authorities to investigate the pandemic's origins. These involved taking environmental samples from the Huanan Wholesale Seafood Market in Wuhan and obtaining records about the wildlife species sold at the market, as well as examining early Covid-19 cases in Wuhan.[80]

The joint mission's call for greater efforts to examine the pandemic's origins was later echoed by the IHR Emergency Committee on the pandemic. Ahead of the annual May meeting of the World Health Assembly, the group advised the WHO to 'work with the World Organisation for Animal Health (OIE), the Food and Agriculture Organization of the United Nations (FAO), and countries to identify the zoonotic source of the virus and the route of introduction to the human population, including the possible

[75] WHO, 'Statement on the first meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of novel coronavirus (2019-nCoV)', News, 23 Jan. 2020.

[76] WHO, 'How WHO is working to track down the animal reservoir of the SARS-CoV-2 virus', News, 6 Nov. 2020.

[77] Mallapaty, S., 'The scientists investigating the pandemic's origins', *Nature*, vol. 588, no. 7837 (10 Dec. 2020).

[78] WHO–China Joint Mission (note 17), p. 8.

[79] WHO–China Joint Mission (note 17), p. 39.

[80] WHO–China Joint Mission (note 17), p. 8.

role of intermediate hosts'.[81] In the days before the World Health Assembly meeting, the European Union (EU), Australia and others also called for an international investigation into the origins of the pandemic.[82]

At the opening of the virtual meeting of the 73rd World Health Assembly on 18–19 May 2020, President Xi Jinping, who had previously strongly opposed an international investigation, seemed to reverse his stance and support an international review—albeit a review on his own terms.[83] The World Health Assembly's resolution on the Covid-19 response echoed the IHR Emergency Committee's request to the WHO director-general 'to continue to work closely' with the OIE, the FAO and states on identifying the virus's zoonotic source and path of transmission to humans, 'as part of the One-Health Approach', 'including through efforts such as scientific and collaborative field missions'.[84]

Based on the request, the WHO and China began work to initiate 'a series of studies that will contribute to origin tracing work'.[85] In July, WHO experts travelled to China to define the role of the international investigative team, which was to explore the potential sources of infection among the first reported cases in Wuhan in December 2019, to attempt to identify earlier human cases through sero-epidemiologic studies, and to conduct further animal and environmental studies.[86] The investigative team, agreed by both the WHO and China, was formed in September, but only made public on 20 November 2020. The team included a broad range of expertise with experts from Australia, Denmark, Germany, Japan, the Netherlands, Qatar, Russia, the UK, the USA and Viet Nam, and also included five WHO experts and two OIE representatives—alongside an equal number of scientists (17) from China.[87] Two FAO representatives participated as observers. The first virtual meeting of the international experts with their Chinese counterparts was held on 30 October 2020, and the terms of reference for the Global Study of the Origins of SARS-CoV-2 was published on 5 November 2020.[88]

Adopting a two-phased approach, the joint study aimed in the first instance to explore how the circulation of SARS-CoV-2 might have started, and to gather evidence from the cluster of cases identified in December 2019 for potential links and clues as to its origin. The first phase, scheduled

[81] WHO, 'Statement on the third meeting of the International Health Regulations (2005) Emergency Committee regarding the outbreak of coronavirus disease (Covid-19)', News, 1 May 2020.
[82] Lentzos, F., 'Will the WHO call for an international investigation into the coronavirus's origins?', *Bulletin of the Atomic Scientists*, 18 May 2020.
[83] Niquet, V., 'Decoding Xi Jingping's speech at the World Health Assembly', The Diplomat, 19 May 2020.
[84] 73rd World Health Assembly (note 28), para. 9(6).
[85] WHO (note 54), p. 2.
[86] WHO (note 76).
[87] WHO, 'Origins of the SARS-CoV-2 virus', updated 18 Jan. 2021.
[88] WHO (note 76); and WHO (note 54).

