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COVID-19: The Dynamics of Quality of Life (QOL) and Artificial Intelligence (AI)[1]

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Abstract

The objective of the study is to conduct an exploratory review of the COVID-19 pandemic by focusing on the theme of COVID-19 pandemic morbidity and mortality considering the dynamics of Artificial Intelligence and Quality of life (QOL). The methods used in this research paper include a review of literature, anecdotal evidence, and reports on the morbidity of COVID-19, including the scope of its devastating effects in different countries such as the US, Africa, UK, China, and Brazil, among others. The findings of this study suggested that the devastating effects of the Coronavirus are felt across different vulnerable populations. These include the elderly, front-line workers, marginalised communities, visible minorities, and more. The challenge in Africa is especially daunting because of inadequate infrastructure, financial, and human resources, among others. Besides, AI technology is being successfully used by scientists to enhance the development process of vaccines and drugs. However, its usage in other stages of the pandemic has not been adequately explored. Ultimately, it has been concluded that the effects of the COVID-19 are producing unprecedented and catastrophic outcomes in many countries. With a few exceptions, the common and current intervention approach is driven by many factors, including the compilation of relevant reliable and compelling data sets. On a positive note, the compelling trailblazing and catalytic contributions of AI towards the rapid discovery of COVID-19 vaccines are a good indication of future technological innovations and their effectiveness.

Keywords: *COVID-19; quality of life; strategies; lessons learned; artificial intelligence*

Introduction

History has a way of reminding us that while the good times are great, a business comes with many unforeseen risks and challenges. Stress, anxiety, and other mental health issues have turned around many mindsets in certain groups. There are now significant and unprecedented levels of compassion, empathy, and more, originating from many populations. One such instance, wherein significant challenges were posed to the community is at the time of the First World War. Besides, there was the Spanish plague, there was the second world war and for the last 60 plus years, we have had to live in a world of misgivings; ranging from populism to political unrests and instability in several parts of the world, primarily the Middle East and some parts of Asia.

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When the current Coronavirus disease-2019 (COVID-19) started in December 2019, many assumed that like its predecessors H1N1, SARS, different plagues, and viruses, etc., it was going to pass with a thud (Chatterjee *et al.,* 2020). However, five months into the pandemic, countries continue to live in fear driven by many unknowns and limited scientific evidence. In the meantime, this aggressive, stealthy, and brutal virus continues to spiral unabated. There is at least some consensus that once the peak of the pandemic has been achieved, there will be a reason for optimism. This assumes that everything being equal (continuous self-exclusion, personal hygiene, social distancing, etc.), the worst would then be behind us. While for the most part this assumption is correct if the processes are effectively and comprehensively implemented. The reality is that the potential for a subsequent wave is real and compelling. To be specific, as per the study findings of Salyer *et al.* (2021: 1265), the second wave of COVID-19, which was evident by December 2020, that more aggressive than the first one in several cases. In this regard, the Spanish flu, also known as the 1918 flu pandemic, serves as a classical example. Its second wave of infection proved to be even deadlier than the first, after non-medical intervention measures put in place at the time had been relaxed (Martini *et al*., 2019: 64).

