Living with the virus: Infection and epidemiology of COVID-19 in hotspot area of India

Rajat Giri | Ashish Kumar | Monika Saini | Rakesh Kumar Sharma

1Department of Biosciences, Manipal University Jaipur, Jaipur, India
2Department of Mathematics and Statistics, Manipal University Jaipur, Jaipur, India

Correspondence
Rakesh Kumar Sharma, Department of Biosciences Manipal University Jaipur-303007, Rajasthan, India. Email: rakeshkumar.sharma@jaipur.manipal.edu
Ashish Kumar, Department of Mathematics and Statistics, Manipal University Jaipur, Jaipur-303007, Rajasthan, India. Email: ashish.kumar@jaipur.manipal.edu

The coronavirus disease (COVID-19) has been identified as a pandemic and affected almost whole world. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the causative agent of this disease, is infecting Indian population since the last week of January 2020. The data were collected from January 30, 2020, to May 23, 2020, to analyze basic trend of COVID-19 cases in India targeting hotspot regions. To find the linear relationship between variables, that is, age, total positive cases, population, and population density data have been statistically analyzed. COVID-19 caused more than 5000 deaths till May 2020 in India. SARS-CoV-2 spread to several Indian cities with more than 100,000 positive cases. Total number of COVID-19 cases and total recovered cases followed the exponential distribution, while number of deaths showed linear behavior. Nearly 50% of the youth, that is, 20–40 years of age had been found to recover from the infection. As a lockdown cannot be a permanent solution, it is important to understand the nature of virus and learn “living with the virus” while minimizing its spreading at the same time.

Keywords
COVID-19, hotspot regions, India, recovery, SARS-CoV-2

1 INTRODUCTION

The coronavirus belongs to a family of viruses that may cause various symptoms from mild to severe and is mainly characterized by fever, breathing difficulty, pneumonia, and lung infection. Earlier, these viruses have been found common in animals worldwide (Y. Guan et al., 2003), but very few cases have been known to affect humans. However, outbreak of novel coronavirus had severely affected human kind resulting into death of individuals at an enormous level. The first genome of COVID-19 was published in January 2020 (NCBI accession No. MN908947.3). Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) affects the lower respiratory tract of patients; however its susceptibility seems to be associated with age, gender, and other health conditions. A higher viral load was observed in the nasal cavity as compared to the throat, either symptomatic, or asymptomatic (Singhal, 2020). Infection can be acquired by inhalation of virus-containing droplets or touching surfaces contaminated by them and then touching the nose, mouth, and eyes. The viral infection has been observed in different body parts. Figure 1 highlights the possible mode of viral entry, its infection sites.

Angiotensin-converting enzyme 2 (ACE2), a membrane-bound amino peptidase, is highly expressed in the heart and lungs cells, having vital role in the cardiovascular and immune systems. It had also been involved the development of hypertension and diabetes mellitus. SARS-CoV-2 requires angiotensin-converting enzyme 2 (ACE-2) which acts as a receptor for virus and type-2 transmembrane protease (TMPRSS2) for proteolytic cleavage of ACE-2 and activation of the spike protein to enter the cells (Groß et al., 2020). This binding of SARS-CoV-2 to ACE-2 receptors in the type II pneumocytes in the lungs triggers a cascade of inflammation, thus affecting the lower respiratory tract. Similar mechanism has been employed by influenza and human metapneumovirus to facilitate viral entry into the host cell (Rabi et al., 2020).

COVID-19 can also result in several critical conditions including systemic inflammation, multiorgan dysfunction, and severe illness. Presence of functional glial–lymphatic pathway has been confirmed in brain (Louveau et al., 2015), also SARS-CoV-2 has been observed in frontal lobe tissue through transmission electron microscopy (TEM) (Paniz-Mondolfi et al., 2020). Thus, the olfactory/cervical lymphatic vessels or hematogenous route might act as an entry route for SARS-CoV-2 to
the brain. However, SARS-CoV-2 might infect the endothelial cells of lymphatic vessels branching from cervical lymph nodes to nasal cavity and reaching to brain resulting into neurological symptoms. Several neurological symptoms such as headache, intracranial infection related symptoms (epilepsy, disturbance of consciousness, headache), and peripheral nervous system symptoms (hypogeusia, hyposmia, deficit in visual function, and neuralgia) (Mao et al., 2020) had been observed in patients with COVID-19. Most recently, neurological disorder such as meningitis/encephalitis has been reported to be associated with COVID-19 (Moriguchi et al., 2020). Moreover, elderly patients might easily get prone to cerebrovascular disease (hemorrhage) due to lower platelet count and increased hypercoagulable states (high D-dimer levels) (Panigada et al., 2020).

