European Journal of Molecular & Clinical Medicine
ISSN 2515-8260 Volume 7, Issue 06, 2020

APPLICATION OF SOFT COMPUTING TECHNIQUES IN THE ANALYSIS OF COVID – 19: A REVIEW

[*1,a]R. Arul, [1,b]M. Moovendan, [1,c]S. Dhivya, [2]R. Kanimozhi, [1,d]S. Angalaeswari, [3]Padmanathan Kasinathan, [4, 5]Oscar Danilo Montoya, [6]Walter Gil-González

[1]School of Electrical Engineering, Vellore Institute of Technology, Chennai 600127, Tamilnadu, India.

[2]Department of Electronics and Communication Engineering, FEAT, Annamalai University, Annamalai Nagar 608002, Tamilnadu, India.

[3]Department of Electrical and Electronics Engineering, Agni College of Technology, Thalambur, Chennai, Tamilnadu, India.

[4]Laboratorio Inteligente de Energía,UniversidadTecnológica de Bolívar, Cartagena 131001, Colombia.

[5]Facultad de Ingeniería, Universidad Distrital Francisco José de Caldas, Bogotá D.C 11021, Colombia.

[6]Grupo GIIEN, Facultad de Ingeniería, Institución UniversitariaPascual Bravo, Campus Robledo, Medellín 050036, Colombia.

**Corresponding Author: R. Arul*

Abstract: Background and objective: Many trends are being raised across global countries for the novel disease 'Corona-Virus' (COVID-19). Shelter-in-place (SIP) orders are implemented worldwide to reduce the proliferation rate of this virus. Since the World Health Organization (WHO) proclaimed it as 'pandemic,' its emergent state prevails worldwide. As a successor of SARS-CoV-2, higher destruction has been enforced on human lives intolerably. However, the prior detection could help shorten this disease's proliferation rate; various prediction and diagnosis tools are useful with artificial intelligence. These tools might assist in preventive measures against the virus infection. The main objective of this article is two-folded. First, to explore the application of soft computing techniques, the overview of machine learning (ML), deep learning (DL), internet of things (IoT), and support vector machines (SVM) have been interpreted concerning COVID-19 analysis. Next, to analyze performance, a comparative study has been represented to show that the soft computing models outperform some of the prevailed analytical models on the COVID-19. Method: To forecast and predict a pandemic outbreak, Cauchy distribution probabilistic approaches are applied. An extensive study of mathematical and theoretical, and approximate models based on soft computing done for COVID-19 prediction. Consecutively, some curious factor such as infection rate based on age groups could be forecasted. Also, Sick rate, and immunity rate during the quarantine period

have been analyzed for nearly 500 sample tests taken globally. Result: This research scopes for extensive analysis of COVID-19 entitled to health policies. It would facilitate the technocrats to develop heuristic models for this wide-spread disease through forecasting of real-time data. It also addresses the statistical analysis of COVID-19 articles and future scope for technocrats regarding COVID-19 prediction and diagnosis.

Keywords: COVID-19, artificial intelligence, soft computing techniques, machine learning, internet of things, health policies, cauchy distribution

Nomenclature:

AI	Artificial intelligence	LS-SVM	Least square support vector machine
ANFIS	Adaptive network-based fuzzy inference system	MAE	Mean absolute error
ARIMA	Autoregressive integrated moving average	ML	Machine learning
BDA	Bulgarian drug agency	MERS-CoV	Middle-East Respiratory Syndrome Corona –Virus
CC	Confirmed cases	MPH	Masters of public health
CI	Confidence interval	MSE	Mean square error
CIoMT	Cognitive internet of medical things	NHS	National health service
CNN	Convolutional neural network	PPE	Personal protective equipment
CT	Computed tomography	RMS	Root mean square
COVID-19	Corona virus disease-2019	RMSE	Root mean square error
DC	Death count	RT-PCR	Reverse transcription-Polymerase chain reaction
DTL	Deep transfer learning	SARS-CoV	Severe acute respiratory syndrome coronavirus
EMA	European medicines agency	SEIAR	Susceptible-Exposed-Infected-Asymptomatic-Recovered
FDA	Food and drug administration	SIR	Susceptible-Infected-Recovered
GEP	Gene expression programming	SIRD	Susceptible-Infected-Recovered-Dead
GP	Genetic programming	SVM	Support vector machine
HTA	Health technology assessment	VOA	Virus optimization algorithm
IoT	Internet of things	WHO	World health organization
IS	Information system		

1. INTRODUCTION:

Various kind of infectious diseases have endangered the lives of infinite individuals in decades of history. These diseases have evoked important things that have taken an extended time to beat true. The term ‘pandemic’ is accustomed to indicate the sickness that transpires over an exact period. “Pandemics measure” outbreaks of communicable disease may staggeringly increase the mortality over a massive geographical region. It is mainly due to the factors like the rise of world - wide problems such as urbanization, deforestation, pollution

and ecological imbalance. In a past scenario, the happening of pox has killed nearly 500 million population of world within a century. Approximately 17 to 100 million lives had been lost during the 1918 Spanish contamination [1]. Severe Acute Respiratory Syndrome Corona-Virus (SARS-CoV), H1N1 contagion and Middle-East Respiratory Syndrome Corona-Virus (MERS-CoV) have been reported in the years 2002, 2009 and 2015 respectively.

2. COVID-19 AROUND THE GLOBE:

Novel COVID-19 has been started to unveil its cruel wings at area of Wuhan, located at China, on end period of 2019. Soon, this virus has continued to proliferate quickly all over the world. It has been inferable from contaminated people of getting the virus. Symptoms have been displaying practically zero indications. The proclamation stated COVID-19 as a worldwide pandemic on Day-11 of March 2020 by World Health Organization has a great significance. Because, the destruction and contamination rate set off by the infection has found to be high. The Centre for Disease control and prevention reported that every one of the 50 states in the United States of America (USA) has affirmed cases. People group dissemination has been getting the conspicuous transmission of this virus in USA. Consequently, the adequacy of restricting social contact is utilized by nearby and public governments being assessed with considerably larger infection rates than SARS, a predecessor of it. Enough information at the regional level is currently accessible to give a reasonable appraisal of the good presidential rules given on March 16, 2020, by restricting social affairs to 10 or fewer individuals [2].The reason for this outbreak has been determined to be a completely unique corona virus, referred to as COVID-19. At the last week of March 2020, the virus has unfolded over 170 nations with the approximate 423,000 confirmed cases and 19,000 death tolls. The reports showed the volatile rates of mortality among nations due to different age factor and demography distribution. 2.3% of mortality rate has occurred in China [3].

As of May 30, 2020, the WHO reports that the SARS-CoV-2 infects around 3.48 million people and leads to fatal of about 248,188 across 213 countries. It is mainly due to the severity of COVID-19 compared to the previous infectious agent past years, and it has been found as the most dreadful disease to date. The major causes of the natural event COVID 19 pandemics highly disturb the countries' political, economic, social, and financial structures. Also, the economic status of the world's developed countries like the US, China, Japan, UK, Germany, France, and other upmost nations critically at the sting of destruction. To halt the transmission of the pandemic disease, nearly 162 countries have enraptured into internment. Also, concerning the money markets, the business worldwide is working to uplift it. Similarly, the sector corresponding to provide the chains, tourism, and transport are facing degradation in profits, and hence the edifice trade damaged predominantly due to this severe pandemic. Furthermore, the construction and textile companies have been affected adversely due to the lack of labor supply and raw materials. In several countries, aviation sectors are in travel restrictions and encounter a slump in demand among travelers and cargo forces [4]. Even if the impact of lockdown is a smaller amount on essential merchandise retailer, different retailers corresponding to outlets and malls are extremely compact by the pandemic [5].

For Russia, the quickest development point and plague top has passed on May 18, and June 4, with a 283,029 and 256,535 dynamic-contaminations respectively. The defining moment where cumulative recovered cases surpassed dynamic contaminations has gone ahead June 10. The quickest development point went ahead June 14, with a total plague size of 330,043. Regarding

India, the plague top is still ahead, which is anticipated on June 24 [6]. Also, the defining moment in India [7] is anticipated toward the beginning of June. Our logistic and prophet model anticipated that the epidemic of Peru topped on center June, bringing about 108,217 dynamic cases, and the size of plague size will arrive at 357,812. The total re-shrouded cases will be more prominent than dynamic cases by late June, according to the data-forecasting [8].

Accurate examination and maintaining distance from others are the primary measures taken by the authorities across the countries to regulate the spread of the COVID-19 pandemic. The suspects are mainly screened for the virus by conducting the two varieties of the tests to diagnose the COVID-19. First is the antibody test, and the next is the RT-PCR test. The former usually find out the occurrence of the virus, which is accepted as direct testing. Suppose the test results are positive means that the antibodies were not detected in the sample and negative if vice versa. It is explored that the antibodies would take 9-8 days to excavate once the viral infection has set in. If the tests are not being properly conducted, the victimized people may unfold the sickness. On the other hand, the latter detects the COVID-19 in four to six hours.