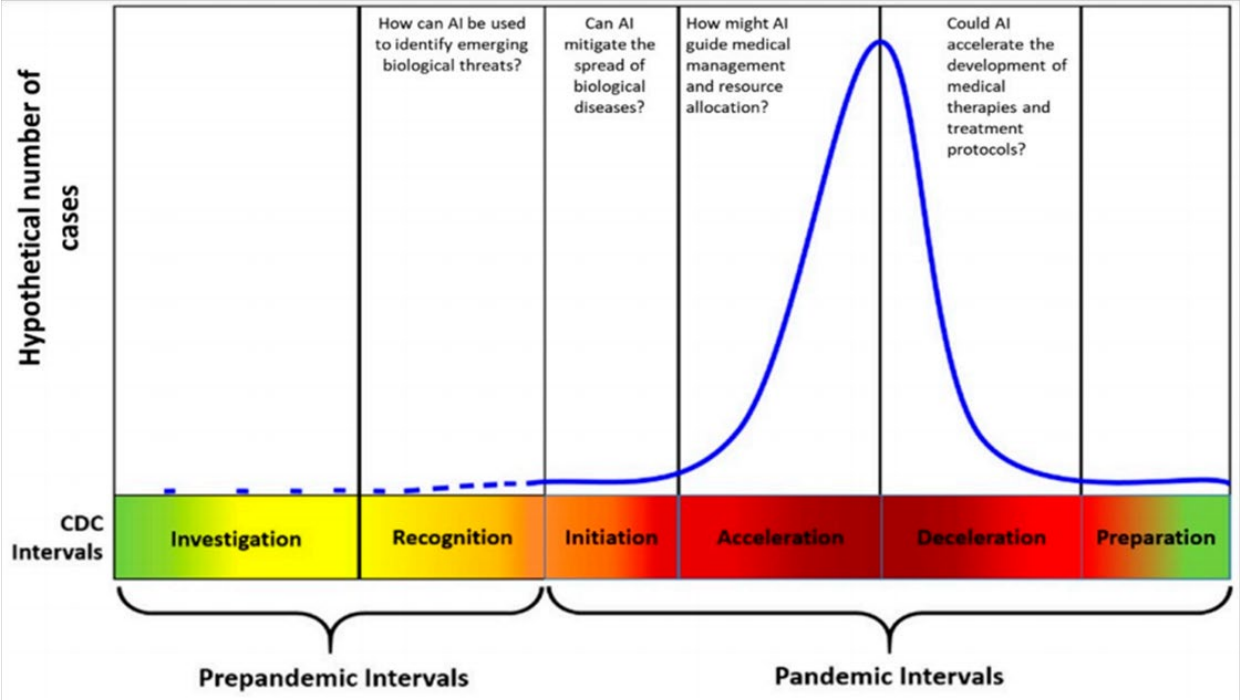
It must also be noted that during the outburst of COVID-19, also known as SARS-CoV-2 disease, healthcare workers are found to play a pivotal role. According to the report published by the World Health Organisation (2021), healthcare workers have been providing frontline services in the pandemic. They are also found to undertake several responsibilities in maintaining health and wellbeing during the outbreak of the coronavirus such as implementing effective health measures, which in turn, can protect the occupational health and safety aspects of the healthcare organisations. Their significant roles, as well as responsibilities in all the COVID-19 pandemic stages, are found to expose them to risks. The hazards that these healthcare workers have been immensely exposed to during this pandemic include psychological distress, pathogen exposure, fatigue, psychological violence, physical impacts, occupational burnout, extensive working hours, and stigma, among others (World Health Organisation 2021: 1). Even community health workers are found to be playing a vital role in facilitating successful COVID-19 vaccination programs. Health workers are found to plan, as well as coordinate the vaccine rollouts. They are also responsible for identifying the target groups for vaccination along with engaging communities, service delivery, facilitating mobilisation, tracking progress, and conducting follow-ups (World Health Organisation and the United Nations Children's Fund (UNICEF) 2021: 8).

Additionally, Al Thobaitya and Alshammari (2020) asserted that healthcare workers and nurses have been played a significant role in disasters and daily routine, especially during the COVID-19 pandemic. They are engaged in providing holistic care to all patients. Since nurses constitute many of the healthcare professionals, they have an important role within healthcare systems. Specifically,

> *Their roles in treating patients with COVID-19 involve triaging patients and detecting suspected cases with infections; providing essential treatment in an emergency and dealing with suspected patients with precautions; helping in decontamination and coordination with other healthcare providers; supplying holistic nursing practices in managing multiple infections simultaneously; playing critical roles in expanding care services; and dealing with relatives* (Al Thobaitya and Alshammari, 2020: 88).