COVID-19 positive patients with digestive symptoms (lack of appetite, diarrhea, vomiting, and abdominal pain) had been monitored to have more antimicrobial treatment, lower monocyte count, longer prothrombin time, and higher mean liver enzyme levels than those without digestive symptoms (Pan et al., 2020). This might be due to upregulation of ACE-2 expression in liver tissue causing tissue injury (G. W. Guan et al., 2020) or damage to intestinal mucosa and flora due to direct/indirect inflammatory response. However, any changes in composition and function of digestive tract flora might affect respiratory tract resulting into pneumonia-like symptoms. Gastrointestinal (GI) symptoms (nausea, vomiting, or diarrhea) in patients with COVID-19 had also been studied earlier (Jin et al., 2020). Detection of live and elevated concentrations of SARS-CoV-2 in stool samples and toilet areas might confirm the fecal–oral route as a possible route for transmission (Liu et al., 2020). Although, even after clearance of respiratory tract from infection, patients have been found positive for viral infection in feces (Xiao et al., 2020). This suggests that GI symptoms could be common and cannot be co-related with presence of virus in stool. Presence of ACE2 cell receptor does not only account for the entry of SARS-CoV-2, transmembrane protease serine 2 (TMPRSS2) has also been reported for successful entry of virus (Hoffmann et al., 2020). Also, co-expression of ACE2 and TMPRSS2 in ileum and colon might suggest invasion of virus in enterocytes of the digestive tract resulting into enteric symptoms (H. Zhang, Kang, et al., 2020).
SARS-CoV-2 has been reported to cause lymphocytic endothelitis and endothelial dysfunctions in the heart, kidney, liver, lung, and submucosal vessels of the small intestine by infecting endothelial cells (Varga et al., 2020). ACE2 acts as a binding spike to virus which had also been reported to be highly expressed in heart (Turner et al., 2004). Patients have also been reported to show myocardial injuries manifested as high blood pressure and high level of high-sensitivity cardiac troponin I (hs-cTnI) (Huang et al., 2020). This might be due to disturbance in ACE2-related signaling pathways, hypoxemia, respiratory dysfunction, or due to altered response from helper T-cells (type 1 and type 2) triggering cytokine level (cytokine storm), thus resulting in damage to myocardial cells (Alhogbani, 2016). ACE2 is a multiaction cell-membrane enzyme that is widely expressed in the lungs, heart tissue, intestine, kidneys, central nervous system, testis, and liver. SARS-CoV-2 had been reported to directly invade the digestive tract through binding with ACE2 receptors in glandular cells of gastric, duodenal, and rectal epithelial cells, as well as in enterocytes of small intestinal thus might alter its normal functioning resulting into gastrointestinal symptoms as stated above. Virus may also enter into human-induced pluripotent stem cell-derived cardiomyocyte (hiPSC-CMs) via ACE2, and the viral replication and cytopathic effects might induce hiPSC-CM apoptosis and cessation of beating resulting in cardiovascular risk factors. Thus, alternation in ACE2 functioning might enhance the risk with adverse health outcomes.

Novel coronavirus, SARS-CoV-2 entered India in February 2020, when the first positive case was reported on February 15, 2020. The viral spread was slow, and only about 100 cases were reported positive in 1 month upto March 15, 2020. Spreading rate of virus increased gradually and the positive reported cases reached to 12,000 in next 1 month upto April 15 and 85,000 upto May 15, 2020. Overall, India observed more than 5000 deaths till May 2020 with a rate of about 100 deaths per day in the month of May 2020. The positive cases reached to more than 50,000 per day in the month of August 2020. However, it was proposed on the basis of initial evidence to reduce the incidence rate of COVID-19 in India and useful in policymaking (Sharma et al., 2020). Thus, the present research article deals with SARS-CoV-2 spread in India with a focus on four hotspot regions as compared to the lower infected regions. The infection caused by SARS-CoV-2 is further discussed with respect to age and pre-medical history. The effect of lockdown has also been correlated with spreading of disease (COVID-19). Further, the article elaborates how to live with the virus. Preventive strategies for healthcare and sanitary staff along with normal public have been discussed to reduce the transmission.

2 | METHODOLOGY

2.1 | Study area

India is situated in south Asia bounded by Himalayan mountains range in north and Indian Ocean in south. It is seventh largest country in world by area and second by population. The population density of India is 464 persons per square kilometer with median age 28.4 years. India is a federal union having 739 districts among 28 states and 8 union territories. In present study, most affected states and red zone districts of India are included for COVID-19 analysis.

2.2 | Data collection and descriptive analysis

The data set related to present study on COVID-19 outbreak has been taken from the website (https://www.covid19india.org/) for the time period January 30, 2020, to May 23, 2020, to analyze basic trend of COVID-19 cases in India. Also, comparative relationship between COVID-19 positive cases, age of patients, deaths, and their percent recovery has been analyzed. A sample of 423 units has been taken to test the effect of age on recovery and death of patients.

2.3 | Comparative analysis

Total number of COVID-19 cases, recovered, active, deaths, recovery rate, and death rate from six most burdened states (Maharashtra, Tamil Nadu, Gujarat, Delhi, Rajasthan, and Madhya Pradesh) and nine most affected red zones (Mumbai, Ahmedabad, Delhi, Chennai, Jaipur, Indore, Nashik, and Pune) had been included in separate comparative analysis.

