

## REVIEW ARTICLE

**Bioshield: Linking Bioscience, Biosecurity and Strategic Plan for Biodefense in Pandemics**

Wasim Sajjad

**ABSTRACT**

Biological threats, whether intentional, unintentional or natural are considered to be the most dangerous hazards, seriously affecting the health system and global economy. In this 21<sup>st</sup> century, COVID-19 outbreak in 212 countries have shown ill preparedness of global health systems to combat the virus. Economic, health and political foundations were jolted and exposed the health security system. This was mainly due to poor implementations of the policy guidelines. Pakistan being an endemic region for emerging and reemerging infectious diseases, fared badly in the numerous different outbreaks in past. Pakistan shares borders with China, India, Iran and Afghanistan and the large influx of travelers through both air and land route puts Pakistan at high risk to the infectious agents.

The game of bio warfare cannot be eliminated and poses significant challenges to security. Countries that learnt from the past like Korea and China had best preparedness, readiness and response capability. They tackled the situation with their up to date biosecurity and bio risk management systems. Biosecurity as a defense against outbreaks, pandemics, biological warfare and bioterrorism has been underestimated in developing countries and therefore there is a need to highlight the urgency at national level to cope with any future outbreaks. Risk assessment, and mitigation strategies through collaborative work need to be adopted by stakeholders for strategic planning of biosecurity. Better means to protect health care workers operating in a difficult environment are also needed. A national biosecurity system in response to outbreaks, prioritizing the emergency R&D in diagnostics, establishing high containment facilities, vaccination should be initiated. Moreover, a permanent national defense force or bio-umbrella on biosecurity should be established to shield the country from biological, chemical, nuclear and radiological threat agents. National Biological Defense Program (NBDP) should be initiated to train and protect military personnel against a wide range of biological threats.

**Key Words:** *Biosecurity, Biorisk, Bioterrorism, Biopreparedness, Pandemics Bio Shield.*

**How to cite this:** Sajjad W. *Bioshield: Linking Bioscience, Biosecurity and Strategic Plan for Biodefense in Pandemics. Life and Science. 2020; 1(suppl): 87-93. doi: <http://doi.org/10.37185/LnS.1.1.163>*

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International license. (<https://creativecommons.org/licenses/by-nc/4.0/>). Non-commercial uses of the work are permitted, provided the original work is properly cited.

**Introduction**

In recent years there has been an increase in emerging and reemerging infections. COVID-19 has shown us that we have underestimated the insidious nature and threat posed by previously unknown microbes. There is also a lack of investment in prevention and mitigation strategies of infectious disease or outbreaks.<sup>1</sup> COVID-19 emerged in Wuhan

China and was considered the biggest crises since World War II.<sup>2</sup> Globalization in the 21<sup>st</sup> century has increased the chances of transmission of contagious diseases. All choices, like what we buy, how frequently we travel and what we eat, have consequences. The resulting “spillover” phenomenon has resulted in the emergence of diseases like Ebola and COVID-19. The lack of preparedness in COVID-19 surprised the world as it has further exposed the fact that there is no money for science.<sup>3</sup>

In context of the recent situation collaborations such as One Health (human, animal, and environment) which focus on biosafety, biosecurity and biocontainment are very important to prevent future pandemics or biological war. Biosafety and bio

*Department of Biological Sciences  
National University of Medical Sciences, Rawalpindi*

*Correspondence:*

*Dr. Wasim Sajjad*

*Assistant Professor, Biological Sciences  
National University of Medical Sciences, Rawalpindi  
E-mail: [sajjadw@numspak.edu.pk](mailto:sajjadw@numspak.edu.pk)*

*Funding Source: NIL; Conflict of Interest: NIL*

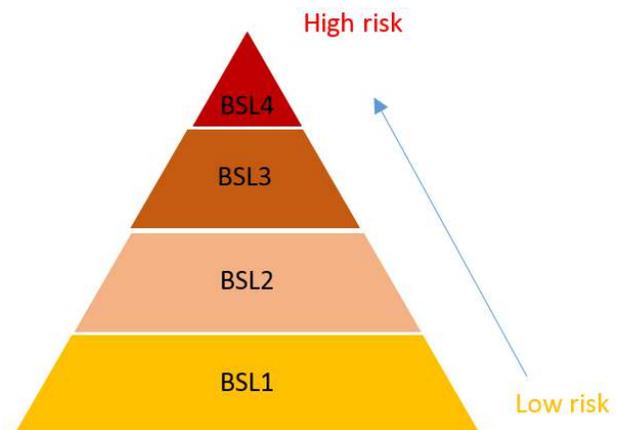
*Received: Sep 14, 2020; Revised: Sep 24, 2020*

