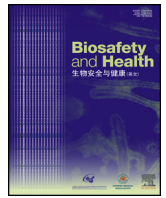




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## For a better world: Biosafety strategies to protect global health

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### ABSTRACT

Biological threats, whether naturally occurring, accidental, or deliberate in origin, can result in disasters that are regional, national, or even global in scope if not properly contained. Many global communities, international programs, and governmental organizations have been established to mitigate these risks and challenges. In China, for example, the government has systematically implemented long-term plans including a complete country-wide architecture for biosafety management. It includes the establishment of a series of improved biosafety laws/regulations/standards and of a large number of high-level biosafety laboratories. All countries should encourage preparedness and improve surveillance systems to predict, identify, and respond to the next public health crisis. More grants and funds should be established for research into biosafety and biosecurity. Most importantly, international collaborations, partnerships, and communications should be enhanced. The journal *Biosafety and Health* aims to provide a global communications platform on biosafety related to human and animal health.

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### 1. Biological threats to public health

The release of biological agents, whether due to natural, accidental or deliberate causes, is among the most serious challenges to humanity. Due to globalization, biological threats have the potential to spread rapidly from one country to many others in a short amount of time, resulting in epidemics/pandemics, psychological trauma and economic and social breakdown [1].

#### 1.1. Naturally occurring biological threats

Emerging and re-emerging infectious diseases have raised global concern in recent years. Urbanization, habitat encroachment, and increased intercontinental travel and commerce, in combination with localized inefficiencies in health-care systems, increase the possibility that infectious diseases will spread rapidly around the world. Unpredictable outbreaks that were previously localized can spread globally, as fast as an international flight. As a result, we must accept the fact that in today's world, "a threat anywhere is a threat everywhere".

The year 2018 marked the 100th anniversary of the 1918 Spanish flu pandemic, which resulted in ~50 million casualties, more than the death toll from the First World War [2,3]. This pandemic is considered the deadliest in modern history. Since the beginning of the 21st century,

the world has experienced a series of major crises due to outbreaks of infectious diseases. In 2003, the severe acute respiratory syndrome (SARS) epidemic affected over 8000 people with a mortality rate about 9.6%, sparking global fear and panic [4]. Other epidemics included the emergence/re-emergence of H5N1 influenza (1997, 2003) [5,6], *Vibrio cholerae* in Haiti (2010), pandemic "swine flu" H1N1 (2009), Middle East respiratory syndrome (MERS) (2012), Ebola virus disease in West Africa (2014), and *Yersinia pestis* in Madagascar (2017). In 2018, a substantial increase in the number of Lassa fever cases were recorded in Nigeria, Nipah virus infections in India, as well as two distinct Ebola virus disease outbreaks in the Democratic Republic of Congo, one of which is still ongoing. As such, infectious diseases will remain a major threat to public health for the foreseeable future.

Another significant threat to global health is the emergence of antimicrobial resistance (AMR). Microbial pathogens readily acquire resistance to commonly used drugs and in many cases, can transmit this resistance to other microbes. Currently we are seeing the worldwide emergence of multidrug-resistant organisms against which we have little or no defense, and it is estimated that AMR will account for an extra 10 million deaths a year globally by 2050 if no action is taken [7]. AMR has been included as a focus in the biosafety strategies of several different countries [1,7], including the 2015 National Security Risk Assessment of the UK as a Tier One risk [8].

The ever-increasing human population and their encroachment on undeveloped areas inhabited by wild animals have led to the emergence of previously unknown diseases. Zoonotic infections, transmitted from animal hosts to humans, account for approximately 60% of total

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infectious diseases in humans, and 75% of all new and emerging infectious diseases [9]. Importantly, the infectious disease outbreaks during the 21st century have all virtually arisen from zoonotic infections. Additionally, we also face the impact of emerging plant and animal diseases on agricultural production (the most recent being African Swine Fever virus in China), which have world-wide implications despite not posing a direct threat to human health. As such, the One Health concept has raised a world-wide call for collaboration to attain optimal health for human, animals, and the environment [10].

### 1.2. Laboratory biological threats

Man-made biological threats exist in many countries. A potential major risk stems from stocks of concentrated infectious pathogens stored in laboratories and the absence of adequate biosecurity measures. Non-compliance of approved biocontainment and biosafety protocols could result in the accidental or deliberate release of pathogens into the environment through a laboratory-acquired infection or a bioterrorist attack.

Advances in biomedical technologies, such as genome editing and synthetic biotechnology, have the potential to provide new avenues for biological intervention in human diseases. These advances may also have a positive impact by allowing us to address risks in new approaches. However, the proliferation of such technologies means they will also be available to the ambitious, careless, inept, and outright malcontents, who may misuse them in ways that endanger our safety. For example, while CRISPR-related techniques provide revolutionary solutions for targeted cellular genome editing, it can also lead to unexpected off-target mutations within genomes or the possibility of gene drive initiation in humans, animals, insects, and plants. Similarly, genetic modification of pathogens, which may expand host range as well as increase transmission and virulence, may result in new risks for epidemics. For example, in 2013, several groups showed that influenza H5N1 viruses with a few nucleotide mutations and H7N9 isolates reassorted with 2009 pandemic H1N1 virus could have the ability for airborne transmission between ferrets [11–14]. Likewise, synthetic bat-origin SARS-like coronaviruses acquired an increased capability to infect human cells [15]. Thus, modifying the genomes of animals (including humans), plants, and microbes (including pathogens) must be highly regulated.

## 2. International collaborations on biosafety activities

To deal with these biological risks and challenges, international partnerships have been formed to assess and reduce the risks, and to tackle such threats at their source.