2.4 | Statistical analysis

2.4.1 | Correlation analysis

To find the linear relationship between variables, that is, age, total positive cases, population, and population density data has been statistically analyzed. To provide direction and strength of relationship between variables, the coefficient of correlation (Chatterjee & Hadi, 2014) has been defined as:

\[
\text{Corr}(X,Y) = r(X,Y) = \frac{\sum(y_i - \bar{y})(x_i - \bar{x})}{\sqrt{\sum(y_i - \bar{y})^2 \sum(x_i - \bar{x})^2}}
\]

And \(-1 \leq r(X,Y) \leq 1\)

2.4.2 | Hypothesis testing

Testing of hypothesis is a test procedure used to decide whether a hypothesis is to be rejected or not. The acceptance or rejection is based upon p-value. “The probability that the value of test statistic is at least as extreme as its computed value on the basis of sample data under null hypothesis.” The effect of demographic variables and association
of geographical location with COVID-19 patient status has been analyzed.

2.5 | Emerging challenges and their future treatment strategies

Information regarding medical conditions and various complications been faced by individuals all over the world especially health care workers has been summarized. Also, treatment strategies regarding various symptoms and blockage of entry route to inhibit the spread of COVID-19 virus has been listed.

3 | RESULTS AND DISCUSSION

3.1 | Cases, deaths, and recovery—general trend in India

Total number of COVID-19 confirmed and recovered cases ranged between 1.2–1.4 lakh and 4–6 thousand till May 23, 2020, respectively (Figure 2(a)). However, total number of COVID-19 cases and total recovered cases followed the exponential distribution while number of deaths showed linear behavior. Age factor has been found to be greatly associated with the no. of positive cases, deaths, and recovery. Most infected individuals ranged from 50 to

![Cumulative Graph]

**FIGURE 2** (a) Trend of COVID-19 cases in India; (b) age versus COVID-19 patient’s recovery (%)

![Age versus COVID-19 cases (%)]

**FIGURE 3** (a) Age versus COVID-19 cases (%); (b) age versus COVID-19 death (%)
70 years of age (Figure 2(b)), which shows that aged (old age) individuals are more susceptible/prone toward the COVID-19 viral infection. Frequency of death also remained high for the individuals with age group between 40 and 80 years (Figure 3(a)). Moreover, nearly 50% of the youth, that is, 20–40 years of age had been found to recover from the infection (Figure 3(b)). This might be due more advanced immune system and its ability to modify quickly under changed environment.

### 3.2 | Comparative analysis

The confirmed COVID-19 patient cases among most burdened states decreased in the order Maharashtra > Gujarat > Tamilnadu > Delhi > Rajasthan > Madhya Pradesh, while the recovered cases decreased in order Maharashtra > Tamilnadu > Delhi > Gujarat > Rajasthan > Madhya Pradesh (Figure 4). Moreover, Maharashtra had been found to have highest death percent of infected individuals followed by Gujarat and other states.

Comparative analysis of red zone areas confirmed Mumbai to have most confirmed and active individuals suffering from COVID-19 infection followed by Delhi (Figure 5). However, Kasaragod had been found to have maximum recovery rate (86.1%), while Ahmedabad had been found to be most struggling due to infection by having 6.68% death rate. Also, Indore had been found to have patients with most diabetic prevalence (Table 1).

### 3.3 | Correlation analysis

Negative and positive values reflect negative and positive relationship between variables, respectively. According to analysis, population and total COVID-19 tests had been found to be positively associated (Table 2). The testing for COVID-19 infected patients is strongly associated with testing for COVID-19. Also, it had been observed that death rate moderately increases with the age and recovery decrease with respect to age. COVID-19 infection spread in red zone areas had been identified specially due to the population density. For these areas, value of coefficient of correlation is 0.707, that is, highly correlated.

### 3.4 | Hypothesis testing

It has been observed that COVID-19 patient’s death and recovery does not follow uniform pattern between different age groups as well
as between male and female (Tables 3 and 4). Also according to geographical location, the patient status change does not follow the similar pattern.

3.5 Emerging challenges and their future treatment strategies

3.5.1 SARS-CoV-2 and other medical condition

Cardiovascular system can also be affected by SARS-CoV-2 with various complications like dysrhythmias, heart failure, myocardial injury, myocarditis, acute myocardial infarction, and venous thromboembolic events (Long et al., 2020). SARS-CoV-2 and Middle East respiratory syndrome–related coronavirus (MERS-COV) have similar pathogenicity, which causes myocardial damage by infection with these viruses.

The disease was well correlated with obesity, smoking, diabetes, and hypertension (Shekhar et al., 2020).

People with diabetes are at higher risk of severe and fatal COVID-19 disease. The prevalence of diabetes in India is 7.3% and in the selected hot spot region is given in Table 1. The data from different countries showed high variation as Chinese studies reported about 5%–11% COVID-19 patients had diabetes, while the maximum COVID-19 patients had diabetes in the USA (58%). An Italian study showed that nearly 36% COVID-19 patients had diabetes. It was also suggested that patients of COVID-19 with diabetes are usually associated with severe or critical conditions varying from 14% to 32% (Singh et al., 2020).

