Review Article

The healthier healthcare management models for COVID-19

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A B S T R A C T

The worldwide pandemic situation of COVID-19 generates a situation in which healthcare resources such as diagnostic kits, drugs and basic healthcare infrastructure were on shortage throughout the period, along with negative impact on socio-economic system. Standardized public healthcare models were missing in pandemic situation, covering from hospitalized patient care to local resident's healthcare managements in terms of monitoring, assess to diagnosis and medicines. This exploratory and intervention-based study with the objective of proposing COVID-19 Care Management Model representing comprehensive care of society including patients (COVID-19 and other diseases) and healthy subjects under integrated framework of healthier management model. Shifting policy towards technology-oriented models with well-aligned infrastructure can achieve better outcomes in COVID-19 prevention and care. The planned development of technical healthcare models for prognosis and improved treatment outcomes that take into account not only genomics, proteomics, nanotechnology, materials science perspectives but also the possible contribution of advanced digital technologies is best strategies for early diagnosis and infections control. In view of current pandemic, a Healthier Healthcare Management Model is proposed here as a source of standardized care having technology support, medical consultation, along with public health model of sanitization, distancing and contact less behaviours practices. Effective healthcare managements have been the main driver of healthier society where, positive action at identified research, technology and management segment more specifically public health, patient health, technology selection and political influence has great potential to enhanced the global response to COVID-19. The implementation of such practices will deliver effective diagnosis and control mechanism and make healthier society.

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Introduction

The emerging and re-emerging infectious diseases, SARS (severe acute respiratory syndrome), MERS (Middle East respiratory syndrome), Ebola, Zika viruses, H1N1 influenza, and chikungunya infections have become a major cause of mortality and morbidity in the world [1]. SARS Co-2 or COVID-19 imposes an unpredictable threat and challenge for the world community and exerts negative impact in terms of economical and public health relevance [2]. Recent viral infection pandemic of COVID-19 has initiated importance of community's knowledge, practices, and people's attitudes during disease outbreaks [3,4]. COVID-19 viral disease which has become a pandemic in a short time across all the continents has generated a big challenge to adhere public health models. There is big question mark on the current healthcare control practices due to the current worldwide epidemiological scenario.

The continued efforts in providing better facilities for healthcare vary from country to country. The current pandemic situation has highlighted several drawbacks of public health practices to associated organizational response and the need of technology-based solutions [5,6]. WHO and the native country health organizations should think on new policies of preventive measures through evaluation of pathogens' geographical variation, disease clinical features, containment regions, asymptomatic persons, pathogen adaptability, and host susceptibility. This information can be used for making preventive measures stronger and help to adopt policy by understanding the real impact of challenges.

The understanding of advanced technology of IoT, Artificial Intelligence, Cloud Computing, mathematical modelling, along with pace in nanotechnology and genomics-based research will give better results and help to develop effective control strategies for better future prospects. The integration between the top three protective care of distancing, sanitization and contactless practices will permit improvements in healthcare results. Further patient monitoring and biomedical research practices helps greater probability of prognosis compliance. Identified precautionary healthcare model based on priority of three primary risks such as transmission possibility, social distancing, and sanitized environment (Fig. 1), ensuring control of risks of COVID-19 extensively at mass level in cost-effective manner. Now, public healthcare is one of the fundamental priorities after COVID-19 pandemic, where a community healthcare requirement is monitored and delivered through bet-

Fig. 1. Identified healthcare management. Adaptation of known precautionary healthcare measures based on three primary risks such as transmission possibility, social distancing, and sanitized environment will help control of COVID-19 extensively in mass community.

ter management only. On the other hand, integrated approaches of structured management and technology-based solutions have potential to deliver mass healthcare services in sustainable model. Therefore, this article emphasizes and support multidisciplinary research, adaptation of technology and structured healthcare management for efficient healthcare services and better control results.

Understanding of trio-models and implementation of proposed healthcare model will help social distancing, sustainable sanitized system, and healthy environment, for protected human and enhance equity of access to high-end-technologies based on multidisciplinary research for better prognosis system. This review describes the importance of below three segments extensively to understand the importance of multidisciplinary research, technology requirement and adaptation of management for better prognosis model as below (Fig. 2):

- *Multidisciplinary research in prioritised segment*
- *Technology oriented healthcare models*
- *Structured healthcare management*

Multidisciplinary research in prioritised segment

The research data of biological, medical, engineering, chemical and physical science can generate enormous information for translational research. Understanding epidemiology, pathogen variations, clinical features, human susceptibility should be prioritised area of science and technology for any prognosis model. Below mentioned area should be preferred based on logical solutions for public healthcare models.

Fig. 2. Healthcare services with support of multidisciplinary research, adaptation of technology and structured healthcare management is featured in this article for efficient and better control results.

- *Research on database resources*
- *Treatment and vaccine*
- *Adaptation of other infectious disease prognosis models*

Research on database resources

This will help to correlate and understand any possibility of low and high severity of the disease. Various databases are available online which can be studied time to time to understand the trend. WHO, Scopus, PubMed, ICMR, CDC, and several such kind of multidisciplinary resources can be cross checked for making future strategy plan. Important materials were listed to provide awareness of quality public health literature and resources [7]. Role of genomics and proteomics in framing prognosis to treatment contribution was based on such kind of interpretation, analysis, and results extensively. Regional healthcare protection model should be based on regional risk assessment. Reviewing, developing, and establishing effective control strategies through a diversified approach for regional healthcare model to avoid any specific risk extensively is best lead. Understanding of all scientific information is possible due to open resources and access of various knowledge databases. During pandemic, many publishers are making their resources freely and temporarily available [8]. This makes it possible to adopt technological and innovative research at a much faster pace. Data analytics has the potential to understand the mode of transmission and take more decision of protection against any possibility of outbreak. The most important part of protection is to break the chain of transmission.

Treatment and vaccine

A global increase in antibiotic-resistant bacteria, limited antiviral drugs is a real challenge for the world in terms of facing the emerging bacterial and viral infections, respectively. Recent research progress on COVID-19 treatment has promising success [9]. Effective and appropriate drugs for the treatment of COVID-19 are missing and other disease drugs and combination of drugs have emerged as the best strategy for treatment. Currently several pharmaceuticals are undergoing clinical trials to assess their safety and efficacy, like remdesivir, interferon β-1a, the antiviral combination lopinavir/ritonavir, the antimalar-

ial chloroquine/hydroxychloroquine, and monoclonal antibodies against components of the immune system such as interleukin-6 (IL-6) and IL-4 for effective treatments of the COVID-19 [6,10]. Study confirmed the decreased rate of disease through vaccines in infectious diseases of viruses (like human immunodeficiency virus (HIV/AIDS), hepatitis C etc.), Bacteria (tuberculosis (TB) and Protozoa (malaria and neglected tropical diseases (NTDs) etc.) are already recognized. COVID-19 substantially increases the risk of death way faster than other infectious diseases. There is a large global effort to develop several vaccines against COVID-19 protection via clinical trials in different phase stages [11]. Furthermore, death number is uncontrolled due to lack of disease mechanism information and therefore absence of appropriate drugs and vaccine.

