Novel coronavirus disease (COVID-19): Emergence, early infection rate, and deployment strategies for preventive solutions

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1 Introduction

Novel coronavirus marked as coronavirus disease 19 (COVID-19) first showed its symptoms in Wuhan, China, and got identified in December 2019 (Zhou et al., 2020). The Republic of China was the first to report to the World Health Organization (WHO) that from December 31, 2019 to January 3, 2020, 44 cases of pneumonia with some unknown etiologies have been registered in different hospitals (Tandon, 2020). On January 7, 2020, the virus was first identified, and the scientists found it as coronavirus having 95% similar homology with the bats (Singhal, 2020). The International Committee on Taxonomy of Virus (ICTV) called it severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and found it similar to severe acute respiratory syndrome (SARS). SARS-CoV-2 has spread quickly throughout the world and caused serious concern about this disease. As it is a newly emerged virus, during the first wave, there was no known medicine or vaccine to treat the disease. However, every possible effort is being applied with all the available facilities and knowledge to safeguard people from this emerging infectious disease.

It has been found that the virus can cause common colds, coughs, breathing difficulties, and loss of taste and smell. At the very beginning, one-sixth

of individuals infected by novel coronavirus developed breathing difficulty and become extremely infected. People having severe diseases like diabetes, heart disease, blood pressure, and blood cancer are found more probability of severe condition. World Health Organization recommended some precautionary measures to stop the spreading of COVID-19 like; wash hands frequently, wear a face mask, avoid contact with sick people, practice good hygiene, and maintain social distance. Simultaneously, various drugs and other remedial therapies and foods (used for other similar kinds of diseases) have been applied to reduce the severity. Researchers around the globe immediately started an investigation to develop new and effective treatment methods and vaccines to overcome this deadly challenge.

Studies on past pandemics exhibited large-scale outbreaks over a wide geographical area and caused morbidity and mortality, and significantly disrupted economic, political, and social well-being. It is also observed in the current COVID-19 pandemic; the effect has created a worldwide devastating situation. This study focuses on the historical perspective of novel coronavirus, transmissibility, and incubation period, spreading behavior of COVID-19 by principal component analysis (PCA), various awareness and preventive measures, and potential application of allopathic therapy, dietary remedy, and herbal medicines to fight against the COVID-19 virus mainly during the first wave and until the development of the vaccine. This chapter can be used as an edifying approach for forestalling and strategy making against any COVID-19 like pandemics in the ensuing times.

2 Various epidemics and pandemics in the history of human civilization

Presently, COVID-19 is an overwhelming challenge faced by the public health system of the entire world. It can be called "History repeating itself" while harking back to the different history of pandemics and how the world combated with these widespread diseases.

2.1 Spanish flu

When peeped into history, one of the oldest and the worst pandemics faced were in 1918, toward the end of World War 1. The influenza disease also called the Spanish flu which was spreading rapidly. It was estimated that it hits the world in spring 1918 and ended in early summer 1919. It had affected around 200–700 million people worldwide and there was a death of 50–100 million, and 21 million in India alone. This pandemic mainly

affected young people, mostly the infants and young people of 20–40 age groups. This led to the closures of schools, businesses, colleges, etc. (Reid, 2005). This flu was highly contagious and spread through cough, sneezes, talks, respiratory droplets, and transmitted through the air. Symptoms observed were the fever with shivers, sore throat, headache, tiredness, cough, and sometimes nosebleeds. In some cases, patients were facing some worst complications, especially in the respiratory system. The postmortem report of the dead bodies caused by Spanish flu showed grossly oversized spleens, swollen lungs, necrotic tissue, and pulmonary alveoli overflowing with albuminous exudate (Tognotti, 2003). It was a very challenging task to control the mortality rate owing to the fewer numbers of hospitals and intensive care units at that time. The areas harshly affected by the disease had a persistent and severe decline in the economy. Altogether the pandemic had a spike in mortality and gave an economic shock (Correia et al., 2020). Thus far, very limited economic data are available for post-1918 influenza. However, the economic problem caused by the 1918 pandemic was short term (Garrett, 2008).

2.2 Plague

There were continuous three plague pandemics that hit the world, first in the 6th century in Byzantium, it swept from Central Asia and killed 40% of the population in Constantinople in 541–542 AD. Second in the 14th century in Europe also called the black death which killed millions in Asia and near Europe East in 1347 to early 1400s and lastly in the 19th century, this plague reappeared in Hong Kong in 1894 (Butler, 2009; Khan, 1995). At that time, the worst affected was India which killed nearly 12 million people between 1896 and 1936. The plague was caused by the bacteria called *Yersinia pestis*. It was a highly infectious and fatal disease characterized by high fever, inflammation of lymphatic glands forming buboes, and pneumonia. It was spread through the urban and densely populated localities transmitted by rats and the sporadic cases through the epizootic infection of several animals. The prevention taken was prompt isolation of the infection suffering from the plague into infectious disease. Later, it was found that streptomycin was the drug of choice for the treatment. Sulfadiazine and sulfamerazine were used during the large outbreaks. In the first week of September 1994, there were 325 suspected cases of plague in 23 states of India. By September last week, the pneumonic plague had spread rapidly in Surat, Gujarat (752 cases and 44 deaths), and by October, it crossed more than 4000

suspected cases countrywide. Surat was the worst affected center of the epidemic. The report indicated that the mortality rate of pneumonic plague in India was found to be 7% (Butler, 2009). The economic losses were suffered around 300–500 million *per annum* and the worst victims were the industries in and around Surat (Gujarat) and Bombay (Maharashtra) (Khan, 1995). Altogether, India suffered a huge economic breakdown during this pandemic.

2.3 Cholera

In 1849, there was the first outbreak of cholera in London, British due to the contaminated water. Since 1817, the world has already faced six epidemics of cholera, and the seventh one began in 1961, came into India and is still in progress. Kolkata city of West Bengal, India was the homeland for this waterborne disease located in the Ganges Delta (Mandal, 2011). The seventh outbreak (El Tor cholera) was first reported in the island of Java. It is the seventh pandemic that spread all over the world. Celebes Island witnessed 29 deaths and 109 cases in 1961. In Macau, 72 cases with first death in 1962. Its way of spreading was found in poor persons having diet deficiency and living in unsanitary conditions. Cholera was generally caused by the bacteria *Vibrio cholerae*. Water was one of the important vectors of infection not because of the possible survival of *Vibrios* but due to the stagnant contaminated water. The isolation of contacts and carriers was necessary for numerous areas, but it was not enforced. Sulfa drugs were used for the treatment. Hong Kong used streptomycin and chloramphenicol and was found to be effective for the treatment. Environmental sanitation was one of the prevention measures that were taken, and public health education and vaccination were developed all over the world in the later period. Proper nutrition intake of Vitamin A and C also protein intakes were made higher in amounts (Felsenfeld, 1969). Symptoms observed were watery and lose bloody mucus in diarrhea and dehydration, fever, and abdominal pain (Dutta et al., 2013).

2.4 Smallpox

Smallpox is one of the most contagious diseases, a frequently fatal feared in the centuries. In the 20th century, because of vaccination, it was reduced in Europe and North America. But in the 1960s, it was endemic in Africa and Asia. In 1905–44, there were 1916 deaths out of 17,510 affected cases. The disease was common, it has characteristic symptoms and distinct seasonality, and it mainly affected small children. Vaccination introduced in 1802 was an

effective measure of prevention. This disease was caused by the *Variola* virus and spread through direct contact. The symptoms observed were headache, backache, fever, and enanthema in the tongue, mouth, and oropharynx. The rash begins with small reddish macules which papules in 2–3 days. The lesion first appeared on the face and gradually covers the whole body, and the rash remains for 5–8 days. Relatively, lesions on palms remain for a longer time. After severe smallpox, pitted lesions are seen in 65%–80% of survivors (Breman and Henderson, 2002).

2.5 Severe acute respiratory syndrome

SARS is an epidemic caused in humans and suspected to be present in animal reservoirs as the host probably civet cats which is still uncertain. The outbreak of SARS was first observed in November 2002 and caused a lot of panic in China and the world at large (Qiu et al., 2018). The first symptom observed was high fever with chill, cough and breathing difficulty, malaise, and headache were some of the other primary symptoms. High and prolonged fever with diarrhea was the confirmed symptoms for SARS. Exposures such as close contact with a person with SARS caused transmission. The study of transmission dynamics of this infection was based on a simple mathematical framework in which different interventions of approaches could be assessed during the epidemic. The researchers attempted to calculate R_0 known as the reproduction number to keep control over the spreading of the infection. Progressive estimation of the effective reproductive number R_t (the secondary cases generation average rate) delivers a quantitative evaluation of success or failure. Guangdong, where the major outbreak took place, had infected more than 8000 people and 774 died. A higher mortality rate was found in people with an age of more than 60 years and lesser mortality in young people. SARS has low transmissibility and effective measures were taken by World Health Organization to keep the spreading of the virus under control. SARS epidemic was under control by taking into account certain preventive measures such as the closing of schools, colleges, and businesses and restricting the movement within the country, isolation of the suspected cases and encouragement of rapid reporting to the health care centers (Anderson et al., 2004). The economic impact triggered by SARS in China and Hong Kong suggested a huge economic loss. The economic effect gave a persistent shock as the epidemic lasted longer than anyone imagined of it. So, the more persistent it was in the core country the larger economic impact was faced by the country (Lee and McKibbin, 2004).