A case study reported the immune responses of a patient with mild-to-moderate symptomatic COVID-19. The results revealed that there were an increased antibody-secreting cells (ASCs), follicular helper T-cells (TFH cells), activated CD4+ T-cells, CD8+ T-cells, and immunoglobulins IgM and IgG in the blood that may bind to SARS-CoV-2. Antibodies may persist even after the full resolution of symptoms (Thevarajan et al., 2020). It was reported that a 5 years’ old COVID-19 patient, who received kidney transplantation earlier, showed higher neutrophil and monocyte counts. Discontinuation of all immunosuppressive agents helped him in recovery within 20 days (Zhu et al., 2020). Similarly, a 13-year-old child with multiple comorbidities, who acquired COVID-19, 5 years post renal transplantation in the United States. A transient rise in his serum creatinine was observed and could be cured by slight reduction in immunosuppression (Bush et al., 2020).

3.5.2 Infection among healthcare workers

Transmission of virus to the healthcare workers caring for patients could be considered as greatest risk in COVID-19 pandemic.
As per the conditions, the protocol for assessment of potential risk factors for COVID-19 among health workers in a health care setting has been already released by WHO.

Some studies reported that no health-related complications or viral symptoms were observed in 41 health care workers having exposure to aerosol-generating procedures for at least 10 min at a distance of less than 2 m from the patient. These health care workers were home quarantine for 14 days, with regular monitoring. To check the viral infection, nasopharyngeal swabs were scheduled from the very first day of home isolation up to 14 day with appropriate intervals. All the RT-PCR-based tests for SARS-CoV-2 were also negative (Ng et al., 2020).

On the other hand, a study reported asymptomatic or mild symptoms of SARS-CoV-2 infection in the clinical staff. Most of these cases showed conjunctivitis as the first symptom. A case with conjunctivitis was noticed at the third day after close contact with a COVID-19 patient. Nasopharynx swab of the patient was positive with SARS-CoV-2 infection, but conjunctival sac swab was a negative result. Another patient detected positive results for SARS-CoV-2 in both nasopharynx and conjunctival sac swabs. However, the ocular symptoms disappeared after 7 days of topical administration of antiviral eye drops (X. Li, Wang, et al., 2020).

China reported 1500 healthcare workers with six deaths to be infected with COVID-19 virus (Singhal, 2020). Indian healthcare workers mostly nurses and some doctors had also been tested positive for COVID-19. Beside proper protocols, it is very important to associate a microbiologist or virologist to regulate the potential viral spreading activities among different health workers. Some hospitals have also started using robots for routine work-like medicine or food distribution to minimize the contact. Also, individuals dealing with COVID-19-infected patients are also expected to be susceptible to mental health-related aspects. However, online mental health consultation might be a good consideration regarding the above (Yao et al., 2020). Medical staff had been reported to have psychological stress, particularly vicarious traumatization caused by the COVID-19 pandemic (Z. Li, Ge, et al., 2020). This might be due to lack of protective technology and elevated workload. Suicidal cases had also been reported in countries like India which might be as a result of mental fear of spreading the virus among other individuals (Goyal et al., 2020). Also, providing mental health care training to the care professionals working in isolation and hospitals might provide an edge toward stress-related issues for staff as well as patients.

A dedicated sterilization system needs to be implemented to avoid the infection. Another reason may be related to the lack of personal protective equipment (PPE) and education about its correct use. Standard measures must be properly followed instead of quick implementation of complex protection strategies.

### 3.5.3 Treatment strategies

COVID-19 patients with elevated IL-6 and pneumonia had been approved for controlled trial with tocilizumab, a licensed medicine for cytokine release syndrome (C. Zhang, Wu, et al., 2020). Growth of SARS-CoV-2 in vitro had been reported to be suppressed by an antiviral drug (remdesivir) and an antimalarial drug chloroquine. Also, chloroquine had been found to provide positive significant viral clearance in Chinese patients (Gao et al., 2020). However, use of an analog of chloroquine, that is, hydroxychloroquine might provide with better results due to lesser drug–drug interactions and its long-term use (allowing advanced daily dose) (Marmor et al., 2016). Administration of the hydroxychloroquine along with azithromycin was reported to be safe when prescribed before COVID-19 complications occur and associated with a very low fatality rate in patients (Million et al., 2020). It was also reported that hydroxychloroquine may have some serious side effects like acute hemolysis in glucose-6-phosphate dehydrogenase-deficient patients (Maillart et al., 2020). Current therapies for COVID-19 may interact with cardiovascular medications (Long et al., 2020). As ACE2 had been regarded as potential receptor for COVID-19 virus; therefore, use of angiotensin-receptor blockers (ARBs) and ACE inhibitors might affect the viral entry passage to extent. However, alternation in ACE2 functioning might result into reduction of cardio-protection (abnormal myocardial and pulmonary involvement), thus highly risking patients with adverse health outcomes (Hemnes et al., 2018). Use of a protease inhibitor, that is, TMPRSS2 inhibitor could be a good choice for limiting viral infection (cell entry) by blocking viral spike (S) proteins priming as reported earlier (Hoffmann et al., 2020). The phyto-cannabinoid (THC) might mimic in actions with endogenous cannabinoids (ECB) at the cannabinoid receptors. CB1 and CB2 (cannabinoid receptors) have been found to be expressed in human tissues (Roche et al., 2006), sensory nerve cells, and immune cells (Graham et al., 2010). Earlier, phytocannabinoid and endogenous cannabinoids had also been reported to inhibit the migration of human neutrophils (McHugh et al., 2008), which otherwise might have resulted into triggering of autoimmune, auto-inflammatory, and neoplastic disorders (Nathan, 2006). Both CB1 and CB2 have also been found to be implicated in inflammatory hypersensitivity (Clayton et al., 2002). Inhibition of cytokine production by cannabinoids had been reported in individuals who smoke cannabis through inhibition of TLR (toll-like receptors)-induced immune activation ( Sexton et al., 2014). T-cell activation (via macrophage signaling) had also been reported to be hindered by THC via CB2 receptor (Chuchawankul et al., 2004). Thus, use phyto-cannabinoids might help in suppression of cytokine storm syndrome being evident in severe in COVID-19 patients. Beside all these medical strategies, it is important to minimize the contact as the strategy adapted by Taiwan by wearing mask and maintain good hygienic conditions (Yi-Fong Su et al., 2020).