Adaptation of other infectious disease prognosis models

Emerging infectious threats, for several risks required to adopt shared policy for early detection, treatment and control. Study on other infectious pathogens (virus, bacteria and protozoa etc.) and their better control model should be adopted in COVID-19 prognosis model for better response in the event of an outbreak. According to the WHO report on malaria (WHO-2014) [12], the death of thousands of children, particularly in African countries, is alarming. Understanding the drug functionality is important in treatment. It is interesting that only trans atovaquone is effective as a malarial drug and its cis isomer is not a malarial drug [13]. The malarial drug choro quinine or hydroxychloroquine is being used as a drug for the treatment of COVID-19. It is known that SARS corona virus (out bust in 2002) was exhaustively studied by Nicol and his group and based on their study, they have recommended that SARS can be treated with chloro quinine or better hydroxy-chloro quinine as was published in 2005 in virology journal [14].

On World Malaria Day 2012, WHO launched a new initiative called T3: Test. Treat. Track. to provide a framework for endemic countries to strengthen malaria control and elimination [15]. Adopting, diagnostic testing, treatment and track of infectious disease, control management programs were launched on regional basis for effective control. Development of effective public health management policy with best medical countermeasures (e.g., vaccines, diagnostics, therapeutics) is helpful for the control of disease incidence. Models predicting severity and mortality of malaria infection lacking on the generalizability as most of these model's due lack of external validation [16]. Overall, malaria and COVID-19 disease research together can give hope for better model of control [14–16].

Understanding prognosis model from HIV, another deadly disease is important to frame diagnosis model for COVID-19. In HIV, plasma HIV-1 viral load independently and in combination with CD4+ cell count measurements provided powerful prognostic information for progression to AIDS and death in a specific population [17].

Study suggest that universal HIV treatment would most effectively and efficiently reduce the HIV burden and increasing public health benefit [18]. Numerical simulations are conducted in a novel HIV/AIDS epidemic model to understand globally asymptotically level [19]. Understanding severity of diseases by risk groups (low, middle and high) using the nomogram an accurate and favorable prognostic prediction for ART treatment in HIV would be very favorable to promote the precise prevention and personalized health management in cost-effectiveness [20]. Dynamic HIV transmission models can provide evidence-based guidance on to treat and prevent, as study suggest that better integration of modelling in decision making can be achieved by systematically reporting on the evidence synthesis process, and by quality of data entered into the model [21].

Clinical complications in COVID-19 are one of key features where various symptoms vary between symptomatic to asymptomatic cases. In case of Tuberculosis, a common modeling approach is the compartmental model, which describes a population divided into mutually exclusive health states and uses differential equations to represent the mechanisms of transition between infection, rapid progression, reactivation, and treatment/recovery health states [22]. Understanding disease progression and transmission based on host susceptibility is important aspects of COVID-19, where disease severity can be predicted for control strategies in advanced. A novel mathematical model that distinguishes between susceptibility amongst the population for tuberculosis depending on the genes is useful to investigate the impact of transmission, severity and treatment [23].

Technology oriented healthcare models

Technologies have potential to accelerate the epidemic management extensively and protect from disease burden. Various adaptations in public health models for better healthcare management area must in disease specific pattern. The policy development process of healthcare technologies can be characterized for testing, shared analysis, validation, implementation, and evaluation via participation of diverse stakeholders' groups [24]. The improvement of decision-oriented processes through technology of GIS, Information technology, Computational analytics, mathematical modeling can save lives and decrease the economic loss of public. Pre-information of incidence can help to initiate protection policy in advanced. The aforesaid policy will initiate protection protocol and help extensively against such kind of deadly and highly infectious diseases burden. In recent times, the healthcare sector has moved towards technology-based utilizations for cost effectiveness and better results. Study suggests that economy and policy influence healthcare technology solutions as we wrestle with keeping healthcare quality high and costs low [25]. Healthcare technologies demonstrate quality, easy access, and cost effectiveness on mass community level so change individual budget extensively. The government has to adopt beneficial policy of patient according to provider benefit, quality, and outreach assessment for national interest. Below mentioned subheadings were prioritised area of science and technology, which may address for better healthcare technologies for COVID-19 pandemic.

- *Mathematical modeling*
- *Surveillance of diseases*
- *Role of nanotechnology in boosting prognosis models*
- *Biosensor based technology and materials industry*
- *Digital healthcare technology for mass community*

Mathematical modeling

The disease transmission is one of the big challenges in such kind of infectious diseases. Mathematical programs can predict, segregate, and define most appropriately for virus transmission, possibility of spreading in localized area or in big community through algorithm. Understanding of super-spreaders subjects, population subgroups of high risk and low risk through mathematical science help to run the control and various awareness programs. Study indicates that mathematical models can predict epidemic curve representing the number of infections caused by the virus over time [26]. Another study of numerical simulations demonstrates the suitability of the proposed disease model for the outbreak that occurred in Wuhan, China [27]. Integration of such kind of algorithms in integrated platforms, where just by data inputs, we get the possible forecasting in advance about disease
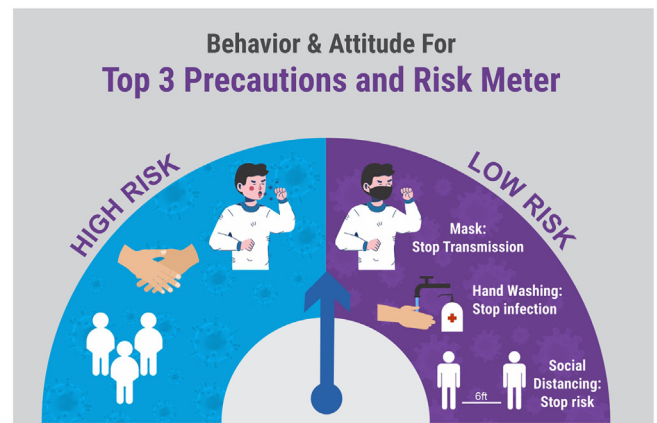
Fig. 3. Behaviour and attitude for top 3 precautions and risk meter. Monitoring precautionary measurements for mask, sanitization, and distancing in community for COVID-19 via technology-based surveillance will alert early for major risks.

spread. This information will help to launch public awareness programs of preventive measures.

Surveillance of diseases

The population demography (density, travel mode, market locations etc.) and ecological factors (climate change, agricultural, etc.) are important for the early identification of infectious threats.