In the context of COVID-19, it has highly influenced the dynamics of quality of life along with incorporating AI. This has been particularly highlighted in the scientific research conducted by Laudanski *et al.* (2020). In this study, it has been understood that technological advancements of AI have significant scope to improve the pandemic response at every stage. The below figure 1 illustrates the pandemic phases propounded by the WHO, wherein distinctive AI applications have been visible considering hypothetical cases. Figure 1 shows that in the majority of all the stages, AI

can be applied in one way or another. It is during this pandemic that AI engines have been prominently performing with a higher level of sensitivity. This has helped to track cases along with the performance of response programs. Even in cases wherein a low amount of data is available, AI can be developed and deployed for training constraints. However, pre-training of AI is found to be highly necessary so that appropriate outcomes can be attained (Laudanski *et al.,* 2020: 2-3).



Source: (Laudanski *et al.,* 2020: 2)

Hence, with the consideration of the COVID-19 pandemic, the transformation, which has been evident across the world concerning the quality of life as well as AI technological advancements, will be explored in this research paper. The key objective of this research paper is to perform an exploratory review of the varied dynamics of the COVID-19 pandemic, thereby emphasising the theme of pandemic morbidity. The reason for conducting this exploratory review on the concerned topic is that exploring the pandemic dynamics are important for addressing such issues in the future. This topic can also be relevant to other health and social issues; hence the present paper can be considered highly relevant. For this, a literature review has been used in this study. Furthermore, a detailed discussion will be provided, and only then pertinent conclusions will be drawn so that the objective of the study can be fulfilled.

Method

The method that has been incorporated in this research study is a review of the literature. Anecdotal evidence along with exploratory reviews and reports on the morbidity of COVID-19 has also been taken into due consideration. This research paper also provides the scope of the devastating effects of the pandemic in select countries: a challenge that should wake all policymakers and create scope for more innovative, cost-effective, and pragmatic interventions. In that regard, the importance of supply chain management systems cannot be adequately emphasised.

Literature Review

The notion that we are all equal in the fight against this virus has been quickly dispelled with early findings, revealing health inequalities amongst populations ranging from front-line service providers, to marginalised communities, to racial minority groups (Centres for Disease Control and Prevention 2020). Specifically, in the United States (US), preliminary nationwide data released by the Centres for Disease Control and Prevention (2020) revealed that although African Americans represent approximately 13 per cent of the U.S. population, they accounted for 30 per cent of all COVID-19 patients. Although far from complete, this data is consistent with the findings from other data collected on race and COVID-19 so far. A disproportionate toll is also being seen in the UK after *The Guardian* did an analysis of 12 593 patients who died of COVID-19 as of April 19, 2020. It showed that 19 per cent were Black, Asian, or minority ethnic (BAME) even though they make up 15 per cent of the population (*The Guardian,* 2020).

In many cases, keeping food on the table means foregoing safe working conditions and a greater risk of exposure to COVID-19. Hence, it can be stated that this issue closely aligns with pandemic morbidity, which has been aimed to be explored in the present paper. A lack of economic resources often translates to food insecurity, amongst other things, which in turn often leads to poor health outcomes that include a higher risk of underlying health conditions. In India, millions of people, including migrant labourers and daily wage earners, are facing hunger since the country's shut down in late March 2020 and left them with no means to earn a living. A similar dire outlook is also threatening First Nation communities in Canada and Black communities in the US. Canada does not report Coronavirus morbidity by race or ethnicity making it difficult to address disparities. The study conducted by Nguyen (2020) further suggested that to eliminate such economic issues, AI technology