Microbial metabolites may exert some positive effects on human health against a number of diseases. Recently, microbes especially the symbiotic gut microbes had been reported to produce several neuroactive compounds such as GABA, serotonin, dopamine, and so forth, which could play an important role in the maintenance of emotion and behavior of the host. These microbial metabolites might be sensed possibly by vagus nerve, HPA axis, or reach directly to the brain via the blood stream altering the brain activity, which could be
of significant importance in mental health treatment. So the use of probiotic strain producing these neuroactive compounds might be a promising tool for the treatment of the individuals suffering from the neurological symptoms due to COVID-19 pandemic (Breit et al., 2018). Patients suffering from COVID-19 had been reported to show various gastrointestinal symptoms such as anorexia, nausea, vomiting, and diarrhea which might be due to injury of the gastrointestinal tract. After infected with SARS-CoV-2, the “gut–lung” axis and the interaction between intestinal microbiota and pro-inflammatory cytokines might lead to the above. The change in the gut environmental conditions due to these symptoms might affect the development of gut microbes, which could alter the release of significant metabolites important for the health, resulting in gut microbial dysbiosis (Minj et al., 2020).

Key nutrients (amino acids, proteins, fats and dietary-carbohydrates) that support the immune system can be obtained through dietary components that include fresh foods (eg. fruits and vegetables), fish, lean meat, dairy, water and other non-sugary beverages, and healthy fats. Proper diet can also decrease the risk of, or help control, hypertension, diabetes, obesity, and muscle atrophy, which are all considered risk factors for COVID-19 complications. Dietary intake of certain food items could also increase the level of neuroactive compound in humans by following ways, lowering the risk of neurological symptoms emerging due to COVID-19 pandemic. However, there are no known supplements that can prevent COVID-19. The supplements in diet can mitigate the health risks associated with COVID-19.

Individuals could get exposed to SARS-CoV-2 directly or indirectly (infectious droplets, body fluids, virus-carrying hands) leading to infection of the mucosal cells in the conjunctiva, mouth, nasal cavity, or throat by the virus for replicating. The virus could reach into the human lungs through the respiratory tract, resulting in various types of fever, cough, or ground-glass opacity of lung on CT examination results and even respiratory failure. Thus, it is really important to always cover the nose to minimize the entry of virus. Complete lockdown gave a time for medical preparations and the social awareness through campaign on telephone and television related to hand sanitization and covering the nose and mouth played very important role to prevent the spread of virus. It is well known that virus keeps on changing its genome; however, different strains may cause different levels of infection, thus the vaccine therapy is designed to target a number of strains of same viral particles.

This requires a basic education of microbiology among health workers, staff, and general public. Presence of the virus in asymptomatic carrier and common public area may create a problem, thus it will be the most crucial step to manage. The best way is to assume “everything is infected.” A zero-contact policy for elders and immune-compromised persons must be followed, and medical history of the patient before starting any medication must be shared with the doctors. Immunity booster or proper diet plant can be followed as per the requirements. Strictly following these guidelines and taking precautions may be helpful under unlock conditions. Further, mental health along with the basic required protocols needs to be taken care of, which mainly include the social behavior with all the Corona warriors, infected person, and general public.

**CONFLICT OF INTEREST**
The authors declare no conflicts of interest.

**DATA AVAILABILITY STATEMENT**
The data that support the findings of this study are available from the corresponding author upon reasonable request.

**ORCID**
Ashish Kumar [https://orcid.org/0000-0001-9749-9140](https://orcid.org/0000-0001-9749-9140)
Rakesh Kumar Sharma [https://orcid.org/0000-0002-2826-1291](https://orcid.org/0000-0002-2826-1291)