Accurate monitoring of infectious disease through pathogen biological information should be linked to surveillance tools focused on risk assessment of any sudden outbreaks to control any possible diseases threats [6]. WHO released COVID-19 documents which emphasize the need to adapt and reinforce existing national systems including appropriate scale-up surveillance capacities [28]. In USA, National Notifiable Diseases Surveillance System (NNDSS) collects and sends data on COVID-19 cases to CDC [29]. Study suggests that surveillance helps epidemiologists to calculate: Incidence (number of new cases reported over a specific period of time), Prevalence (number of cases at one specific point in time), Hospitalizations (number of cases resulting in hospitalization) and Deaths (number of cases resulting in death) and other related important information of disease [29]. Monitoring top 3 precautionary measurements such as mask, sanitization and distancing of COVID-19 in community via technology-based surveillance is one of major requirement in present corona crisis. Fig. 3, defined about risk measurement with proposed Corona risk meter, which is able to alert early for major risks and getting chance of infections. Linking human activity to regional disease outbreaks is also important. Because, human behaviours and attitude monitored through epidemic intelligence methods and move towards adopting better public health models of control for sustainable solution.

Role of nanotechnology in boosting prognosis models

Contagious diseases have shaped human history and they are with us even in this technological explosion of 21st century. The crown shaped virus seen under Electron Microscope having nano-dimensions is so new that many unknowns still remain about the virus, including its origin, its transmission-how easily it spreads, how it invades the body, how immune system responds, and how deadly it is. Since it is going to stay with us as the weather changes, nanotechnologies will have ultimate solutions but till then, aggressive precautionary measures are answers.

Scientists have to tackle Covid-19 from many angles while working on a diagnostic device that consists of coated antibodies that

bind to a specific viral protein, while second antibody is attached to gold nanoparticles nanoparticles or other nanomaterial, this is how nanotechnology helps in faster diagnosis.

Research focused on modeling of infectious disease dynamics and transmission of COVID-19 is important for making hygiene strategies and protect against infectious droplets.

Presently, there is an urgent need to focus research on design and evaluation of nanotechnology-based drug delivery systems, pharmacology of delivered drugs and the (patho-) physiology of the host for better results in disease [30]. Perspective study suggests that bio-nanotechnology can manage the COVID-19 in a personalized manner [31]. Kostas Kostarelos shares his views on how the nanoscience community could contribute to fight against COVID-19 through scientific fact [32].

Hopefully, nanoparticles-based vaccine to fight the COVID-19 will be soon available in the market. Medical needs continue to challenge scientists to seek innovative technological solutions, many of which involve increasing the functionality of materials. Most promising opportunities in materials are at the intersection of traditional research fields such as materials science and biology. But scientists across disciplines and students should come forward to find innovative solutions for this beast, which is moving very fast.

Biosensor based technology and materials industry

The advantages of biosensors-based-technology in the biomedical field lie in the short response times and real-time monitoring of biological processes that can help in point-of-care measurements in mass community. There are studies on antibodies, DNA molecules, and enzymes to develop biosensors that use graphene and its derivatives to produce effective biosensors, which can detect pathogens and biomolecules linked to diseases [33]. Recent study shows that dual-functional LSPR biosensor exhibits a high sensitivity toward the selected SARS-CoV-2 sequences with a lower detection limit down to the concentration of 0.22 pM [34]. There is an urgent need of the unique world-class metal environmental dissolution technology and colloidal metal nanoparticles production technology. From raw materials to nano metal and nano metal oxide production, there is requirement of different kinds of spherical nanoparticle colloidal solutions by using a single production process [35]. Recent development of effective ingredients for anti-covid-19 virus in TPNT is kind of hope for next level utilization of technology in COVID-19 care [35]:

- The nanocomposite colloidal solution named, TPNT1, successfully killed COVID-19 virus with test by National Taiwan University which is currently in the application product development stage.
- Lateral flow assay: Using the principle of conjugation nanoparticles with antibody and antigens, different colors of nanoparticles are already available, such as AuNPs (red), PtNPs (black), SeNPs (Orange), Au/PtNPs (purple), Au/ZrO2 (deep red), used as labels on the Lateral flow assay.
- Environmental disinfection: The use of nanoparticle composite colloidal solution named, ND50, can be effectively used as environmental anti-COVID-19 disinfection. Tripod Nano Tech Can Help! Nano metal/ metal oxide is an effective solution on the COVID-19 epidemic prevention [36].

Understanding the various perspectives for the development of novel point of care (POC) diagnostics for cost-effective public healthcare is most important task after COVID-19 pandemic. These POC biosensors which are made of polydimethylsiloxane (PDMS), papers, flexible materials (textile, film, and carbon nanosheets) have advantages, challenges and future perspectives as they can manage the spread of COVID-19 very fast [37]. The direction

of materials science research should be focused mostly towards biosafety materials [38]. Presently, deleterious effects of coronavirus have prompted the development of novel materials to control the disease faster across world.

Digital healthcare technology for mass community

Mass community services are required during pandemic situations where a wealth of new age technologies play effective role. Supportive clinical care along with new age technologies adapted with IoT, Surveillance, Sensors, Cloud support systems, Artificial intelligence, Machine learning, and Nanotechnology may be the best feasible tools for decision-making under emergency situations [6]. A digital health industry focused on diagnosis, prevention, and management is increasing day by day [39]. This pandemic has triggered an unprecedented demand for digital health technology, which have healthcare solutions such as for population screening, tracking the infection, and designing targeted responses [40]. A series of applications involved through using artificial intelligence in infectious disease field especially in low-income countries [41]. mHospitals technology company is devoted on mass healthcare mission for regional COVID-19 through translational research programs involving artificial intelligence and mobile technology [42]. WHO has received an overwhelming support from healthcare technology organisations to fight the COVID-19 pandemic On 02 April 2020, 30 of the world's leading digital technology experts gathered in a virtual roundtable to help advance WHO's collaborative response to COVID-19 [39]. Epidemiological modeling can be used as a tool that can be used to mitigate pandemic risk by predicting disease transmission dynamics. The importance of designing a model to address global health challenges can be done through interdisciplinary collaboration among empiricists, policymakers and technology companies to improve the public health decision-making [43].
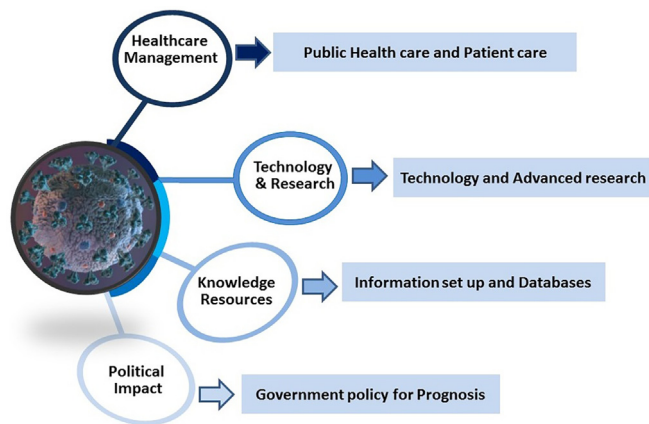
Structured healthcare management

Successful public health model can be adopted for all infectious disease outbreaks with slight modification and change of strategies based on regional information or nature of disease. Community's knowledge and people's behaviour also impact transmissions during pandemic. So, the best strategy would be to involve common public in the awareness programs. Important public health management (e.g., case tracing, outbreak investigations, social distancing) slows down the rate of outbreak. Identifying strategies to reduce the spread of COVID-19 is important to understand for healthcare professionals with standard training and knowledge [44].