2.6 H1N1 influenza

H1N1 influenza is also known as swine flu named because the genes in the virus showed similarity with the influenza viruses occurring in North American pigs (CDCP, 2019). The outbreak of H1N1 came into notice in 2009 and spread across the globe. Subsequently, the infected persons were hospitalized, and antiviral treatment was given, and all the suspected cases were isolated for further screening. The most death rates were found in people below 30 years of age (Mishra et al., 2010). Its transmission was through cough, sneeze, and respiratory droplets (CDCP, 2019). Symptoms reported were asthma, shortness of breath, pneumonia, fever and cough, chest pain, low blood pressure, drowsiness, hemoptysis, and cyanosis for age 65 years and above. In children, persistent fever, convulsions, dyspnea, and respiratory distress were detected in most of the cases. The diagnosis was performed with the help of reverse transcription–polymerase chain reaction (RT-PCR). H1N1 influenza caused a severe influence on the economic framework and morbidity of our society. The shutdown of schools, offices, and industries resulted in an economic breakdown. The economic flow has been disturbed and earning members were bound to miss work which caused a huge financial loss and burdened with hospitalization expenditure. The mean age which affected the most was found to be 41.5 years from 3 months to 85 years of age (Kumar et al., 2015). However, it was less devastating than the 1918 pandemic.

All these diseases have swept the communities and killed many people as it is now observed in the COVID-19 impact which has already created a devastating effect in the United States, India, Brazil, Spain, and other parts of the world. These diseases have greatly affected the whole world in the past both in terms of economy and mortality rates. Comparatively, the past pandemics were less virulent than COVID-19 as they spread through direct transmission as well as they were less contagious. Therefore, there was a need for necessary precautionary measures and information particularly during the initial stage of COVID-19 to minimize and control the impacts of the pandemic.

3 Transmissibility and severity of COVID-19

Coronavirus is a single nanosegmented, single-stranded, encompassed ribonucleic acid. Coronavirus is named because of its crown type appearance with 9–12 nm long spikes which is similar to solar corona (Zu et al., 2020).

It is a group of viruses belong to the family coronaviridiae and mostly affects humans through zoonotic transmission. In the year 1966, scientists Tyrell and Bynoe first discovered coronavirus from the patients of common colds (Velavan and Meyer, 2020). There are seven subtypes of coronavirus present in nature and out of these seven subtypes; β coronavirus has the potential to cause severe disease. COVID-19 virus belongs to B lineage of the β coronavirus (Zhou et al., 2020) and it is a new strain that has not been identified earlier in human beings and also the first strain of COVID-19 among various other strains identified till date and that is the reason it is called novel coronavirus (nCoV).

Once a person is infected by nCoV, then it has been noticed that clinical manifestation starts within a week in most of the cases consisting of dry cough, fever, fatigue, breathing problem, loss of taste and smell, and pneumonia in most severe cases (Guarner, 2020). Though the COVID-19 virus or SARS-CoV-2 is categorized in the family of severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East respiratory syndrome coronavirus (MERS-CoV) family, SARS-CoV-2 is completely different in behavior as compared to MERS-CoV and SARS-CoV. The main difference of the COVID-19 virus is that it spreads faster than MERS-CoV and SARS-CoV. The incubation period of this virus is around 2–14 days and symptoms start appearing a minimum after 3–4 days, thus the virus is unknowingly spread to other people by the infected person and increases the spreading rate. A survey showed that the COVID-19 pandemic getting double in number within a week and each infected person infecting 2.2 other people on average (Chan et al., 2020).

Initially, the COVID-19 virus shows the possible transmission from animal to human. But further studies confirmed the transmission of this disease from human to human, either through direct contact or droplets (Chan et al., 2020; Wang et al., 2020; Chang et al., 2020). During the initial days of spreading, the unavailability of testing kits and medical equipment created the worst situation to diagnose the infected patients. Thin slice chest computed tomography (CT) did a significant job in batting this irresistible sickness, and then real-time PCR came into picture to diagnose this disease at the clinical level (Zu et al., 2020). Wooden shaft is not recommended while collecting the swabs sample as it may contain substances that may destroy some viruses subsequently which will destroy the real-time PCR result. At the same time for better sample collection, deep cough sputum should be collected for testing after the mouth of the patient is rinsed properly with water (Islam et al., 2020).

The number of deaths from COVID-19 is much more than its predecessors. At the time of SARS-CoV, the fatality rate was 10% (774 deaths out of 8098 cases) and during the MERS-CoV, the fatality rate was 34% (858 deaths out of 2494 cases) (Mahase, 2020). Whereas the COVID-19 has reported many more deaths and confirmed cases than SARS-CoV and MERS-CoV (3,751,988 deaths out of 174,376,256 cases) up to June 8, 2021 (Worldometer, 2021). The United States is leading both in the number of cases and deaths from COVID-19 (Worldometer, 2021). Aged people (age more than 60 years) with past medical history (like lung disease and diabetes), pregnant women, and health professionals are at high risk of this disease. Moreover, high population densities, less diagnosis capacity, and poor hygiene maintenance are some of the key points for the speedy spreading of this virus.

Gathering a large number of people is considered to be the key reason behind this epidemic becoming pandemic (Dharmshaktu, 2020). The mass gathering includes cultural and spiritual events, festivals, sporting events, performances, conferences, shopping malls, cinema halls, public spaces (parks, beaches), public transport, etc. Mass gathering that draws participants from other affected regions or countries would increase the spreading of this disease. Local transmission is also one of the factors of the severity and the spreading rate of this virus in highly populated countries such as China, India, and other parts of the world.

4 Incubation period of COVID-19 virus

Research has reported that the COVID-19 virus incubation period based on 138 cases found that the average duration of appearance of the first symptoms to dyspnea, admitting in the hospital to acute severe respiratory syndrome, was observed as 5 days (range 1–10), 7 days (range 4–8), and 8 days (range 6–12), respectively (Wang et al., 2020; Wu et al., 2020). In another report covering 425 cases, the average was 5.2 days (95% CI, 4.1–7.0 days) and the median incubation period was 3 days (range 0–24) based on the study of 1324 cases (Guan et al., 2020; Li et al., 2020). It might be in some cases symptoms were visible as early as the first range and a single case might have shown late symptoms as of the last range mentioned. On the other hand, SARS, MERS, and swine flu were found to be 2–7 days (Docherty et al., 2020), 2–14 days (CDCP, 2020), and 1–4 days (Jilani et al., 2019), respectively. This estimation showed a lot of variation based on the sample size and the medical history of the infected persons. As of

now, the COVID-19 virus incubation period is found varying and as more information and data will be available, higher precise estimations will emerge (Chatterjee et al., 2020).

5 Symptoms of COVID-19

According to data from the World Health Organization, this CoV falls into one of the major viruses responsible for the illness. This type of virus can cause common cold, cough, and pneumonia. The major common symptoms are dry cough (60%), high fever (99%), sore throat or difficulty in breathing, myalgia (44%), and dyspnea. Other mild symptoms seen in the patient are chest pain, headache, runny nose, nasal congestion, diarrhea, dizziness, and vomiting which instigate gradually (Wang et al., 2020; Chang et al., 2020). In addition to respiratory symptoms, 36.4% (78 out of 214) patients appeared with COVID-19 symptoms which affect the central nervous system of the body and gives birth to above-mentioned neurological diseases along with disturbed consciousness and paresthesia (Wu et al., 2020). Patients suffering from severe infections have acute symptoms such as abdominal pain, pharyngeal pain, dyspnea, and anorexia (Chen et al., 2020). Also, the elderly person having comorbidities have more risks especially people suffering from hypertension, diabetes, cardiovascular diseases, and cerebrovascular diseases have the most adverse outcomes.