**REFERENCES**
Alhogbani, T. (2016). Acute myocarditis associated with novel Middle East respiratory syndrome coronavirus. *Annals of Saudi Medicine*, 36, 78–80. https://doi.org/10.5144/0256-4947.2016.78
Breit, S., Kuperberg, A., Rogler, G., & Hasler, G. (2018). Vagus nerve as modulator of the brain–gut axis in psychiatric and inflammatory disorders. *Frontiers in Psychiatry*, 9, 44.
Bush, R., Johns, F., Acharya, R., & Upadhyay, K. (2020). Mild COVID-19 in a pediatric renal transplant recipient. *American Journal of Transplantation*, 20, 2942–2945. https://doi.org/10.1111/ajt.16003
Chatterjee, S., & Hadi, A. S. (2014). Regression analysis by examples. *Wiley series in probability and statistics*. John Wiley & Sons.
Chuchawankul, S., Shima, M., Buckley, N. E., Hartmann, C. B., & McCoy, K. L. (2004). Role of cannabinoid receptors in inhibiting macrophage costimulator activity. *International Immunopharmacology*, 4(2), 265–278. https://doi.org/10.1016/j.intimp.2003.12.011
Clayton, N., Marshall, F. H., Bountra, C., & O’Shaughnessy, C. T. (2002). CB1 and CB2 cannabinoid receptors are implicated in inflammatory pain. *Pain*, 96(3), 253–260. https://doi.org/10.1016/S0304-3959(01)00454-7
Gao, J., Tian, Z., & Yang, X. (2020). Breakthrough: Chloroquine phosphate has shown apparent efficacy in treatment of COVID-19 associated pneumonia in clinical studies. *Bioscience Trends*, 14, 72–73. https://doi.org/10.5582/BST.2020.01047
Goyal, K., Chauhan, P., Chikara, K., Gupta, P., & Singh, M. P. (2020). Fear of COVID-19: First suicidal case in India! *Asian Journal of Psychiatry*, 49, 101989. https://doi.org/10.1016/j.ajp.2020.101989
Graham, E. S., Angel, C. E., Schwarz, L. E., Dunbar, P. R., & Glass, M. (2010). Detailed characterisation of CB2 receptor protein expression in peripheral blood immune cells from healthy human volunteers using flow cytometry. *International Journal of Immunopathology and Pharmacology*, 23(1), 25–34. https://doi.org/10.1177/039463201002300103
Groß, S., Jahn, C., Cushman, S., Bär, C., & Thum, T. (2020). SARS-CoV-2 receptor ACE2-dependent implications on the cardiovascular system:

**4 | CONCLUSION**

The viral infection is continuously increasing in India. No doubt the lockdown strategy and public awareness have reduced the rate of infection, initially but still the virus is spreading. Some Indian regions are prevailing in infection, which shows a positive correlation between population density and viral spreading. Further death rate can be well correlated with aged people, and recovery rate is much higher in young generations. On the basis of the results and present scenario, it is recommended that we need to learn living with the virus.
From basic science to clinical implications. *Journal of Molecular and Cellular Cardiology*, 144, 47–53. https://doi.org/10.1016/j.yjcc.2020.04.031

Guo, G. W., Gao, L., Wang, J. W., Wen, X. J., Mao, T. H., Peng, S. W., Zhang, T., Chen, X. M., & Lu, F. M. (2020). Exploring the mechanism of liver enzyme abnormalities in patients with novel coronavirus-infected pneumonia. Zhonghua Gan Zang Bing Za Zhi = Zhonghua Ganzangbing Zazhi = Chinese Journal of Hepatology, 28(02), 100–106. https://doi.org/10.3760/cma.j.issn.1007-3418.2020.02.002

Guo, Y., Zheng, B. J., He, Y. Q., Liu, X. L., Zhuang, Z. X., Cheung, C. L., Luo, S. W., Li, P. H., Zhang, L. J., Guan, Y. J., Yu, B. T., Kung, K. L., Wong, K. L., Chan, K. W., Lim, W., Shortridge, K. F., Yuen, K. Y., Peiris, J. S. M., & Poon, L. L. M. (2003). Isolation and characterization of viruses related to the SARS coronavirus from animals in southern China. Science, 302, 276–278. https://doi.org/10.1126/science.1087139

Hennes, A. R., Rathinasabapathy, A., Austin, E. A., Brittain, E. L., Carrier, E. J., Chen, X., Fessel, P. J., Fike, C. D., Fong, P., Fortune, N., Gerstzen, R. E., Johnson, J. A., Kaplowitz, M., Newman, J. H., Plana, R., Pugh, M. E., Rice, T. W., Robbins, I. M., Wheeler, L., ... West, J. (2018). A potential therapeutic role for angiotensin-converting enzyme 2 in human pulmonary arterial hypertension. *European Respiratory Journal*, 51(6), 1702638. https://doi.org/10.1183/13993003.02638-2017

Hoffmann, M., Kleine-Weber, H., Schroeder, S., Krüger, N., Herrler, T., Erichsen, S., Schiergens, T. S., Herrler, G., Wu, N.-H., Nitsche, A., Müller, M. A., Drosten, C., & Pöhlmann, S. (2020). SARS-CoV-2 cell entry depends on ACE2 and TMPRSS2 and is blocked by a clinically proven protease inhibitor. Cell, 181, 271–280.e8. https://doi.org/10.1016/j.cell.2020.02.052

Huang, C., Wang, Y., Li, X., Ren, L., Zhao, J., Hu, Y., Zhang, L., Fan, G., Xu, J., Gu, X., Cheng, Z., Yu, T., Xia, J., Wei, Y., Wu, W., Xie, X., Yin, W., Li, H., Liu, M., ... Cao, B. (2020). Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The Lancet, 395, 497–506. https://doi.org/10.1016/S0140-6736(20)30183-5