Applications	Types of Data	Challenges	Related	AI Methods
Screen and triage patients, identify effective personalized medicines and treatments, risk evaluation, survival prediction, healthcare and medical resource planning.	Clinical symptoms, routine laboratory tests, blood exams, electronic health records, heart rate, respiratory rate, data observed from previous patients, e.g. clinical information, administered treatments, patients' case history.	- Challenging to collect physiological characteristics and therapeutic outcomes of patients. - Low-quality data would make biased and inaccurate predictions. - Uncertainty of AI models' outcomes. - Privacy and confidentiality issues.	[100]–[114]	Machine learning techniques, e.g. naive Bayes, logistic regression, KNN, SVM, MLP, fuzzy logic system, ElasticNet regression [115], decision tree, random forest, nonparametric Gaussian process [68], deep learning techniques such as LSTM [55] and other recurrent networks, and optimization methods.
Predict number of infected cases, infection rate and spreading trend.	Time series case data, population density, demographic data, intervention strategies.	- Insufficient time series data, leading to unreliable results. - Complex models may not be more reliable than simple models [116].	[26]–[34]	
COVID-19 early diagnosis using medical images.	Radiology images, e.g. chest X-ray and CT scans.	- Imbalanced datasets due to insufficient COVID-19 medical image data. - Long training time and unable to explain the results. - Generalisation problem and vulnerable to false negatives.	[117]–[158] and works in Table I.	Deep learning CNN-based models (e.g. AlexNet [3], GoogLeNet [4], VGG network [5], ResNet [6], DenseNet [23], ResNeXt [24], and ZFNet [159]), AI-based computer vision camera systems, and facial recognition systems.
Scan crowds for people with high temperature, and monitor people for social distancing and mask-wearing or during lockdown.	Infrared camera images, thermal scans.	- Cannot measure inner-body temperature and a proportion of patients are asymptomatic, leading to imprecise results. - Privacy invasion issues.	[160]–[163]	
Analyse viral genomes, create evolutionary (phylogenetic) tree, find virus origin, track physiological and genetic changes, predict protein secondary and tertiary structures.	Viral genome and protein sequence data	- Computational expenses are huge for aligning a large dataset of genomic or proteomic sequences. - Deep learning models take long training time, especially for large datasets, and are normally unexplainable.	[64], [85], DeepMind's AlphaFold [57], [58]	- Sequence alignment, e.g. dynamic programming, heuristic and probabilistic methods. - Clustering algorithms, e.g. hierarchical clustering, k-means, DBSCAN [82] and supervised deep learning.
Discover vaccine and drug biochemical compounds and candidates, and optimize clinical trials.	Viral genome and protein sequences, transcriptome data, drug-target interactions, protein-protein interactions, crystal structure of protein, co-crystalized ligands, homology model of proteins, and clinical data.	- Dealing with big genomic and proteomic data. - Results need to be verified with experimental studies. - It can take long time for a promising candidate to become a viable vaccine or treatment method.	[59], [164]–[174]	Heuristic algorithm, graph theory, combinatorics, and machine learning such as adversarial autoencoders [59], multitask CNN [164], GAN [59], [165], deep reinforcement learning [59], [166], [167].
Making drones and robots for disinfection, cleaning, obtaining patients' vital signs, distance treatment, and deliver medication.	Simulation environments and demonstration data for training autonomous agents.	- Safety must be guaranteed at the highest level. - Trust in autonomous systems. - Huge efforts from training agents to implementing them to real machines.	[175]–[179]	Deep learning, computer vision, optimization and control, transfer learning, deep reinforcement learning [180], learning from demonstrations.
Track and predict economic recovery via, e.g. detection of solar panel installations, counting cars in parking lots.	Satellite images, GPS data (e.g. daily anonymized data from mobile phone users to count the number of commuters in cities).	- Difficult to obtain satellite data in some regions. - Noise in satellite images. - Anonymized mobile phone data security.	[181], [182]	Deep learning, e.g. autoencoder models for feature extraction and dimensionality reduction, and CNN-based models for object detection.

can be implemented. In this context, it has been recommended that economic recovery can be predicted and tracked with the help of AI applications by counting cars, as well as solar panel installations in parking lots, which has been illustrated in table 1 below.