Symptoms such as lymponia, prolonged prothrombine time, elevated lactase dehydrogenase, and elevated D-dimer were also observed in COVID-19–infected persons. The most common complications found were acute respiratory distress syndrome, acute cardiac injury shock, arrhythmias, and acute kidney problems. These abnormalities were very similar to that of symptoms found in SARS-CoV and MERS-CoV (Chatterjee et al., 2020). It can cause pneumonia, even seizure pneumonia, and also severe diseases like MERS and SARS. Research indicated that olfactory dysfunction or anosmia is now recognized as one of the symptoms of COVID-19. COVID-19 virus infects and damages the epithelium nasal cells by interacting with the spike(s) protein and angiotensin-converting enzyme 2 (ACE-2) proteins on the target cell which leads to the olfactory dysfunction of the patients (Brann et al., 2020). This infection can be as severe as admitting people to the intensive care unit (ICU) and may require ventilator support and can be as mild as having a short-term illness. Acute pancreatic, the elevation of alanine aminotransferase (ALT) to more than fivefold upper normal limit and anaphylaxis are also the outcomes of

COVID-19 (Bhatnagar et al., 2020). To tackle this infection, it is needed to reduce the symptoms which can only be possible by constructing multi–disciplinary care and isolation wards, which would empower the health system. Scientists, researchers, and health experts are working together to get more evidence about the transmissibility and severity of COVID-19.

6 Spreading behavior of COVID-19 by PCA during the initial phase

Principal component analysis was implemented for analyzing the COVID-19 spreading behavior in the whole world during the first wave. The application of PCA is an innovative approach for significantly interpreting the spreading behavior of the virus. A total of four components namely the number of confirmed cases, number of recovered cases, number of active cases, and number of deceased cases were considered for the mapping of PCA within different countries (Worldometer, 2020). Results demonstrated in Fig. 1 showed the COVID-19 spreading behavior within different countries. Total cases, total recovered, total deaths, and active cases
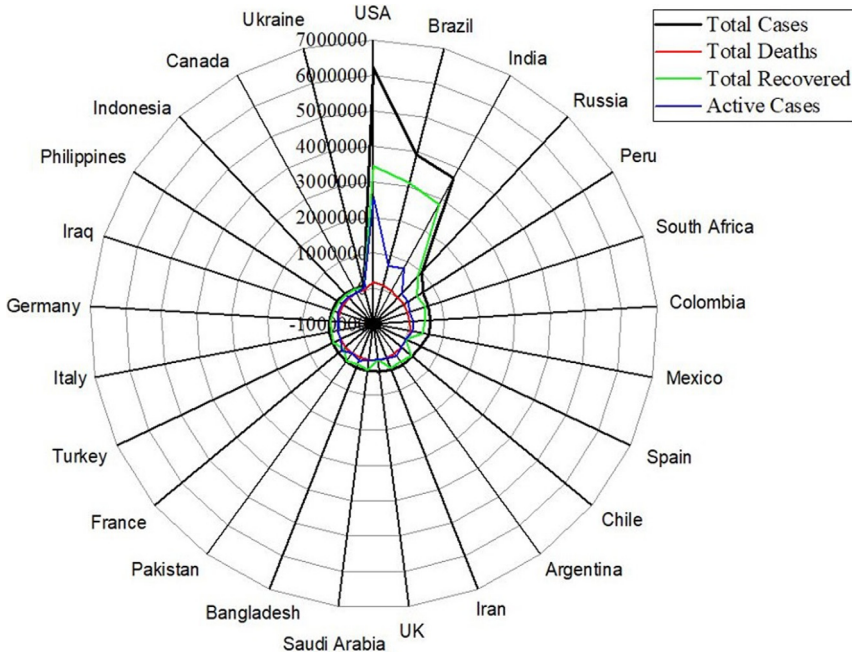

Fig. 1 The scenario of COVID-19 spreading across the whole world.

Table 1 Extracted eigen vectors of the PCA for COVID-19 spreading rate in the world.

Types of cases	Coefficients of PC-1	Coefficients of PC-2
Total cases	0.51506	−0.22024
Total deaths	0.49506	0.39401
Total recovered	0.4954	−0.70737
Active cases	0.49417	0.54395

were considered as the components for PCA. A total of 25 countries were considered for the PCA–based interpretation. Based on the results of Table 1, total and active cases were selected as PC–1 and PC–2, respectively. From the scores represented in Table 2, the highest ranking of the United States can be observed. Fig. 2 shows the position of different countries based

Table 2 PCA scores for the COVID-19 spreading rate in the world.

| Country	Principal component 1	Principal component 2
United States	7.35991	1.02625
Brazil	3.83766	−0.93391
India	3.0631	−1.1328
Russia	−0.05745	−0.33435
Peru	−0.2299	0.07801
South Africa	−0.4496	−0.21125
Colombia	−0.37968	−0.02601
Mexico	0.1028	0.40101
Spain	−0.67603	0.27283
Chile	−0.69056	−0.14815
Argentina	−0.68968	−0.02866
Iran	−0.60114	0.01152
United Kingdom	−0.57545	0.40732
Saudi Arabia	−0.85394	−0.13002
Bangladesh	−0.81685	0.02188
Pakistan	−0.84948	−0.10992
France	−0.52413	0.42022
Turkey	−0.86654	−0.06902
Italy	−0.53869	0.23671
Germany	−0.85536	−0.01885
Iraq	−0.87554	0.02578
Philippines	−0.92308	0.01802
Indonesia	−0.92733	0.06505
Canada	−0.96378	0.05953
Ukraine	−1.01927	0.09879
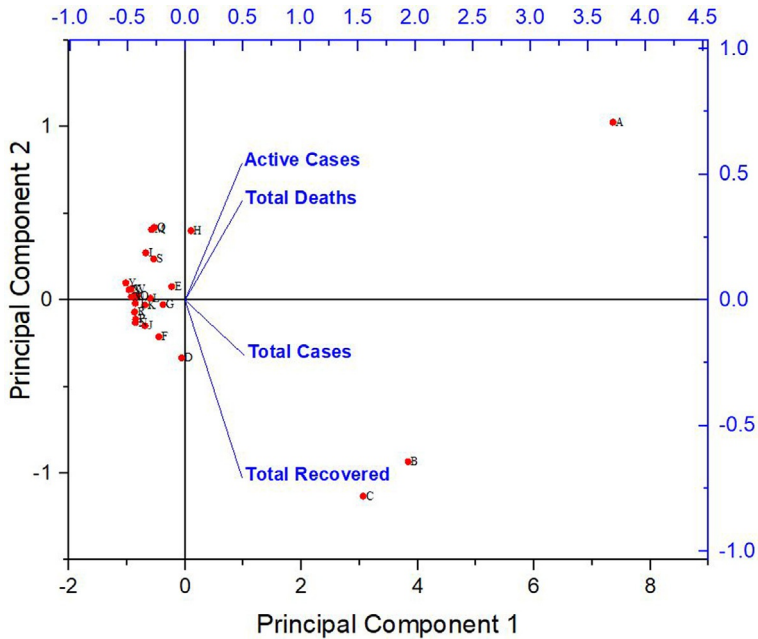
Fig. 2 Results of PCA for the COVID-19 spreading within the whole world. A: USA; B: Brazil; C: India; D: Russia; E: Peru; F: South Africa; G: Colombia; H: Mexico; I: Spain; J: Chile; K: Argentina; L: Iran; M: UK; N: Saudi Arabia; O: Bangladesh; P: Pakistan; Q: France; R: Turkey; S: Italy; T: Germany; U: Iraq; V: Philippines; W: Indonesia; X: Canada; Y: Ukraine.

on PCA ranking. The United States shows its position in between PC–1 and PC–2. On the other hand, from Fig. 2, it can also be revealed that India and Brazil hang around total recovered cases.

7 Preventive measures taken by the top most affected countries to combat the COVID-19 during the first wave

7.1 Screening to find suspected cases

Initially when the number of cases started increasing during early January 2020 in Wuhan, China, and other regions of China, immediately various countries started screening all the passengers coming from China. As soon as it was found that the spreading rate of COVID-19 increases in Wuhan and Hubei province of China, countries around the world started airlifting their citizens from China as well as from other affected countries. Different countries have set the number of symptoms for proper screening to ascertain

the suspected cases. Symptoms like fever, sore throat, running nose, coughing, etc. were taken into consideration while screening the suspected cases (Gupta et al., 2020). Later, several countries have initiated screening people showing the symptoms of COVID-19 even though they have no foreign travel history or close contact history with the person suffering from COVID-19.

7.2 Detecting and monitoring the rate of spreading

Countries throughout the world have started incorporating various laboratory testing criteria after observing an increased number of COVID-19 cases worldwide (Chan et al., 2020). Testing of samples collected from different suspected cases was initiated in various countries with immediate effect. Oropharyngeal and nasopharyngeal sample collection and transferring for further laboratory testing at 4°C temperature within 24 h of the collection were started from suspected cases. As it is a new virus, the initial diagnosis was difficult, so to get the final confirmation, collection of stool, blood, and urine samples was begun for examination. Further, a real-time PCR kit was employed to detect the suspected cases and increase the testing rate (Gupta et al., 2020). For accurate detection, better monitoring and to reduce the rate of spreading, once a confirmed case is known, police and local administrative bodies started finding all the persons who came in contact with the infected person for testing and quarantining as per the symptoms.