*Accepted: Nov 10, 2020*

preparedness in pandemics is the future focused area of many developed countries.<sup>4</sup> In a nutshell, bioterrorism, natural outbreaks and biological weapons may cause significant harm to national security, economy and other health security systems and the risk is continuously growing in future.<sup>5,6</sup> The US federal government spent \$6.69 billion in 2012 on different aspects of biosecurity and established a center for health security in Johns Hopkins to focus on potential global catastrophic risks (GCRs) and pandemic preparedness.<sup>7</sup>

According to Council Aviation Recovery Task Force (CART 2020)<sup>8</sup> the success to restart air connectivity needs mutually and internationally accepted harmonized policies to mitigate the current and future risks. Some developed countries have already implemented multi-layer biosecurity measures for biocontainment and also to ensure that travelers are not a meaningful vector for spread of any infectious agent, intentional or unintentional (International Air Transport Association IATA).<sup>9</sup> States and territories in developed countries have also implemented policy guidelines for a biosecure environment in maritime ships.<sup>10</sup> Protecting people from dangerous pathogens (biosafety) vs protecting pathogens from dangerous people (biosecurity) in association with the implementation of good work practices, administrative procedures and policies, is highly adopted by developed nations.<sup>11,12</sup> Biosecurity is still considered the cheapest and most effective means of contagious disease control available. No disease surveillance or prevention program can be effective without taking proper biosecurity measures. The Inspector-General of Biosecurity Australia issued some recommendations and essential biosecurity information for military forces at the border and offshore as well to minimize the risks posed by the recent pandemic of COVID-19. Complex biosecurity risk management measures have been taken by the Australian government to prevent the entry of any exotic pets or diseases to the country (Biosecurity Act 2015).<sup>13</sup> However, the technological dependency of developing nations increases their vulnerability to disease and presents special biosecurity risks. There are multiple regulatory agencies, government and non-government organizations, currently working on biosecurity related issues. Since 1972 Pakistan is signatory to the Biological Toxic Weapon Convention

(BTWC), Cartagena Protocol on Biosafety (1992), as a non-permanent member of UN Security Council 1540 Committee, International Health Regulations (IHR) 2005 and other partners to contain the spread of infectious diseases across the border and also to implement policy guidelines to discourage nuclear, chemical and biological weapons.<sup>14</sup> There is still need for signatory countries to sensitize scientists, public policy makers, diplomats and other law and enforcement agencies to the risk of genetic engineering and also to ensure a code of conduct in life sciences.



**Fig 1: Biosafety levels and its containment from low risk to high risk group microbes**

### Why biosecurity

Infectious diseases know no borders. Natural outbreaks could pose significant challenges to global security. The incident of Anthrax spores in an envelope at Washington DC in 2001<sup>15</sup> trapping of a single browsing ant in 2018 at RAAF Base Pearce western Australia (Review report No. 2018–19/01)<sup>16</sup> biological attack of *Salmonella* in Oregon<sup>17</sup> *Shigella* outbreak in donuts<sup>18</sup> 1918 Spanish flu, dengue outbreak, SARS 2003, recent pandemic of COVID-19 and other events have highlighted the great global risk of these possible agents of bioterrorism. In September 2018 US president Donald Trump signed a memorandum on national security and issued a national biodefence strategy to effectively counter biothreats and to mitigate the risks from natural, deliberate or accidental release of bioagents and toxins. Multiple stakeholders including the Departments of Defense, Health and Human Services, Agriculture and Homeland Security drafted the strategy and established a national level mechanism to prevent, monitor and respond.<sup>19,20</sup>

Pakistan shares borders with China, India and Iran and has experienced an exponential increase in numbers of COVID-19. The large influx of travelers both through air and land routes puts Pakistan at a high risk. In March 2020, a rapid spread of COVID-19 was observed in Pakistan.<sup>21</sup> Today the world is facing tremendous health security risks due to globalization of travel and trade. A number of biosafety laboratories and capacity building programs were initiated to train the manpower for bio preparedness and to promote social sustainable development. A hospital which specialized in infectious diseases was built for members of army during the Eastern Han Dynasty (25-200 AD) called An Lu. The quarantine system of China has gradually shaped and in 1863 the Inspector General of Chinese Maritime Custom Service setup a Custom clinic.<sup>22</sup>