When comparing the frequency of pandemic spread, the RT-PCR is not founded to be too fast, and also it possesses some limitations. The major disadvantage is that many chemicals and parts utilized for the test kit are importing from various regions across the globe [9]. This study highlights some of the recent research employed using AI technologies, focusing on augmenting the researchers on all sides. Also, it provides some additional challenges and errors with the misalignment of algorithms due to real-world issues. Consecutively, in this study, the implications and suggestions let the researchers to explore themselves in a modern way and provided the medical examiners and policy-makers with the present-day scenarios. AI technologies' automation improves the treatment practices, screening methods, social distance tracing, predicting the suspects around the person, vaccine development, and minimization of human contact. But still, the adoption of AI technologies is not fully deployed and utilized by the people due to real-world operational issues. It needs to be upgraded to address the COVID-19 pandemic. Thus, a quantitative transmission analysis founds to be more significant than the other pandemic diseases.

This enhanced exploration is organized in the following manner. Section 3 describes the mathematical, theoretical, and approximate modelling for COVID-19 prediction. Section 4 explains Soft computing techniques for solving the above predicted models and proposed solution methodology using Cauchy probability distribution. Section 5 brings out the auxiliary procurement of technology and health policies for COVID-19. Section 6 enlightens the statistical analysis of COVID-19 articles. Section 7 enlightens the future scope for technocrats regarding COVID-19 prediction and diagnosis.

3. MODELLING FOR COVID-19 PREDICTION:

3.1 Mathematical models:

To predict the rate of spread of COVID-19 disease around all the countries, umpteen models have been developed. Major mathematical models have been used a differential equation to measure the susceptible (S), Exposed (E), Infected (I), Asymptomatic (A), recovered (R), dead (D) population which will help us in guiding the government to take remedial measures. An Auto-regressive three-phase transition model has been developed and tested among various nations. When SIR is considered, its amplitudes are being assessed by the R^2 regressive

determination ratio as shown in Fig. 1 [10]. The co-efficient of R^2 are 0.770, 0.996, 0.957, 0.987, 0.990, 0.9830, and 0.995 for Korea, USA, Israel, Russia, Italy, Germany, and Spain respectively. This model has been predicted by a sampling duration of 10 days.

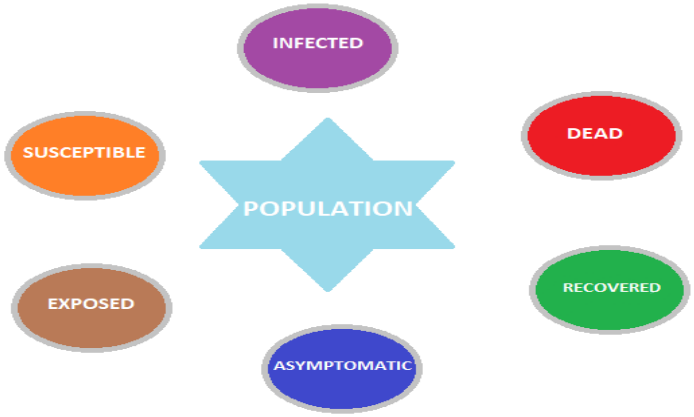

Fig.1: **Parameters of COVID–19 models**

It has been assumed in an appropriate model, that there are no infected people in the considered population. The cumulative distributive function is used to find the probability of people recovered from the infection. Its main objective is to calculate the reproduction number, which when increased above one. It implies that an infection rate gets increased. These secondary infection rates could be determined by Van de Driessche and Watmough's approach. Lyapunov's function is used to analyze global stability with the use of sensitivity analysis [11]. As a result, the analysis is made for different reproduction numbers (R_0) such as 0.99, 1.5, 2.5, and 4.5. It is found that the infection rate would be reduced when the reproduction number is less than one.

The regressive analysis could also be made by neglecting the death class from the equilibrium point. Caputo-Facbrizio (CF) and Atangana-Baleanu (AB) fractional derivatives are used for various fractional values order in the corona model. Finally, numerical simulation of CF derivative for different classes such as S, E, I, R, D among the population for different values of fractional orders α such as 0.79, 0.91, 0.88, 0.85, 0.89, 1, 0.94 is obtained. These simulations show the rate of spreading and restricting parameters [12].

The MATLAB software is used in measuring the reproduction number. The ODE solver of MATLAB is equipped with the Runge - Kutta fourth-order method. The different parameters such as birth rate, natural death rate, etc. are considered for the global analysis. The partial rank correlation coefficient is used in the prediction of the spreading rate. As a result, the smaller transmission rate reduces infected cases that get stimulated in a short time [13]**.**

Similarly, local stability analysis and, reproduction numbers from the population are consisting of transmission rate, recovery rate, re-infected rate, birth and, death rates are simulated using MATLAB ode solver with XPPAUT bifurcation analysis. This result shows that even when the reproduction rate is less than unity, the bi-stable behavior of other parameters will increase the infection rate [14].

The main factors, such as dead and recovered populations, are removed from the analysis, and only the transmission rate from cases "susceptible to infected" and "infected to confirmed" are considered. Then these factors are analyzed using MATLAB solver Isqcurve and Monte Carlo

simulations to find unidentified infected persons. It gives a reduced number of unidentified infected patients as time increases [15].

A comparative analysis has been made between Autoregressive integrated moving average (ARIMA) and Least square support vector machine (LS-SVM) with the collective data from five different countries. The main evaluation criteria for the validation are the mean absolute error (MAE), mean square error(MSE), RMS error (RMSE), and coefficient of determination (R^2). For example the forecasted and observed data for Italy, from ARIMA are MAE = $7.773x10^3$, MSE = $1.029x10^8$,RMSE = $10.147x10^3$, R^2 = 0.9817 which is less accurate when compared to LS-SVM, MAE = $7.484x10^3$, MSE = $0.849x10^8$, RMSE = $9.214x10^3$, R^2 = 0.9788. Similarly, the data are forecasted for Spain, France, UK, and USA [16].

Errors are most common in data collection. It is due to time-delay in the incubation period of the virus, test, and analysis. Various methods such as reverse transcription-polymerase chain reaction RTPCR, I_gG, and I_gM test, computed tomography (CT) images, are analyzed. ARIMA model has been employed to predict the trend of the disease. The real-time data from chile have been collected. It is compared with the corrected data, which shows a difference in the daily report as of May 25, 2020. The reported data is found to be 5000 cases, whereas the corrected report shows 6000 cases. Similarly, the total number of cases lag by 2 x 10^4 total cases, which have to be corrected. For the correction of errors induced by the delay, a statistical-based temporal reclassification algorithm has been developed according to the above reports [17].

All the data obtained by the above methods have white noise intensity in it [Table-1]. This might make a drastic variation in the forecasting. It means that the COVID-19 may even extinct with the increase in time with the increase in white noise intensity. The simulation results show that the change in white noise intensity has a great influence on the dynamics of the disease [18].

Table –1: Rate of Transmission and Mortality for different white noise intensity [18]

Rate	High-intensity white noise	Low-intensity white noise
Transmission	0.5	0.6
Mortality	0.1	0.2

A random graph and percolation theories are used to predict the spreading features of the COVID-19 cases with the data obtained from the SIR 3 group of people. The square lattice has allowed a simple visualization. These graphs have been obtained for two different factors, such as strict lockdown and the other case without lockdown. It is found that strict lockdowns could deplete the rate of infection [19].

The derivation of fractional differentiation with power low kernel and with Mittag-Leffler kernel techniques has been introduced to analyze the SEIAR population. Each group of affected people is being increased with time [20].

The default daily dynamical values in this model are the isolation rate (1.8, 0.2), the confirmed isolation (0.9, 1), the harmonic coefficient is 10, the confirmed rate (0.09663, 0.2322), the incurable mortality rate (0, 0.01166), natural recovery rate 0.001, non-treatment mortality rate (0.006), among 11081000 population [21]. The recovery rate and disease-induced death are also considered for an equilibrium model. The stability of local and global equilibrium is analyzed using Lasalle's invariance principle and Lyapunov's direct method. For various R_0 values, the

stability regions are analyzed. Based on health care availability, the death rate is reduced. The graphical representation is simulated, showing the result that with the increase in $R_{0,}$ the health care availability would get reduced in turn, the death rate would be increased [22].

For early forecasting, the ecological niche model (ENM) could help to identify the COVID-19 potential risk zones. This has been analyzed with three cities in a one-month duration. The collected data could be population density, floating population, subway stations, and daily life demands and medical sources, hospitals, and fever clinics. Using this data, the areas are marked with grades/risk levels according to the area under the curve-division standards, as shown in Table - 2 [23].

Table – 2: Area under the curve-division standard [23]

Area Under Curve division standard	**Grades / Risk level**
Excellent	0.9 to 1.0
Good	0.8 to 0.9
Acceptable	0.7 to 0.8
Bad	0.6 to 0.7
Insufficient	0.5 to 0.6

Different non-pharmaceutical control measures are obtained from Lagos with quantitative studies. These could be tested with social distancing, use of face mask, and increased testing. This gives a reduction in the reproduction rate. Hence the disease would die out with time [24].

Artificial Intelligence (AI) models of forecasting are used in dealing with dynamical behaviors of COVID-19. The Bayesian regression neural network, cube regression, K-nearest neighbors, quantile random forest, and support vector regression are used separately as well as with the combination of variation mode decomposition. The climatic changes may also even affect the forecasting result, so the climatic variables are also included in the model to obtain more accuracy in forecasting [25].

The effect of COVID-19 among the population affected by the Human Immuno-deficiency Virus (HIV) has different features. Even when combined with the climatic variation, it may cause a rapid change in the model output, which has been made previously. The fractional model has been solved, and backward bifurcation for the COVID-19 sub-model has been created. For global stability analysis, the Lyapunov-Lasalle method has been used. Additionally, the Transmission of COVID-19 through animal has been found and included in the model. Collectively the mortality rate has been increased with the higher transmission rate [26].