7.3 Other preventive measures

Starting from the beginning of COVID-19, governments of various countries and their respective administrative departments have started close monitoring of the situation. Constant review of different emergency issues such as hospital preparedness, diagnostics, infection prevention and control, logistics, and risk management have been initiated with immediate effect. A country like India (National Centre for Disease Control) introduced a helpline number to address public concerns (World Health Organization, 2020a). Apart from screening foreign return passengers, governments of various countries around the world began issuing different travel advisories regarding foreign travel (Gössling et al., 2020). In a highly populated country like India, both the central government and all the states' governments commenced working together to provide additional manpower and logistics support for better and smooth screening (World Health Organization, 2020b). The Ministry of Tourism, Government of India instigated

communication with the hotels association in India to embolden travelers visiting in different identified states to come forward for voluntary screening and help the government to stop the spreading of COVID-19 (World Health Organization, 2020c). Governments around the world along with WHO started appealing to all the citizens to stay at home and follow COVID-19 appropriate behavior such as wearing a mask, social distancing, frequent hand washing or hand sanitization, etc. Children below 10 years of age and people over 65 years of age (excluding medical professionals, public representatives, and government servants) were strictly instructed to stay at home and to avoid any kind of mass gathering. Mask and hand sanitizers were considered essential commodities in various countries. Almost every country has started imposing restrictions on international flights in order to break the transmission chain of COVID-19. A country like India has experienced the world's biggest nationwide "lock down" to halt the transmission chain. On March 24, 2020 when confirmed cases in India starts increasing, the Government of India declared a nationwide lockdown for 21 days with effect from March 25, 2020, to April 14, 2020, under section 6(2) (i) of the Disaster Management Act, 2015. Further, international and domestic flight services, railway services, and interstate passenger connectivity were suspended till April 14, 2020 (World Health Organization, 2020d). To assess the risk of COVID-19 infection of the citizens of India, the Government of India launched a mobile-based app named, "Aarogya Setu" on April 2, 2020. The Ministry of Health and Family Welfare (MoHFW) provided a guiding document on the appropriate management strategy as represented in Fig. 3 (Ministry of Health and Family Welfare, 2020).

8 Potential dietary remedies, herbal medicines, and allopathic therapy for COVID-19

Foods and herbs have always been a potential supplement for the prevention and treatment of several diseases like influenza, SARS-CoV-1, and MERS for decades. Foods such as *Aloe vera, Astragalus membranaceous, Angelica gigas, Ganoderma sucidum, Panax ginseng,* and *Scutellaria baicalensis* (Chinese skull cap) exhibit various immunomodulatory properties. They stimulate cytokines and activate lymphocytes, which enhances macrophage actions and increases killer cell counts (Tan and Vanitha, 2004). Rice bran, *Lawsonia alba* (Henna), wheat bran, *Echinacea purpurea* (Eastern purple cornflower), *Cisampelos pareira* Linn (Velvetleaf), and *Plumbago zeylanica* (Ceylon leadwort) stimulate phagocytosis. Eucalyptus oil has been reported to give
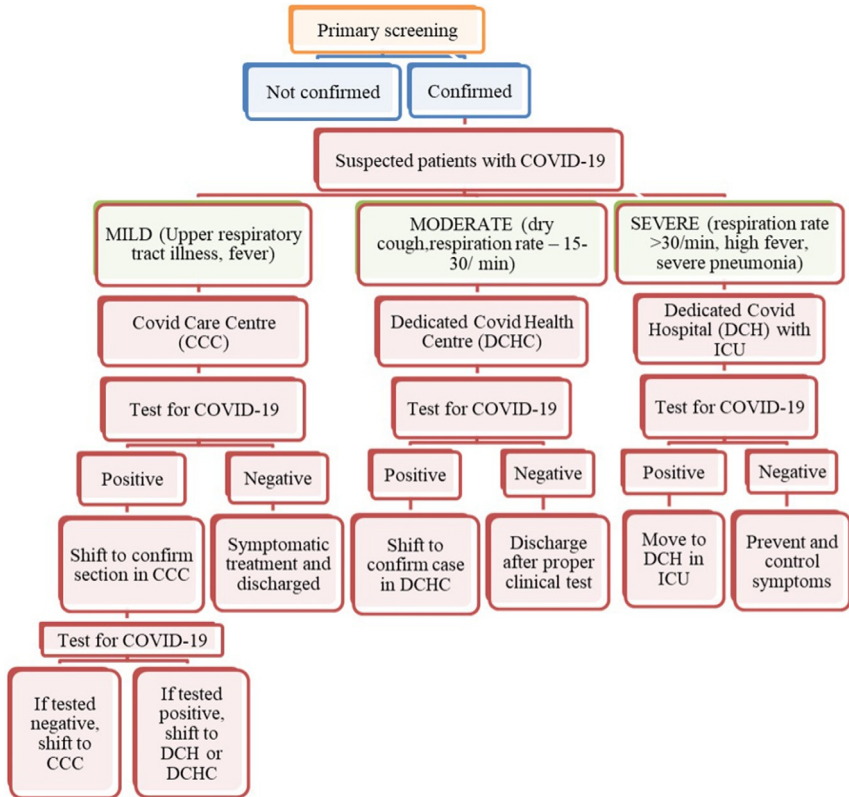
Fig. 3 Appropriate management strategy laid down by the Ministry of Health and Family Welfare, Government of India.

immunoregulatory effects against infectious diseases (Sadlon and Lamson, 2010; Serafino et al., 2008). It can be said that the collective use of these foods and herbs can help to increase the immune system to combat COVID-19. However, their applications must be verified through proper scientific studies (Panyod et al., 2020). During the first wave of COVID-19, there was not a single approved vaccine or treatment for this infectious disease and different possible approaches were applied to fight against the virus.

Studies revealed that various bioactive compounds present in foods and herbs can serve as a dietary therapy against COVID-19. The authors believe that foods and herbs can be helpful for four potential approaches: (a) to boost the immune system and prevent infection, (b) it can be used as an antiviral agent by coating them over masks, (c) essential oil can be used as a

disinfectant to stop air transmission, and (d) can be used as surface sanitizers to provide a disinfected environment. Reaerosolization of masks is a good method to disinfect the masks. So, the coating of essential oil or any antiviral compound can reduce infection chances (Panyod et al., 2020). The phytochemicals, bioactive compounds in foods, and various supplements employed during the first wave of COVID-19 which may be still useful as a therapeutic option for the prevention and treatment of the COVID-19 virus are summarized in the following sections.

8.1 Vitamins

B vitamins are water soluble, and they function as coenzymes. Vitamin B2 serves for the energy metabolism of all cells, and it has been found that the United States elder groups suffer from its deficiency (Powers, 2003). The research indicated that MERS CoV was reduced in the human plasma products by the consumption of vitamin B2 (Keil et al., 2016). Vitamin B3 (nicotinamide) inhibits neutrophil infiltration in the lungs with an antiinflammatory effect due to ventilator-induced lung injuries (Jones et al., 2015). Vitamin B6 has a vital role in defining human immune function. Therefore, B vitamins were on the list of an alternative to COVID-19 treatment (Zhang and Liu, 2020).

Vitamin C also called ascorbic acid is a water-soluble vitamin. It has been seen that vitamin C enhanced the chick embryo trachean organ cultures resistance against avian coronavirus infection. It also acts as an antihistamine agent to give relief from flu–like symptoms such as swollen sinuses, runny nose, and sneezing. Human–controlled trials have also supported these findings. Vitamin C-supplemented herbs reduce or lower the incidence of pneumonia COVID which causes respiratory tract infection which can be sustained by the help of vitamin C (Field et al., 2002; Hemilä, 1997; Atherton et al., 1978).

Vitamin D helps in stimulating the maturation of cells known as immune cells, also maintains bone integrity in calves which give rise to bovine coronavirus (Nonnecke et al., 2014). Researchers have described the promising results of vitamin D related to the supplementation for respiratory tract infections, pulmonary fibrosis, and autoimmune diseases (Panfili et al., 2020). Normal to high blood levels of vitamin D have also shown a synergistic effect with tocilizumab patients by suppressing interleukin 6 (IL-6) improved osteocyte-mediated osteoclastogenesis and decreasing disease activity. Nevertheless, the data and information on COVID-19 survivors

are lacking; vitamin D supplements before and after the injection may produce an antifibrotic role. Based on these direct and indirect productions, there can be a possible influence of this vitamin reaction to the virus and may provide a modulating result on the drug being administered (Panfili et al., 2020).