Table 1: AI Applications for Dealing with COVID-19 Pandemic (Nguyen, 2020: 8)

Many front-line workers like transport employees, sanitary workers, delivery personnel, etc., are often made up of BAME groups (The Metropolitan Transportation Authority, 2020). In New York City, for example, Blacks and Latinos make up more than 60 per cent of the hard-hit Metropolitan Transportation Authority (MTA) as of April 22, 2020, 83 MTA workers have died (Politico 2020). Apart from them, healthcare workers are also found to be adversely affected due to COVID-19 economically. According to Shukla, Pradhan, and Malik (2021: 489), the outbreak of COVID-19 has posed an economic impact on the healthcare sector of India. As a result of which "A stimulus package at 0.8 per cent of GDP was announced on 26 March 2020 and included in-kind and cash transfer to lower income households, insurance coverage of healthcare workers and financial support to low wage workers and others seeking jobs." (Shukla, Pradhan, and Malik (2021: 491).

Basic Safeguards: A Privilege for Some

Even the most basic health recommendations to avoid contracting or spreading infection, like hand washing and social distancing, are major challenges in marginalised communities without sufficient access to water or housing. The number of people who don't have regular access to water is mind-boggling: 36 million people in Mexico, over 2 million in the US, more than 100 First Nation communities in Canada, 63.4 million in India, etc. In all, 40 per cent of the world's population lack access to basic hand-washing facilities in their homes (The Council of Canadians 2020; United Nations n.d.; US Water Alliance 2020; WaterAid 2020). The inability to self-isolate, when faced with a virulent virus, places additional stress on people within communities who are affected by overcrowding and housing shortages. In many indigenous communities in Canada – often living in remote areas with limited medical services – there are sometimes two or three families living in the same house (Statistics Canada, 2020). Indigenous Australians face the same troubling dilemma, compounded by a higher prevalence of underlying health conditions in indigenous communities compared to general populations (Statistics Canada, 2020). There is compelling evidence that one of the risk factors that exacerbated the morbidity rates (incidence and prevalence) in Italy was ubiquitous intergenerational households.

For Brazil's indigenous groups, some having little or no contact with non-indigenous societies leaving them particularly vulnerable to disease, fear that the entire community could be wiped out amidst a rising number of illegal land invasions from loggers, miners, etc. As of April 17, 2020, Brazil's Socio-Environmental Institute (ISA) has recorded at least 27 confirmed COVID-19 cases and 3 deaths, including a 15-year-old from a village on the Uraricoera River - an access route for gold rush miners (Al Jazeera, 2020). In South-East Asia, it has been reported that COVID-19 has been evident earlier than in other parts of the world. However, the concerned states took 17 days to declare an emergency i.e., after 50 positive cases of the contamination of the virus (United Nations, 2020a: 6). Similarly, several African nations have recorded less than 1000 cases. Specifically, "WHO has warned that the pandemic could kill between 83 000 and 190 000 people in 47 African countries in the first year, mostly depending on governments' responses; and the virus could 'smoulder' for several years." (United Nations, 2020b: 2).

Impact of COVID-19 on Health Workers

Based on the understanding derived from the preliminary research, it has been found that due to the significant roles and responsibilities undertaken by the healthcare workers they become prone to being infected by the virus. This is the reason why Lahner *et al.* (2020) affirmed that there is a high prevalence of COVID-19 infections among healthcare workers. This was prominently evident from the cross-sectional study, which was done considering the retrospective data of healthcare workers. The results of this study showed that

> *A total of 2057 HWs (median age 46, 19–69 years, females 60.2%) were assessed by the RNA RT-PCR assay and 58 (2.7%) tested positive for SARS-CoV-2 infection. Compared with negative HWs, SARS-CoV-2-positives were younger (mean age 41.7 versus 45.2, $p < 0.01$; 50% versus 31 per cent under or equal to 40 years old, $p < 0.002$) and had a shorter duration of employment (64 versus 125 months, $p = 0.02$). Exposure to SARS-CoV-2 was more frequent in positive HWs than in negatives (55.2% versus 27.5%, $p < 0.0001$)* (Lahner *et al*., 2020: 1).