In Heilong Jiang, the data are collected from Jan 23 to March 25 and the model has been made with differential equations using ode solver in MATLAB (R2018b). This model is used to characterize the imported ‘escaper’ for the newly confirmed COVID-19 cases from April 9 to 19. The probabilistic simulation has been done with the τ-Leap model suggest strict interventions to be imposed on the people. The model shows an initial hike in the reproduction rate to 5.0692 and quickly drops to 1 with intervention imposed [27].Usually, the models are being made with SEAIR models, in that the Asymptotic (A) has two different groups they are detected and undetected. The model shows two types of equilibrium point. (i) COVID-19 free: It is locally

and asymptotically stable if the reproduction number (R_0) is less than unity; (ii) COVID-19 pandemic: It always exists when $R_0 > 1$. The model also shows backward bifurcation at $R_0 = 1$. It happens whenever the treatment saturation parameter is larger than the threshold. The model considers factors such as unidentified cases, rapid tests to trace hidden cases, medical resources limitation, social distancing, isolation, and incidence data. The analysis gives better results with social distancing than result without social distancing, as shown in Table-3 [28].

Table – 3: Number of Infected, Asymptotic cases for with and without social distancing [28]

Population	**Easing social distancing with rapid test (X 10^4)**	**Rapid test with social distancing (X 10^4)**	**Easing social distancing without rapid test (X 10^4)**
INFECTED	20	5	35
ASYMPTOTIC	5	2	11

The unknown state variables in COVID-19 could be obtained by developing an Ensemble of Kalman filter (EnKf) approach. This model has proved that the previous models have left some variables and parameters in their models, which will certainly increase the resulting data. This has shown that the estimated value is more than unity (i.e., $R_0 > 2$) [29].

With the introduction of a Caputo-Fabrizio fractional derivative, it includes Adamas-Bashforth numerical simulation. This gives a graphical representation concerning time, which gives rise in the exposed (E) population compared to the recovered (R) population. This contributed to the analysis of control and data analysis for medical science [30].

Age factor is also considered to be the main factor that could increase the mortality rate. Thus it plays a major role in any mathematical analysis. The basic reproduction number for the age-structured model of South Africa, Turkey, Brazil, has been obtained as R_0 = 1.6685, 1.9184, 1.8882, respectively [31].

A SIRD model could be utilized to calculate an optimal lockdown period. Simply imposing strict restrictions such as lockdowns, wearing a mask, social distancing would not be an effective tool. It should be noted that only an optimal selection of the lockdown period is required. So the three-phase term is chosen with four different variables such as SIRD to find the optimal lockdown period with the non-linear regression approach. As a result of the testing rate susceptible human beings, the obtained value of lockdown periods for Italy, India, and China might be 88 days, 69 days, and 73 days respectively. Similarly, for different testing rates, different results have been obtained [32].

3.2 .Theoretical and Approximate models:

A SIR model has been formulated with a non-linear function between death and the recoveries. The analysis is being carried out for various countries such as China, South Korea, India, Australia, the USA, Texas, and Italy. The flattening of the curve has been used, which will increase the pandemic duration with the same number of cases. This would make a less impact on demand in hospitals [33].

In theoretical modeling, the assessment of functional propagation patterns for COVID -19 helps forecast the spreading of disease from different regions with time series. For this, the evolution of data and global data are acquired and analyzed. Functional network reconstruction and topological metrics the spatial propagation pattern for COVID-19 was obtained. The daily death rate or confirmed rate are collected, and the difference between different time series has been calculated. With this preprocessing, the Granger causality is applied to time series to detect trends drifts of the disease. This helps in improving the effectiveness of containment policies [34].

The transformation of the disease forms its susceptible (S) stage to the death (D) stage is explained pictorially along with its transmission rates and probabilities. The curve fitting for the final size, the death, and the duration changes with the increasing values of mild symptom people are discussed. Similarly, the number of cases exposed, infected with various symptoms, hospitalized are identified with the number of days, and it is observed that the early isolation measures reduce the peak number of cases [35].

The economic disruption and technology challenges have been focused on controlling the pandemic situation. The students and retired health professionals are provided with proper quality PPE's. Providing immune developing vaccines to COVID affected individuals is one of the trail methods to reduce the severity of the disease. It listed out the social restrictions among the people given by WHO and highlighted the mortality rate among the affected countries. On correcting all the problems as mentioned above, globe could obtain a good result in reduction of the COVID 19 ill-effects [36].

4. SOFT COMPUTING TECHNIQUES FOR COVID-19 PREDICTION AND DIAGNOSIS:

4.1 Machine Learning Techniques:

Forecasting of epidemiologic phases could be envisioned through hierarchical learning methodologies. It has been analyzing the event of management strategies to reduce the proliferation rate [37]. Numerous COVID-19 information are brazenly open-access for the people [38]. However, the major requirement has been observed for capturing and developing additional information as it could result in both economic and social impacts [39]. The primary cause for virus transmission could be sneezing and cough. The whole nations are largely inhabited and compelled to get better alerts [40]. In order to provide prior diagnosis of ill-affected people, quick-screening forestalls the wide-spread through machine learning approaches [41].

An AI calculation has been forecasted for mechanical ventilation of COVID-19 patients around 24 hours. Hence, it shows a high affectability to beat a general admonition scoring framework. The calculation is equipped to recognize 16% of total patients [42], as shown in Fig. 2.

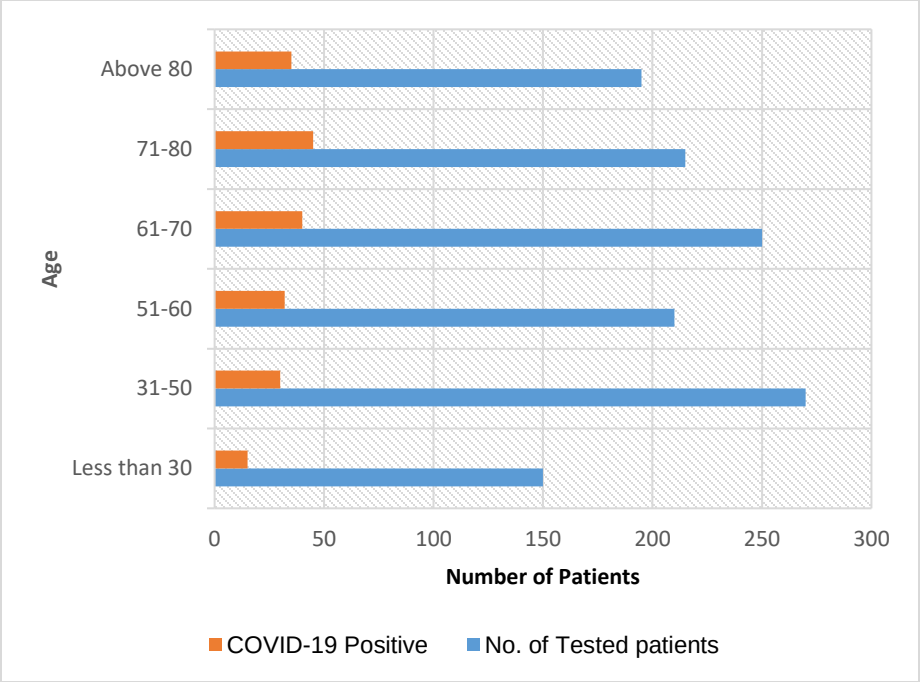

Fig.2: **Comparison on patients based on age limits [42]**

A unique methodology has been formulated to observe Covid-19 diagnosis comprising of initial processing and uprooting of indices followed by excerption and classification phases. 87 X-ray images with Covid-19 disease are being sampled [43].

As per the WHO, a few ecological elements could impact the spread of transferable illnesses that could cause pestilences. The most significant factors are water flexibly, disinfection offices, food, and atmosphere. The hidden hypothesis is the quantity of cases and the spread of past irresistible infections exhibit occasions influenced by the atmosphere. Besides, temperature and mugginess changed all through seasons, affect the quantity of infection occurrences [44].The main commitment is identified with the proposition of two casing works. They are non-deteriorated and decayed phases in the assignment of anticipating the contemporary instances of COVID-19 at every 5 states of Brazil and USA [45].

Distinct Asian nations have been taken into consideration [46] for a subsequent report regarding obscure tracing of cases[47]. An explicit contrast has led to 168 seriously sick patients [48], and the outcomes are observed to look into their impacts. A contextual ML analysis on quick classification of this virus with reference to the genetic marks has been presented in article [49]. A multivariate forecast model has been explored in [50] based on the boundaries, including current viral transmission and clinical qualities, to duplicate pandemic-related bearings in 16 nations from various scopes and beneficial classes. Mathematical expectations utilizing Monte Carlo analysis and Gauss blunder work are introduced to investigate the episode of the pandemic COVID-19 in Italy. Hence, the people have to keep patience in getting the accurate and verified solutions acquired for the COVID-19 pandemic. Balancing the risk and rapidity should always be prevailing among various communities. To balance this issue, the actual requirements have to be optimized to come out with the best clinical value. Collaborating the clinical expertise with the machine learning would pave the way for guaranteeing broad and developmental clinical effect [51].