for early 2021, will carry out in-depth reviews of hospital records for cases compatible with Covid-19 before December 2019; review surveillance trends for disease in the months preceding the outbreak; review death registers for specific causes of death compatible with Covid-19; conduct in-depth interviews and reviews of currently identified earlier cases and potentially earlier cases identified during the mission; and undertake serological studies on stored blood/serum samples collected in the weeks and months before December 2019. The results of the first phase will inform a second phase of detailed, longer-term studies, which may include in-depth epidemiologic, virologic, serologic assessments in humans in specific geographic areas or specific settings; and similar studies among animal populations before and after the outbreak in targeted geographic areas. The second phase 'could be conducted elsewhere in China, in neighbouring countries and globally'.[89]

Covid-19 implications for the global biosecurity architecture

The Covid-19 pandemic, and its public and socio-economic impacts, throws into sharp relief a problem faced by all governments: how to successfully predict and prepare for biosecurity-related threats to citizens and to national and international security. The biological threat spectrum is complex and evolving. It includes natural disease outbreaks; the 'slow burn' risk of antimicrobial resistance; the unintended consequences of laboratory accidents; the intentional use of disease as a weapon; and now also, arguably, biological information warfare.

Risks of natural and unintended outbreaks

This pandemic has demonstrated the deep and wide impacts, and the significant national security risks, of pandemics generally and more specifically those involving a novel pathogen like SARS-CoV-2. It has particularly highlighted the need for better national biopreparedness, including (*a*) national strategic leadership on biosecurity efforts; (*b*) annual reporting on the status of national preparations by government and regular scrutiny by parliamentary committees; (*c*) ring-fenced, multi-year funding to support horizon-scanning and stronger preparations for major disruptive events (including biological emergencies); (*d*) increased capabilities to scale up testing, border detection checks, isolation, contact-tracing and hospital care; (*e*) inclusive and regular drills and table-top exercises to test biosecurity response capabilities; and (*f*) safeguarding of national capacities to

[89] WHO (note 54), pp. 6–8.

manufacture critical biosecurity and pandemic supplies, including personal protective equipment and vaccines.[90]

But while the pandemic has highlighted threats from natural and emerging diseases, threats from accidental and deliberate biological outbreaks must not be underestimated. Globally, as of December 2020 there were well over 50 high-containment BSL-4 laboratories, either in operation or under construction, spread throughout Africa, Asia, Europe, Russia and the USA. These facilities carry out some of the most dangerous manipulations of pathogens, some of which have pandemic potential. Additionally, as a consequence of Covid-19, many more researchers are now working with coronaviruses—including researchers who may not have previously worked with these viruses and who therefore have less biosafety experience of coronavirus work. That accidents are a regular occurrence in laboratories has been highlighted for years by expert communities, and in 2020 by high profile, in-depth articles from the *New Yorker* and the *South China Morning Post*, as well as by more general media discussion around Covid-19.[91] The increasing potential for accidental biological threats underscores the need to make the global biosecurity architecture more fit for purpose. A key element called for by civil society includes an international body, ideally UN-based, to monitor and inspect high-containment facilities and high-risk biological activities.[92]

Intentional use of disease as a weapon

Deliberate biological threats are also of increasing concern. Should the intent be there, advances in science and technology, and especially in genomic technologies, are significantly facilitating the enhancement of pathogens to make them more deadly; the modification of low-risk pathogens to become high-impact; the engineering of entirely new pathogens; or even the re-creation of extinct, high-impact pathogens like the variola virus that causes smallpox. These possibilities are coming at a time when new delivery mechanisms for transporting pathogens into human bodies are also being developed. In addition to the bombs, missiles, cluster bombs, sprayers and injection devices of past biowarfare programmes, it is now also technically possible to use drones, nano-robots and even insects to deliver pathogens.[93] Moreover, as genomic technologies develop and converge with

[90] See e.g. British Parliament, Joint Committee on the National Security Strategy, *Biosecurity and National Security: First Report of Session 2019–21*, Report HC 611/HL 195, 18 Dec. 2020.