Jin, X., Lian, J. S., Hu, J. H., Gao, J., Zheng, L., Zhang, Y. M., Hao, S.-R., Jia, H.-Y., Cai, H., Zhang, X.-L., Yu, G.-D., Xu, K.-J., Wang, X.-Y., Gu, J.-Q., Zhang, S.-Y., Ye, C.-Y., Jin, C.-L., Lu, Y.-F., Yu, X., ... Yang, Y. (2020). Epidemiological, clinical and virological characteristics of 74 cases of coronavirus-infected disease 2019 (COVID-19) with gastrointestinal symptoms. Gut, 69, 1002–1009. https://doi.org/10.1136/gutjnl-2020-320926

Li, X., Wang, M., Dai, J., Wang, W., Yang, Y., & Jin, W. (2020). Novel coronavirus disease with conjunctivitis and conjunctivitis as first symptom: A retrospective analysis of 1061 cases in Marseille, France. *Travel Medicine and Infectious Disease*, 35, 101738. https://doi.org/10.1016/j.tmaid.2020.101738

Minj, J., Chandra, P., Paul, C., & Sharma, R. K. (2020). Bio-functional properties of probiotic lactobacillus: Current applications and research perspectives. *Critical Reviews in Food Science and Nutrition*, 1–18. https://doi.org/10.1080/10408398.2020.1774496

Moriguchi, T., Harii, N., Goto, J., Harada, D., Sugawara, H., Takamino, J., Ueno, M., Sakata, H., Kondo, K., Myose, N., Nakao, A., Takeda, M., Hara, H., Inoue, O., Suzuki-Inoue, K., Kubokawa, K., Ogihara, S., Sasaki, T., Kinouchi, H., ... Shimada, S. (2020). A first case of meningitis/encephalitis associated with SARS-CoV-2. *International Journal of Infectious Diseases*, 94, 55–58. https://doi.org/10.1016/j.ijid.2020.03.062

Nathan, C. (2006). Neutrophils and immunity: Challenges and opportunities. *Nature Reviews Immunology*, 6(3), 173–182. https://doi.org/10.1038/nri1785

Ng, K., Poon, B. H., Kiatt Puar, T. H., Shan Quah, J. L., Loh, W. J., Wong, Y. J., Tan, T. Y., & Raghuram, J. (2020). COVID-19 and the risk to health care workers: A case report. *Annals of Internal Medicine*, 172, 766–767. https://doi.org/10.7322/1533-8516-2020-10-0175

Pan, L., Mu, Y., Yang, P., Sun, Y., Wang, Y., Yan, J., Li, P., Hu, B., Wang, J., Cai, J., Liu, Y., Xiao, P., Du, Y., Li, T., Xu, G., Hu, Q., & Tu, L. (2020). Clinical characteristics of COVID-19 patients with digestive manifestations in Hubei, China: A descriptive, cross-sectional, multicenter study. *The American Journal of Gastroenterology*, 115, 766–773. https://doi.org/10.14309/ajg.0000000000000620

Panigada, M., Bottino, N., Tagliabue, P., Grasselli, G., Novembrino, C., Chantarangkul, V., Pesentl, A., Pevyandi, F., & Tripodi, A. (2020). Hypercoagulability of COVID-19 patients in intensive care unit. A report of Thromboelastography findings and other parameters of hemostasis. *Journal of Thrombosis and Haemostasis: JTH*, 18, 1738–1742. https://doi.org/10.1111/jth.14850

Paniz-Mondolfi, A., Bryce, C., Grimes, Z., Gordon, R. E., Reidy, J., Lednicky, J., Sordillo, E. M., & Fowkes, M. (2020). Central nervous system involvement by severe acute respiratory syndrome coronavirus –2 (SARS-CoV-2). *Journal of Medical Virol*, 92, jmv.25915. https://doi.org/10.1002/jmv.25915

Rabi, F. A., Al Zoubi, M. S., Al-Nasser, A. D., Kasasbeh, G. A., & Salameh, D. M. (2020). Sars-cov-2 and coronavirus disease 2019: What we know so far. *Pathogens*, 9, 231. https://doi.org/10.3390/pathogens9030231

Roche, R., Hoareau, L., Bes-Houtmann, S., Gonthier, M. P., Laborde, C., Baron, J. F., Haffaf, Y., Cesari, M., & Festy, F. (2006). Presence of the...
cannabinoid receptors, CB1 and CB2, in human omental and subcutaneous adipocytes. *Histochemistry and Cell Biology*, 126(2), 177–187. https://doi.org/10.1007/s00418-005-0127-4

Sexton, M., Cudaback, E., Abdullah, R. A., Finnell, J., Mischley, L. K., Rozga, M., Lichtman, A. H., & Stella, N. (2014). Cannabis use by individuals with multiple sclerosis: Effects on specific immune parameters. *Inflammopharmacology*, 22(5), 295–303. https://doi.org/10.1007/s10787-014-0214-z

Sharma, P., Singh, A. K., Agrawal, B., & Sharma, A. (2020). Diabetes in COVID-19: Prevalence, pathophysiology, prognosis and practical considerations. *Diabetes and Metabolic Syndrome: Clinical Research and Reviews*, 14(4), 303–310. https://doi.org/10.1016/j.dsx.2020.04.004