4.2 Deep Learning Techniques:

A COVID-19 infected patient's classification model employed for predicting the pandemic using Deep Transfer Learning (DTL) [52] techniques. The obtained results reports that the proposed model provides good economic results against the opposite supervised learning models [53].The error measure obtained between the actual and the predicted is found to be less for the suggested classification model containing the tuned weights. For further analysis, the model was experimented and analyzed with the traditional pioneering mechanisms [54].

SqueezeNet, associate in-depth learning model, contains convolutional layers, pooling layers, and hearth layers. The key good thing about this model is that it performs successful analysis results with the reduced number of parameters, thereby decreasing the model size capacity [55]. Also in this research, a deep learning- based approach has been coined to detect virus infection from X-ray images taken on chest. A deep convolutional neural network (CNN) model to classify differing kinds of Pneumonia; microorganism respiratory disease, infectious agent pneumonia and COVID-19 pneumonia [56].

The radiography images obtained from the infected patients help facilitate the model for determining the virus infection, thereby assisting the doctor's diagnostic practices and further follow-ups of COVID positive patients. Though the model not fully replaces the existing testing methods and reducing the progressive emergency cases and reports of experts [57]. Various laboratory data have been analyzed with different deep learning train-test split approach [58]. Two completely different eventualities, such as binary and multi-class models, have been used. A new three-fold methodology has been aimed to detect and discriminate a chest X-ray image to grade the patient with generic respiratory organ disease [59]. Throughout the coaching phase, the performance of methodology has been evaluated with ten-fold cross-validation with the amount of fifty epochs [60]. A hierarchical classification methodology has been projected to predict COVID positive infected patients by victimization chest X-ray associated CT scan pictures. At the outset, the image datasets are resized based on quicker algorithmic thinking, and consecutively, the resized images are again reframed into the RGB format [61].

In this work, deep learning method has been proposed with a synthetic Neural Network [62]. On-line progressive learning technique has worked on estimating parameters of knowledge stream models. Hence it is used to check the dynamics of transmission and preventive mechanism on SARS-Cov-2. Thereby, it would assist in best policy formulation, forecasting, and simulation [63].

4.3 IOT Techniques:

As Internet of Things (IoT) is increasing worldwide, technological advancement is becoming progressively accessible for anticipating, forestalling and screening irresistible sickness. Best in class IoT-Enabled Health Monitoring Systems give continuous reconnaissance using wear-capable well-being observing gadgets, cloud-based distant wellbeing testing, and man-made brainpower [64].

In recent decades, the Internet of Things offers application-specific, reduced power, energy effective, and computational cheaper services to solve real-world problems. Typically, the

sensors served as the input devices, which collects the real-world phenomenon, and the actuators allow the objects to act accordingly using the input from the sensors. In COVID-19 diagnosis, the infrared thermometers can be accustomed to checking for the body temperature and face recognition techniques to find out about the infected persons among the crowd. In practice, it has been adopted by placing the optical cameras at the outsets of the airports, railway stations, crowded areas such as malls, bus stand, etc. In IoT, sensors in the planned architecture are placed on the body to observe the body parameters like temperature and pulse rate. Consecutively, the sensors are set for automatic door functions, water management at the public places, and toilets. Also, to avoid the general crowds and direct contact with the physical world, online conferences are coming into practice among the public and private sectors. More significantly, AI and deep learning techniques facilitate outcome predictions, associated risks, and aid trends [65].

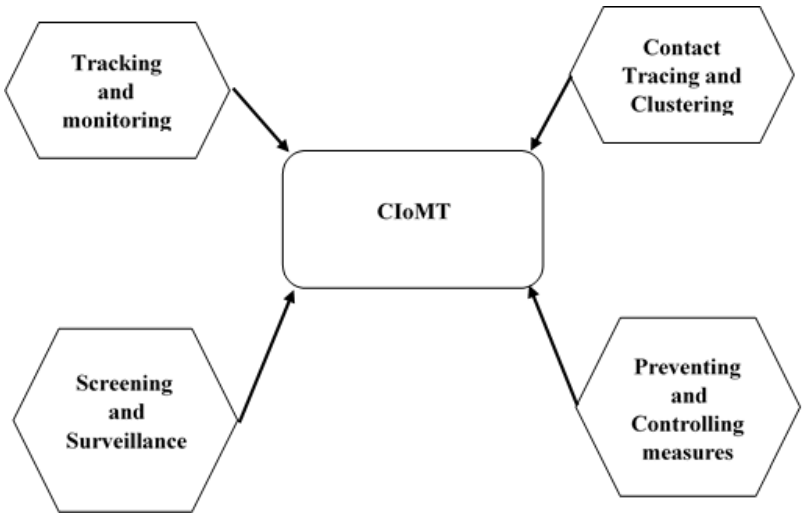

Fig. 3: CIoMT data analysis for COVID-19 [66]

As mentioned above, several analysis models on telemedicine have been carried out for remote healthcare over the past few decades, which serves as the predominant application of IoMT. Despite the traditional treatment methods, IoMT offers diversified features and opportunities to uplift the advancements in COVID-19 management. Figure 3 shows that the activities such as tracking, monitoring, and diagnosis status for daily recorded new fever cases are conducted [66]. Since the data recorded every second is found to be increased in high numbers, it is tedious to analyze and visualize the data of intended persons unless real-time updates exist [67].

The internet of things (IoT) could provide a proper channel of interconnected computing tactics. Additionally, mechanical and digital devices possess the capability of transmitting information over the defined network without human intervention at any stage. In this pandemic period, all the nations, including India, are searching for a practical and efficient resolution with confronting COVID-19 in several ways. Researchers in medical, science and engineering groups are forging new analysis on problems with user-centered explanations through various meta-heuristic theories [68].

4.4 SVM Techniques:

COVID-19 causes health problems in humans and creates severe harm within the lungs. However, COVID-19 has killed many human beings in the entire world. Support Vector

Regression analysis on doing the primary task would offer the thought concerning the amount of spread. In accordance to that, the government and also the voters can build correct plans to handle things by taking measures to attenuate the virus unfold by numerous mitigation and alternative necessary actions [69].

The empirical effects of various hyper variable-settings on prediction performance have been investigated. It has main capability to capture nonlinear patterns from the data [70].The HTA project has constitutional review methods for peer and college feedback. Therefore, the HTA report and policy transient could be required for the MPH degree with prizes given to the scholars for best reports and peer-reviewed publications [71].

4.5 Other soft computing Techniques:

The coaching and validation datasets are designed for the Bayesian optimization-based online learning structure. It needs a validation result to reduce the target function error. Capsule networks are planned to be trained with massive data sets to realize the extent of success that may assist physicians in the designation of coronavirus disease. A coaching method with large data sets is fundamental in deciding the validity and reliability of the system [72].

For a better contribution to the present clinical trials, an automatic diagnostic system planned to come into existence to reduce the effects of COVID-19. The system adopts the CNN framework, and training is performed from the initial stage itself as the transfer learning approach. The tested-positive cases can be detected easily with enhanced sensitivity by exploiting the X-ray images through this model. Once evaluated, the model also supports better decision-making containing the physiologists and radiology experts[73].

It has additionally projected an abstract combined model with its forthcoming challenges on functioning of vital sites and real data. Hence, this article also thought-about some prior studies that are aiming to form some contributions in mitigating current pandemic [74]. A hybrid technique [75] has been using fuzzification to train and test the neuron set-up. Sugeno inference-rules on loop for five hundred epochs having strictly zero error-tolerance levels. The estimating technique includes noise filtered as per moving ridge decomposition that extracts characteristics trained & tested to forecast the predictor variables. Consideration phenomenon includes the scenario of China, the Republic of India, and the USA for 3 major divisions that are Daily Confirmed cases, Daily deaths cases, and Daily recovered cases as per the information analytics.

With the unfolding dynamics of COVID-19 in Chile, a new framework has been formulated to determine the results on the SARS-CoV-2 spread rate through the antecedent approach. The projected methodology conjointly is a non - invasive smoothing process, because it solely resorts cases which get reported daily in line with possible time delays. The Trust Region Reflective algorithm uses the initial data from the real-time and has projected them with time to get the forecasted result [76].

A heuristic analysis using linear approximations and generalized logistic equations are interpreted with Simulated Annealing and Simplex methods. It gives accurate output that nearly equals the real-time data [77]. Gene Expression Programming (GEP) has emerged as an enhanced version of Genetic Programming (GP). It is used in designing an evolutionary model for the COVID-19. The GP produces new differential equations and could be applied to higher-dimensional problems when compared to the genetic algorithm (GA). The enhanced GEP

overcomes the drawback of both GA and GP. Based on GEP, the confirmed cases (CC) and Death count (DC) have been modeled across 15 countries. This showed that China would acquire negative growth in CC and DC in the future, whereas Brazil would get the highest expected percentage rise in the number of CC and DC. The USA would be expected to get the highest DC [78].

Virus Optimization Algorithm (VOA) has three phases such as initialization, replication, and maintenance phase. This is a population-based algorithm that measures the virus count inside the human cell. In the three phases, the number of strong and weak viruses has been calculated with different formulae, and the steps get repeated until the termination criteria of the algorithm is reached. An adaptive network-based fuzzy inference system (ANFIS) has the fuzzy-based system in an adapted network structure. This will discover the information between the initial and final variable settings of a system using the fuzzy "If-then" rule. It contains both antecedent and consequent parts. It is mainly used to investigate the COVID-19 spread based on climatic and population density [79].