Effective public health policy is helpful in early diagnosis, better prevention and complete treatment with great potential in cost-effective manner. Preventive policies must embrace research and technology at community level to cover healthcare solutions for all the society to influence public policy formation, and their implementation to varying degrees. Therefore, management of public health model may address evidence of efficacy for varied segments with the focus to specific and regional management models. This kind of structured management with integrated technology approaches providing logical and cost-effective solutions is more useful in pandemic crisis [Fig. 4 and Table 1]. Below mentioned management categories is useful for effectiveness in healthcare to make it healthier for society.

- *Public health management*
- *Patientcare management*
- *Healthcare technology*

Table 1
Management type categories, technology, information resources and political impact of COVID-19.

Management type	Description	Reference
Public health management	Discover value-based health: a new paradigm for healthcare	[45]
	Healthcare workers exposed to COVID-19	[46]
	CDNA guidelines for the prevention, control in Australia	[47]
	Management of the COVID-19 by public health establishments	[48]
	Maternal health care management during the COVID-19	[49]
	Hospital medicine management in the Time of COVID-19	[50]
	Adaptations and lessons from COVID-19 in industries	[51]
	Commercial health plans of populations and personalized care	[52]
	Global policy and agenda	[53]
	Pathophysiology, epidemiology and clinical management	[54]
	Heathcare cloud services	[55]
Patientcare management	COVID-19, technical guidance & patient management	[56]
	Guidance on testing	[57]
	Contact tracing of persons exposed with COVID-19 cases	[58]
	Medical management of COVID-19	[59]
	Intensive care management of coronavirus disease 2019	[60]
	Health information	[61]
	Transformational healthcare outcomes	[62]
	Managing healthcare delivery system and experience in Japan	[63]
Healthcare technology	Propeller sensors track medication	[64]
	Monitoring approaches for health-care workers	[65]
	Covid-19 and health care's digital revolution	[66]
	Smart healthcare: making medical care more intelligent	[67]
	Source of knowledge	[68]
	Source of knowledge	[69]
Information resources	Call for papers on management science in the COVID-19	[70]
	IPR and patents in COVID-19	[71]
	Political and crisis communication	[72]
	Politics, trust, and behaviours	[73]
Political impact	Economic, social and political issues	[74]
	Policy sciences: initial reactions and perspectives	[75]

Fig. 4. Effective management of public health defined in structured healthcare models, which will address high efficacy of COVID-19 prognosis under management and integrated technology approaches.

- *Information resources*
- *Political impact*

Public health management

Strong public health policy is devoted to a description of rapid identification and effective control programmes in accordance with specific principles, while carrying a regional perspective. Quantification of viral loads or antigen or antibody in human body may give idea of infection progress and information about turn up full positive conditions in COVID-19 in vulnerable communities. How do we make risk assessment, COVID-19 diagnosis, and control as an integral part of the public health management during pandemic crisis is important to know. Table 1 [45–54], signifies importance of COVID-19 management. Here, discovering value-based health,

country guidelines, public health establishment, medicine management, industry adaptation is important to know for making better management plan [45,47,48,50,51]. While framing healthcare policy and agenda for personalised and population level, we have to focus on other risk subjects like healthcare professionals, maternal issues, complex diseases under epidemiology and defined clinical set up in advanced [46,49,52,46–54]. Below mentioned categories and Table 1 [45–54], define more better way for focused region.

- *Key research policy*
- *COVID-19 screening through rapid tests*
- *Importance of being screening and cost effective policy*

Key research policy

Key research policy must address the implications of advance public health settings and their impact on the disease risk reduction. Identification and elucidation of the biological research of the COVID-19 is always key point for diagnosis and pathogenesis point of view. Disease transmission continues so understanding diagnostic mechanism and establishing effective drugs via research is helpful for health care policy. Research on disease modeling based on data of regional micro epidemics provide a framework for dynamic and compartmental transmission model for virus [27]. The approach to fighting the Coronavirus pandemic must also pay special attention to the integration of diagnosis and control approaches in healthcare management, where infected persons are identified and receive care. Policy for public health here includes (a) surveillance and diagnosis, and (b) screening and control mechanism under appropriate public health settings.

COVID-19 screening

Diagnostic for community level in the context of the public health system, is important for individuals, who are unaware of

their infection. Early screening through diagnosis strategy help to control for those persons whose infections were positive promptly. As some may unknowingly spread infections to their close relatives, friends and others in the society. Early diagnosis therefore carries not only benefit for the individual but also the society. Prompt control offers an opportunity to stop further spread of infections and reduction of risk by hygienic environment and treatment that support to decreases the viral load in human body. The rationale of screening at community level to find out the COVID-19 patients is important to launch control programs in advance for negative persons also. Primarily, identification of immunodeficiency persons or other diseases or old age persons having clinical history of other diseases is most important steps of screening as presence of such clinical features may predisposes to opportunistic infections of pandemic disease in future. Rapid test for screening at community level helpful for immediate decision for better public health management. Technically, these point-of-care settings refer pathogen exposure in terms of positive and negative.

Importance of screening and cost effective policy

Being screening at community level in pandemic situation is important to make a decision to avoid high risk for COVID-19 infection. If we delay in testing, then there will be chance to have been exposed to COVID-19. Considering, one wants to always negative for COVID-19 infection better to promote earlier testing. The economic costs for public healthcare management matters to deliver healthcare facility for common man. A comprehensive public health approach with lower cost is highly significant in terms of community utility for diagnosis, treatment and control. Presently, technology based healthcare management is found to be effective to reduce cost and deliver services at broad level.

Patientcare management

During the 2020, there has been a significant global increase in the COVID-19 exposure and transmission. Ensuring timely access to care for patient with COVID-19 infection, management should be focus on COVID-19 risk behaviours, control mechanism, and treatment strategies.

The majority of patient who are aware of their clinical status, and who have access to medical facility to treat themselves is first priority. For patients continuous monitoring of clinical status and providing drugs remains a better impediment to successful prevention strategies.

On the other hand, all the healthy persons come in close contact with patient, have received medical counselling and have prevention tools, to take preventive measures to stop the further transmission of COVID-19 to other persons is second important step. Due to highly infectious nature of COVID-19, patientcare is most important in management, where patients are isolated and treat effectively. Table 1 [55–60], signifies importance of patient-care management, and its role in shaping healthier environment. Monitoring and follow-up of patients with technology based cloud services management under clinical guidance is useful in patient-care [55,56]. Segregation of patient, healthy and asymptomatic based on clinical testing and follow-up of exposed subjects is important task during COVID-19 pandemic [57–59]. Medical and intensive care management for diagnosis, isolation, and infection control is necessary for health-care workers and other patients through defined clinical management protocol [59,60].