Although different organization like Pakistan Biological Safety Association in collaboration with other partners did much progress in the area but the developing nations do not have a proper biosafety and biosecurity system. This is a threat not only to the health care workers but also to the public and environment. It is very essential to map risks and find out gaps countrywide among stakeholders for multidisciplinary risk assessment and collaborative strategies for risk mitigation through one health approach. Risk assessments related to biosafety and biosecurity, including transnational border control/security and cybersecurity elements, at national and regional level is very important in biodefense and bio preparedness. Biosecurity remains a great challenge in South East Asian countries and the Middle East. Geographic nature of the region, porous borders, no point-of-care testing and monitoring, make these regions susceptible to hazardous agents.<sup>23</sup>

#### **Pandemics: Concern and impact**

Biothreat agents have been ranked accordingly to the lethality, ways of dissemination, dose required and contagion. The NATO bio warfare defense handbook lists 31 human pathogen of concern each with very different action and effect. Human, agriculture, food chain and the environment are equally vulnerable but have been ignored by politicians and the media.<sup>24,25</sup>

In today's world, outbreaks have become more frequent. Great economic loss has also been

observed in the past. The seasonal flu annually costs \$10.4 billion for US population<sup>26</sup> yet the robust seasonal flu vaccination remains out of reach. Similarly, once the 1st case of Ebola was detected the US government allocated a \$5.4 billion response fund.<sup>27</sup> The global cost for SARS outbreak in 2003 was estimated as \$40–\$54 billion for one year.<sup>28-30</sup> Moreover the economic impact for influenza pandemic ranges from \$570 billion per year<sup>31</sup> for human cost, to \$2 trillion in indirect cost.<sup>32</sup>

These unseen microbes can be a disaster with profound economic, political and cultural disruptions. In the recent COVID 19 pandemic the world has been badly affected economically. There is rise in unemployment and reduction in income. A collaborative effort internationally is required not only to save lives but also the economy. Covid-19 like pandemic in 21<sup>st</sup> century may be a wakeup call for world leaders to work together for a better tomorrow. Although we had enough evidence from the past epidemics and pandemics of the cost we already paid in term of economic crises and human loss, the world failed to invest on preventive and preparedness measures to tackle such outbreaks. The COVID-19 pandemic has made a major impact on the travel and tourism industry and has also changed the perception and behavior of the public worldwide during the intra pandemic.<sup>33</sup> A study conducted in China determined that the increase in the willingness to travel in personal or private car in spite of public transport due to health concerns, results an extra pressure on existing transport facilities.<sup>33</sup> There is little literature to highlight the economic cost of infectious diseases pandemics. The economic impact of the influenza of 1987 is one of example of early analysis by Schoenbaum (1987).<sup>34</sup> Several vaccine-based interventions were evaluated in 1999 to examine the influenza pandemic impact on the US economy.<sup>35</sup>

Today the aviation industry drives \$2.7 trillion of GDP and 65.5 million jobs thereby enabling the trade by 35% of goods by value (IATA 2020).<sup>8</sup> The irreplaceable service of the airlines is highlighted in recent pandemic when the world suffered shortage of PPEs medical equipment's and pharmaceuticals. Passengers all over the world are now experiencing temporary biosecurity measures which highlights the importance of this topic globally. Moreover, due

to recent advances in science, pandemics are also considered a national security threat. The association between outbreaks and national security threat become prominent in the 1990s when world health assembly revised the International Health Regulations (IHR). In 2005 these IHR revisions were adopted. It was stated that the purpose and scope of the IHR were "to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks (International health regulations 2005).<sup>36,37</sup>

The recent pandemic has seen a reduction in workforce (global labor supply), increased government spending on public health, increased cost of international trade (1% increase in electronics, trade air transport 5%) and reduction in private consumption, which lead to cautiousness of consumers to spend money (Australia Matters March 2020). COVID-19 pandemic is also a new sign for bio-geopolitics that accelerated a change in direction from US centric globalization to China centric globalization and economy.<sup>38</sup>