4.6 Proposed solution methodology:

Based on the progressive review, it is found that the focus on infection rate based on ageing should be classified. Moreover, sick rate, and immunity rate of individuals during quarantine should be observed for tracking. Hence, we have used a Cauchy probability distribution [80] based on immune optimization to classify the people based on young and adult groups [81]. Because of the infinite variance and independent distribution of randomized variables, Cauchy probability would be advantageous in deriving the higher number of positive cases at initial stages.When the 5 sequences of each 100 sample tests are being made, the optimal number of positive cases have been selected at first sequence of testing itself. As sequence of tests are getting progressed, the percentage of infection rate could be found to be at inverse proportion with it. This analysis could be conducted on both young age people (age < 40) and adult age people (age ≥ 40).Using Matlab R2018 (A) environment, i3 core processor, we have simulated the Cauchy probability distribution of sampled data. Henceforth, the percentage infection rates for both young age and adult age people are projected in Fig. 4.

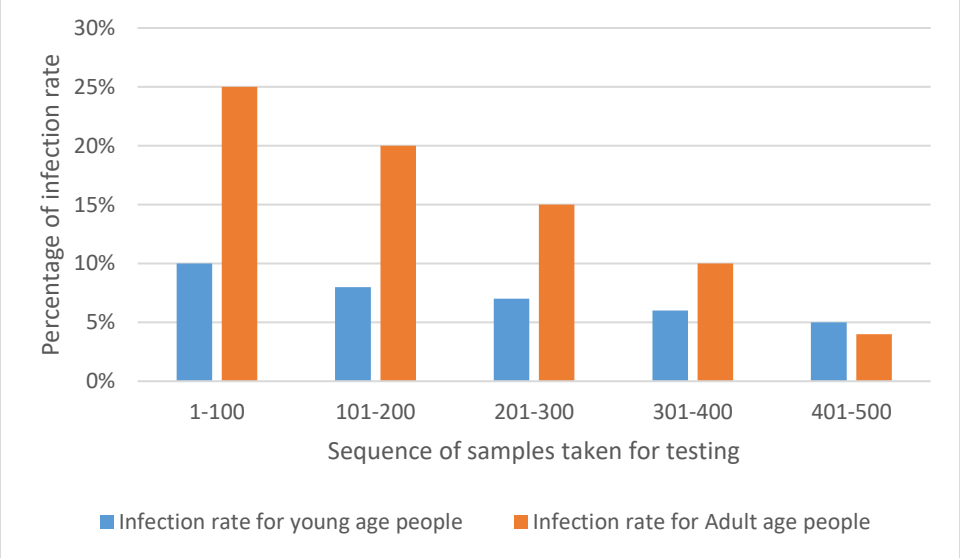

Fig. 4: Optimal results for infection rate comparison for a group of people

During the quarantine period, the immunity level of people gets raised as a result of immune-booster medications. With the merits of Cauchy distributionas mentioned above, the higher percentage of sick rate would come under the first sequence. The sick rate falls down in its range as testing sequence proceeds further. Simultaneously, immunity rate gets raised with consecutive sequence of tests irrespective of age groups. This analysis could be performed for 5 sequences of each 100 sample tests [82] taken globally, as shown in Fig. 5.

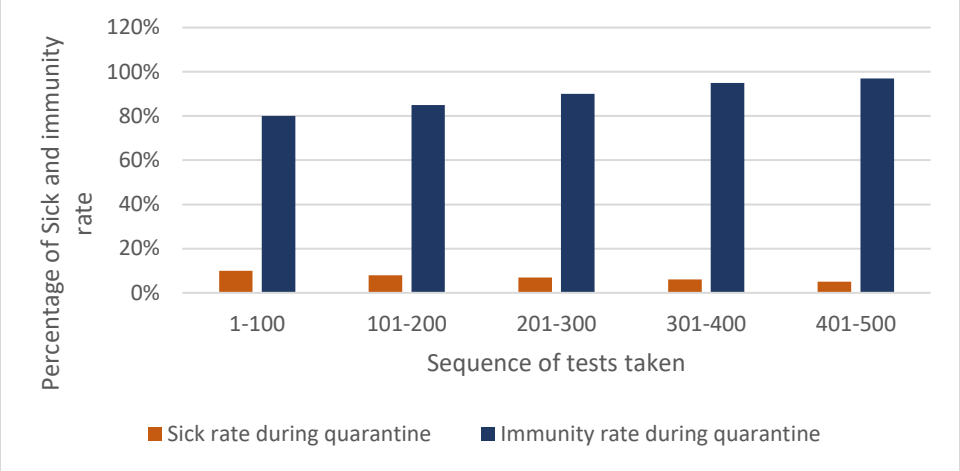

Fig. 5: Optimal results for sick and immunity rate comparison during the quarantine period

Cauchy probability distribution is found to be the important key factor for optimal classification of random variables such as infection rate, sick rate, and immunity rate of individuals. Earlier detection would help the doctors in treating the patients for faster recovery rate.

5. Auxiliary procurement in technology and health policies for COVID-19:

5. 1 Technological Support during COVID-19:

The research activities are erupting every day for controlling the severity of the spreading of COVID-19 among human society. This becomes a major objective in developing technologies such as Information technology, telecommunication, Artificial Intelligence, machine learning, Internet of things, Drone technology for its prediction, classification, diagnosis, treatments, and imposing strict lockdowns. These would fulfill the gap in the supply chain, telemedicine facility, online education, work from home, etc. [83].

Different regions such as China, Taiwan, Singapore, USA, Iceland, South Korea, Germany, India, Hong Kong have implemented different tracking methodologies that include Artificial Intelligence, immigration data collection, UP-code, cloud-based tools, mobile technology, Thermometer, camera, and facial identification, Bluetooth signals, smart-watch, pulse generation, GPS, Aarogyasetu, wristband, etc. to track the people who were symptomatic to COVID-19 and those who are in contact with COVID patients and had a travel history from containment zones [84].

During a pandemic, Tele-pharmacy can be a better solution to reduce the risk of an in-person contact between the patient and health care providers. This will avoid the risk of self-diagnosing and the use of medicines, which will lead to dangerous drug effects on patients. This ensures the safety of both health care providers and patients [85]. The National Health Service (NHS) allied business services have given special importance to mobile technology. This in turn made an enormous development of apps nearly Eighty-two apps from thirty-five countries related to COVID-19. Even though these developments increase the awareness around the world, it may lead to risk in data privacy, which has to be widely concentrated worldwide [86].

5.2 Health Policies:

The Bulgarian Drug Agency (BDA), the European medicines Agency (EMA), and Food & Drug Administration (FDA), have not given any approval for new vaccines against this novel disease. However, Off-label therapies have been increased with the increase in the spread of COVID-19. For example, usage of Remdesivir 200 mg for the day-1 and continued with 100 mg for the remaining 9 days. It gives an adverse improvement in 68% of patients in oxygen support. This suggests the update of the national regulations among BDA, EMA, and FDA [87].

Bio-similars are the alternative to an approved biological medicine. The European Union (EU) public authorities are trying to make it more accessible to health care professionals and patients. After evaluation by EMA, it would make more competition to the reference medicines, which in turn reduces the cost of all the health care system. The bio-similars have a minute variation which is equal to different batches of the same biological medicine [88].

A fundamental statistical tool Confidence Interval (CI) is used to estimate values and compare them between groups. This CI is computed between the upper and lower bounds of risk or ratio. Rates are usually very small in number since their denominators are high compared to the numerator. Usually, repeatable event rate has been computed using a Poisson distribution and skewed towards the upper bound with high consequences. The normal computing instead of Poisson distribution would give wrong information about rates among COVID-19 groups [89].

6. STATISTICAL ANALYSIS OF COVID-19 ARTICLESIN THE LITERATURE:

In this COVID-19 period, several publications in the Scopus, Web of science, and Pubmed related to COVID-19 are done consecutively. The analysis is performed with the top 10 institutions, the top ten countries, best 10 authors. The data chosen for the analysis could be the article type, authors, journal type and year, institute and its location, keywords, and the field along with the number of citations. In this article, the keyword COVID-19 or coronavirus has been used for the study, and the articles collected from the initial 2020 and the data are analyzed using VOSviewer software. Territory wise analysis is carried out and summarized as clusters, and the relationship between the author and coauthor is also visualized in display mode [90].

An exhaustive review has been done on the synthesis of the evolving published literature on COVID-19. A systematic approach is followed to find COVID-19 related topic related topics in all published literature. Various databases such as WHO, PubMed, git-hub and VoxSanguinis are available. The limitations associated with plasma-therapy have been pointed out. Moreover, it

helps to collect collated information from multiple sources for blood transfusion-related articles. [91].

Wearable technology is the best way of monitoring patients. These wearable sensors can be used on hospital in-patients, out-patients, and community of people at higher grade of dangerous disease. The captured data could indicate the positive and negative levels of testing. These data are connected through cloud-based systems. The drawbacks that are to be addressed are data privacy, geo-location and appropriate parameters [92].

7.FUTURE SCOPE FOR TECHNOCRATS:

Government, frontline workers, and researchers play a major role in creating awareness among people against COVID-19. There is an enormous amount of medical researches related to COVID being developed during this pandemic period. Nevertheless, apart from the influence of disease, there are some more issues in society due to the pandemic all around the world. To overcome those, plenty of researches has been raised on the 8E's issues such as Employment, E-health, E-commerce, Education, Enterprise, Entertainment, Environment, Equality [93].