The future of patient healthcare lies to have complete package of diagnosis and treatment covering to handle all associated risk data, contact details, follow-up, clinical history, status improvement, possible risk and cost effectiveness. Therefore, it cannot be overemphasized how patient care management structured and fulfil all aspects in a sustainable treatment model.

Healthcare technologies and management

The future of healthcare lies in digital healthcare technologies, such as internet of things, artificial intelligence, nanotechnology etc. in order to be able to deliver public health model more effectively. Transforming health care delivery system thorough use of technology is most important strategies in present pandemic situation like COVID-19. This transformation will require changes of the public health system to delivery both diagnosis to control setup system by involving valid clinical kits, medical experts, evidence-based research on best practices and a better outcome perspective, for the patient. For mass healthcare perspectives and cost-effectiveness healthcare technologies can play major role in enhancing public health services, Table 1 [61–67], signifies its importance in detail. Healthcare information's, transformational outcomes through regional healthcare models is important to understand for technology adaptation [61–63]. Adherence of sensor based technologies in monitoring of patients and healthcare professionals, revolutionaries the healthcare management [64–66].

The system supported by experts of engineering, biotechnology, medical science, pharma and chemical science professionals working hand-in-hand with technology and healthcare together in order to stay relevant in the present pandemic. In healthcare, technology could transform healthcare systems into cheaper, faster and better solutions covering models which can win the battle for us against COVID-19. COVID-19 diagnosis provides infection information's which help to take type of control strategies early. At community level, early diagnosis forms the basis to care, control and treatment support for persons in need. Recent digital revolution has catalysed the medical healthcare field and generate an intelligent and smart healthcare model for public and community [66,67]. Embracing emerging technologies and their design and development according to present healthcare requirement in cost effective way should be promoted and supported at the level for effective management in public health.

Information resources and management

The continuing importance to adopt effective public health policy in COVID-19 is reflected in the present pandemic. There is an association between clinical practices, knowledge, technology improvement, research outputs and treatment delivery based on available information sources on open sources. By adopting several resource centre information's in public healthcare practices one could increase knowledge. Any valuable or related information was, however, comprehensively sourced from valid and authentic point help to avoid any risk in healthcare.

Currently, there is urgent need of universal data management system which categorically provides information's under one umbrella in comparative and evaluation mode with valid references. However, present resources are not able to provide systematic data due to complexity and lack of complete structure for all dimensions. Therefore, experiences that the informants sought should adopted by public health policy makers. Table 1 and several references establishing importance of resource and knowledge management in COVID-19 crisis [68–72]. Collection of articles and other resources in one place and open single depository system for knowledge is beneficiary for scientific community engaged in research and technology development of COVID-19 [68–70].

Information and communication technologies simply lead to healthier communities through the use of health services and information, where resource canters publish new research and findings on the key challenges of the public health problem. The univer-

sal model of resources should offer comprehensive and systematic information that takes into consideration all the important specificity existing for better understanding of disease epidemiology and clinical practices. Understanding the innovation and IPR information and translate it in useful product is useful for worldwide community [71]. Overall, political decision based on available epidemiological information influence extensively life of public [72]. Below mentioned categories, signifies importance of information management in this pandemic era.

- *Characteristics of informants and resources*
- *COVID-19 Treatment Information Resources*
- *COVID-19 Prevention, Information Resources*

Characteristics of informants and resources

The extensive exploration of information sources by healthcare professionals, help them to correlate the results, scores on knowledge for public health decision. Further, with wider access to COVID-19 diagnosis, control and therapy information's, healthcare professionals able to reconsidering or modify their clinical decisions. Government authority's asses and revised the clinical management at time to time for better healthcare management (https://www.mohfw.gov.in/pdf/RevisedNationalClinicalManagementGuidelineforCOVID1931032020.pdf). The informants for the COVID-19 pandemic should give an overview of overall clinical process during treatment and control strategies during disease containment region.

COVID-19 treatment information resources

The authenticate list includes treatment information's, drug trials reports of valid organizations. The information available on web resources should have all minor details for effectiveness of therapy in reducing the risk with further contact information's available for counselling and referrals to the services. Valid public health information on treatment helpful for making decisions for the broader community.

COVID-19 prevention, information resources

The current pandemic context shows evidence of the effectiveness of control in reducing the transmission, by using effective preventive mechanism and technologies. For prevention the surveillance and epidemiological data are the most useful information's sources that helps to create more efficient methods for the control of COVID-19 disease. Health professionals providing services in prevention of disease at community level should be mentioned with report in index journal, organization index at national level for validity point of view.

Political impact

Political leadership is main driver of any country's healthcare system. Political action is based on leaders of the government, who impact on appropriate actions on healthcare issues such as COVID-19 pandemic. Political government has the opportunity to develop or improve the public health by policy. As a disease associated with transmission, insufficient diagnosis, inappropriate treatment facility, infectious disease control system etc. in all the contexts ignorance have greater influence on disease incidence. Politics play essential role to deliver better prognosis ideology, as best practice is the determinants of appropriate implementation. Table 1 and references [73–75], denotes importance of political impact in public health management. COVID-19 has also severely affected the global economy and financial markets results in income crisis, unemployment, transportation and industries disruptions in many countries [73]. So, governments should be active in their immediate response to protect financial prosperity.

Appropriate prevention policies and programmes are the regulations commitment addresses the risk populations without socio-economic affiliations. Here unprecedented levels of resources have been mobilised for public health access, at aim to halt the transmission of pandemic and protect an individual and their community. Government and public officials deciding on a prevention models by specific attention, direct involvement, recommendations and involvement in interventions of public health management. Country's political leadership can launch health campaigns, public testing and voluntary control through treatment by free government hospitals whenever pandemic is needed. It is country political head who accept, recommend healthcare policies according to modes of transmission, affected populations and regional incidences. The economic crisis and recession due to COVID-19 established the fact and importance of better political decision for public health. In response to COVID-19 global outbreaks social distancing, travel restrictions, closed industry, loss of food sector and schools denotes the socio-economic effects [74].

The policy makers can recommend several options according to international law, regional public health models and based on evidence in epidemic or endemic conditions.

Study signifies the importance of trust in government decisions and actions relating to the management of COVID-19 as a major challenge worldwide [75]. Economic, social and political issues raised by the COVID-19 pandemic should be deal with appropriate policies otherwise lack of knowledge will lead to complications [76]. Study explores the ways in which scientific and technical expertise, emotions, and narratives influence policy decisions and shape relationships among citizens, organizations, and governments [77]. Most important, understanding adaptation, policy responses, alterations in networks (locally and globally), and assessing policy success and failure in terms of various aspects of the policy sciences should deserve attention [77]. Political decision influencing public health management ensures that the appropriate tools are available to monitor and evaluate data about pandemic disease and they control all risk factors that might enhance COVID-19 prevalence. Overall, social, legal and economic analyse drives political law and impact on public health policy for healthier society.