[91] See e.g. Furmanski (note 64); Eaves, E., 'The risks of building too many bio labs', *New Yorker*, 18 Mar. 2020; and Baptista, E. et al., 'The labs where monsters live', *South China Morning Post*, 12 Sep. 2020.

[92] Lentzos, F., 'Statement on biological weapons', Speech delivered to the UN General Assembly First Committee, 12 Oct. 2020.

[93] Reeves, R. G., 'Agricultural research, or a new bioweapon system?', *Science*, vol. 362, no. 6410 (5 Oct. 2018).

artificial intelligence, machine learning, automation, affective computing and robotics, an ever more refined record of human biometrics, emotions and behaviours will be captured and analysed.[94] Governments and, increasingly, private companies will be able to sort, categorize, trade and use biological data far more precisely than ever before, creating unprecedented possibilities for social and biological control.[95] Adding computing power to bioinformatics could not only be used to speed up the identification of harmful genes or DNA sequences, but could open up the possibility of ultra-targeted biological warfare.[96]

These developments highlight the need (*a*) to ensure countries comply with and live up to their obligations under the 1972 Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (Biological and Toxin Weapons Convention, BWC); and (*b*) for a strengthened UN Secretary-General Mechanism for Investigation of Alleged Use of Chemical and Biological Weapons (UNSGM), to conduct independent, in-depth investigations of suspected biological weapons use, as well as for a framework to coordinate an international response following any confirmed use of biological weapons. See section II for discussion of the BWC and the UNSGM.[97]

Biological information warfare

A biological threat that is becoming ever more apparent, and which has significantly increased during the rapidly evolving Covid-19 pandemic, is biological information warfare. A hallmark of the pandemic has been what the WHO called an 'infodemic': the constant production of information, from political, scientific and lay arenas, describing often contradictory findings relating to the natural history, epidemiology and clinical outcomes of Covid-19. The overabundance of information has not only included high levels of scientific reporting and official guidance, but also a vast swathe of media reporting, conflicting statistical interpretations, rumours, theories and fake news. The infodemic has made it difficult to separate truthful and trustworthy sources from false or misleading ones.[98] While misinformation and outbreaks have long coexisted, this phenomenon has been disproportionately amplified in the last decade by a combination of

[94] Gleiser, M., 'Biometric data and the rise of digital dictatorship', NPR, 28 Feb. 2018.

[95] Connell, N. et al., 'Driving responsible innovation of AI, life sciences and next generation biotech', *Beyond Standards*, 3 Feb. 2021.

[96] Lentzos (note 44).

[97] For a summary and other details of the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction, see annex A, section I, in this volume.

[98] WHO, 'WHO ad-hoc online consultation on managing the Covid-19 infodemic' (note 27).

social media, the normalization of fake news and the delegitimization of scientific expertise.[99]

Bioweapons narratives related to Covid-19 became apparent as early as the second half of January 2020. As the first coronavirus cases outside China were reported, rumours started circulating that linked the developing outbreak to secret Chinese laboratories and alleged bioweapons research. The stories were based on speculation and insinuations but spread quickly on social media and conspiracy theory websites, as well as through mostly minor tabloid news outlets. One prominent article, published on 24 January 2020 in *The Washington Times*, claimed a high-security government facility at the pandemic's initial epicentre in Wuhan could have been researching military applications for the coronavirus and may have been the source of the outbreak. While lacking any evidence, the story spread widely, before the false narrative was exposed a few days later in reputable, high-profile media outlets, most notably in the *Washington Post* and *Foreign Policy*.[100] Yet insinuations and assertions linking the outbreak to biological weapons continued in the ensuing weeks. Elected officials and government representatives with larger outreach platforms became involved. US Senator Tom Cotton, for example, suggested in a Fox News interview on 16 February that the virus was a Chinese military creation.[101] Manish Tewari, a prominent Indian parliamentarian and spokesperson for the Indian National Congress, tweeted to his more than 380 000 followers an article from UK's *Daily Express* tabloid that claimed the coronavirus was a bioweapon leaked from a Chinese research laboratory.[102]