Singhal, T. (2020). A review of coronavirus Disease-2019 (COVID-19). *The Indian Journal of Pediatrics*, 87(4), 281–286. https://doi.org/10.1007/s12098-020-03263-6

Thevarajan, I., Nguyen, T. H. O., Koutsakos, M., Druce, J., Caly, L., van de Yao, X., Ye, F., Zhang, M., Cui, C., Huang, B., Niu, P., Liu, X., Zhao, L., Singh, A. K., Gupta, R., Ghosh, A., & Misra, A. (2020). Diabetes in COVID-19: Evidence for Varga, Z., Flammer, A. J., Steiger, P., Haberecker, M., Andermatt, R., Singhal, T., Zhou, M., Tong, S. Y. C., Lewin, S. R., & Kedzierska, K. (2020). Breadth of concomitant immune responses prior to patient recovery: A case report of non-severe COVID-19. *Nature Medicine*, 26, 453–455. https://doi.org/10.1038/s41591-020-0819-2

Turner, A. J., Hiscox, J. A., & Hooper, N. M. (2004). ACE2: From vaso-peptidase to SARS virus receptor. *Trends in Pharmacological Sciences*, 25, 291–294. https://doi.org/10.1016/j.tips.2004.04.001

Varga, Z., Flammer, A. J., Steiger, P., Haberecker, M., Andermatt, R., Zinkernagel, A. S., Mehra, M. R., Schuepbach, R. A., Ruschitzka, F., & Moch, H. (2020). Endothelial cell infection and endothelitis in COVID-19. *The Lancet*, 395, 1417–1418. https://doi.org/10.1016/S0140-6736(20)30937-5

Xiao, F., Tang, M., Zheng, X., Liu, Y., Li, X., & Shan, H. (2020). Evidence for gastrointestinal infection of SARS-CoV-2. *Gastroenterology*, 158, 1831–1833.e3. https://doi.org/10.1053/j.gastro.2020.02.055

Yao, X., Ye, F., Zhang, M., Cui, C., Huang, B., Niu, P., Liu, X., Zhao, L., Dong, E., Song, C., Zhan, S., Lu, R., Li, H., Tan, W., & Liu, D. (2020). In-vitro antiviral activity and projection of optimized dosing Design of Hydroxychloroquine for the treatment of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). *Clinical Infectious Diseases: An Official Publication of the Infectious Diseases Society of America*, 71, 732–739. https://doi.org/10.1093/cid/ciaa237

Yi-Fong Su, V., Yen, Y.-F., Yang, K.-Y., Su, W.-J., Chou, K.-T., Chen, Y.-M., & Perng, D.-W. (2020). Masks and medical care: Two keys to Taiwan’s success in preventing COVID-19 spread. *Travel Medicine and Infectious Disease*, 38, 101780. https://doi.org/10.1016/j.tmaid.2020.101780

Zhang, C., Wu, Z., Li, J. W., Zhao, H., & Wang, G. Q. (2020). The cytokine release syndrome (CRS) of severe COVID-19 and Interleukin-6 receptor (IL-6R) antagonist Tocilizumab may be the key to reduce the mortality. *International Journal of Antimicrobial Agents*, 55, 105954. https://doi.org/10.1016/j.ijantimicag.2020.105954

Zhang, H., Kang, Z., Gong, H., Xu, D., Wang, J., Li, Z., Li, Z., Cui, X., Xiao, J., Zhan, J., Meng, T., Zhou, W., Liu, J., & Xu, H. (2020). Digestive system is a potential route of COVID-19: An analysis of single-cell coexpression pattern of key proteins in viral entry process. *Gut*, 69, 1010–1018. https://doi.org/10.1136/gutjnl-2020-320953

Zhu, L., Xu, X., Ma, K., Yang, J., Guan, H., Chen, S., Chen, Z., & Chen, G. (2020). Successful recovery of COVID-19 pneumonia in a renal transplant recipient with long-term immunosuppression. *American Journal of Transplantation*, 20, 1859–1863. https://doi.org/10.1111/ajt.15869

**AUTHOR BIOGRAPHIES**

Mr Rajat Giri holds Master’s degree in Biotechnology. He is actively involved in the field of microbial technology and exploring different application of microbes for industrial applications.

Dr Ashish Kumar is working as an Assistant Professor in the Department of Mathematics & Statistics, Manipal University Jai-pur. He hold a Ph D degree and having more than 7 years experience in the field of statistical analysis of data.

Dr Monika Saini is working as an Assistant Professor in the Department of Mathematics & Statistics, Manipal University Jai-pur. She is a Ph D and actively involved in the teaching and research for last 6 years in the field of statistics.

Dr Rakesh Kumar Sharma, Ph D in Microbiology is actively involved in the teaching and research. He has worked as UGC DSK Postdoctoral fellow and having more than 7 years of post Ph D experience in the field of Microbiology.

How to cite this article: Giri R, Kumar A, Saini M, Sharma RK. Living with the virus: Infection and epidemiology of COVID-19 in hotspot area of India. *J Public Affairs*. 2021;21:e2651. [https://doi.org/10.1002/pa.2651](https://doi.org/10.1002/pa.2651)