Interpretation and proposed regional healthcare models

Research interpretation of improving the translational research findings for clinical practice can be broadened in the directions of effectiveness, cost, new development, and the idea of improvement through socially desirable innovations [78]. Addressing drawbacks of public health models and counterbalance it with advanced healthcare technologies is the best strategy for any pandemic-like situations. The standard interpretation opens the scope of public policy to include technology assessment (identifying deficiencies, benefits, and costs of new developments) [78]. Using genomics and proteomics research for diagnosis, drug, and vaccines and AI, IoT, Electronics and Cloud computing models for preventive methods will be on the same line [6]. Under pandemic condition, healthcare facility demand is high while technological transformation is slow towards structured management and integrated technology environment. Here, we are proposing regional healthcare models based on priority of three primary risks such as transmission possibility, social distancing, and sanitized environment (Fig. 1). Ensuring control of all these three primary risks will stop the spread of COVID-19 extensively. Behaviour decides handling of precautionary measurements, while attitude for top 3 precautionary measurements decides to spread of disease in community. We have mentioned CORONA Risk Meter in Fig. 3, defined about adaptation of three
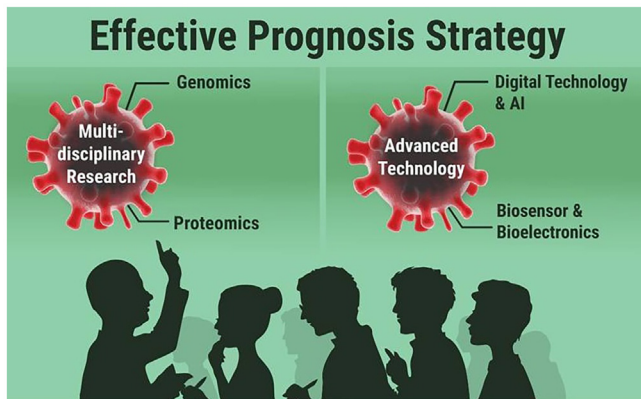
Fig. 5. Effective prognosis strategy defines adoption of trio models where combination of multidisciplinary research, advanced technology, and structured healthcare management work together in combating COVID-19 disease.

important precautionary measurements to stop the associated risk before infection such as:

- Mask: stop transmission
- Hand washing: stop infection
- Social distancing: stop risk

Apart from precautionary measurement structured and specific healthcare management is required to get prognosis results effectively (Table 1 and Fig. 4). Prognosis strategy can be move with the help of multidisciplinary research and advanced technology models. Where, genomics, proteomics, clinical research, nanotechnology will help in disease-drug based research while biosensor technologies will be effective in diagnosis-based methods. Effective prognosis strategy adopts combination of multidisciplinary research, advanced technology and structured healthcare management, where all these together can contribute appropriately in combating COVID-19 disease (Fig. 5). Additionally, we should understand important signature, message and results of several studies reported varied healthcare management options (Table 1). Understanding of varied healthcare models and their study is important because it will help to make strategies under complex and variable risk. Public health management and patient care management should be improved with advanced healthcare technologies and biomedical research data (Table 1). These varied management studies can be adopted according to risk assessment of COVID-19 and analyse the results of effectiveness at time to time for better decision. Therefore, healthcare management for regional healthcare practices with high rate of success, characterized by lower risk and cost-effective treatment should be gained more effectively by technology oriented public healthcare models. All kind of mentioned, adopted, and integrated control models will prevent the spread of the disease more effectively. This manuscript emphasizes more about adaptation of best healthcare management practices based on other disease models, advanced technology, and COVID-19 multidisciplinary research experiences across continents.

Conclusion and future prospects

More specifically, this article presents an overview of the prognosis and preventive challenges that must be addressed in advance to combat pandemic-like condition in proposed structured framework of management. Majorly, identifying several local clinical features and transmission possibility associated with behavioural interventions in an outbreak region should be discussed in management for making preventive model. The effective interventions in a public health model through advance technology can have profound positive consequences for health and socio-economic status. With a standard healthcare policy and the proper precautions; we can avoid spreading of infectious diseases. Although, healthier healthcare management preparation has to go a long way in order to control the incidence of the disease worldwide and the data presented through this study shall be helpful for stakeholders in framing policies along with research and technology for better public health management. The healthcare service becoming advance due to advent of technology, analytics, artificial intelligence, and clinical information's systems, which deals with high end experts at one side and intellectual customers on other side. The futuristic sustainable model of healthier outcomes heavily relies on novel biomarkers, intelligent therapeutics, and quality care strategies, which again depend on fast transformation of healthcare system through strong policy of technology enabled structured healthcare management.

Competing interests

None declared.

Ethical approval

Not required.

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References

[1] Bloom David E, Cadarette Daniel. Infectious disease threats in the twenty-first century: strengthening the global response. Front Immunol 2019;10:549.

[2] Nicola Maria, Alsafi Zaid, Sohrabi Catrin, Kerwan Ahmed, Al-Jabir Ahmed, Iosifidis Christos, et al. The socio-economic implications of the coronavirus pandemic (COVID-19): a review. Int J Surg 2020;78(June):185–93.

[3] Hadil Alahdal, Fatemah Basingab, Reem Alotaibi. An analytical study on the awareness, attitude and practice during the COVID-19 pandemic in Riyadh, Saudi Arabia. https://doi.org/10.1016/j.jiph.2020.06.015.

[4] Zhong BL, Luo W, Li HM, Zhang QQ, Liu XG, Li WT, et al. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey. Int J Biol Sci 2020;16(10):1745–52, http://dx.doi.org/10.7150/ijbs.45221.

[5] Fegert JM, Vitiello B, Plener PL, Clemens V, et al. Challenges and burden of the coronavirus 2019 (COVID-19) pandemic for child and adolescent mental health: a narrative review to highlight clinical and research needs in the acute phase and the long return to normality. Child Adolesc Psychiatry Ment Health 2020;14:20, http://dx.doi.org/10.1186/s13034-020-00329-3.

[6] Mishra A, Patra S, Shukla SK, Pandey P, Shukla Y, Osmera P, et al. Current scenario of coronavirus pandemic. Adv Mater Lett 2020;11(4):20041494, http://dx.doi.org/10.5185/amlett.2020.041494.

[7] COVID-19 Databases and Journals: https://www.cdc.gov/library/researchguides/2019novelcoronavirus/databasesjournals.html.

[8] Freely available COVID-19 resources:https://library.maastrichtuniversity.nl/collections/databases/free-access-to-resources-during-the-covid-19/.

[9] COVID research updates: https://www.nature.com/articles/d41586-020-00502-w.

[10] Vaccines and treatment of COVID-19: https://www.ecdc.europa.eu/en/covid-19/latest-evidence/vaccines-and-treatment.

[11] World Health Organisation (WHO), Available from: Clinical management of COVID-19. Interim guidance. WHO; 2020 https://www.who.int/publications/i/item/clinical-management-ofcovid-19.

[12] WHO World Malaria Report 2014, http://www.who.int/malaria/publications/world_malaria_report_2014/wmr-2014-foreword.

[13] Basumallic S, Guru Row TN. Binding study of cis atovaquone with cytochrome bc1 of yeast. Comput Mol Biosci 2015;5:57–63.