Another version of the bioweapons narrative also surfaced. Pushed most prominently by Iran, Russia and China, including by current and former government officials, the outbreak was portrayed as a biological attack by the US military.[103] Former Iranian president Mahmoud Ahmadinejad sent an open letter to the UN secretary-general asserting that the virus was clearly 'produced in laboratories . . . by the warfare stock houses of biologic war belonging to world hegemonic powers'.[104] Iran's supreme leader issued

[99] Bernard, R. et al., 'Disinformation and epidemics: Anticipating the next phase of biowarfare', *Health Security*, vol. 19, no. 1 (2021).

[100] Taylor, A., 'Experts debunk fringe theory linking China's coronavirus to weapons research', *Washington Post*, 29 Jan. 2020; and Ling, J., 'The Wuhan virus is not a lab-made bioweapon', *Foreign Policy*, 29 Jan. 2020.

[101] Stevenson, A., 'Senator Tom Cotton repeats fringe theory of coronavirus origins', *New York Times*, 17 Feb. 2020.

[102] Tewari, M. (@ManishTewari), Twitter, 13 Mar. 2020, <https://twitter.com/ManishTewari/status/1238299436205236225>; and Hoare, C., 'Coronavirus shock claim: "Smoking gun of Chinese lab leak" exposed by bioweapons expert', *Daily Express*, 12 Mar. 2020.

[103] See e.g. Russia Today, 'Coronavirus may be a product of US "biological attack" aimed at Iran & China, IRGC chief claims', 5 Mar. 2020; and Radio Farda, 'Influential Iran lawmaker says coronavirus is a "bio-terror attack"', 6 Mar. 2020.

[104] Ahmadinejad, M. (@Ahmadinejad1956), Twitter, 9 Mar. 2020, <https://twitter.com/Ahmadinejad1956/status/1237072414841937920>.

an edict on 12 March 2020 endorsing the idea that 'this incident might be a biological attack'.[105]

Russia's state television networks, as well as social media bots and troll farms run by its intelligence services, spread fallacious information.[106] Between 22 January and 19 March 2020, the EU disinformation monitoring team collected over 110 coronavirus-related disinformation cases from Russian sources covering a wide range of narratives, including claims the coronavirus was a biological weapon deployed by China, the US, the UK or even Russia, and that the true origin of the coronavirus is the USA or US-owned laboratories across the world.[107] The report also indicated that a key Russian tactic was to seek to amplify disinformation originating in Iran, China or the US far right, to avoid accusations of Russia creating false content. An updated report in May 2020 stated that the EU team found pro-Russia sources continuing to push narratives linking Covid-19 to biological warfare, and both pro-Kremlin media outlets and Chinese officials and state media falsely portraying high-security public health laboratories in former Soviet republics as involved in covert development of biological weapons.[108] US government officials accused Russia of using thousands of accounts across a variety of social media platforms to promote fake news and conspiracy theories, the most prevalent being that the virus is a US-created bioweapon intended to damage China economically.[109]

China also spread disinformation.[110] Chinese foreign ministry spokesperson Zhao Lijian repeated claims by a prominent Chinese epidemiologist that although the virus was first discovered in China, it may not have originated there—in what became the dominant Beijing narrative by the end of 2020. Zhao later told his 300 000 Twitter followers 'it might be US army who brought the epidemic to Wuhan'.[111] Despite the Chinese ambassador to the USA publicly distancing himself (and his government) from the allegations,

[105] 'Khamenei calls coronavirus "possible biological attack", asks guards to contain it', Radio Farda, 13 Mar. 2020.