It was further observed that nearly half of the healthcare workers considered for this study were not exposed to any COVID-19 infected subjects. This helps in reflecting the vulnerability of the healthcare workers while dealing and responding to the pandemic because they are playing the essential role of the frontline workers (Lahner *et al*., 2020:1). This study is found to significantly contribute to the literature review. The main reason being that in conducting vaccination drives, the healthcare professionals have important roles. However, if they are affected, the healthcare programs may not lead to positive outcomes. This study can be used in the future for exploring situations and understanding the risks that are associated with healthcare workers so that the third wave of COVID-19 can be managed appropriately along with responding to future healthcare issues.

Discussion

Impact of COVID-19 on the Way and Quality of Life

While lockdowns continue to serve as a geopolitical prevention strategy against COVID-19, the financial and economic outcomes on the poor populations are undoubtedly and remarkably onerous. In Asia, for example, according to the Economic and Social Commission for Asia and the Pacific (ESCAP), 70 per cent of workers belong to the informal economy (no benefits or safety net) (UNESCAP, 2020). Many countries in this region have introduced support mechanisms – financial and economic (rice, sugar, etc.). These strategies are necessary but not sufficient. As demonstrated by the lockdown insubordination in countries like Bangladesh, the poor in these economies remain vulnerable with limited options and an extremely unenviable way of life: contract the virus by risking going out or follow the lockdown and starve. The biggest concern for the World Health Organisation (WHO) is COVID-19's potential to spread in countries with weak health systems. While the 2019 Global Health Security Index (a health security assessment listing of 195 countries) highlighted fundamental weaknesses of healthcare systems around the world, it's not surprising that many countries found to be the least prepared were in Africa (Global Health Security Index, 2019). Less than 50 per cent of the continent's population has access to modern health facilities and countries are plagued with shortages ranging from low numbers of healthcare workers compared to the population, to medical equipment, medications, and capacity (AFRIC, 2019).

Densely populated cities, slums, and displacement camps struggles with other simultaneous communicable diseases, ongoing conflicts in some regions, and myriads of other dangerous conditions, these make it seem inevitable that the continent will experience a substantial epidemic. The one silver lining in terms of mortality rates is that the continent has the youngest population in the world – 60 per cent of its 1.25 billion people are under the age of twenty-five, an age group likely

to recover from the COVID-19 infection. Besides, data collected from the Chinese Centre for Disease Control and Prevention (China CDC) in January and February 2020, identified people aged 60 and over as the most vulnerable to COVID-19. Mortality rates based on these findings were determined by University of Bern researchers as 4.6 per cent for ages 60-69, 9.8 per cent for ages 70-79, and 18 per cent for ages 80 and over. Unsurprisingly, with 23.1 per cent of Italy's population being 65 and over, it has one of the highest mortality rates in the world (28,236 as of May 1, 2020). In Canada, 79 per cent of all deaths in the country have been linked to seniors' homes and long-term care facilities as of April 13, 2020, according to chief public health officer Theresa Tam.

Furthermore, the study of Samlani *et al.* (2020: 130) suggested that in Morocco, the quality of the people's lives was moderately affected by the pandemic. This was because the Mental Health Score (MCS) of all the participants was 34.49. On the other hand, their Physical Health Score (PCS) accounted for 36.10. It was also found that the impact of the concerned pandemic was evident in those people with chronic illnesses, which significantly deteriorated their wellbeing and quality of life. The main reason for such results were that people with or without chronic illness were found to suffer from mental health and panic issues. The isolation and quarantine made people face psychological health problems (Samlani *et al.* 2020: 133). It has also been observed that COVID-19 has led to the death of several people, which has further affected the food systems and has presented unprecedented challenges to work-life and public health (Chriscaden, 2020).

