Editorial

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Will the COVID-19 Pandemic have a Silver Lining? An Indian Perspective

Immunology and Infectious Diseases Section

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The current COVID-19 (***Co***rona***vi***rus ***D***isease-2019) pandemic is caused by the Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2). The first coronavirus to infect humans was SARS-CoV-1 which was discovered in China in 2002. This was followed by five other human-specific coronaviruses, namely, MERS-CoV, OC43, HKU1, 229E, and NL63. The present SARS-CoV-2 is the seventh coronavirus to infect humans. While SARS-CoV-1, MERS-CoV and SARS-CoV-2 produce severe symptoms, the others produce relatively milder symptoms. Although coronavirus outbreaks have occurred many times in the past, none of them were of the magnitude as the present COVID-19 pandemic. In fact, this is the first pandemic to be spread by a coronavirus.

MAJOR GLOBAL CALAMITIES AND THEIR POSITIVE MEDICAL CONSEQUENCES

There have been many instances of pandemics since recorded history that have decimated vast populations across the globe. Besides pandemics caused by microbes, many man-made calamities have also occurred many times since pre-biblical times. Although these have largely brought death and destruction to mankind, in many instances, they have also positively impacted the medical field, which have led to major advancements in the medical sciences. A snapshot of a few of these global calamities are discussed below, in order to better understand the potential positive medical consequences that may arise from the current COVID-19 pandemic.

Black Death and Initiation of Social Distancing and Quarantine Practices [1,2]

The Black Death was the most devastating pandemic in human history, which killed a staggering 75-200 million people in Eurasia and North Africa. In Europe alone, the disease killed 30-60% of the population. This deadly bubonic plague was caused by the bacterium *Yersinia pestis* and most probably was spread by fleas living on black rats. The disease peaked in Europe between 1347 and 1351 AD. Although the doctors at that time had no notion of viruses and bacteria, they had a fair idea of how to contain the disease by means of the world's first public health measures. An important component of these measures was social distancing and quarantining, which were based on their remarkable understanding of the incubation period of the causative bacterium.

Battle of Solferino and the Establishment of the 'Red Cross' [3]

The history of 'First Aid' dates back to pre-biblical times. First Aid activities have been mentioned in the medical texts of various civilizations throughout history, particularly with reference to injuries sustained during warfare. In the modern era, the concept of First Aid originated exactly 161 years ago, when a battle in northern Italy known as the Battle of Solferino took place. During this battle there were immense casualties. On 24 June 1859, a young businessman from Geneva named Henry Durant was horrified by the suffering he saw. He immediately organised help for taking care of the injured, procured necessary medical supplies, and set up makeshift hospitals. He described this incident in his book entitled *'A Memory of Solferino'*, which inspired the establishment of the *International Committee of the Red Cross (ICRC)* in 1863. This is how the *'Red Cross'* came into existence. Subsequently, in 1919 the *International Federation of Red Cross and Red Crescent Societies (IFRC)* was established, which has been serving humanity for over a century now.

World War I and Introduction of Blood Donation and Development of Orthopaedic Splints [4,5]

World War I, also known as First World War or Great War, was a global war that originated in Europe and then spread across the world. It spanned over a period of four years (1914-1918). It was one of the largest wars in history, involving over 70 million military personnel, including 60 million European troops. World War I was one of the deadliest wars ever fought that claimed over 16 million lives. The wounds inflicted on soldiers were very gruesome. Since blood was essential for sustaining the lives of these soldiers, the practice of donating and giving blood was initiated during World War I. The idea of collecting and stockpiling human blood was conceived by Captain Oswald Robertson, who was an US Army doctor. Robertson set up the world's first blood bank on the Western Front in 1917 and was the first to use sodium citrate as an anticoagulant agent to prevent the blood from clotting and becoming unusable. Another important medical innovation was the *'Thomas splint'*, which is a special rod that is used for supporting a broken leg. At the start of the war in 1914, 4 out of 5 soldiers with a broken femur died. Astonishingly, by 1916, 4 out of 5 soldiers survived, thanks to the Thomas splint. Another important medical advancement during World War I was the use of ambulances driven by volunteer drivers who went out into the battlefield to pick-up the wounded.