[106] Mackinnon, A., 'Russia knows just who to blame for the coronavirus: America', *Foreign Policy*, 14 Feb. 2020; Anderson, J. and Gamberini, S. J., 'Infodemic: Russian disinformation campaigns, public health, and Covid-19', *Inkstick*, 25 Mar. 2020; and 'Russian media amplify coronavirus conspiracy theories', BBC Monitoring, 6 Feb. 2020.

[107] EUvsDisinfo, 'EEAS special report: Disinformation on the coronavirus—short assessment of the information environment', 19 Mar. 2020; and EUvsDisinfo, Disinfo Database, <https://euvsdisinfo.eu/disinformation-cases/>.

[108] EUvsDisinfo, 'EEAS special report update: Short assessment of narratives and disinformation around the Covid-19 pandemic (update 23 April–18 May)', 20 May 2020.

[109] Glenza, J., 'Coronavirus: US says Russia behind disinformation campaign', *The Guardian*, 22 Feb. 2020.

[110] Scott, M., 'Russia and China push "fake news" aimed at weakening Europe: Report', Politico, 1 Apr. 2020.

[111] Myers, S. L., 'China spins tale that the US army started the coronavirus epidemic', *New York Times*, 13 Mar. 2020.

Zhao's comments fuelled further conspiracy theories online, which were not removed by China's strict internet censors.[112]

The active disinformation campaigns around Covid-19, combined with misinformation spread by social media, likely influenced the course and severity of the pandemic by amplifying mistrust of official reporting and the rejection of scientific evidence by parts of the general public. This has had real health consequences, including people not seeking treatment; stigmatization of those infected; violence against government response facilities or healthcare personnel; and exacerbation of existing political sentiment and movements, such as those opposed to government, foreigners and immigrants.[113]

It has been suggested that the 'consequential nature' of the campaigns means they should be considered as a form of biological threat. By using disinformation campaigns, states can 'produce the consequences of biological terrorism and warfare without deploying a traditional biological agent, and without the technical and regulatory ramifications of their use'.[114] The full potential of this new type of biowarfare is still emerging but some researchers believe 'the necessary conditions for its development' are now in place: (*a*) the weaponization of far-reaching online fake news campaigns; (*b*) the potential for these campaigns to have 'significant negative impact on public health'; (*c*) the 'exacerbating effect' that misinformation and disinformation spread on social media has during an outbreak; and (*d*) the 'delegitimization of science and mistrust of officials'.[115]

Deliberately propagating false stories is nothing new, but the speed and reach of contemporary campaigns to shape and influence opinions and actions across the globe is unprecedented in history. Biological information warfare aims to undermine sociopolitical and economic systems by weaponizing or virtually escalating natural outbreaks, rather than directly inducing mortality and morbidity in populations through the deployment of harmful biological agents. Such battles of influence are likely to escalate in the future. As 'the lines between reality and deception become blurred', the potential for people, resources and weapons to mobilize on a large scale around false narratives 'creates significant global risks', especially in a pandemic.[116] A biological information warfare capability that could replicate the effects of a biological agent while remaining outside of existing normative frameworks poses significant challenges to disarmament efforts.

[112] Swan, J. and Allen-Ebrahimian, B., 'Top Chinese official disowns US military lab coronavirus conspiracy', Axios, 22 Mar. 2020; and Liu, D., Shi, A. and Smith, A., 'Coronavirus: Rumors and misinformation swirl unchecked in China', NBC News, 6 Mar. 2020.

[113] Bernard et al. (note 99), pp. 7–8.

[114] Bernard et al. (note 99), p. 9.

[115] Bernard et al. (note 99), p. 4.

[116] Pauwels, E., *The New Geopolitics of Converging Risks: The UN and Prevention in the Era of AI* (United Nations University Centre for Policy Research: New York, 29 Apr. 2019), p. i.

Improvements in cyber regulations for health and security are crucial to the sustainability and coherence of current frameworks targeting the interface of natural and engineered biological threats.

Conclusions

At the end of 2020, the Covid-19 pandemic was far from over. Its impacts will likely be deep and wide for years to come, including in international security policy.