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ARTICLE

Science Communication at the Intersection of Science and International Relations: Success Stories and Learnings from the COVID-19 Pandemic

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ABSTRACT

The world has witnessed many challenges, such as economic slump, catastrophes and pandemics. However, the global health pandemic, COVID-19, has created quite a stir. To address a global pandemic like COVID-19 requires a strong interlinkage of science and scientific communication as a tool for global health diplomacy with joint research activities; sharing of data on infection, laboratory, diagnostics and virology; knowledge exchange including best practices, etc. as a global public good. Science being objective and fact-based has played a unifying role in international relationships. It is even more evident during global health emergencies where science and its use as diplomatic communication tool have the potential to promote peace and healthy living for communities.

In this perspective, it is essential to understand the soft power role of science communication and the autonomous role that science and scientists can play in international relations. Three cases have been analysed to explore the role of science and its effective communication as a tool for diplomatic persuasion and attraction using three classifications, namely: science directing foreign relations; science enabling international relations; and science advising policy-making. With learnings from the cases, the path ahead in the case of a pandemic like COVID-19 is projected with emphasis on 'Open Science Diplomacy' as a model for next-generation science communication and diplomacy in international relations.

KEYWORDS: Science Communication, Science Diplomacy, Global Health Diplomacy, International Relations, Open Science Diplomacy, Vaccine Diplomacy

Introduction

In the last few decades, the world has witnessed various new and emerging diseases that have created havoc on the global health system. With the ease and continuous rise in the mobility of people, especially air travel, these diseases can become pandemics with the potential of a global outbreak. In December 2015, the World Health Organization (WHO) identified Severe Acute Respiratory Syndrome coronavirus (SARS-CoV) and the Middle East Respiratory Syndrome coronavirus (MERS-CoV) diseases as the top diseases with potential cause for concern (World Health Organization (a), 2015). The world had already witnessed such a scenario during the epidemic outbreak of Severe Acute Respiratory Syndrome coronavirus (SARS-CoV) during 2002-03 that had affected 26 countries infecting more than 8000 cases causing 774 deaths (Roper & Rehm, 2009; World Health Organization (b), 2020).

More recently, the outbreak of severe acute respiratory syndrome coronavirus-2 also known as COVID-19, identified in November 2019 in Wuhan, China, has been declared as a pandemic infecting more than 41.05 million people and causing death of almost 1.13 million people globally and still counting (as on 21st October 2020) (Worldometer, 2020). The virus had the potential to bring the entire world nearly to a standstill with more than half of the global population under some form of restriction as many countries announced strict lockdowns.

With a growing trend of positive cases, the pandemic is not expected to wane soon. Anticipating substantial economic and social cost, many countries as of today are even planning to ease out restrictions and appealing to people to live with the coronavirus by making lifestyle and social changes. Incidentally, the SARS epidemic outbreak during 2002-03 and the recent outbreak of COVID-19 have reiterated the “potential cause of concern” observed by WHO. With lack of effective approved antiviral drugs available for the treatment of COVID-19, vaccination is suggested to be the most likely mode of prevention especially for healthcare workers, doctors etc. who are at the highest risk of contamination (Roper & Rehm, 2009). With more than 90 vaccines under development globally

(Callaway, 2020), the challenge is 'cross border collaboration' including open science initiatives for COVID-19.

Amidst the blame game and hard diplomatic manoeuvring, the 'soft power' of scientific communication as a diplomatic tool combined with science-based health diplomacy may be the only thread that has the potential to bind all nations together to seek a vaccine for the welfare of the society. Science diplomacy that intertwines two policy spheres of science policy and foreign affairs is the usage of scientific knowledge to foster international relations to normalise political relations between two or more nations. Communication of the science by diplomats and scientists also plays a crucial role in international relations in general and science diplomacy in particular. In a global relationship, communication of science has the potential to exacerbate or accelerate international competition through international agreements, development, cooperation with the potential to converge science and politics (Kaltofen & Acuto, 2018). Therefore, it is important that the role of scientific communication in harmonizing the diplomatic manoeuvres to shape the foreign policy objectives be explored.