World War II and Development of Antibiotics and Novel Orthopaedic Procedures [6,7]

World War II, also known as Second World War, affected virtually every part of the globe and spanned from 1939 to 1945. World War II claimed between 40 and 50 million lives, making it the largest and bloodiest war in history. During the war, several advancements in medicine were made. For example, the use of antibiotics expanded significantly during the war and helped to successfully treat wound infections. Notable antibiotics were sulphonamides, discovered in 1935 and penicillin, developed in 1939. These have led to the development of many other classes of antibiotics that continue to benefit humanity. Another major medical advancement during World War II was in the area of orthopaedics. German doctors had developed metal plates for healing fractures, which was much faster

than conventional methods. The use of metal plates and joints is now very common in orthopaedic surgery.

POSITIVE HEALTH AND ENVIRONMENTAL IMPACTS OF THE COVID-19 PANDEMIC

The COVID-19 pandemic and its associated lockdown could have significant positive impact on several diseases, Indian health infrastructure, as well as air and water pollution, among others. These are briefly discussed below.

Tuberculosis

Tuberculosis (TB) is the world's leading cause of death from an infectious agent. In India also, it is the biggest health problem. This is compounded by the fact that totally drug-resistant TB (TDR-TB) has recently emerged, which is unresponsive to any of the existing anti-TB drugs, namely, rifampicin, isoniazid, ethambutol, and pyrazinamide. This is over and above the already existing problems associated with the presence of multi-drug-resistant TB (MDR-TB) and extensively drug-resistant TB (XDR-TB). The magnitude of the problem in India is evident from the data available from the World Health Organisation (WHO) [Table/Fig-1] [8]. The enormity of this health issue is also reflected by the huge annual budget allocated solely for tackling TB. For example, the National TB Budget for 2019 was a staggering USD 583 million, of which 77% of the funds came from domestic sources and 23% from international sources.

Estimated TB burden (2018)	Number	Rate (per 100,000 population)
Total TB incidence	2.69 million	199
HIV-positive TB incidence	92,000	6.8
MDR/RR-TB incidence	130,000	9.6
HIV-negative TB mortality	440,000	32
HIV-positive TB mortality	9,700	0.72

[Table/Fig-1]: Estimated burden of TB in India in 2018 [8].
HIV: Human immunodeficiency virus; MDR/RR: Multi-drug-resistant/Rifampicin-resistant

In order to tackle the TB menace in India, the Government of India launched the *Revised National TB Control Programme (RNTCP)* in 1997, which has since made major headway in TB control in the country. The RNTCP's *National Strategic Plan for TB Elimination 2017-2025 (NSP)* aims to eliminate TB from India by 2025. The NSP is based on four basic strategic pillars, namely, *'Detect-Treat-Prevent-Build' (DTPB)*. Another initiative of the RNTCP is *'Nikshay'*, which is a case-based web-based TB surveillance system. Since its implementation, over 4 million patients across India have registered in *'Nikshay'* [9].

Although TB may affect various organs of the body, the most common type is pulmonary TB, in which the lungs become infected by *Mycobacterium tuberculosis*. Pulmonary TB is spread by droplet transmission through coughing and sneezing. Therefore, it is recommended that both TB patients and health professionals treating these patients should wear masks. However, in India, only 10% of healthcare workers wear N95 masks, which are most effective against droplet transmission [10]. Unfortunately, no data on the use of masks by patients is currently available. Since the practice of wearing face masks is being enforced across the world due to the ongoing COVID-19 pandemic, people are becoming more aware of its importance. This could result in people becoming habituated to wearing face masks in the future.

Malaria

Malaria is caused by *Plasmodium vivax* and *P. falciparum*, both of which are intracellular parasites, which produce severe life-threatening disease. Female *Anopheles* mosquitoes are responsible for spreading malaria. As per the statistics published for 2018, malaria was responsible for 228 million cases and 405,000 deaths globally [11]. As per the *World Malaria Report 2019* [12], in 2018, India and 19 countries in sub-Saharan Africa carried 85% of the global malaria burden. Interestingly, the WHO South-East Asian Region carries the highest burden of *P. vivax* malaria, accounting for 53% of all cases worldwide. Of these cases, the majority (47%) are from India alone. Importantly, the lion's share of all global malaria deaths (85%) in 2018 were from India and 20 countries from the WHO African Region. It is encouraging to note that in India, there was a reduction of 2.6 million malaria cases in 2018, compared to 2017. India in one of 11 countries belonging to the group of High Burden to High Impact (HBHI) countries. In this regard, it should be noted that all of the HBHI countries contributed miniscule amounts towards malaria control from domestic funds, compared to international funding. In this regard, it is heartening to know that India is the only exception, which has contributed substantially from domestic funds towards controlling malaria in the country.