The major application used for solving the above-mentioned issues could be the Information system [IS]. It would gain the business management sectors being involved in data outsourcing. The relation between social and moral issues are highlighted. The IS-related themes are collecting, monitoring and organizing the digital information in sequential manner. Its adaptive behavior has great importance in building the digitalized firms. These themes provide different research opportunities for the researchers to tackle this kind of new grand challenges in the future [94].

8. CONCLUSION

This article reviews the different mathematical models, soft computing techniques, statistical studies, technological support, and health policies that have been made to minimize the escalation rate of COVID-19 world-wide. Different techniques are used during this pandemic period, and different immunity rates are optimized to fulfill the gaps in all aspects. We have suggested to utilize the independent probability distribution called Cauchy probability for forecasting infection rate based on age groups. Additionally, this probability serves as important key factor for deriving sick rate and immunity rate of individuals during quarantine period. All these models and techniques have rendered several controlling measures such as strict optimal lockdown, social distancing, the usage of masks, hand-sanitizers, increasing the test count, which are recommended the same. These preventive measures would ensure a reduction in the vulnerability of spreading and death rates. Every citizen should be highly responsive to lead their day-to-day activities strictly abide by government guidelines. Popular emerging areas like big data analytics, edge computing, machine learning, and data science need to be focused on biomedical diagnosis to provide immune-environment.

ACKNOWLEDGEMENTS:

The authors are very grateful to VIT University-Chennai campus for the extensive facilities in rendering this work.

REFERENCES:

[1] SpreeuwenbergPeter ,KronemanMadelon , Paget John . "Reassessing the global mortality burden of the 1918 influenza pandemic. Am J Epidemiol 2018;187(12):2561–7 .
[2] J.S. Cobb and M.A. Seale. Examining the effect of social distancing on the compound growth rate of COVID-19 at the county level (United States) using statistical analyses and a random forest machine learning model, Elsevier Public Health, 185 (2020) 27-29.
[3] MohammadrezaNemati, Jamal Ansary, NazafarinNemati. Machine-Learning Approaches in COVID-19 Survival Analysis and Discharge-Time Likelihood Prediction Using Clinical Data, 2020, Patterns 1, 100074. https://doi.org/10.1016/j.patter.2020.100074
[4] H. Swapnarekha ,HimansuSekharBehera , JanmenjoyNayak , BighnarajNaik. Role of intelligent computing in COVID-19 prognosis: A state-of-the-art review, Chaos, Solitons and Fractals 138 (2020) 109947, https://doi.org/10.1016/j.chaos.2020.109947.
[5] Kankan Sarkar, SubhasKhajanchi and Juan J. Nieto. Modeling and forecasting the COVID-19 pandemic in India, Chaos, Solitons and Fractals 139 (2020) 110049, https://doi.org/10.1016/j.chaos.2020.110049
[6] Peipei Wang, XinqiZheng, Jiayang Li and Bangren Zhu. Prediction of epidemic trends in COVID-19 with logistic model and machine learning technics. Chaos, Solitons and Fractals 139 (2020) 110058, https://doi.org/10.1016/j.chaos.2020.110058.
[7] Parul Arora, Himanshu Kumar and BijayaKetanPanigrahi. Prediction and analysis of COVID-19 positive cases using deep learning models: A descriptive case study of India, Chaos, Solitons and Fractals 139 (2020) 110017, https://doi.org/10.1016/j.chaos.2020.110017
[8] Bijay Kumar Sahoo and Balvinder Kaur Sapra. A data driven epidemic model to analyse the lockdown effect and predict the course of COVID-19 progress in India, Chaos, Solitons and Fractals 139 (2020) 110034, https://doi.org/10.1016/j.chaos.2020.110034
[9] Harsh Panwar, P.K. Gupta, Mohammad Khubeb Siddiqui, Ruben Morales-Menendez and Vaishnavi Singh. Application of deep learning for fast detection of COVID-19 in X-Rays using nCOVnet. Chaos, Solitons and Fractals 138 (2020) 109944, https://doi.org/10.1016/j.chaos.2020.109944.
[10] VladislavSoukhovolsky, Anton Kovalev, Anne Pitt, Boris Kessel. A new modelling of the COVID 19 pandemic, Chaos, Solitons and Fractals 139 (2020) 110039, https://doi.org/10.1016/j.chaos.2020.110039.
[11] A.M. Mishra , S.D. Purohit, K.M. Owolabi, Y.D. Sharma. A nonlinear epidemiological model considering asymptotic and quarantine classes for SARS CoV-2 virus,Chaos, Solitons and Fractals 138 (2020) 109953, https://doi.org/10.1016/j.chaos.2020.109953.
[12] Zizhen Zhang. A novel covid-19 mathematical model with fractional derivatives: Singular and nonsingular kernels. Chaos, Solitons and Fractals, 139 (2020) 110060, https://doi.org/10.1016/j.chaos.2020.110060.
[13] SaifUllah, Muhammad Altaf Khan. Modeling the impact of non-pharmaceutical interventions on the dynamics of novel coronavirus with optimal control analysis with a case study, Chaos, Solitons and Fractals 139 (2020) 110075, https://doi.org/10.1016/j.chaos.2020.110075.
[14] Mohd Hafiz Mohd, Fatima Sulayman. Unravelling the myths of R 0 in controlling the dynamics of COVID-19 outbreak: A modelling perspective.Chaos, Solitons and Fractals 138 (2020) 109943, https://doi.org/10.1016/j.chaos.2020.109943.
[15] Chaeyoung Lee, Yibao Li, Junseok Kim. The susceptible-unidentified infected-confirmed (SUC) epidemic model for estimating unidentified infected population for COVID-19.

Chaos, Solitons and Fractals 139 (2020) 110090, https://doi.org/10.1016/j.chaos.2020.110090.

[16] Sarbjit Singh, Kulwinder Singh Parmar, Sidhu Jitendra Singh Makkhan, Jatinder Kaur, ShrutiPeshoria, Jatinder Kumar. Study of ARIMA and least square support vector machine (LS-SVM) models for the prediction of SARS-CoV-2 confirmed cases in the most affected countries. Chaos, Solitons and Fractals 139 (2020) 110086, https://doi.org/10.1016/j.chaos.2020.110086

[17] Sebastián Contreras, Juan Pablo Biron-Lattes, H. Andrés Villavicencio, David Medina-Ortiz, NynaLlanovarced-Kawles, Álvaro Olivera-Nappa, Statistically-based methodology for revealing real contagion trends and correcting delay-induced errors in the assessment of COVID-19 pandemic.Chaos, Solitons and Fractals 139 (2020) 110087, https://doi.org/10.1016/j.chaos.2020.110087.

[18] AnwarudDin , Amir Khan , DumitruBaleanu. Stationary distribution and extinction of stochastic coronavirus (COVID-19) epidemic model. Chaos, Solitons and Fractals 139 (2020) 110036, https://doi.org/10.1016/j.chaos.2020.110036.

[19] FabrizioCroccolo, H. Eduardo Roman. Spreading of infections on random graphs: A percolation-type model for COVID-19.Chaos, Solitons and Fractals 139 (2020) 110077, https://doi.org/10.1016/j.chaos.2020.110077.

[20] Sachin Kumar, Jinde Cao, Mahmoud Abdel-Aty. A novel mathematical approach of COVID-19 with non-singular fractional derivative,.Chaos, Solitons and Fractals 139 (2020) 110048, https://doi.org/10.1016/j.chaos.2020.110048.

[21] YuboHuang , Yan Wu , Weidong Zhang. Comprehensive identification and isolation policies have effectively suppressed the spread of COVID-19. Chaos, Solitons and Fractals 139 (2020) 110041, https://doi.org/10.1016/j.chaos.2020.110041.

[22] SümeyyeÇakan. Dynamic analysis of a mathematical model with health care capacity for COVID-19 pandemic. Chaos, Solitons and Fractals 139 (2020) 110033, https://doi.org/10.1016/j.chaos.2020.110033.

[23] HongyanRen, Lu Zhao, An Zhang, Liuyi Song, Yilan Liao, Weili Lu, Cheng Cui. Early forecasting of the potential risk zones of COVID-19 in China's megacities. Science of the Total Environment 729 (2020) 138995, https://doi.org/10.1016/j.scitotenv.2020.138995.

[24] D. Okuonghae , A. Omame . Analysis of a mathematical model for COVID-19 population dynamics in Lagos, Nigeria, Chaos, Solitons and Fractals 139 (2020) 110032, https://doi.org/10.1016/j.chaos.2020.110032.

[25] Ramon Gomes da Silva ,Matheus Henrique Dal Molin Ribeiro , Viviana CoccoMariani, Leandro dos Santos Coelho. Forecasting Brazilian and American COVID-19 cases based on artificial intelligence coupled with climatic exogenous variables. Chaos, Solitons and Fractals 139 (2020) 110027, https://doi.org/10.1016/j.chaos.2020.110027

[26] Emile F. DoungmoGoufo, Yasir Khan, Qasim Ali Chaudhry. HIV and shifting epicenters for COVID-19, an alert for some countries.Chaos, Solitons and Fractals 139 (2020) 110030, https://doi.org/10.1016/j.chaos.2020.110030

[27] TingzheSun ,Yan Wang. Modeling COVID-19 epidemic in Heilongjiang province, China.Chaos, Solitons and Fractals 138 (2020) 109949, https://doi.org/10.1016/j.chaos.2020.109949

[28] DipoAldila, Sarbaz H.A. Khoshnaw, EgiSafitri, YusrilRais Anwar, Aanisah R.Q. Bakry, Brenda M. Samiadji, Demas A. Anugerah, M. FarhanAlfarizi GH, Indri D. Ayulani, Sheryl N. Salim, A mathematical study on the spread of COVID-19 considering social

distancing and rapid assessment : The case of Jakarta, Indonesia, 2020, https://doi.org/10.1016/j.chaos.2020.110042 .