8.2 Omega (Ω) 3 fatty acids

Ω–3 fatty acids consist of a long chain of polyunsaturated fatty acids (PUFA) which are mediators of inflammation and adaptive responses. Ω–3 and Ω–6 PUFA present in food provide anti- and proinflammatory effects. Protectin D1 Ω–3 PUFA–derived lipid mediator attenuates influenza virus replication by RNA export machinery. Application of protectin D1 with peramivir may save mice from mortality against flu (Morita et al., 2013). Therefore, Ω–3 along with D1 was also on the list to serve as an antiviral drug against COVID-19 (Zhang and Liu, 2020).

8.3 Selenium

Selenium is found in trace amounts and is one of the essential elements in the body which provides defense against diseases. Selenium deficiency can cause oxidative stress in the host which can bring alteration in the genome of the virus making it more virulent (Guillin et al., 2019). It is because selenium assists a group of an enzyme in accordance with vitamin E in order to avoid the oxidative damage and free radicals formation (Harthill, 2011). It was found that selenium along with ginseng leaf saponins has a synergistic effect to give an immune response to the live virulent infectious bronchitis COVID in chicks (Ma et al., 2019) and that is the reason selenium is considered as an alternative treatment for COVID-19.

8.4 Zinc

Zinc is a dietary mineral that is necessary for the improvement of the adaptive and inherent immune system. A deficiency of this mineral in the system can cause susceptibility to infections. Zinc supplement reduces the mortality rate caused due to lower respiratory tract infections (Awotiwon et al., 2017). It has been seen that zinc along with zinc ionospheres pyrithione can impair a range of RNA viruses, and these at low concentrations impede replication of SARS corona (TeVelthuis et al., 2010). So, zinc is effective not only on symptoms like low respiratory infection and diarrhea, but also for COVID treatment (Zhang and Liu, 2020).

8.5 Curcumin

It is a natural polyphenolic compound that can be used as a potential treatment for COVID-19 patients. The preliminary for COVID infection is interaction with the human cell and viral spike protein. Angiotensin-converting enzyme 2 (ACE-2) presents in the human respiratory tract which acts as the receptor is identified by the SARS-CoV-2 spike protein. Then the viral genome RNA is released in the cytoplasm which follows membrane fusion and the RNA codes for instant replication of proteins and transcription complex (Jia et al., 2005). After entering the cell, the CoV enables the expression of gene and encoding of genome ensues. This will again in turn encode the accessory protein which allows the adaption of CoV to the human host. This curcumin can restrain the virus entry to the cell, prevent the virus encapsulation and viral protease, and modulate different cell signaling pathways. Curcumin has various antiviral activities and is a therapeutic choice for the management of COVID-19 infection. Curcumin can modulate several molecular targets that get attachment and internalization of SARS-CoV-2 in various organs including the kidney and liver. Curcumin can modulate cellular signals such as apoptosis, inflammation, and RNA replication. It also suppresses pulmonary edema and fibrosis associated with the pathway of COVID-19 infection. But the bioavailability of curcumin is less which can only be mitigated by the administration of nontoxic limits. Overall, the immunomodulatory and antiinflammatory effects show evidence of the antifibrotic and pulmonary protective nature of this phytochemical on lung tissue making it a potential way of COVID-19 treatment (Zahedipour et al., 2020).

8.6 Probiotics

Probiotic actions like the influence on cytokine production by intestinal epithelial cells. Immunoglobulin A (IgA) secretion and stimulation increase mucosal immunity and activate phagocytosis and macrophage production. Its principal effect on innate and adaptive immunity makes it a possible inhibitor. But all probiotics do not possess the same characteristics, thus a more potential targeted approach is required through characterization of properties by the development of potential COVID-19 application. The virus of COVID-19 has shown influences on intestinal microbiota dysbiosis, and probiotics have demonstrated efficacy for the respiratory tract viral infections management. The postmortem of many COVID-19 patients

has revealed that severe respiratory syndrome and severe lung, heart, and liver tissue damage. Some exhibited intestinal microbial dysbiosis with reduced probiotics such as bifidobacterium and lactobacillus which indicate the need for the gastrointestinal function of all the infected persons (Xu et al., 2020). This dysbiosis is linked with various other infections of the respiratory tract through the gut lung axis. Application of prebiotic or probiotic and nutritional support are recommended for COVID-19–infected persons to control the intestinal microbiota and decrease secondary infection owing to translocation of bacteria. As there was no effective treatment for COVID-19 infection during the first wave due to a lack of evidence and trait, so the urgent need for prevention using probiotics against COVID-19 related to gut microbiota was one of the alternative methods (Bottari et al., 2020). Further research is required to address the probiotic role in attenuating COVID-19 either by the immunomodulatory actions on systematic inflammation or by direct interaction with the lungs.

8.7 Chinese medicines

Rhizoma Polygonati is an herbal food grown in Mount Tai whose rhizome is commonly used as herbal medicine and it belongs to the family *Liliaceae polygonatum*. It consists of polysaccharides and has been used to treat symptoms having a deficiency of lungs, spleen, and weakness of qi. Various clinical applications and recommendation evidence, and different potential compounds were observed in Rhizoma Polygonati for anti–COVID-19. Rhizoma Polygonati can also eliminate the cytokine of COVID-19 by treatment of lung inflammation enhancing the immune system response in mice. Furthermore, polygonatum polysaccharide from rhizome and sulfation Radix Codonopsis (Dangshen) composition polysaccharide were observed to have an effect against the new castle disease virus. This can be a promising feature of Rhizoma Polygonati to combat viruses. Further investigation and more trials are required to develop the drugs (Mu et al., 2021). Glycyrrhizin present in licorice root can prevent the SARS virus replication in vitro and also serve as an alternative approach for the treatment of SARS. Baicalin, another Chinese herb shows the potential to inhibit SARS-CoV. Ginseng stem leaf saponins could be used for the significant enhancement of specific antibody responses to the infectious bronchitis virus. Therefore, researchers suggested that these can also be used to enhance immunity against COVID-19 (Zhang and Liu, 2020).

8.8 *Nigella sativa* (*N. sativa*) compounds

N. sativa, a black seed globally used as medicine in the plant as for its oil and seeds in food systems. It consists of potential natural antiviral agents against COVID-19. Nigellone has a high affinity toward COVID as the ACE–2 interface interacts with various hydrophilic and hydrophobic bonding. *N. sativa* possesses gut absorption ability and high solubility which makes it suitable for future optimization of potent derivatives. ACE–2 is a highly stable interface that can bind free energy assay by acquiring a low level of energy. It was found to have a higher binding affinity (8.2 kcal/mol) compared to chloroquine against SARS-CoV2:ACE2 which can be an acceptable inhibitor to interrupt the interaction of viral host. So, these findings suggested that nigellone, a carbonyl polymer of thymoquinone has the potential to act as the inhibitor (Ahmad et al., 2020).

8.9 Application of allopathic therapy

During the initial phase, there was not a single effective treatment available for COVID-19 (Wu and McGoogan, 2020). Throughout the world, various drugs have been applied to treat COVID-19 patients. It has been found that more than a dozen of allopathic drugs have been applied and many of them showed their potentiality at different levels although the clinical affectivity was under observation. As there was no specific drug or vaccine available for this disease and the world was desperately waiting for a vaccine or effective medicine against this pandemic. Doctors were trying to apply all possible drugs based on their previous track record against other similar kinds of diseases to save as much as possible lives (Singh et al., 2020). Chloroquine, hydroxychloroquine (HCQ)- the derivative of chloroquine, and remdesivir were at the top of the list among all the drugs applied to treat COVID-19 patients. Chloroquine is an old drug and medically used worldwide for more than the last 70 years. Chloroquine is cheap, approved for malaria, and WHO recommended it as an essential drug. HCQ is used in India for treating type II diabetes patients since 2004 (Singh et al., 2020; Cortegiani et al., 2020). Similarly, remdesivir showed effective results against MERS and SARS. A study on remdesivir in mice showed that remdesivir improved lung function by reducing the viral load (Cortegiani et al., 2020). Methylprednisolone was also used for the treatment of COVID-19. Thymosin α-1 has been used as an immune enhancer for SARS patients to control the spreading. As methylprednisolone has side effects related to corticoid–induced death of thymocytes, therefore, researchers