With reference to malaria treatment, although chloroquine has largely become resistant against *P. falciparum* [11], it still exhibits high efficacy against *P. vivax* [12]. Besides chloroquine, its analogue, hydroxychloroquine is also recommended for the prevention or treatment of malaria [13]. Both these drugs are being evaluated by WHO in its *'Solidarity Trial'*, along with three other drugs, namely, (i) Remdesivir (antiviral drug used to treat Ebola virus disease), (ii) Lopinavir/Ritonavir (HIV type 1 aspartate protease inhibitors used to treat AIDS), and (iii) Interferon β-1a (a cytokine in the interferon family used to treat multiple sclerosis). The *'Solidarity Trial'* will compare these four treatment options against standard of care, to assess their relative effectiveness in treating COVID-19. This will be a very large, randomised, multinational trial, involving numerous hospitals in over 90 countries (as of 8 April 2020), which will reduce the time taken by 80% compared to standard clinical trials [14].

Helminthiasis

Helminthiasis is an intestinal parasitic disease caused by worm or helminth infestation. Helminths constitute a broad range of organisms that include roundworms, hookworms and whipworms. Infected individuals excrete the helminth eggs in the faeces that contaminate the soil in regions where there is poor sanitation. Other people can become infected by ingesting the helminth eggs through contaminated food. Therefore, the major mode of transmission is through the feco-oral route. Helminthiasis can cause serious complications and sometimes, even death [15]. Over 1.5 billion people, or 24% of the global population are infected by Soil-Transmitted Helminths (STH). Over 267 million preschool-age children and over 568 million school-age children live in areas of the globe where helminthiasis is highly prevalent [16].

The primary preventive measure for tackling helminthiasis is through the implementation of *WASH (Water, Sanitation and Hygiene)* strategies [17]. Four trials involving WASH interventions have been conducted in India so far. These were carried out in Tamil Nadu, Odisha, and Madhya Pradesh. Two of these trials were part of the *'Total Sanitation Campaign'* initiated by the Government of India. All four trials showed benefits in households that adopted WASH strategies [18]. A systematic review and meta-analysis also found that overall STH infections were significantly reduced by implementation of WASH interventions [19]. Based on these studies, it is encouraging to note that hand hygiene plays an instrumental role in reducing the transmission of helminthiasis. Therefore, the practice of frequent handwashing with soap and water that is being advocated by WHO and other health organisations to prevent SARS-CoV-2 transmission will sensitise people around the world to follow stringent hand hygiene practices, even after the COVID-19 pandemic abates.

Health Infrastructure

Over the past few months, there have been dramatic inputs - both financial and logistical - in the public sector and healthcare system. The looming COVID-19 catastrophe has cut all red-tapism and the decisions taken by the Indian government have been quick and

based on sound scientific evidence, provided by leading Indian medical experts and scientists. This type of accelerated decision-making process is very unlike what is normally observed. The financial impetus given to healthcare in such a short period of time has been remarkable and probably unlike any previous attempts. Doctors, nurses and other paramedical staff at different levels, whether in mainstream modern allopathic medicine or traditional systems of medicine under the umbrella of AYUSH (Ayurvedic, Yoga and Naturopathy, Unani, Siddha, and Homeopathy) have had a steep learning curve on infection control within a matter of a couple of months. This is something which otherwise would have taken many years to achieve, through innumerable workshops, short courses and CMEs. Infections, particularly nosocomial or Hospital-Acquired Infections (HAI) have been one of the most serious concerns in healthcare in this country. High infection rates has led to high antibiotic usage, which has encouraged the emergence of multidrug resistant pathogens. Simple practices, such as frequent handwashing have been repeatedly shown to be pivotal in decreasing nosocomial infections. If these continue to be followed regularly by all hospital staff, it is bound to reduce hospital infection rates. If the enthusiastic use of hand sanitizers and frequent handwashing become a culture within the society, the benefits will be reaped by generations to come.

The authors are aware of many district hospitals which did not have ventilators or isolation rooms. Now, many have ventilators and staff is also being quickly trained and isolation rooms are being set up in all healthcare facilities across the country. One may argue that this is all temporary and it cannot change the mindset of people, nor can health professionals be trained overnight to ventilate sick patients. Indeed, some of this may be lost once the fear of COVID-19 lessens. However, what proportion of change that still lingers, will itself remain a valuable asset for the healthcare system. The authors feel confident that if this change happens, it could take our healthcare system forward by almost a decade.