In this paper, 'science communication and its diplomacy' is explained using three cases from the health sector wherein scientific inputs such as facts, dynamics, uncertainties, etc. in the socio-economic system are identified and are communicated by the diplomats as well as scientists thereby enabling policymakers to make informed decisions at both national as well as international level (Royal Society of London, 2010). The learnings from the cases could form the theoretical foundation to address the present COVID-19 pandemic that requires establishing a strong communication network enabling global health diplomacy. The communication channel could help in establishing trans-border scientific collaborations such as joint research activities; sharing of data on infection, laboratory, diagnostics and virology; knowledge exchange that includes best practices, etc. as a global public good.

In the following session role of science communication as a soft power of persuasion in international relations and the emerging concept of science diplomacy are introduced. This is followed by three cases illustrating the role of "science and its effective communication in foreign affairs". The learning of the cases is then condensed to develop open science diplomacy and communication as the way forward.

Role of Science Communication and Emergence of Science Diplomacy

Science and its communication in the international platform have varied connotations and mandate compared to general science communication. Scientists and other researchers have been communicating and collaborating across borders creating linkages to leverage national as well as international resources. Right from science and technology marketing activities to education, science communication plays a central role in international relations of a nation (Leach, 2015).

However, the role of science communication in diplomacy has a different implication especially pertaining to the 'soft power' that science plays. According to Nye (2011, p. 21) the soft power is the '*ability to affect others through the co-optive means of framing the agenda, persuading, and eliciting attraction in order to obtain preferred outcomes*'. For this various resources are used and one such effective resource is communication. Science communication in particular has been used quite often by the State especially during estranged relationships with other countries. The soft power of science is used for persuasion and attraction, along with artefacts of communication that will help in streamlining the alienated relationships. More recently, science diplomacy has been evolving and many countries have started to mainstream science diplomacy into their policy framework. A proper structure and mechanism has been evolving for science communication by Scientific Attachés, Foreign Diplomats, scientists, etc. under the science diplomacy framework.

Science diplomacy is about the coupling of science and scientists to the exercise of diplomacy, thereby using it as an instrument (soft power in our case) to influence countries through their research strength (Siddhartha, 2019). In other words, as Turekian *et al.* (2015) have described: *'Science diplomacy, therefore, is the process by which states represent themselves and their interests in the international arena when it* *comes to areas of knowledge – their acquisition, utilisation and communication – acquired by the scientific method*.' Science diplomacy is thus utilizing the knowledge of science and scientists in the international arena for addressing global issues such as health, climate change, energy shortage, pandemics, food security, national disaster management, water resource accessibility, etc. as well as strengthening a nation's global soft power.

Historically, there are numerous examples to cite for the role of science communication in harmonizing international relations right from the cold war era. Especially during the cold war period, science diplomacy occupied a pivotal role in easing tension between the western world and the Communist bloc. The classic example is of Pugwash Conference for which Bertrand Russell and Albert Einstein called up eminent physicists across the world including physicists from the Soviet Union to join and to discuss the treatment of thermonuclear warfare in the city of Pugwash in 1957 (Flink & Schreiterer, 2010). This science communication through conference paved the way for informal diplomacy by scientists to become a mode for track-two transnational dialogue to contain the danger of nuclear weapons during the cold war period (Pugwash, n.d.). Another example is the scientific interaction between Weizmann Institute of Israel and Max Planck Society of Germany, during the 1950s post World War II, that cemented the first high-level communication channel between both the countries (Turekian, *et al.*, 2015), SESAME centre in Jordan, which is the first major international research centre established for collaboration between scientists from different countries, including scientists from Israel and Palestine. The centre provides a breeding ground for scientific communication focusing on research to address common questions that are detached from politics (Berkman, 2018). The next section provides a detailed account of science communication and its diplomatic use with the help of three cases.

Science Communication and its Diplomacy: Cases from Health and Vaccine Diplomacy

Case 1: Health Diplomacy U.S. – Germany Pork war 1880 - 1891

During the late nineteenth century, France, Germany, Italy, Austria–Hungary and many other European countries prohibited import of pork products from the United States of America. Americans were exporting 60 percent of their pork products amounting to 0.6 million tonne to Europe valued at nearly $100 million. The reason for this ban was the likely infection of the pork products with *Trichinella spiralis* (*T. spiralis*), a parasite that causes trichinosis in humans (Chalecki, 2008). Trichinosis, a roundworm parasite, requires a host body, particularly animals like bears, fox, pigs and wild boar to live and reproduce. In the case of pork, dead hogs can contract the disease from filthy barnyards or rats or farmyard offal (Hoy & Nugent, 1989). When humans eat undercooked or raw meat containing trichinella larvae, they mature in the intestine over several weeks within the body, causing *T. spiralis* infection (Trichinosis, n.d.).