### Risk Mapping

Mapping risk and finding the gaps is very important in today's world where biological threats cannot be ignored. Threat in one region can easily be spread to another region due to globalization of trade and economy.<sup>39</sup> The facts of bio-geopolitics and power games in economy cannot be denied in 21<sup>st</sup> century as well.<sup>40</sup> Developed countries have already prioritized their list of biological agents of concern while developing nations including Pakistan still have no list of bio-threats that could pose potential threat to country economy and health security. No uniformity in policies at national level, lack of coordination and creation of hype have put an extra pressure on health system. China has established a complete infectious disease control and prevention, biosafety and biosecurity system to reduce the emerging and reemerging infectious disease prevalence.<sup>22</sup>

The involvement of scientists, researchers and academicians in outbreaks and pandemics is the key to success as seen in the Chinese, Korean, Australian models. Other developed countries handled the situation variably.<sup>41</sup> In Pakistan and other developing countries there is no concept of multidisciplinary

team work. This initially put the state in trouble during Dengue (2017, 2018) and recently COVID-19. There was no psychological counselling of patients in quarantine centers to relieve their anxiety and stress and this also created a mess during the whole pandemic. A cross sectional study in China focusing on medical staff infighting in COVID-19 was conducted which showed that the level of anxiety was higher during occupational exposure.<sup>42</sup> Public refused to stay in quarantine centers despite the fact that the triage for containment was so simple. This shows the lack of awareness of stakeholders in risk assessment and mitigation strategies for any infectious disease.



**Fig 2: Collaborative strategies for multidisciplinary risk assessment and mitigation strategies**

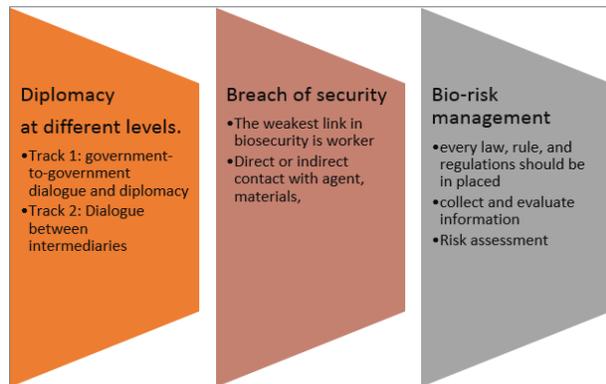
The current supply chain system for medical equipment and other pharmaceutical products is not well matched to the demand and is considered a threat to health security. Despite the progress made in health systems and political stability in many developing countries, the violence and war associated with these regions is a great challenge. Occupational health and safety programs are a great matter of concern to frontline soldiers. Large-scale migration is the second most likely global risk of concern according to World Economic Forum Annual Risk Report 2017.<sup>43</sup> Lack of effective measures for management of waste generated in COVID-19 health care settings and diagnostic facilities is also of great concern. There is also lack of risk communication and good practices for bio risk management. The bottom line is outbreaks of infectious disease clearly impose a huge cost in term of economic, political, human suffering and mortality that threaten progress and stability around the world.<sup>3</sup> Sufficient progress in vaccine development, diagnostics and surveillance has not been made to prevent, detect, and respond to these bio threats.

### Recommendations

Influenced by globalization, modern medical and agricultural practices, changes in human behavior

and environmental factors, dealing with infectious diseases has become a serious challenge both to the international community and governments.<sup>44</sup> They have even replaced direct military threats from hostile countries in a priorities list.

- Biosecurity remains a challenge among developing nations. Risk assessments related to biosafety and biosecurity, including transnational border control, security and cybersecurity elements at national and regional levels are needed.
- Multi-track diplomacy at different levels, government to government dialogues, strategic partnerships and mediators e.g. academics, religious leaders, and other citizens, are needed to participate and play a role in all aspects of creating public awareness.
- A strategic plan for biosecurity is needed among different stakeholders with a complete loop from top to bottom and bottom to top. This will create a multidisciplinary approach with new ideas and problem-solving strategies.<sup>45,46</sup>