[29] C. HameniNkwayep, S. Bowong, J.J. Tewa, J. Kurths.Short-term forecasts of the COVID-19 pandemic: study case of Cameroon, 2020, https://doi.org/10.1016/j.chaos.2020.110106

[30] Ram Prasad Yadav, RenuVerma . A numerical simulation of fractional order mathematical modeling of COVID-19 disease in case of Wuhan China,. Chaos, Solitons and Fractals 140 (2020) 110124, https://doi.org/10.1016/j.chaos.2020.110124

[31] SalihDjilali, BehzadGhanbari. Coronavirus pandemic: A predictive analysis of the peak outbreak epidemic in South Africa, Turkey, and Brazil. Chaos, Solitons and Fractals 138 (2020) 109971, https://doi.org/10.1016/j.chaos.2020.109971

[32] SoniyaLalwani, GunjanSahni, BhawnaMewara, Rajesh Kumar. Predicting optimal lockdown period with parametric approach using three-phase maturation SIRD model for COVID-19 pandemic. Chaos, Solitons and Fractals 138 (2020) 109939, https://doi.org/10.1016/j.chaos.2020.109939

[33] Ian Cooper, ArghaMondal, Chris G. Antonopoulos. A SIR model assumption for the spread of COVID-19 in different communities.Chaos, Solitons and Fractals 139 (2020) 110057, https://doi.org/10.1016/j.chaos.2020.110057.

[34] MassimilianoZanin, David Papo. Assessing functional propagation patterns in COVID-19.Chaos, Solitons and Fractals 138 (2020) 109993, https://doi.org/10.1016/j.chaos.2020.109993.

[35] QiuhuiPan , Ting Gao , Mingfeng He. Influence of isolation measures for patients with mild symptoms on the spread of COVID-19. Chaos, Solitons and Fractals 139 (2020) 110022, https://doi.org/10.1016/j.chaos.2020.110022.

[36] Donald RJ Singer. Health policy and technology challenges in responding to the COVID-19 pandemic. Health Policy and Technology 9 (2020) 123–125, https://doi.org/10.1016/j.hlpt.2020.04.011

[37] E. Chen, K. Lerman, E. Ferrara, COVID-19: The First Public Coronavirus Twitter Dataset, arXiv preprint: 1603.07252 (2020).

[38] ShreshthTuli, ShikharTuli, RakeshTuli and SukhpalSingh Gill. Predicting the growth and trend of COVID-19 pandemic using machine learning and cloud computing, Internet of Things 11 (2020) 100222, https://doi.org/10.1016/j.iot.2020.100222.

[39] J.P. Cohen, P. Morrison, L. Dao, COVID-19 image data collection, arXiv preprint: 2003.11597 (2020).

[40] Y. Bai , L. Yao , T. Wei , F. Tian , D.-Y. Jin , L. Chen , M. Wang , Presumed asymptomatic carrier transmission of COVID-19, JAMA (2020) .

[41] Samuel Lalmuanawma, Jamal Hussain and LalrinfelaChhakchhuak. Applications of machine learning and artificial intelligence for Covid-19 (SARS-CoV-2) pandemic: A review, Chaos, Solitons and Fractals 139 (2020) 110059, https://doi.org/10.1016/j.chaos.2020.110059.

[42] H. Burdick, C. Lam, S. Mataraso, A. Lynn-Palevsky, G. Braden, R.P.Dellinger, A. McCoy, J.-L. Vincent, A. Green-Saxena, G. Barnes, J. Hoffman, J. Calvert, E.Pellegrini, R. Das, Prediction of respiratory decompensation in Covid-19 patients using machine learning: The READY trial, Computers in Biology and Medicine (2020), doi: https://doi.org/10.1016/j.compbiomed.2020.103949.

[43] TurkerTuncer, SengulDogan and FatihOzyurt. An automated Residual Exemplar Local Binary Pattern and iterative ReliefF based COVID-19 detection method using chest X-ray

image, Chemometrics and Intelligent Laboratory Systems 203 (2020) 104054, https://doi.org/10.1016/j.chemolab.2020.104054.

[44] ZohairMalki, El-SayedAtlam, Aboul Ella Hassanien, GueshDagnew, Mostafa A. Elhosseini, Ibrahim Gad, Association between Weather Data and COVID-19 Pandemic Predicting Mortality Rate: Machine Learning Approaches, Chaos, Solitons and Fractals (2020), doi: https://doi.org/10.1016/j.chaos.2020.110137.

[45] Ramon Gomes da Silva, Matheus Henrique Dal Molin Ribeiro, Viviana CoccoMariani and Leandro dos Santos Coelho. Forecasting Brazilian and American COVID-19 cases based on artificial intelligence coupled with climatic exogenous variables, Chaos, Solitons and Fractals 139 (2020) 110027, https://doi.org/10.1016/j.chaos.2020.110027.

[46] Durga Prasad Kavadi, RizwanPatan, Manikandan Ramachandran and Amir H. Gandomi. Partial derivative Nonlinear Global Pandemic Machine Learning prediction of COVID 19, Chaos, Solitons and Fractals 139 (2020) 110056, https://doi.org/10.1016/j.chaos.2020.110056.

[47] Lan F-Y, Wei C-F, Hsu Y-T, Christiani DC, Kales SN. Work-related COVID- 19 transmission in six Asian countries/areas: a follow-up study. PLoS One 2020;15(5):e0233588 May 19. doi: 10.1371/journal.pone.0233588 .

[48] Meng Y, Wu P, Lu W, Liu K, Ma Ke, Huang L, et al. Sex-specific clinical characteristics and prognosis of coronavirus disease-19 infection in Wuhan, China: a retrospective study of 168 severe patients. PLoSPathog 2020;16(4):e1008520 April 28. doi: 10.1371/journal.ppat.1008520

[49] Randhawa GS, Soltysiak MPM, El Roz H, de Souza CPE, Hill KA, Kari L. Ma- chine learning using intrinsic genomic signatures for rapid classification of novel pathogens: COVID-19 case study. PLoS One 2020;15(4):e0232391 April 24. doi: 10.1371/journal.pone.0232391 .

[50] Chowdhury R, Heng K, ShawonMdSR, Goh G, Okonofua D, Ochoa-Rosales C, et al. Dynamic interventions to control COVID-19 pandemic: a multivariate prediction modelling study comparing 16 worldwide countries. Eur J Epidemiol 2020;35:389–99 May. doi: 10.1007/s10654- 020- 00649- w .

[51] PatrikBachtiger, Nicholas S Peters and Simon LF Walsh. Machine learning for COVID-19—asking the right questions, www.thelancet.com/digital-health **Vol 2 August 2020**https://doi.org/10.1016/S2589-7500(20)30162-X.

[52] Y.Pathak, P.K.Shukla, A.Tiwari, S.Stalin, S.Singh and P.K.Shukla.Deep Transfer Learning Based Classification Model for COVID-19 Disease, IRBM, 2020, https://doi.org/10.1016/j.irbm.2020.05.003.

[53] SunyiZheng, Xiaonan Cui, et al., Deep learning-based pulmonary nodule detection: Effect of slab thickness in maximum intensity projections at the nodule candidate detection stage, Computer Methods and Programs in Biomedicine 196 (2020) 105620, https://doi.org/10.1016/j.cmpb.2020.105620.

[54] SrinivasKoppu, Praveen Kumar Reddy Maddikunta and Gautam Srivastava. Deep learning disease prediction model for use with intelligent robots, Computers and Electrical Engineering 87 (2020) 106765, https://doi.org/10.1016/j.compeleceng.2020.106765.

[55] MesutTogacar ,BurhanErgen, ZaferComert. COVID-19 detection using deep learning models to exploit Social Mimic Optimization and structured chest X-ray images using fuzzy color and stacking approaches, Computers in Biology and Medicine 121 (2020) 103805, https://doi.org/10.1016/j.compbiomed.2020.103805.

[56] Asif Iqbal Khan ,JunaidLatief Shah , Mohammad MudasirBhat.CoroNet: A deep neural network for detection and diagnosis of COVID-19 from chest x-ray images, Computer Methods and Programs in Biomedicine 196 (2020) 105581, https://doi.org/10.1016/j.cmpb.2020.105581.

[57] X. Xu, X. Jiang, C. Ma et al., A Deep Learning System to Screen Novel Coronavirus Disease 2019 Pneumonia, Engineering, https://doi.org/10.1016/j.eng.2020.04.010

[58] TalhaBurakAlakus and Ibrahim Turkoglu. Comparison of deep learning approaches to predict COVID-19 infection, Chaos, Solitons and Fractals 140 (2020) 110120, https://doi.org/10.1016/j.chaos.2020.110120.

[59] Luca Brunese, Francesco Mercaldo, Alfonso Reginelli and AntonellaSantone. Explainable Deep Learning for Pulmonary Disease and Coronavirus COVID-19 Detection from X-rays, Computer Methods and Programs in Biomedicine 196 (2020) 105608, https://doi.org/10.1016/j.cmpb.2020.105608.