The German Government, in 1880, issued an order prohibiting the import of pork products from America as a result of likely infection with *T. spiralis*. Germany was facing the *T. spiralis* infection due to its entrenched habit of consuming raw or slightly cooked pork, whereas Americans preferred cooked pork. The Imperial German Government, during the 1880s, instead of directing its citizens to cook its pork, attempted to guarantee that the pork sold in Germany was *T. spiralis* free. Several courses of action to ward off *T. spiralis* were suggested. But the German Government adopted microscopic inspection as the best method since it was scientific and did not require mass public re-education (Hoy & Nugent, 1989). Germany had devised a stringent sanitary test for its domestic producers, and the same strict test had to be passed by the imported pork products as well. It trained nearly 18,581 full-time inspectors in the use of a microscope and microscopic inspection to identify the presence of *T. spiralis* in pork, hog and pork products (Chalecki, 2008). During the 1880s, handbooks explaining how to use a microscope, what to look for, how to focus & clean, etc. were transcribed and circulated amongst inspectors (Hoy & Nugent, 1989). America, on the other hand, had no such elaborate arrangements to check the pork products exported. There were no federal inspection laws that existed in the United States. The inspection and supervision of meatpackers in America was very casual since the packing houses were booming industries employing more people and becoming a capitalistic structure.

The ban created a diplomatic challenge between the two countries, with both the countries contesting each other's policy. Both the countries agreed that *T. spiralis* was an unwanted toxin in the meat. However, the scientific approach to detect the parasite was the difference that drove their foreign policies respectively, thereby the point of contention in the issue of pork import (Chalecki, 2008). Germany categorically communicated that the prohibition was a necessary public health issue. However, Americans questioned the ban and claimed that their pork and pork products were safe. They further contended that the ban was to protect and appease the German agricultural interest. The U.S. Minister to Berlin as well as newspapers were sceptical and advocated trade retaliations. The entire episode was a full-blown diplomatic issue with charges and counter-charges.

Germany, with its well established modern microscopy and scientific methods, had great optimism in the microscopic approach that reflected their recognition of the germ theory of disease (Chalecki, 2008). Meanwhile, scientists from Amerca were beginning to catch up with the scientific knowledge of Europe. Within the American scientific establishment, there was a division of opinion on the sort of microscopic inspection to be conducted on the meat bound for export. American expats in Germany mounted diplomatic pressure. But the German Government was unfazed and stood its ground, stating that the Government could not lift the import ban unless domestic producers adopted the same stringent sanitary test.

During the 1890s, science communication by the American science community pushed the foreign policy of U.S. and forced Congress to pass two laws that required pork to be microscopically examined for trichinea. With the passing of the law, the German Government lifted the ban promptly with American agreement of their demand for microscopic examination. The U.S.–German Pork war was a typical example of scientific communication fostering harmonization of foreign policy that advocated the use of microscopy as against retaliatory sanctions, thereby saving millions in earnings.

Case 2: Vaccine Diplomacy – the case of U.S. Russia during 1957

United States of America and Russia, erstwhile Soviet Union, were engaged in a bitter cold war post-World War-II. The two superpowers and their allies tried to dominate each other and the world using their social, political and military dominance. This dominance was carried out not directly but through indirect means such as espionage, psychological warfare, the space race, propaganda campaigns, nuclear arsenal, etc. The cold war's span is generally accepted to be between the 1947 Truman Doctrine to 1991 dissolution of the Soviet Union. The undercurrent goal of U.S. foreign policy during the late 1940s was to contain Soviet power (Sempa, 2002).