and scientists have recommended using thymosin α-1 before methylprednisolone (Zhang and Liu, 2020). Similarly, cyclophilin has also played a vital part in inhibiting virus replication. So, it was expected to inhibit cyclophilus and halt the coronavirus genomes replication including SARS-CoV and avian infections such as bronchitis virus. So, this may act as a COVID-19 inhibitor and therefore, scientists and doctors were expecting positive results from these medicines while treating COVID-19 patients, especially HCQ for COVID-19 patients with diabetes and in many cases positive results were observed after using all these drugs. However, the efficiency of these drugs for COVID-19 is still not clear. Apart from chloroquine, hydroxychloroquine, and remdesivir drugs like; ribavirin plus interferon, camostat mesilate, lopinavir or ritonavir, darunavir or cobicistat, nelfinavir, favipiravir, umifenovir, etc., were the other drugs that have been applied for COVID-19 treatment around the world (Singh et al., 2020; Lai et al., 2020). Ribavirin plus interferon (showed mixed result against MERS-CoV), camostat mesilate (found efficiently blocked COVID-19 virus in lung cells during in vitro study), and lopinavir or ritonavir (found efficient against SARS-CoV-1 both in human and in vitro studies) were the other promising drugs after chloroquine, hydroxychloroquine, and remdesivir and applied to manage COVID-19–infected persons in various places. Some drugs like darunavir, cobicistat, and nelfinavir were used for COVID-19 patients because of their anti-HIV ability. However, darunavir or cobicistat was never approved against coronavirus or other respiratory viruses. Similarly, medicine having a previous track record as an antiviral medicine such as favipiravir for filovirus, arenavirus, bunyavirus, etc., and umifenovir for coronaviruses were also in the trial and have been applied to treat many COVID-19 patients (Singh et al., 2020).

Patients with comorbidity are at higher risk of COVID-19 than patients with a strong immune system. Therefore, drugs that are effective for other diseases and drugs with antiviral, antioxidant, antiinflammatory, and immunomodulation ability can be practiced for the treatment of COVID-19 patients to lessen the severity of other diseases as well as to boost up the body immune system to fight against COVID-19. Infected persons having mild symptoms such as cough, fever, throat pain, etc. can also take these drugs depending on the condition of the symptoms after consulting with the medical practitioner and they can stay in home isolation so that severe patients will get a bed in hospitals (Lai et al., 2020). However, the application of antiviral drugs for patients with comorbidity is risky and the probability of mortality rates is high (Pascarella et al., 2020).

Depending on the severity of the patient apart from medicine, saving the failure of the respiratory system is an effective technique to save the life from COVID-19 (Pascarella et al., 2020). In the case of hypoxia or respiratory distress, oxygen therapy is especially required to save the respiratory system. But to avoid any kind of lung injury, level of arterial $SatO_2$ must be monitored carefully at the time of oxygen therapy and the level of $SatO_2$ must be within the range of 93%–96%.

Apart from all these practices, it has been found that some specific antibodies developed in the bodies of patients get recovered from COVID-19 and these antibodies have the potential to treat other active COVID-19 patients through plasma therapy. Initially, it was found that five out of five patients in critical condition with acute respiratory distress syndrome showed clinical improvement after the application of plasma therapy. States like Delhi (capital of India) officially applied plasma therapy to treat COVID-19–infested persons and achieved several positive outcomes. Similarly, other countries also applied this technique and get several positive outputs, and countries like the United States adopted this technique to treat COVID-19 patients during the initial phase of COVID-19. However, a significant level of scientific studies is still required to get clarity about the adoptability of plasma therapy against COVID-19. Moreover, enhancement of the immune response of the host body is the main concern during the initial days and before the discovery of vaccines to fight against the SARS-CoV-2 virus. Therefore, particularly until there was not a specific vaccine or medicine for COVID-19, doctors and scientists around the world were applying all these allopathic treatments along with other remedies to reduce the worst scenario of this pandemic.

9 Conclusions

Lessons from the various historical pandemics and epidemics, COVID-19 transmissibility, severity, incubation period, spreading behavior using PCA application of allopathic therapy, dietary remedy and herbal medicine, and precautionary measures taken by the various countries to combat COVID-19 pandemic particularly during the first wave were deciphered in this chapter. PCA showed the spreading behavior of COVID-19 within different countries. The analysis within the 25 most severely affected countries during the first wave showed the United States at a higher position in between PC-1 and PC-2. It was observed that India and Brazil were around total recovered cases. Foods and herb-based

products were employed in different approaches: improve the immune system, prevent infection, use as an antiviral agent by coating them over the mask, and the essential oil as a disinfectant to stop air transmission and as a surface sanitizer to provide a disinfected environment. During the initial phase, chloroquine, hydroxychloroquine, and remdesivir were the most commonly used drugs to treat COVID-19 patients in terms of allopathic therapy along with some dietary remedies and medicinal herbs as an immunity booster. Although there was no such strong scientifically and experimentally verified evidence regarding the application of allopathic therapy, dietary remedy, and medicinal herbs for the treatment of COVID-19–infected persons, these techniques were commonly applied to fight this deadly pandemic, particularly during the initial phase when there was no known vaccine.

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References

Ahmad, S., Abbasi, H.W., Shahid, S., Gul, S., Abbasi, S.W., 2020. Molecular docking, simulation and MM-PBSA studies of Nigella sativa compounds: a computational quest to identify potential natural antiviral for COVID-19 treatment. J. Biomol. Struct. Dyn. 12, 1–16. https://doi.org/10.1080/07391102.2020.1775129.

Anderson, R.M., Fraser, C., Ghani, A.C., Donnelly, C.A., Riley, S., Ferguson, N.M., Gabriel, M.L., Lam, T.H., Anthony, J.H., 2004. Epidemiology, transmission dynamics and control of SARS: the 2002–2003 epidemic. Philos. Trans. R. Soc. B Biol. Sci. 359, 1091–1105.

Atherton, J.G., Kratzing, C.C., Fisher, A., 1978. The effect of ascorbic acid on infection chick–embryo ciliated tracheal organ cultures by coronavirus. Arch. Virol. 56, 195–199. https://doi.org/10.1007/BF01317848.

Awotiwon, A.A., Oduwole, O., Sinha, A., Okwundu, C.I., 2017. Zinc supplementation for the treatment of measles in children. Cochrane Database Syst. Rev. 6, 1–17. https://doi.org/10.1002/14651858.CD011177.pub3.

Bhatnagar, T., Murhekar, M.V., Soneja, M., Gupta, N., Giri, S., Wig, N., Gangakhedkar, R., 2020. Lopinavir/ritonavir combination therapy amongst symptomatic coronavirus disease 2019 patients in India: protocol for restricted public health emergency use. Indian J. Med. Res. 151, 184–189. http://www.ncbi.nlm.nih.gov/pubmed/23144490.

Bottari, B., Castellone, V., Neviani, E., 2020. Probiotics and Covid-19. Int. J. Food Sci. Nutr. 72 (3), 293–299. https://doi.org/10.1080/09637486.2020.1807475.

Brann, D., Tsukahara, T., Weinreb, C., Logan, D.W., Datta, S.R., 2020. Non-neuronal expression of SARS-CoV-2 entry genes in the olfactory system suggests mechanisms underlying COVID-19-associated anosmia. BioRxiv. https://doi.org/10.1101/2020.03.25.009084. The Preprint Server for Biology.

Breman, J.G., Henderson, D.A., 2002. Diagnosis and management of smallpox. N. Engl. J. Med. 346, 1300–1308.

Butler, T., 2009. Plague into the 21st century. Clin. Infect. Dis. 49, 736–742.

CDCP, 2019. H1N1 Flu. Centers for Disease Control and Prevention, pp. 1–9.

CDCP, 2020. Middle East Respiratory Syndrome (MERS). Centers for Disease Control and Prevention.

Chan, J.F.W., Yuan, S., Kok, K.H., To, K.K.W., Chu, H., Yang, J., Xing, F., Liu, J., Yip, C.C.Y., Poon, R.W.S., Tsoi, H.W., 2020. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. Lancet 395 (10223), 514–523. https://doi.org/10.1016/S0140-6736(20)30154-9.

Chang, D., Lin, M., Wei, L., Xie, L., Zhu, G., Cruz, C.S.D., Sharma, L., 2020. Epidemiologic and clinical characteristics of novel coronavirus infections involving 13 patients outside Wuhan, China. JAMA 323 (11), 1092–1093. http://jamanetwork.com/article.aspx?doi=10.1001/jama.2020.1623.

Chatterjee, P., Nagi, N., Agarwal, A., Das, B., Banerjee, S., Sarkar, S., Gupta, N., Gangakhedkar, R.R., 2020. The 2019 novel coronavirus disease (COVID-19) pandemic: a review of the current evidence. Indian J. Med. Res. 151 (2–3), 147–159. https://doi.org/10.4103/ijmr.ijmr_519_20.

Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., Qiu, Y., Wang, J., Liu, Y., Wei, Y., Yu, T., 2020. Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. Lancet 395 (10223), 507–513. https://doi.org/10.1016/S0140-6736(20)30211-7.

Correia, S., Luck, S., Verner, E., 2020. Pandemics depress the economy, public health interventions do not: evidence from the 1918 flu. SSRN Electron. J. https://ssrn.com/abstract=3561560.

Cortegiani, A., Ingoglia, G., Ippolito, M., Giarratano, A., Einav, S., 2020. A systematic review on the efficacy and safety of chloroquine for the treatment of COVID-19. J. Crit. Care 57, 279–283. https://doi.org/10.1016/j.jcrc.2020.03.005.

Dharmshaktu, N.S., 2020. The lessons learned from current ongoing pandemic public health crisis of COVID 19 and its management in India from various different angles, perspectives and way forward. Epidemiol. Int. 5 (1), 1–4. https://orcid.org/0000-0002-4520-079X.

Docherty, A.B., et al., 2020. Features of 20 133 UK patients in hospital with Covid-19 using the ISARIC WHO Clinical Characterisation Protocol: prospective observational cohort study. BMJ. https://doi.org/10.1136/bmj.m1985.

Dutta, D., Chowdhury, G., Pazhani, G.P., Guin, S., Dutta, S., Ghosh, S., Rajendran, K., Nandy, R.K., Mukhopadhyay, A.K., Bhattacharya, M.K., Mitra, U., 2013. Vibrio cholerae non-O1, non-O139 serogroups and cholera-like diarrhea, Kolkata, India. Emerg. Infect. Dis. 19 (3), 464–467.

Felsenfeld, O., 1969. Some observations on the cholera (E1 Tor) epidemic in 1961–62. Bull. World Health Organ. 28, 289–296.

Field, C.J., Johnson, I.R., Schley, P.D., 2002. Nutrients and their role in host resistance to infection. J. Leukoc. Biol. 71 (1), 16–32. https://doi.org/10.1189/jlb.71.1.16.

Garrett, T.A., 2008. Pandemic economics: the 1918 influenza and its modern-day implications. Fed. Reserve Bank St. Louis Rev. 90, 75–93.

Gössling, S., Scott, D., Hall, C.M., 2020. Pandemics, tourism and global change: a rapid assessment of COVID-19. J. Sustain. Tour. 29 (1), 1–20. https://doi.org/10.1080/09669582.2020.1758708.

Guan, W.J., Ni, Z.Y., Hu, Y., Liang, W.H., Ou, C.Q., He, J.X., Liu, L., Shan, H., Lei, C.L., Hui, D.S., Du, B., 2020. Clinical characteristics of coronavirus disease 2019 in China. N. Engl. J. Med. 382 (18), 1708–1720. https://doi.org/10.1016/S0140-6736(20)30211-7.

Guarner, J.M.D., 2020. Three emerging coronaviruses in two decades: the story of SARS, MERS, and now COVID-19. Am. J. Clin. Pathol. 153 (4), 420–421. https://doi.org/10.1093/ajcp/aqaa029.

Guillin, O.M., Vindry, C., Ohlmann, T., Chavatte, L., 2019. Selenium, selenoproteins and viral infection. Nutrients 11 (9), 2101. https://doi.org/10.3390/nu11092101.

Gupta, N., Potdar, V., Praharaj, I., Giri, S., Sapkal, G., Yadav, P., Choudhary, M.L., Dar, L., Sugunan, A.P., Kaur, H., Munivenkatappa, A., 2020. Laboratory preparedness for SARS-CoV-2 testing in India: harnessing a network of virus research & diagnostic laboratories. Indian J. Med. Res. 151 (2–3), 216–225. https://doi.org/10.4103/ijmr.IJMR_594_20.

Harthill, M., 2011. Micronutrient selenium deficiency influences evolution of some viral infectious diseases. Biol. Trace Elem. Res. 143 (3), 1325–1336. https://doi.org/10.1007/s12011-011-8977-1.

Hemilä, H., 1997. Vitamin C intake and susceptibility to pneumonia. Pediatr. Infect. Dis. J. 16 (9), 836–837. https://doi.org/10.1097/00006454-199709000-00003.

Islam, A., Ahmed, A., Naqvi, I.H., Parveen, S., 2020. Emergence of deadly severe acute respiratory syndrome coronavirus-2 during 2019–2020. Virusdisease 31 (2), 128–136. http://link.springer.com/10.1007/s13337-020-00575-1.

Jia, H.P., Look, D.C., Shi, L., Hickey, M., Pewe, L., Netland, J., Farzan, M., Wohlford-Lenane, C., Perlman, S., McCray Jr., P.B., 2005. ACE2 receptor expression and severe acute respiratory syndrome coronavirus infection depend on differentiation of human airway epithelia. J. Virol. 79 (23), 14614–14621. https://doi.org/10.1128/JVI.79.23.14614-14621.2005.

Jilani, T.N, Jamil, R.T., Siddiqui, A.H., 2019. H1N1 Influenza. StatPearls.

Jones, H.D., Yoo, J., Crother, T.R., Kyme, P., Ben-Shlomo, A., Khalafi, R., Tseng, C.W., Parks, W.C., Arditi, M., Liu, G.Y., Shimada, K., 2015. Nicotinamide exacerbates hypoxemia in ventilator-induced lung injury independent of neutrophil infiltration. PLoS One 10 (4). https://doi.org/10.1371/journal.pone.0123460, e0123460.

Keil, S.D., Bowen, R., Marschner, S., 2016. Inactivation of Middle East respiratory syndrome coronavirus (MERS-CoV) in plasma products using a riboflavin-based and ultraviolet light-based photochemical treatment. Transfusion 56 (12), 2948–2952. https://doi.org/10.1111/trf.13860.

Khan, S.I., 1995. Plague in India. Aligarh Muslim University, Aligarh, India.

Kumar, P., Sachan, A., Kakar, A., Gogia, A., 2015. Socioeconomic impact of the recent outbreak of H1N1. Curr. Med. Res. Pract. 5 (4), 163–167. https://doi.org/10.1016/j.cmrp.2015.06.007.

Lai, C.C., Liu, Y.H., Wang, C.Y., Wang, Y.H., Hsueh, S.C., Yen, M.Y., Ko, W.C., Hsueh, P.R., 2020. Asymptomatic carrier state, acute respiratory disease, and pneumonia due to severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2): facts and myths. J. Microbiol. Immunol. Infect. 53 (3), 404–412. https://doi.org/10.1016/j.jmii.2020.02.012.

Lee, J.W., McKibbin, W.J., 2004. Globalization and disease: the case of SARS. Asian Econ. Pap. 3 (1), 113–131.

Li, Q., Guan, X., Wu, P., Wang, X., Zhou, L., Tong, Y., Ren, R., Leung, K.S., Lau, E.H., Wong, J.Y., Xing, X., 2020. Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. N. Engl. J. Med. 382, 1199–1207. https://doi.org/10.1056/nejmoa2001316.

Ma, X., Bi, S., Wang, Y., Chi, X., Hu, S., 2019. Combined adjuvant effect of ginseng stem-leaf saponins and selenium on immune responses to a live bivalent vaccine of Newcastle disease virus and infectious bronchitis virus in chickens. Poult. Sci. 98 (9), 3548–3556. https://doi.org/10.3382/ps/pez207.

Mahase, E., 2020. Coronavirus: covid-19 has killed more people than SARS and MERS combined, despite lower case fatality rate. BMJ 368. https://doi.org/10.1136/bmj.m641, m64.

Mandal, S., 2011. Cholera epidemic in and around Kolkata, India: endemicity and management. Oman Med. J. 26 (4), 288–289.

Ministry of Health and Family Welfare, 2020. Guidance Document on Appropriate Management of Suspect/Confirmed Cases of COVID-19. https://www.mohfw.gov.in/. (Accessed 21 May 2020).

Mishra, A.C., Chadha, M.S., Choudhary, M.L., Potdar, V.A., 2010. Pandemic influenza (H1N1) 2009 is associated with severe disease in India. PLoS One 5 (5), e10540.

Morita, M., Kuba, K., Ichikawa, A., Nakayama, M., Katahira, J., Iwamoto, R., Watanebe, T., Sakabe, S., Daidoji, T., Nakamura, S., Kadowaki, A., 2013. The lipid mediator protectin D1 inhibits influenza virus replication and improves severe influenza. Cell 153 (1), 112–125. https://doi.org/10.1016/j.cell.2013.02.027.

Mu, C., Sheng, Y., Wang, Q., Amin, A., Li, X., Xie, Y., 2021. Potential compound from herbal food of *Rhizomapolygonati* for treatment of COVID-19 analyzed by network pharmacology: viral and cancer signaling mechanisms. J. Funct. Foods 77. https://doi.org/10.1016/j.jff.2020.104149, 104149.