Air Pollution

Air pollution in India poses a major threat to health and wellbeing. India is home to 21 out of 30 most polluted cities in the world, with Ghaziabad topping the list in 2019 [20]. The major sources of air pollution in India is presented in [Table/Fig-2] [21].

Source	Percent contribution
Dust and construction	45%
Waste burning	17%
Transport	14%
Diesel generator	9%
Industries	8%
Domestic cooking	7%

[Table/Fig-2]: Major sources of air pollution in India [21].

There have been several initiatives by the Government of India to check the rapid increase in air pollution in the country. One of these is the *Air (Prevention and Control of Pollution) Act (1981)*. Others include the development of the *National Air Quality Index* in collaboration with IIT Kanpur in 2015 [22], and the launching of the *National Clean Air Programme (NCAP)* in 2019, with a target of reducing PM2.5 and PM10 by 20-30% by 2024 [23]. Also, in 2019, IIT Bombay and the James McKelvey School of Engineering, Washington University in St. Louis jointly launched the *Aerosol and Air Quality Research Shared Facility* in Mumbai, to study air pollution in India [24].

Taking New Delhi as an example, the average particulate matter of less than 2.5-micron diameter (PM2.5) for the years 2017, 2018 and 2019 were 108.2, 113.5 and 98.6 respectively [20]. The minimum and maximum PM2.5 values for New Delhi over the past month has been presented in [Table/Fig-3].

Average PM2.5 for New Delhi		
Duration	Minimum	Maximum
Past 1 month	20	106
Past 1 week	7	114
Past 1 day	0	168

[Table/Fig-3]: Average PM2.5 levels in New Delhi between 21st March and 21st April, 2020 [25].

From the above table, it is clearly evident that although some variability in the maximum PM2.5 value is present, the minimum PM2.5 value has progressively decreased over the past month, which became 'zero' on 21st April, 2020. This directly correlates with the lockdown period, which began on 21th March 2020. Therefore, the lockdown in India, which is the largest in world history, has had a dramatic positive impact on the quality of air that we breathe.

Water Pollution

Water pollution, much like air pollution, is also a major environmental issue in India. The major sources of water pollution in India are disposal of untreated sewage and discharge of toxic effluents from chemical industries into surface water bodies, especially rivers [26]. Similar to air pollution, Delhi is again taken as an example to study the quality of water in the river Yamuna. This data is available from the Water Quality Database, under the National Water Quality Monitoring Programme (NWMP), Ministry of Environment and Forests, Government of India [27]. The latest data on water pollution levels in the river Yamuna, shows that it was heavily contaminated at all four sampling points in Delhi in 2016, with the Yamuna at Okhla being the most polluted. The Yamuna had dissolved oxygen levels of just 0.1-1.6 mg/L (min-max), where the standard for good quality water is >4 mg/L of dissolved oxygen. Moreover, the contamination of the Yamuna at Okhla by coliform bacteria, present in faecal matter, was just as appalling. Whereas the safety limit for total coliform bacteria is <5,000 MPN*/100 mL, the total level of coliforms at Okhla was a staggering 160 million MPN*/100 mL (*MPN: Most Probable Number) [28].

Following the lockdown, which began on 21th March 2020, water samples have been collected from the Yamuna at Delhi and are currently being analysed in the lab [29]. In the meantime, while waiting for the lab results, it is very encouraging to note that already there has been a significant visible improvement in the water quality of the Yamuna at Delhi, India [30].

Spitting Ban [31]

The Ministry of Home Affairs (MHA), Government of India has banned spitting in public places under Section 51 (b) of the Disaster Management Act (2005). This was announced by the MHA during the second phase of the lockdown, in a bid to prevent the transmission of COVID-19. Spitting in public places will now be a punishable offence with a fine. In this regard, the Brihanmumbai Municipal Corporation (BMC) has already imposed a fine of Rs. 1,000 if anyone is caught spitting in public. This spitting ban is likely to bring about behavioural changes among the general public, which could have a lasting impact, long after the COVID-19 pandemic is over.

CONCLUSION(S)

From the foregoing discussion, it is clearly evident that history has taught us much about the positive impacts that global calamities can have on society, despite the trail of death and destruction that they leave behind in their wake. Importantly, the current COVID-19 pandemic is nothing short of a global calamity that is having catastrophic consequences for mankind. Nevertheless, there is still a ray of hope as it is well known that 'history repeats itself'. Therefore, this global catastrophe might also leave behind a legacy that could have some positive impact on human society in the years to come.

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