Though the cold war was a historical period of mistrust and competition amongst the United States and the Soviet Union, both the countries faced a common enemy – poliomyelitis shortly called 'polio'. Poliovirus spread through the faecal matter since the 1930s, causing paralysis in children and young adults. Medical breakthrough was achieved in America with the research work of two virologists Jonas E. Salk and Albert B. Sabin. Both the vaccines developed were valid, but approaches were different. The vaccine developed by Salk had polioviruses inactivated using chemical formalin. The Salk vaccine was injectable and was tested on two million schoolchildren across the U.S. in 1955. The vaccine was the first to receive U.S. government approval after successful tests. The vaccine developed by Sabin had weakened active poliovirus that was expected to generate lifelong immunity. With the Salk vaccine already in use, Sabin was unable to test his vaccine on millions of samples.

The Soviet Union, on the other hand, was reeling with the polio epidemic. However, the authorities under the dictatorship of Joseph Stalin denied that polio was a problem. With the demise of Joseph Stalin in 1953, the next successor was less rigid and was ready to seek help outside the boundaries of the Soviet block to control the fast-spreading epidemic (Swanson, 2012). In January 1956, amid the cold war, the Soviet Union and U.S. State Department both cautiously agreed for opening up communication channels between the Soviet virologists, Anatoli

Smorodintsev, Mikhail Chumakov and Chumakov's wife to deliberate with several American virologists, including Sabin and Salk (Hotez, 2017). The Soviet scientists visited the U.S.; however, the visit had imprints of the cold war. For example, the Russian scientists were not allowed to travel by air; instead, they were required to navigate the country by rail. Similarly, the Americans believed that at least one of the doctors accompanying the team was a KGB undercover agent (Swanson, 2012).

Despite the challenging situation between the two countries, the communication between both the scientific communities generated a great deal of knowledge, especially between Chumakov and Sabin. In June 1956, Sabin, though under the watchful eyes of FBI, flew to the Soviet Union to interact with Chumakov, Smorodintsev and other researchers. Sabin developed valuable professional as well as close relations with Russian hosts particularly Chumakov. The scientific collaboration during the cold war was very fruitful, and within two years, Sabin's poliovirus strains arrived in the Soviet Union. The polio vaccine was further manufactured in large scale in Chumakov's laboratory (Hotez, 2017). In 1959, Chumakov tested the oral polio vaccine that was administered to nearly 10 million children throughout the Soviet Union. With this success, the vaccination was scaled up and everybody below the age of 20, i.e. almost 100 million people, were provided the vaccine in the next few months. Within a year, extensive testing of the vaccine required Chumakov to go directly to the Kremlin leadership bypassing the Health Department. The World Health Organization (WHO) recognised the vaccine's safety and a substantial drop in paralytic cases. In 1972, Sabin donated his poliovirus strain to the WHO, making the vaccine available across the globe, especially the most impoverished countries (Swanson, 2012).

This scientific communication and cooperation between the U.S. and Russia during the cold war period illustrated the dual role of refining both international relations as well as scientific associations. The approach provides learning for promoting communication and cooperative humanitarian efforts while concurrently creating lifesaving vaccines (Hotez, 2017).

Case 3: Health Diplomacy – the case of Colistin antibiotic

Antibiotics are medications that either stop bacterial infections from reproducing or destroy them and save lives when given appropriately (Felman, 2019). Discovery of penicillin, an antibiotic, revolutionised medical history in the 20^{th} Century, which was followed by many discoveries that have increased the effectiveness and easy access to antibiotics, making it a generic drug. Modern-day medicinal achievements such as surgery, transplantations, chemotherapy, etc. would not have been possible without effective treatment of bacterial infection. However, the high rate of antibiotic use in hospitals, agriculture, and community has considerably contributed to the development of antibiotic-resistant strains (Laxminarayan , *et al.*, 2013).

In the medical field, doctors resort to colistin, an antibiotic, when all other antibiotics fail. Primarily, it is increasingly used to treat intensive care patients with severe multi-drug resistant gram-negative bacterial infection (Srivastava, 2014). However, in an emerging problem, researchers across different countries had started reporting new cases of bacterial infections which display colistin resistance. In one such research collaboration, scientists from UK-China had identified that *E. coli*, found in pigs and which could no longer be killed by colistin, had a new gene "mobile colistin-resistant 1" (MCR-1). The new gene, which carries a small piece of DNA in the bacteria called a plasmid, could replicate itself inside the bacteria and make copies that could be passed from one *E. coli* to another (D'Silva & Webster, 2017). The UK-China research work found that colistin was used as animal feed in China. They also suggested that there was a possibility of the plasmid carrying resistance spreading from farms to people. As soon as this discovery was announced, many laboratories in different countries started examining their bacteria collected from humans, food and animals and discovered that MCR-1 gene was present in Europe, Asia, North America and Africa (D'Silva & Webster, 2017).