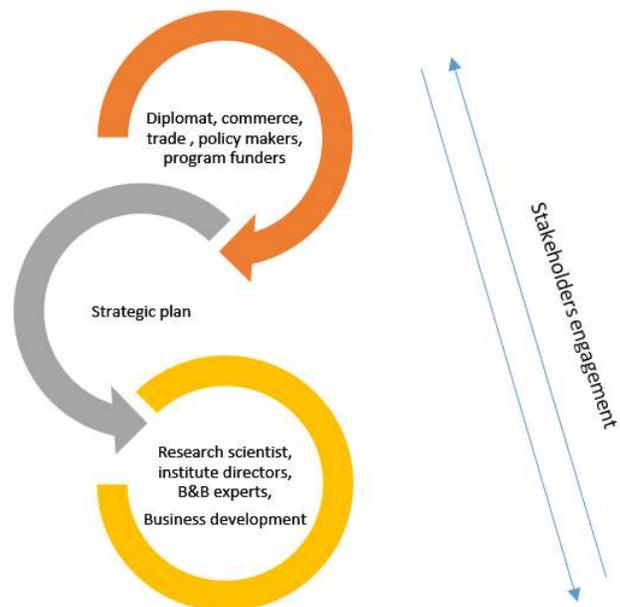


**Fig 2: A multi-track diplomacy is required for bio-risk management**

- There is need of systemic analysis of the information already available from Security council 1540 Committee National implementation action plan.<sup>23</sup> and to develop a bio risk management system prioritizing the list of biological agents of concern.
- Capacity building of human resource for understanding the importance of biosecurity among all stakeholders is Important in this regard. Biosecurity training among the health care workers and awareness about One Health approach, and responsible conduct in life science and dual use of research concern should be

highlighted at national level.

- Local regional and international biosafety and biosecurity experts should be involved in implementation of EU-CBRN CoE projects (European Commission's Joint Research Centre 2019).<sup>47</sup>
- Physical systems, standard operation procedures, infrastructure and inventories, should be standardized to meet the international guidelines. For public health emergency any country around the world should need to meet the international guidelines IHR, (global health security agenda (GHSA)).<sup>48</sup>

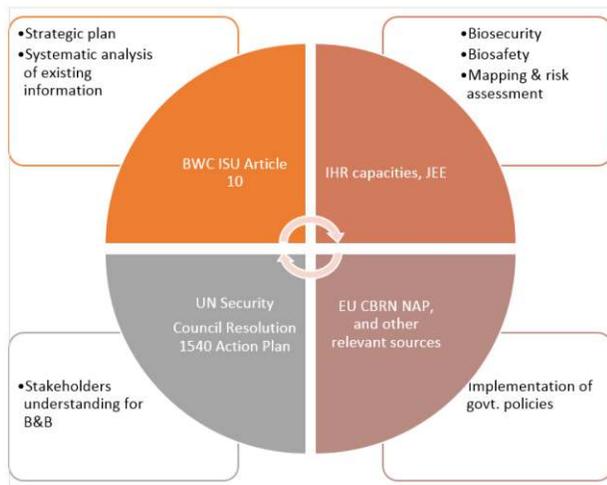


**Fig 3: Stakeholder's engagement for strategic plan in biosecurity and bio preparedness**

- There is an urgent need to implement the international guidelines and protocols according to our needs. Prioritizing the capacity to detect emerging zoonotic diseases and containment of the bioagents by engaging public sector universities and academicians is required.
- Common understanding of biosecurity should be developed among all stakeholders to ensure personnel and information security and a to ensure a well-coordinated response.
- There is also the need to develop a standardized bio risk management strategy in rural and other remote areas as well to ensure bio-preparedness for any future outbreaks.
- Establishment of check points for carriers of high-

risk biological material on borders and airports to ensure the control of any accidental or deliberate release (by non-state actors) is necessary due to porous shared borders the emergence of terrorist groups cannot be denied and need legislations for the chemical, biological and radiological (CBR) materials.

- Public health experts with knowledge of salient science for Epidemic Intelligence Service (EIS) should be included in civil defense budget activities to train the multidisciplinary team for health management system and investigation of outbreaks and also to assist official health agencies. This will eliminate the chances of monopolized media stunts, myths, rumors and power games as observed in COVID-19.
- Sustainable funding to build capacity in the field of biosafety and biosecurity for bio preparedness and also to build a resilient health system in low resources settings is also essential. Unless money is invested on research and development global health security will remain a challenge. Scientists, researchers and other agencies and public health experts will be constantly scrambling to get ahead of the outbreak.