[14] J.Vincent M, Bergeron E, Benjannet S, Erickson B, Rollin P, Ksiazek T, et al. Chloroquinine is a potent inhibitor of SARS chrona virous infection and itsspread. Virol J 2005;2:69–79.

[15] https://www.who.int/malaria/areas/test_treat_track/en/.

[16] Njim T, Tanyitiku BS. Prognostic models for the clinical management of malaria and its complications: a systematic review. BMJ Open 2019;9(11):e030793, http://dx.doi.org/10.1136/bmjopen-2019-030793. Published 2019 November 26.

[17] Vlahov D, Graham N, Hoover D, Flynn C, Bartlett JG, Margolick JB, et al. Prognostic indicators for AIDS and infectious disease death in HIV-infected injection drug users: plasma viral load and CD4+ cell count. JAMA 1998;279(January (1)):35–40, http://dx.doi.org/10.1001/jama.279.1.35. PMID: 9424041.

[18] Ross JM, Ying R, Celum CL, Baeten JM, Thomas KK, Murnane PM, et al. Modeling HIV disease progression and transmission at population-level: the potential impact of modifying disease progression in HIV treatment programs. Epidemics 2018;23:34–41, http://dx.doi.org/10.1016/j.epidem.2017.12.001.

[19] Huo Hai-Feng, Chen Rui, Wang Xun-Yang. Modelling and stability of HIV/AIDS epidemic model with treatment. Appl Math Model 2016;13(40):6550–9.

[20] Hou X, Wang D, Zuo J, Li J, Wang T, Guo C, et al. Development and validation of a prognostic nomogram for HIV/AIDS patients who underwent antiretroviral therapy: data from a China population-based cohort. Lancet 2019;48:414–24.

[21] Krebs E, Enns B, Wang L, Zang X, Panagiotoglou D, Del Rio C, et al. Developing a dynamic HIV transmission model for 6 U.S. cities: an evidence synthesis. PLoS One 2019;14(5):e0217559, http://dx.doi.org/10.1371/journal.pone.0217559.

[22] Dowdy DW, Dye C, Cohen T. Data needs for evidence-based decisions: a tuberculosis modeler's 'wish list'. Int J Tuberc Lung Dis 2013;17(7):866–77, http://dx.doi.org/10.5588/ijtld.12.0573.

[23] Okuonghae D. A mathematical model of tuberculosis transmission with heterogeneity in disease susceptibility and progression under a treatment regime for infectious cases. Appl Math Model 2013;37(10–11):6786–808.

[24] Houngbo PT, Coleman HLS, Zweekhorst M, De Cock Buning T, Medenou D, Bunders JFG. A model for good governance of healthcare technology management in the public sector: learning from evidence-informed policy development and implementation in Benin. PLoS One 2017;12(1):e0168842, http://dx.doi.org/10.1371/journal.pone.0168842.

[25] Kern SE, Jaron D. Healthcare technology, economics, and policy: an evolving balance. IEEE Eng Med Biol Mag 2003;22(1):16–9, http://dx.doi.org/10.1109/memb.2003.1191444.

[26] Panovska-Griffiths J. Can mathematical modelling solve the current Covid-19 crisis? BMC Public Health 2020;20:551.

[27] Ndaïrou Faïçal, Area Iván, Nieto Juan J, Torres Delfim FM. Mathematical modeling of COVID-19 transmission dynamics with a case study of Wuhan. Chaos Solitons Fractals 2020;135(June):109846.

[28] https://www.who.int/publications-detail-redirect/surveillance-strategies-for-covid-19-human-infection.

[29] https://www.cdc.gov/coronavirus/2019-ncov/cases-updates/about-epidemiology/monitoring-and-tracking.html.

[30] Zhang RX, Li J, Zhang T, Amini MA, He C, Lu B, et al. Importance of integrating nanotechnology with pharmacology and physiology for innovative drug delivery and therapy—an illustration with first hand examples. Acta Pharmacol Sin 2018;39:825–44, http://dx.doi.org/10.1038/aps.2018.33.

[31] Paliwal Praveen, Sargolzaei Saman, Bhardwaj Sheetal K, Bhardwaj Vinay, Dixit Chandra, Kaushik Ajeet. Grand challenges in bio-nanotechnology to manage COVID-19 pandemic. Front Nanotechnol 2020, http://dx.doi.org/10.3389/fnano.2020.00003.

[32] Kostarelos K. Nanoscale nights of COVID-19. Nat Nanotechnol 2020;15:343–4, http://dx.doi.org/10.1038/s41565-020-0687-4.

[33] Peña-Bahamonde J, Nguyen HN, Fanourakis SK, et al. Recent advances in graphene-based biosensor technology with applications in life sciences. J Nanobiotechnol 2018;16:75.

[34] Qiu Guangyu, Gai Zhibo, Tao Yile, Schmitt Jean, Kullak-Ublick Gerd A, Wang Jing. Dual-functional plasmonic photothermal biosensors for highly accurate severe acute respiratory syndrome coronavirus 2 detection. ACS Nano 2020, http://dx.doi.org/10.1021/acsnano.0c02439.

[35] Sui-Yuan Chang, Kuo-Yen Huang, Tai-Ling Chao, Han-Chieh Kao, Yu-Hao Pang, Lin Lu, et al. Nanoparticle composite TPNT1 is effective against SARS-CoV-2 and influenza viruses. Research Square (Preprint). https://doi.org/10.21203/rs.3.rs-52066/v1.

[36] Nanomaterials based company: http://www.tripod-nano.com/en.

[37] Choi JR. Development of point-of-care biosensors for COVID-19. Front Chem 2020;8:517, http://dx.doi.org/10.3389/fchem.2020.00517. Published 2020 May 27.

[38] Yingjie Y, Fanqiang B, Huiling Z, Yongheng W, Jianxun C, Xing W, et al. Biosafety materials: an emerging new research direction of materials science from the COVID-19 outbreak. Mater Chem Front 2020;4:1930–53, http://dx.doi.org/10.1039/D0QM00255K.

[39] https://www.who.int/news-room/detail/03-04-2020-digital-technology-for-covid-19-response.

[40] Cohen AB, Dorsey ER, Mathews SC, Bates DW, Safavi K. A digital health industry cohort across the health continuum. Npj Digit Med 2020;3:68, http://dx.doi.org/10.1038/s41746-020-0276-9.

[41] Agrebia Said, Larbi Anis. Use of artificial intelligence in infectious diseases. Artif Intel Precis Health 2020:415–38.

[42] Technology company on mass healthcare: https://www.mhospitals.com/.

[43] Fitzpatrick MC, Bauch CT, Townsend JP, Galvani AP. Modelling microbial infection to address global health challenges. Nat Microbiol 2019;4:1612–9.

[44] https://www.cdc.gov/coronavirus/2019-ncov/php/contact-tracing/strategies-to-reduce-spread.html.

[45] Delivering better insights for better health: https://www.ibm.com/industries/healthcare/solutions/population-health-insights.