Following the discovery in November 2015, the UK-China research team started communicating with the Chinese Government highlighting the impact and risk of MCR-1. With persistent efforts and a positive attitude toward the public good, the Chinese Government acted immediately. Within one year, the Chinese Ministry of Agriculture sanctioned a ban on 'usage of antibiotic colistin as an animal feed additive in China' (Medical Research Council, 2016). The scientific discovery and the science behind the use of colistin and its effective communication were instrumental in policy formulation in China that contained the possible adverse effect in the future.

Conclusion

A look back at the cases

Having studied the three cases pertaining to the role of science communication in enabling science-driven policy-shaping in international relations, we can conclude that the scientific epistemic community is indispensable for governments while responding to scientific matters, thereby strengthening the role of science diplomacy. The science in diplomacy is further classified as science directing foreign relations (U.S.–Germany pork war); Science enabling strained international relations (Polio vaccine during U.S.–Russia cold war); and science advising policy-making (China banning colistin in animal feed).

In the case of the pork war between U.S. & Germany, the U.S. government could have gone in for retaliatory sanctions and other diplomatic manoeuvres as suggested by many American diplomats, newspapers and others who had taken a non-scientific recourse. Similarly, Germany could have relaxed its scientific posture. However, reliance on science by Germany and scientific communication by the U.S. agricultural scientific community was responsible for negotiating two laws passed by the Congress mandating microscopic examination of pork exported – a clear case of 'science directing foreign policy'.

The vaccine diplomacy case demonstrated the subtle role of scientific communications in international relations during estranged relations. In the case of the polio vaccine, the U.S. and Russia had kept aside their geopolitical differences and opened communication channels between their scientists to develop and deliver a vaccine that later was responsible for the eradication of polio globally.

The third case highlights the prudent role of scientists and their persistent communication with the policy makers. The scientific communication sought a ban on colistin, a lifesaving antibiotic, which was being used as animal feed thereby causing the development of colistin-resistant bacteria in animals and later transmitted to humans as well. The international collaboration between the U.K. and China scientists negotiated with the Chinese Government to impose a ban which the Chinese Government immediately accepted.

As evident from the cases, science and its communication has been objective and fact-based playing a unifying role in international relationships. The three cases that have elaborated the role of science communication in action during health emergencies have also highlighted the independent and nonpartisan role of science and scientists in directing and enabling foreign relations and also advising policy formulation, respectively. Berkman (2018), for example, stresses on the autonomous character of science and scientists: '*Science is a neutral platform that allows for less politically charged dialogues, which in turn create bridges that help overall diplomatic efforts'* (Berkman, 2018).

Science communication, its diplomacy and COVID-19

The three cases illustrated show the potential of science in addressing the humanitarian causes of the epidemic. The cases particularly highlight the role of communication in health diplomacy and vaccine diplomacy with a focus on the role of science and scientists as an agent of international relations. With the vaccine development in full steam, and the latest development in technology as well as geopolitical issues, two sets of challenges, concerning foreign affairs, can be deduced looking at the current scenario.

The first is related to communication of scientific research work relating to sharing of data, methods and results in an open science approach enabling usefulness of knowledge on virus linked with the socio-political aspect of the COVID-19 pandemic. Some strategies have already been initiated. For example, the U.S. National Center for Biotechnology Information maintains a DNA database with gene sequences; data and codes are openly available. CORD-19 datasets, literature tracker-LitCovid, etc. are readily accessible for the research community. bioRxiv and medRxiv are platforms through which non-peer-reviewed results are shared with the research community (Mayer, 2020). Further, to overcome this international challenge, Katja Mayer (2020) suggests 'Open Science Diplomacy' as a communication tool that provides a robust legal and governance framework for sharing of data & methods, and also the necessary infrastructure for those exchanges. The World Health Organization has the bandwidth and mandate to implement these kinds of programs.