Nonnecke, B.J., McGill, J.L., Ridpath, J.F., Sacco, R.E., Lippolis, J.D., Reinhardt, T.A., 2014. Acute phase response elicited by experimental bovine diarrhea virus (BVDV) infection is associated with decreased vitamin D and E status of vitamin–replete preruminant calves. J. Dairy Sci. 97 (9), 5566–5579. https://doi.org/10.3168/jds.2014-8293.

Panfili, F.M., Roversi, M., D'Argenio, P., Rossi, P., Cappa, M., Fintini, D., 2020. Possible role of vitamin D in Covid-19 infection in pediatric population. J. Endocrinol. Investig., 1–9. https://doi.org/10.1007/s40618-020-01327-0.

Panyod, S., Ho, C.T., Sheen, L.Y., 2020. Dietary therapy and herbal medicine for COVID-19 prevention: a review and perspective. J. Tradit. Complement. Med. 10, 420–427. https://doi.org/10.1016/j.jtcme.2020.05.004.

Pascarella, G., Strumia, A., Piliego, C., Bruno, F., Del Buono, R., Costa, F., Scarlata, S., Agrò, F.E., 2020. COVID-19 diagnosis and management: a comprehensive review. J. Intern. Med. 288 (2), 192–206. https://doi.org/10.1093/ajcn/77.6.1352.

Powers, H.J., 2003. Riboflavin (vitamin B-2) and health. Am. J. Clin. Nutr. 77 (6), 1352–1360. https://doi.org/10.1093/ajcn/77.6.1352.

Qiu, W., Chu, C., Mao, A., Wu, J., 2018. The impacts on health, society, and economy of SARS and H7N9 outbreaks in China: a case comparison study. J. Environ. Public Health, 1–8. https://doi.org/10.1155/2018/2710185.

Reid, A., 2005. The effects of the 1918–1919 influenza pandemic on infant and child health in Derbyshire. Med. Hist. 49 (1), 29–54.

Sadlon, A.E., Lamson, D.W., 2010. Immune–modifying and antimicrobial effects of Eucalyptus oil and simple inhalation devices. Altern. Med. Rev. 15 (1), 33–43.

Serafino, A., Vallebona, P.S., Andreola, F., Zonfrillo, M., Mercuri, L., Federici, M., Rasi, G., Garaci, E., Pierimarchi, P., 2008. Stimulatory effect of Eucalyptus essential oil on innate cell–mediated immune response. BMC Immunol. 9 (1), 1–16. https://doi.org/10.1186/1471-2172-9-17.

Singh, A.K., Singh, A., Shaikh, A., Singh, R., Misra, A., 2020. Chloroquine and hydroxychloroquine in the treatment of COVID-19 with or without diabetes: a systematic search and a narrative review with a special reference to India and other developing countries. Diabetes Metab. Syndr. Clin. Res. Rev. 14 (3), 241–246. https://doi.org/10.1016/j.dsx.2020.03.011.

Singhal, T., 2020. A review of coronavirus disease-2019 (COVID-19). Indian J. Pediatr. 87 (4), 281–286. https://doi.org/10.1007/s12098-020-03263-6.

Tan, B.K., Vanitha, J., 2004. Immunomodulatory and antimicrobial effects of some tradi-
tional Chinese medicinal herbs: a review. Curr. Med. Chem. 11 (11),
1423–1430. https://doi.org/10.2174/0929867043365161.

Tandon, P.N., 2020. COVID-19: impact on health of people & wealth of nations. Indian
J. Med. Res. 151 (2–3), 121–123. http://www.ncbi.nlm.nih.gov/pubmed/23144490.

TeVelthuis, A.J., van den Worm, S.H., Sims, A.C., Baric, R.S., Snijder, E.J., van Hemert,
M.J., 2010. Zn^{2+} inhibits coronavirus and arterivirus RNA polymerase activity in vitro
and zinc ionophores block the replication of these viruses in cell culture. PLoS Pathog. 6
(11). https://doi.org/10.1371/journal.ppat.1001176, e1001176.

Tognotti, E., 2003. Scientific triumphalism and learning from facts: bacteriology and the
'Spanish flu' challenge of 1918. Soc. Hist. Med. 16 (1), 97–110.

Velavan, T.P, Meyer, C.G, 2020. The COVID-19 epidemic. Trop. Med. Int. Health 25 (3),
278–280. https://doi.org/10.1111/tmi.13383.

Wang, D., Hu, B., Hu, C., Zhu, F., Liu, X., Zhang, J., Wang, B., Xiang, H., Cheng, Z.,
Xiong, Y., Zhao, Y., 2020. Clinical characteristics of 138 hospitalized patients with 2019
novel coronavirus–infected pneumonia in Wuhan, China. JAMA 323 (11), 1061–
1069. https://doi.org/10.1001/jama.2020.1585.

World Health Organization, 2020a. Novel Coronavirus (2019-nCov): Situation Report-1.
https://www.who.int/docs/default-source/wrindia/india-situation-report   1.pdf?
sfvrsn=5ca2a672_0. (Accessed 3 July 2020).

World Health Organization, 2020b. Novel Coronavirus (2019-nCov): Situation Report-4.
https://www.who.int/docs/default-source/coronaviruse/situation-reports/
2020a0124-sitrep-4-2019-ncov.pdf?sfvrsn=9272d086_8. (Accessed 3 July 2020).

World Health Organization, 2020c. Novel Coronavirus (2019-nCov): Situation Update
Report-6. https://www.who.int/docs/default-source/wrindia/situation-report/india-
situation-report-6606711da860b4d38b266c91265952977.pdf?sfvrsn=2f6c5c95_2.
(Accessed 15 July 2020).

World Health Organization, 2020d. Novel Coronavirus (2019-nCov): Situation Update
Report-10.   https://www.who.int/docs/default-source/wrindia/situation-report/
india-situation-report-10.pdf?sfvrsn=48298da5_2. (Accessed 15 July 2020).

Worldometer, 2020. Coronavirus Cases. https://www.worldometers.info/coronavirus/?
fbclid=IwAR35ZFiRZJ8tyBCwazX2N-k7yJjZOLDQiZSA_MsJAfdK74s8f2a_
Dgx4iVk. (Accessed 31 August 2020).

Worldometer, 2021. Coronavirus Cases. https://www.worldometers.info/coronavirus/?
fbclid=IwAR35ZFiRZJ8tyBCwazX2N-k7yJjZOLDQiZSA_MsJAfdK74s8f2a_
Dgx4iVk. (Accessed 8 June 2021).

Wu, Z., McGoogan, J.M., 2020. Characteristics of and important lessons from the corona-
virus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases
from the Chinese Center for Disease Control and Prevention. JAMA 323 (13), 1239–
1242. https://doi.org/10.1001/jama.2020.2648.

Wu, D., Wu, T., Liu, Q., Yang, Z., 2020. The SARS-CoV-2 outbreak: what we know. Int.
J. Infect. Dis. 94, 44–48. https://doi.org/10.1016/j.ijid.2020.03.004.

Xu, Z., Shi, L., Wang, Y., Zhang, J., Huang, L., Zhang, C., Liu, S., Zhao, P., Liu, H., Zhu,
L., Tai, Y., 2020. Pathological findings of COVID-19 associated with acute respiratory
distress syndrome. Lancet Respir. Med. 8 (4), 420–422. https://doi.org/10.1016/
S2213-2600(20)30076-X.

Zahedipour, F., Hosseini, S.A., Sathyapalan, T., Majeed, M., Jamialahmadi, T., Al-Rasadi,
K., Banach, M., Sahebkar, A., 2020. Potential effects of curcumin in the treatment of
COVID-19 infection. Phytother. Res. 34 (11), 2911–2920. https://doi.org/10.1002/
ptr.6738.

Zhang, L., Liu, Y., 2020. Potential interventions for novel coronavirus in China: a systematic
review. J. Med. Virol. 92 (5), 479–490. https://doi.org/10.1002/jmv.25707.

Zhou, P., Yang, X.L., Wang, X.G., Hu, B., Zhang, L., Zhang, W., Si, H.R., Zhu, Y., Li, B., Huang, C.L., Chen, H.D., 2020. A pneumonia outbreak associated with a new coronavirus of probable bat origin. Nature 579 (7798), 270–273. https://doi.org/10.1038/s41586-020-2012-7.

Zu, Z.Y., Jiang, M.D., Xu, P.P., Chen, W., Ni, Q.Q., Lu, G.M., Zhang, L.J., 2020. Coronavirus disease 2019 (COVID-19): a perspective from China. Radiology 296 (2), E15–E25. https://doi.org/10.1148/radiol.2020200490.