**Fig 4: Gap analysis and risk mapping with recommendations to strengthen biosecurity**

#### REFERENCES

1. MacIntyre R. The risk of selective investment in downstream pandemic planning. *Global Biosecurity*. 2019; 1: 85-90.
2. Shangguan Z, Wang MY, Sun W. What caused the outbreak of COVID-19 in China: From the perspective of crisis management. *International Journal of Environmental Research and Public Health*. 2020; 17: 3279.
3. David Quammen. Spillover Warning: How We Can Prevent the Next Pandemic. 2020
4. Ahmad T, Haroon H, Dhama K, Sharun K, Khan FM, Ahmed I, et al. Biosafety and biosecurity approaches to restrain/contain and counter SARS-CoV-2/COVID-19 pandemic: a rapid-review. *Turkish journal of biology*. 2020; 44: 132-45.
5. Suk JE, Zmorzynska A, Hunger I, Biederbick W, Sasse J, Maidhof H, et al. Dual-use research and technological diffusion: reconsidering the bioterrorism threat spectrum. *PLoS Pathog*. 2011; 7: e1001253.
6. Imperiale MJ, Casadevall A. A new approach to evaluating the risk–benefit equation for dual-use and gain-of-function research of concern. *Frontiers in bioengineering and biotechnology*. 2018; 6: 21.
7. Sell TK, Watson M. Federal agency biodefense funding, FY2013-FY2014. *Biosecurity and bioterrorism: Biodefense strategy, practice, and science*. 2013; 11: 196-216.
8. <https://www.icao.int/covid/cart/Pages/CART-Report---Executive-Summary.aspx>
9. <https://www.iata.org/contentassets/4cb32e19ff544df590f3b70179551013/biosecurity-air-transport.pdf>
10. McKirdy SJ, O'Connor S, Thomas ML, Horton KL, Williams A, Hardie D, et al. Biosecurity risks posed by a large sea-going passenger vessel: challenges of terrestrial arthropod species detection and eradication. *Scientific reports*. 2019; 9: 1-4.
11. Heckert RA, Reed JC, Gmuender FK, Ellis M, Tonui W. International biosafety and biosecurity challenges: Suggestions for developing sustainable capacity in low-resource countries. *Applied Biosafety*. 2011; 16: 223-30.
12. Sture J, Whitby S, Perkins D. Biosafety, biosecurity and internationally mandated regulatory regimes: compliance mechanisms for education and global health security. *Medicine, Conflict and Survival*. 2013; 29: 289-321.
13. <https://www.legislation.gov.au/Details/C2017C00303>
14. Khalil A, Tanveer F, Shinwari ZK. Pakistan's bio-preparedness with regard to biosecurity, biodefense strategies and policy measures. *Journal of Bioterrorism & Biodefense*. 2015; 6: 2.
15. Meyer J. Anthrax Investigation Should Be Investigated, Congressmen Say. *Los Angeles Times*. 2008.
16. Australian Government Inspector-General of Biosecurity. *Military biosecurity risk management in Australia. Review report No. 2018-19*.
17. Török TJ, Tauxe RV, Wise RP, Livengood JR, Sokolow R, Mauvais S, et al. A large community outbreak of salmonellosis caused by intentional contamination of restaurant salad bars. *Jama*. 1997; 278: 389-95.
18. Kolavic SA, Kimura A, Simons SL, Slutsker L, Barth S, Haley CE. An outbreak of *Shigella dysenteriae* type 2 among laboratory workers due to intentional food contamination. *Jama*. 1997; 278: 396-8.
19. Berger KM, DiEuliis D, Meyer C, Rao V. Roadmap for biosecurity and biodefense policy in the United States. *J Health Security*. 2018.
20. Ye L. The United States issues national biodefense strategy. *Journal of Biosafety and Biosecurity*. 2019; 1: 3-4.
21. Abid K, Bari YA, Younas M, Javaid ST, Imran A. Progress of COVID-19 Epidemic in Pakistan. *Asia-Pacific Journal of*