On the other hand, as of March 2021, a total of 1 521 068 people has been infected by the pandemic in South Africa and the most affected region was Gauteng (Johannesburg), which reported about 406 729 COVID-19 cases. It was further found that the highest increase in the daily cases of Coronavirus was evident on 8 January 2021, with 21 980 new cases. Besides, it has been found that the pandemic significantly hampered businesses across the nation, thereby adversely affecting their survivability at large (Galal, 2021; Galal, 2021a). This indicates that South Africa has been largely affected by the pandemic, which is bound to change the quality of life of people living and working therein. Concerning South Africa, COVID-19 largely influenced the deaths and mortality rates of the nation due to the presence of underlying causes. It has made a significant impact on the quality of life. Contextually, the mental health of people was negatively affected by the pandemic due to the uncertainty that it created. Restrictions, quarantine, financial losses, high infectivity, continuous lockdowns, fatality, and unemployment rates have altered the daily lives, as well as activities of people, which further led to problems associated with mental health along with substance abuse. Even educational institutions have remained closed, which negatively influenced the learning and teaching activities of people. Even teenage marriages were observed to increase along with gender-based violence, demonstrations, and social unrest. This implies that there will be less human capital and economic opportunities in the future of the nation (Mbunge, 2020: 1811).

Another study conducted by Guo *et al.* (2020: 1) portrayed that the lockdowns, which have been implemented as a precautionary measure during the COVID-19 pandemic, have significantly influenced the quality of life of people with Parkinson's disease (PD). In this regard, it was found that the concerned patients were unable to seek medical advice or guidance from their respective doctors. Hence, as a result, most of the patients had to alter their routine medicines, which made their quality of life or health conditions even worse. In such situations, telemedicine was found to be significantly effective and efficient for the patients during the lockdown. However, the challenges concerning adequate treatment caused the symptoms of patients to get aggravated, which further declined their quality of life. On the other hand, healthcare professionals are also finding it difficult to maintain healthcare quality (Guo *et al*., 2020: 1-2; Haleem, Javaid, and Vaishya, 2020: 78). Zhang and Ma (2020: 1) further affirmed from their study that the quality of life, as well as mental health, of local people, especially that of China, has deteriorated significantly. Specifically, a mild level of stress was evident

among most of the survey participants irrespective of the devastating pandemic outbreak. The mean Impact of Event Scale (IES) score was found to be 13.6 ± 7.7 (Zhang and Ma, 2020: 1). Even social and economic developments have been adversely affected, thereby increasing poverty along with inequality (Millard, 2020: 1). All these aspects depict that COVID-19 has largely influenced people throughout the world, thereby transforming the way they live or their quality of life.

On a similar note, Dey *et al*. (2020: 1) highlighted that because of COVID-19, there are several psychosocial and psychological impacts, especially fear, among the public. In this review, it was particularly found that the psychological effect was more taxing because of the long-term quarantine that were implemented by the governmental bodies of various countries. This is the reason why boredom, fear, and frustration has been observed to be highly evident among the citizens. This has increased the difficulties in the trying times of the COVID-19 outbreak. However, the latter stages of the pandemic were observed to pose more significant impacts such as psychological disorders and stress along with mental stigma and financial losses. It is further reported in this study that "22 per cent of adults (a survey among 1,000 people) have been experiencing worse sleep patterns during this pandemic, which may increase the risk of cardiovascular events (Lahner et al., 2020).