[60] SuatToraman, TalhaBurakAlakus and Ibrahim Turkoglu. Convolutional capsnet: A novel artificial neural network approach to detect COVID-19 disease from X-ray images using capsule networks, Chaos, Solitons and Fractals 140 (2020) 110122, https://doi.org/10.1016/j.chaos.2020.110122.

[61] Dasari Naga Vinod and S.R.S. Prabaharan. Data science and the role of Artificial Intelligence in achieving the fast diagnosis of Covid-19, Chaos, Solitons and Fractals 140 (2020) 110182, https://doi.org/10.1016/j.chaos.2020.110182.

[62] AbdelhafidZeroual, FouziHarrou, AbdelkaderDairi and Ying Sun. Deep learning methods for forecasting COVID-19 time-Series data: A Comparative study, Chaos, Solitons and Fractals 140 (2020) 110121, https://doi.org/10.1016/j.chaos.2020.110121.

[63] Junaid Farooq and Mohammad AbidBazaz. A novel adaptive deep learning model of Covid-19 with focus on mortality reduction strategies, Chaos, Solitons and Fractals 138 (2020) 110148, https://doi.org/10.1016/j.chaos.2020.110148.

[64] Md. Siddikur Rahman, Noah C. Peeri, Nistha Shrestha, RafdzahZaki, UbydulHaque, SitiHafizahAb Hamid. Defending against the Novel Coronavirus (COVID-19) outbreak: How can the Internet of Things (IoT) help to save the world?, Health Policy and Technology 9 (2020) 136–138, https://doi.org/10.1016/j.hlpt.2020.04.005.

[65] KeAi Communications Co., Ltd. Role of IoT to avoid spreading of COVID-19, International Journal of Intelligent Networks 1 (2020) 32–35. https://doi.org/10.1016/j.ijin.2020.05.002

[66] Swati Swayamsiddha and ChandanaMohanty. Application of cognitive Internet of Medical Things for COVID-19 pandemic, Diabetes & Metabolic Syndrome: Clinical Research & Reviews 14 (2020) 911-915, https://doi.org/10.1016/j.dsx.2020.06.014.

[67] Yang T, Gentile M, Shen CF, Cheng CM. Combining point-of-care diagnostics and internet of medical things (IoMT) to combat the COVID-19 pandemic Diagnostics (Basel) 2020;10(4).

[68] Ravi Pratap Singh, MohdJavaid, AbidHaleem and Rajiv Suman. Internet of things (IoT) applications to fight against COVID-19 pandemic, Diabetes & Metabolic Syndrome: Clinical Research & Reviews 14 (2020) 521-524.

[69] MilindYadav, MurukessanPerumal, M Srinivas. Analysis on novel coronavirus (COVID-19) using machine learning methods, Chaos, Solitons and Fractals 139 (2020) 110050, https://doi.org/10.1016/j.chaos.2020.110050.

[70] YaohaoPeng and MateusHiro Nagata. An empirical overview of nonlinearity and overfitting in machine learning using COVID-19 data, Chaos, Solitons and Fractals 139 (2020) 110055, https://doi.org/10.1016/j.chaos.2020.110055.
[71] Kanchan Mukherjee. A SMART framework for HTA capability development: Lessons from India, Health Policy and Technology 9 (2020) 42–44, https://doi.org/10.1016/j.hlpt.2019.12.001.
[72] FerhatUcar and DenizKorkmaz. COVIDiagnosis-Net: Deep Bayes-SqueezeNet based diagnosis of the coronavirus disease 2019 (COVID-19) from X-ray images, Medical Hypotheses 140 (2020) 109761, https://doi.org/10.1016/j.mehy.2020.109761.
[73] Majid Nour, ZaferCömert and Kemal Polat. A Novel Medical Diagnosis model for COVID-19 infection detection based on Deep Features and Bayesian Optimization, Applied Soft Computing Journal,2020, 106580, https://doi.org/10.1016/j.asoc.2020.106580.
[74] Abu Sufian, Anirudha Ghosh, Ali SafaaSadiq and FlorentinSmarandache. A Survey on Deep Transfer Learning to Edge Computing for Mitigating the COVID-19 Pandemic, Journal of Systems Architecture 108 (2020) 101830, https://doi.org/10.1016/j.sysarc.2020.101830.
[75] Rashmi Bhardwaj , AashimaBangia , Data Driven Estimation of Novel COVID-19 Transmission Risks Through Hybrid Soft-Computing Techniques, Chaos, Solitons and Fractals (2020), doi: https://doi.org/10.1016/j.chaos.2020.110152
[76] KhondokerNazmoonNabi. Forecasting COVID-19 pandemic: A data-driven analysis, Chaos, Solitons and Fractals 139 (2020) 110046, https://doi.org/10.1016/j.chaos.2020.110046
[77] Gabriele Martelloni, GianlucaMartelloni. Modelling the downhill of the Sars-Cov-2 in Italy and a universal forecast of the epidemic in the world. Chaos, Solitons and Fractals 139 (2020) 110064, https://doi.org/10.1016/j.chaos.2020.110064
[78] RohitSalgotra, MostafaGandomib, AmirH. Gandomic. Evolutionary modelling of the COVID-19 pandemic in fifteen most affected countries.Chaos, Solitons and Fractals 140 (2020) 110118, https://doi.org/10.1016/j.chaos.2020.110118
[79] Ali Behnood, EmadaldinMohammadiGolafshani, SeyedehMohaddesehHosseini. Determinants of the infection rate of the COVID-19 in the U.S. using ANFIS and virus optimization algorithm (VOA), Chaos, Solitons and Fractals 139 (2020) 110051, https://doi.org/10.1016/j.chaos.2020.110051
[80] Wei, J.; Chen, Y.; Yu, Y.; Chen, Y. Optimal Randomness in Swarm-Based Search. *Mathematics* **2019**, *7*, 828. https://doi.org/10.3390/math7090828.
[81] Cleve's Corner: Cleve Moler on Mathematics and Computing https://blogs.mathworks.com/cleve/2020/03/29/second-version-of-a-covid-19-simulator
[82] Github. https://github.com/, 2020.
[83] Rajvikram Madurai Elavarasan , Rishi Pugazhendhi . Restructured society and environment: A review on potential technological strategies to control the COVID-19 pandemic, Science of the Total Environment 725 (2020) 138858, https://doi.org/10.1016/j.scitotenv.2020.138858
[84] Sera Whitelaw, Mamas A Mamas, Eric Topol, Harriette G C Van Spall. Applications of digital technology in COVID-19 pandemic planning and response. Lancet Digital Health 2020; 2: e435–40 https://doi.org/10.1016/ S2589-7500(20)30142-4.

[85] ArefehAmeri, FarzadSalmanizadeh, KambizBahaadinbeigy . Tele-pharmacy: A new opportunity for consultation during the COVID-19 pandemic, Health Policy Technology, 2020; 9(3): 281–282.
[86] Swathikan Chidambaram, Simon Erridge, James Kinross, Sanjay Purkayastha. Observational study of UK mobile health apps for COVID-19, The LANCET-digital health, VOL. 2 (8), E388-E390, 2020, https://doi.org/10.1016/ S2589-7500(20)30144-8.
[87] NigyarDzhafer, MD ,JannisPapathanasiou, MD. Compassionate drug use: an imperative challenge for Bulgarian health system during COVID-19. Health Policy and Technology, 2020, 9(3): 274–275, https://doi.org/10.1016/j.hlpt.2020.05.001
[88] Rosa Gonzalez-Quevedo, Elena Wolff-Holz, Melanie Carr, Juan Garcia Burgos. Biosimilar medicines: Why the science matters, Health Policy and Technology 9 (2020) 129–133, https://doi.org/10.1016/j.hlpt.2020.03.004
[89] Arnaud Tarantola, Laurent Gautier. Biostatistics to better detect fishy findings.TheLancetInfetc Dis.,2020, https://doi.org/10.1016/ S1473-3099(20)30557-0
[90] Mohamed El Mohadab, BelaidBouikhalene, Said Safi. Bibliometric method for mapping the state of the art of scientific production in Covid-19. Chaos, Solitons and Fractals 139 (2020) 110052, https://doi.org/10.1016/j.chaos.2020.110052
[91] Simon J Stanworth, Helen V New, Torunn O Apelseth, Susan Brunskill, Rebecca Cardigan, Carolyn Doree, Marc Germain, Mindy Goldman, Edwin Massey, Daniele Prati, Nadine Shehata, Cynthia So-Osman, JeckoThachil. Effects of the COVID-19 pandemic on supply and use of blood for transfusion, Lancet Haematology,2020, VOL. 7 (10), E756-E764.https://doi.org/10.1016/ S2352-3026(20)30186-1
[92] Damien K. Minga, SorawatSangkaewa, Ho Q. Chanhc, Phung T.H. Nhatc, Sophie Yacoubc,d, PantelisGeorgioue, Alison H. Holmesa. Continuous physiological monitoring using wearable technology to inform individual management of infectious diseases, public health and outbreak responses, International Journal of Infectious Diseases 96 (2020) 648–654, https://doi.org/10.1016/j.ijid.2020.05.086
[93] Stuart J. Barnes. Information management research and practice in the post-COVID-19 world, International Journal of Information Management, 2020, https://doi.org/10.1016/j.ijinfomgt.2020.102175
[94] Shan L. Pana, Sixuan Zhang. From fighting COVID-19 pandemic to tackling sustainable development goals: An opportunity for responsible information systems research, International Journal of Information Management, 2020, https://doi.org/10.1016/j.ijinfomgt.2020.102196