- Public Health. 2020 May 19.
22. Huigang L, Xiaowei X, Cui H, Haixia M, Zhiming Y. A brief history of the development of infectious disease prevention, control, and biosafety programs in China. *Journal of Biosafety and Biosecurity*. 2020; 1: 56–8.
  23. Castriciones EV, Vijayan V. Biosecurity risk mapping and gap analysis in South East Asia. *Journal of Biosafety and Biosecurity*. 2020.
  24. Wiener SL. Strategies of biowarfare defense. *Military medicine*. 1987; 152: 25-8.
  25. Collins BJ. NATO: A Guide to the Issues. ABC-CLIO. 2011.
  26. Molinari NA, Ortega-Sanchez IR, Messonnier ML, Thompson WW, Wortley PM, Weintraub E, et al. The annual impact of seasonal influenza in the US: measuring disease burden and costs. *Vaccine*. 2007; 25: 5086-96.
  27. Epstein SB, Lister SA, Belasco A, Jansen DJ. FY2015 Funding To Counter Ebola And The Islamic State (IS). *International Journal of Terrorism & Political Hot Spots*. 2015.
  28. CDC Ebola response in the United States and abroad. 2015.
  29. Jonas O, Parry I, Chisholm D, Banatvala N, Ladminarayan R. Global health threats of the 21st century. *Finance and Development*. 2014; 51: 16-20.
  30. McKibbin WJ. Economic modeling of sars: The g-cubed approach. Prepared for handbook on the rapid assessment of the economic impact of public health emergencies of international concern. World Health Organisation. 2004.
  31. Fan VY, Jamison DT, Summers LH. The inclusive cost of pandemic influenza risk. *National Bureau of Economic Research*. 2016.
  32. Burns A, Van der Mensbrugge D, Timmer H. Evaluating the economic consequences of avian influenza. Washington, DC: World Bank. 2006.
  33. Nguyen TH, Coca-Stefaniak JA. Coronavirus impacts on post-pandemic planned travel behaviours. *Annals of Tourism Research*. 2020; 28: 102964
  34. Schoenbaum SC. Economic impact of influenza: the individual's perspective. *The American Journal of Medicine*. 1987; 82: 26-30.
  35. Meltzer MI, Cox NJ, Fukuda K. The economic impact of pandemic influenza in the United States: priorities for intervention. *Emerging infectious diseases*. 1999; 5: 659.
  36. Merianos A, Peiris M. International health regulations (2005). *The Lancet*. 2005; 366: 1249-51.
  37. Fidler DP. From international sanitary conventions to global health security: the new International Health Regulations. *Chinese Journal of International Law*. 2005; 4: 325-92.
  38. Allen J, Burns N, Garrett L, Haass RN, Ikenberry GJ, Mahhubani K, et al. How the world will look after the coronavirus pandemic. *Foreign Policy*. 2020; 20: 2020.
  39. Koblenz GD. Biosecurity reconsidered: calibrating biological threats and responses. *International security*. 2010; 34: 96-132.
  40. Dillon M, Lobo-Guerrero L. Biopolitics of security in the 21st century: An introduction. *Review of International Studies*. 2008; 1: 265-92.
  41. COVID W. PHEIC Global research and innovation forum: towards a research roadmap.
  42. Sun N, Wei L, Shi S, Jiao D, Song R, Ma L, et al. A qualitative study on the psychological experience of caregivers of COVID-19 patients. *American journal of infection control*. 2020; 48: 592-8.
  43. Gap GG. World economic forum. Cologny/Geneva. 2017.
  44. Luong TA. Globalization and infectious diseases: Evidence on the reproduction rate of the COVID-19 pandemic. Tuan Luong and Thu hang Nguyen, (2020)' Globalization and Infectious Diseases: Evidence on the Reproduction Rate of the COVID-19 Pandemic', *Economics Bulletin*. 2020; 40: 1675-85.
  45. Chigas D. Track II Resources. 2014; <https://www.sfcg.org/track-ii-resources/>. Accessed 29 August 2019.
  46. Chigas D. Track II (Citizen) Diplomacy, Beyond Intractability. Org. 2003.
  47. European Commission's Joint Research Centre (JRC). EU Chemical, Biological, Radiological and Nuclear Risk Mitigation Centres of Excellence (CoE). 2019; <https://ec.europa.eu/jrc/en/research-topic/chemical-biological-radiological-and-nuclear-hazards/cbrn-risk-mitigation-centres-of-excellence>. 2019.
  48. Ayotte K, Gerberding J, Morrison JS. Ending the Cycle of Crisis and Complacency in US Global Health Security. 2019.
-