[46] Public Health Management of Healthcare Workers: https://www.cdc.gov/coronavirus/2019-ncov/hcp/non-us-settings/public-health-management-hcw-exposed.html.

[47] CDNA guidelines for the prevention, control and public health management: https://www.health.gov.au/resources/publications/cdna-guidelines-for-the-prevention-control-and-public-health-management-of-covid-19-outbreaks-in-correctional-and-detention-facilities-in-australia.

[48] Barroa K, Malone A, Mokede A, Chevance C. Management of the COVID-19 epidemic by public health establishments—analysis by the Fédération Hospitalière de France. J Visc Surg 2020;157(3):19–23.

[49] Chen Y, Li Z, Zhang YY, Zhao WH, Yu ZY. Maternal health care management during the outbreak of coronavirus disease 2019. J Med Virol 2020;92(July (7)):731–9, http://dx.doi.org/10.1002/jmv.25787. Epub 2020 Apr 17. PMID: 32219871.

[50] Garg M, Wray CM. Hospital medicine management in the time of COVID-19: preparing for a sprint and a marathon. J Hosp Med 2020;15(May (5)):305–7, http://dx.doi.org/10.12788/jhm.3427. Epub 2020 Apr 8. PMID: 32379037.

[51] Velic A, Jaggessar A, Senevirathne SWMAI, Mathew A, Paritala PK, Islam M, et al. Adaptations and lessons from COVID-19: a perspective on how some industries will be impacted. Adv Mater Lett 2020;11(7):20071533, http://dx.doi.org/10.5185/amlett.2020.071533.

[52] Whole-person health management solutions for any value-based care initiative: https://www.zeomega.com/.

[53] A well-functioning healthcare system is the need of the hour: https://www.downtoearth.org.in/blog/health/covid-19-a-well-functioning-healthcare-system-is-the-need-of-the-hour-72504.

[54] Pathophysiology, Epidemiology, Clinical Management and Public Health Response: https://www.frontiersin.org/research-topics/13377/coronavirus-disease-covid-19-pathophysiology-epidemiology-clinical-management-and-public-health-resp.

[55] Personalize patient care on one unified platform: https://www.salesforce.com/solutions/industries/healthcare/health-cloud/.

[56] WHO technical guidance: Patient management: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/patient-management.

[57] Overview of Testing for COVID-19: https://www.cdc.gov/coronavirus/2019-ncov/hcp/testing-overview.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fhcp%2Fclinical-criteria.html.

[58] Management of persons, including healthcare workers, who had contact with COVID-19 cases, including tracing, identification, listing and follow-up: https://www.ecdc.europa.eu/en/covid-19-contact-tracing-public-health-management.

[59] Bose S, Adapa S, Aeddula NR, Roy S, Nandikanti D, Vupadhyayula PM, et al. Medical management of COVID-19: evidence and experience. J Clin Med Res 2020;12(6):329–43, http://dx.doi.org/10.14740/jocmr4201.

[60] Phua J, Weng L, Ling L, Egi M, Lim CM, Divatia JV, et al. Intensive care management of coronavirus disease 2019 (COVID-19): challenges and recommendations. Lancet Respir Med 2020;8(5):506–17, http://dx.doi.org/10.1016/S2213-2600(20)30161-2.

[61] Population health: https://www.wipro.com/en-IN/healthcare/population-health-management-bending-the-curve-with-collaboration-access-and-interoperability/.

[62] Healthcare data and software company: https://www.arcadia.io/.

[63] Gai R, Tobe M. Managing healthcare delivery system to fight the COVID-19 epidemic: experience in Japan. Glob Health Res Policy 2020;5:23, http://dx.doi.org/10.1186/s41256-020-00149-064.

[64] The doctor-recommended way to manage asthma or COPD: https://www.propellerhealth.com/.

[65] Bielicki JA, Duval X, Gobat N, Goossens H, Koopmans M, Tacconelli E, et al. Monitoring approaches for health-care workers during the COVID-19 pandemic. Lancet Infect Dis 2020;20:e261–67.

[66] Keesara Sirina, Jonas Andrea, Schulman Kevin. Covid-19 and health care's digital revolution. N Engl J Med 2020;382:e82, http://dx.doi.org/10.1056/NEJMp2005835.

[67] Tian S, Yang W, Grange JML, Wang P, Huang W, Ye Z. Smart healthcare: making medical care more intelligent. Glob Health J 2019;3(3):62–5.

[68] A collection of articles and other resources on the Coronavirus (Covid-19): https://www.nejm.org/coronavirus.

[69] COVID-19 Resource Centre: https://www.thelancet.com/coronavirus.

[70] Papers on Management Science in the Fight Against COVID-19: https://www.springer.com/journal/10729/updates/18040716.

[71] Sengupta Mayuree, Purushotham H. Severe acute respiratory syndrome-related coronavirus: a patent based view. Adv Mater Lett 2020;11(5):20051503, http://dx.doi.org/10.5185/amlett.2020.051503.

[72] Jo Wonkwang, Chang Dukjin. Political consequences of COVID-19 and media framing in South Korea. Front Public Health 2020;8(425), http://dx.doi.org/10.3389/fpubh.2020.00425.

[73] Anton Pak, Adegboye Oyelola A, Adekunle Adeshina I, Rahman Kazi M, McBryde Emma S, Eisen Damon P. Economic consequences of the COVID-19 outbreak: the need for epidemic preparedness. Front Public Health 2020;8(241), http://dx.doi.org/10.3389/fpubh.2020.00241. ISSN=2296-2565.

[74] Nicola M, Alsafi Z, Sohrabi C, Kerwan A, Al-Jabir A, Iosifidis C, et al. The socio-economic implications of the coronavirus pandemic (COVID-19): a review. Int J Surg 2020;78:185–93, http://dx.doi.org/10.1016/j.ijsu.2020.04.018.

[75] Fancourt Daisy, Steptoe Andrew, Wright Liam. The Cummings effect: politics, trust, and behaviours during the COVID-19 pandemic. Lancet 2020;396(10249):464–5, http://dx.doi.org/10.1016/S0140-6736(20)31690-1.

[76] Tisdell CA. Economic, social and political issues raised by the COVID-19 pandemic. Econ Anal Policy 2020;68:17–28, http://dx.doi.org/10.1016/j.eap.2020.08.002.

[77] Weible CM, Nohrstedt D, Cairney P, Carter DP, Crow DA, Durnová AP, et al. COVID-19 and the policy sciences: initial reactions and perspectives [published online ahead of print, 2020 Apr 18]. Policy Sci 2020:1–17, http://dx.doi.org/10.1007/s11077-020-09381-4.

[78] Institute of Medicine (US) Committee on Technological Innovation in Medicine, Gelijns AC, Halm EA, editors. The changing economics of medical technology. Washington (DC): National Academies Press (US); 1991 (Medical Innovation at the Crossroads, No. 2.) 9, Medical Device Innovation and Public Policy in the European Economic Community. Available from: https://www.ncbi.nlm.nih.gov/books/NBK234302/.