The second set of the diplomatic challenge faced during the development of COVID-19 vaccine relates to speed of vaccine development, cost of the vaccine, global reach, anti-hoarding of vaccines, etc. that requires a policy decision as well as planning for large-scale production as well as distribution. For this, the communication channel of diplomats, scientists, and policy makers has to be streamlined and synchronised with foreign counterparts for effective collaboration and development of the vaccine as a global public good. Some COVID-19 communication channels involving India in this direction have already been initiated. For example, U.S. Secretary of State Mr. Mike Pompeo has informed that 'U.S. and India are collaborating to develop vaccines against the coronavirus' (Biswas, 2020). The strategic communication between U.S. and India has enabled a U.S. pharma firm Gilead signing agreement with five generic drug manufacturing companies in India to manufacture and supply the drug remdesivir targeting 127 countries for treating COVID-19 (BBC, 2020). Similarly, scientific collaboration between India and Taiwan is also in the pipeline with Taiwan proposing to set up a regular communication channel with India enabling linkage between the two medical agencies (Krishnan, 2020). As illustrated in the cases, the engagement of science diplomacy shall provide a neutral venue for diplomatic negotiations, thereby emerging as a better alternative to the hard diplomatic manoeuvres.

With the evolution of technology and global competition and advancing broader national interests, many countries have now started to believe in the strength of science and its communication as a soft power as a tool for persuasion and attraction that can provide a competitive edge in their arsenal of international relations. Further, with the emergence of the role of science communication as a strategic tool in science diplomacy, many countries have started placing their science advisors in foreign ministries or embedding science and technology units within departments (Gluckman, Turekian, Grimes, & Kishi, 2017). During the COVID-19 pandemic, it will be prudent for the science diplomats, advisors as well as scientists to be activated and engaged unanimously for the development, testing and delivery of COVID-19 vaccine as a global public good, thereby fostering COVID-19 diplomacy.

Finally, it may be noted that the autonomous roles of science and scientists are developed at the intersection of STI policy and foreign policy with the complex interplay of many actors such as Governments, R&D institutions (including scientists), academia (Fahnrich, 2017) that require a communication channel embedded in an 'Open Science Diplomacy framework' as a model for next-generation science diplomacy, with adequate legal structures to overcome global challenges. The open science diplomacy framework will enable a communication network to address a global pandemic, like COVID-19, that requires establishing a global communication channel with strong interlinkage of science as a tool for global health diplomacy engaging trans-border scientific collaborations.

References

BBC (2020). Remdesivir: Five Indian and Pakistani firms to make drug to 'fight coronavirus'. [Online] Available at: https://www.bbc.com/news/world-asia-india-52659052 [Accessed 20 May 2020].

Berkman P A (2018). Could science diplomacy be the key to stabilizing international relations? [Online] Available at: https://theconversation.com/could-science-diplomacy-be-the-key-to-stabilizing-international-relations-87836 [Accessed 25 May 2020].

Biswas S (2020). Coronavirus: How India will play a major role in a Covid-19 vaccine. [Online] Available at: https://www.bbc.com/news/world-asia-india-52363791 [Accessed 13 May 2020].

Callaway E (2020). The race for coronavirus vaccines: a graphical guide. *Nature,* 28 April, Volume 580(7805), pp. 576-577.

Chalecki E L (2008). Knowledge in Sheep's Clothing: How Science Informs American Diplomacy. *Diplomacy & Statecraft,* pp. 1-19.

D'Silva J & Webster J (2017). The Meat Crisis: Developing More Sustainable and Ethical Production and Consumption. s.l.:Routledge, Taylor & Francis Group.

Fahnrich B (2017). Science diplomacy: Investigating the perspective of scholars on politics-science collaboratiaon in international affairs. *Public understanding of science,* Volume Vol. 26(6), pp. 688-703.

Felman A (2019). What to know about antibiotics. [Online] Available at: https://www.medicalnewstoday.com/articles/10278#what-are-antibiotics [Accessed 2 May 2020].

Flink T & Schreiterer U (2010). Science diplomacy at the intersection of S&T policies and foreign affairs: toward a typology of national approaches. *Science and Public Policy,* November, Volume 37(9), pp. 665-677.