The International Federation of Biosafety Associations (IFBA), formerly the International Biosafety Working Group, was established in 2001 and is currently a thriving global community for promoting the safe and secure handling of biological materials [16]. The American Biological Safety Association International (ABSA International) was founded in 1984 and now not only serves the growing needs of biosafety professionals in the US, but also engages in broad international communication with other associations throughout the world. Other regional associations include the European Biosafety Association (EBSA) and the Asia Pacific Biosafety Association (A-PBA), founded in 1996 and 2005, respectively, representing countries in Europe and in Asia-Pacific regions.

Since its establishment in 1948, the WHO has pioneered the development of surveillance networks for the monitoring and control of emerging and re-emerging infectious diseases. These networks involve programs initiated by the WHO as well as alliances with independent programs, such as the Global Influenza Surveillance and Response System (GISRS, [https://www.who.int/influenza/gisrs\\_laboratory/en/](https://www.who.int/influenza/gisrs_laboratory/en/)) and the Global Infection Prevention and Control Network (GIPCN, [https://www.who.int/csr/bioriskreduction/laboratorynetwork/gipc\\_next\\_steps/en/](https://www.who.int/csr/bioriskreduction/laboratorynetwork/gipc_next_steps/en/)).

The Global Health Security Agenda (GHSA), a new multisectoral, inter-agency governmental approach to cope with global infectious

disease threats, was launched in 2014 by the USA and its international partners. In addition to working with partner countries around the world on the biosafety and biosecurity, the GHSA is also committed to mitigating the impact of naturally occurring outbreaks as well as accidental/deliberate releases of dangerous pathogens [17,18]. The Global Virome Project (GVP) launched in 2018 by specialists from the USA, China, Brazil, Italy, and Nigeria will help identify the bulk of the viral threats and provide timely critical data support for public health interventions against future pandemics [19,20].

## 3. Progress on biosafety management in China

The SARS epidemic in 2002–2003 wreaked havoc on both the society and economy of China [4], highlighting the urgent requirement to establish a modern biosafety management system in China. To achieve this objective, the Chinese government formulated and systematically implemented a long-term plan including a complete architecture for biosafety management. This framework was characterized by a series of laws, regulations, and standards involving different departments, organizations, and institutes in China. Based on this, many BSL-3 laboratories and a few BSL-4 laboratories have been built since. Meanwhile, the largest network in the world for the surveillance of a diverse spectrum of emerging pathogens was established [21]. This network implemented and maintained strict biosafety regulations in over 800 laboratories with different hierarchical levels, from national to provincial reference laboratories, as well as in sentinel hospitals. This coordinated, nationwide biosafety laboratory network ensures the early-warning and prevention of pathogen spread, and prompts initiation of clinical treatments in China. China has also expanded broad international collaborations with other countries for the improvement of global biosafety. During the 2013–2016 Ebola virus disease epidemic in West Africa, a mobile BSL-3 lab and a fixed BSL-3 lab supported by Chinese specialists greatly contributed to the control of further infections [22]. The fixed BSL-3 lab is still playing a pivotal role in the system for disease control in Sierra Leone [23]. In 2018, the 13th A-PBA Biosafety Conference was successfully held in Beijing, China. This conference, the 1st international biosafety conference to be held in China, was co-chaired by Prof. Guizhen Wu from the National Institute for Viral Disease Control and Prevention, Chinese Center for Disease Control and Prevention (China CDC), and Ms. T.S. Saraswathy Subramaniam, the President of the A-PBA.

Recently, the peer-reviewed journal *Biosafety and Health* was founded. This journal, published in English, is sponsored by the Chinese Medical Association, managed by National Institute for Viral Disease Control and Prevention, China CDC, and distributed by Elsevier B.V. in Amsterdam. *Biosafety and Health* will provide an academic exchange platform for new achievements and developments in the field of biosafety related to human, animal and environmental health. This journal will track research breakthroughs in the field of biosafety, guide international research directions, and publish new theories and new technical methods in a timely manner. Meanwhile, cooperation and exchange between China and international communities will be accelerated by this journal. *Biosafety and Health* will be edited by two distinguished scientists, Dr. Guizhen Wu as the Editor-in-chief, and Dr. Jianwei Wang as the Executive Editor-in-chief. Currently, members of editorial board consist of 76 scientists from 10 different countries.

## 4. Perspectives

One of the most significant challenges faced by humanity in the 21st century is the rapid, global spread of infectious diseases, which have the potential to cost millions of lives, disrupt social order, and greatly damage global travel and commerce. Thus, it is pivotal to mitigate the risk of biological incidents. Recent outbreaks of emerging and deadly viruses have highlighted a global vulnerability to public health emergencies. Countries around the world and international communities need to boost preparedness, and improve surveillance systems to predict, rapidly

identify, and respond to the next public health crisis [2]. These systems need to be sensitive enough to cope with the challenges of emerging and re-emerging infectious diseases, risks associated with advances in biotechnology, and bio-terrorism threats. Meanwhile, to address biological threats, more grants and funds should be established for the development of better antibiotics, antiviral drugs, and efficient therapies. In underdeveloped and developing countries, both biosafety-related hardware (i.e. biosafety laboratories) and technical expertise are urgently needed. International collaborations, partnerships, and communication should be enhanced. The proper and timely sharing of biosafety achievements, including infectious diseases prevention and control, AMR, genome editing, and synthetic biotechnology, will promote the capacity of all the partners to control current and future biological-related threats, guaranteeing human health. With this journal, *Biosafety and Health*, we have a biosafety communications platform for everyone, for anyone, and for all. Let's work together for a better world.

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### Conflict of interest statement

The author declares that there are no conflicts of interest.

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