Gluckman P D, Turekian V C, Grimes R W & Kishi T (2017). Science Diplomacy: A Pragmatic Perspective from the Inside. *Science & Diplomacy, Vol. 6, No. 4.*

Hotez, P. J., 2014. "Vaccine Diplomacy": Historical Perspectives and Future Directions. *PLoS Neglected Tropical Diseases,* 26 June.Volume 8(6).

Hotez P J (2017). Russian-United States vaccine science diplomacy: Preserving the legacy. *PLoS Neglected Tropical Disease,* Issue 11(5), pp. 1-4.

Hoy S & Nugent W (1989). Public Health Or Protectionism? The German-American Pork War, 1880-1891. *Bulletin of the History of Medicine,* pp. 198-224.

Kaltofen C & Acuto M (2018). Science Diplomacy: Introduction to a Boundary. *Global Policy,* November, Volume 9(Supplement 3), pp. 8-14.

Krishnan A (2020). Coronavirus | Taiwan is eager to work with India to fight the COVID-19 pandemic, says Foreign Minister Joseph Wu. [Online] Available at: https://www.thehindu.com/news/international/coronavirus-taiwan-is-eager-to-work-with-india-to-fight-the-covid-19-pandemic-says-foreign-minister-joseph-wu/article31577577.ece [Accessed 24 May 2020].

Laxminarayan R *et al.* (2013). Antibiotic Resistance—the Need for Global Solutions. *The Lancet Infectious Diseases,* 13(12), pp. 1057-1098.

Leach J (2015). The Role of Science Communication in International Diplomacy. In: *Science Diplomacy.* s.l.:world Scientific, pp. 155-169.

Mayer K (2020). Open Science Diplomacy to tackle the COVID-19 pandemic. [Online] Available at: https://www.s4d4c.eu/open-science-diplomacy-to-tackle-the-covid-19-pandemic/ [Accessed 24 May 2020].

Medical Research Council (2016). UK-China collaboration informs animal feed antibiotic ban. [Online] Available at: https://mrc.ukri.org/news/browse/uk-china-collaboration-informs-animal-feed-antibiotic-ban/ [Accessed 13 May 2020].

Nye J (2011). Soft Power. 2nd Edition ed. New York: Public Affairs.

Pugwash, n.d. *Pugwash Conferences on Science and World Affairs - History.* [Online] Available at: https://pugwash.org/history/[Accessed 12 May 2020].

Roper R L & Rehm K E (2009). SARS vaccines: where are we?. *Expert Rev Vaccines,* 8(7), pp. 887-898.

Royal Society of London (2010). New Frontiers in Science Diplomacy: Navigating the changing balance of power, s.l.: American Association for the Advancement of Science (AAAS) and the Royal Society of London.

Sempa F P (2002). Geopolitics: From the Cold War to the 21st Century. New Jersey: Transaction Publishers, New Brunswick.

Siddhartha V (2019). A new lexicon of science diplomacy. [Online] Available at: http://www.fisd.in/sites/default/files/FISD%20Case%20Study_Fnl-min.pdf

Srivastava R (2014). New worry: Resistance to 'last antibiotic' surfaces in India. [Online] Available at: https://timesofindia.indiatimes.com/city/pune/New-worry-Resistance-to-last-antibiotic-surfaces-in-India/articleshow/45664238.cms[Accessed 3 May 2020].

Swanson W (2012). Birth of a cold war vaccine. *Scientific American*, April, 306(4), pp. 66-69.

Trichinosis, n.d. *Trichinosis.* [Online] Available at: https://www.mayoclinic.org/diseases-conditions/trichinosis/symptoms-causes/syc-20378583 [Accessed 23 May 2020].

Turekian V C *et al.* (2015). The Emergence of Science Diplomacy. In: *Science Diplomacy New Day or False Dawn.* Singapore: World Scientific Publishing Co. Pte. Ltd., pp. 3-24.

World Health Organization (a) (2015). World Health Organization. [Online] Available at: https://www.who.int/medicines/ebola-treatment/WHO-list-of-top-emerging-diseases/en/ [Accessed 20 April 2020].

World Health Organization (b) (2020). World Health Organization. [Online] Available at: https://www.who.int/ith/diseases/sars/en/[Accessed 13 April 2020].

Worldometer (2020). Worldometer. [Online] Available at: https://covid19.who.int/ [Accessed 21 October 2020].