In this situation of adversity, yoga, meditation, and video chat with relatives and friends induce mental relaxation, to some extent. In contrast, self-isolation gives us opportunities to connect with our passions and inner identity." (Dey *et al.,* 2020: 2). Correspondingly, AI along with augmented intelligence, plays a significant role in understanding the gathered data through data analytics, pattern recognition, anomaly detection, and machine learning (Santosh, 2020: 2). Similarly, Mukherjee *et al.* (2021) stated that AI-driven tools have been used to track as well as observe the developments of positive cases during the outbreak of the pandemic. However, it was argued that differences in data can influence the critical decision-making concerning the preparedness and responses of the pandemic. With the advancement in the pandemic stages, technical innovations concerning AI have also been evident, especially for detecting and predicting purposes (Mukherjee *et al*., 2021: 99).

Current Achievements during COVID-19

Currently, there are several achievements, which have been evident during the outbreak of a pandemic. According to report findings of United Nations (2020: 39), telephone-enabled services such as teleconferencing along with social media and other smartphone applications, as well as online shopping, have been increasing. These services are used to resolve the problems that have materialised due to COVID-19 in most nations, including the US and China. These improvements have increased e-commerce business activities and forced traditional businesses to undergo digitalisation (United Nations, 2020: 39). In a social context, one of the positive aspects, which has been highlighted by the pandemic, is the role and contribution of women in society. Cities and communities have facilitated innovation for achieving sustainable developments even in this crisis. Marine, as well as land ecosystems are also improving during this pandemic due to reduced exploitation of resources. Therefore, due to lockdowns and isolations, the flora and fauna are being restored in their natural habitat, as they are not disturbed by humans. Another positive aspect of this pandemic is the unity with which people have been fighting against Coronavirus (Gulseven, Al Harmoodi, Al Falasi, and ALshomali, 2020:1-2; Srivastava, Sharma, and Suresh, 2020: 4968].

Furthermore, COVID-19 has facilitated the importance of distance learning. However, there are varied students, who are facing problems in switching to the online mode of learning due to the lack of adequate resources and support from their parents (Di Pietro *et al*., 2020:2; UNESCO 2020a: 4-5; UNESCO 2020b). On the contrary, Gonzalez *et al*. (2020: 1) affirmed that the confinement due to

COVID-19 had a positive impact on the performance of the students in Spain. Similarly, it was found in the study conducted by Chaudhary, Gupta, Jain, and Santosh (2021: 127) that the air quality was considerably improved during the lockdown phase of the COVID-19 pandemic in most nations. Hence, it can be stated that due to COVID-19, isolation practices were implemented, which proved to be climate favourable. In many regions of the US, Brazil, China, and India, air quality indices improved due to restrictions in air pollution activities (Chaudhary, Gupta, Jain, and Santosh 2021: 127). Besides, currently, big data and AI incorporation have been evidenced to enhance the pandemic situation and reduce the adverse impacts of COVID-19. In this context, it has been found that "by training on an open-source dataset with 13 975 images of 13 870 patients, the proposed CNN model can achieve an accuracy of 93.3 per cent." (Pham, Nguyen, Hwang, and Pathirana, 2020: 5). Herein, CNN's model refers to the convolutional neural network (CNN), which incorporates AI techniques (Pham, Nguyen, Hwang, and Pathirana, 2020: 5).

Post-Pandemic Ethical Issues

Ethical issues are being faced in several areas during the pandemic, especially in terms of physical distancing, conducting clinical trials, rights of healthcare workers, priority-setting, public health surveillance, and resource allocation. The ethical issues are mainly at the time of conducting healthcare research, policy-making, and decision-making processes (WHO, 2021). Hence, it is highly essential that ethical aspects are closely considered while responding to the issues at the post-pandemic stage. Specifically, ethical concerns have emerged with the increase in the influx of patients requiring ICUs. Healthcare professionals have been facing ethical dilemmas along with life-support withdrawal decisions. Similar issues have also been faced concerning the 'quality of end-of-life support' and family visits. Effective triage policies are to be formulated so that these issues may not be faced in the post-pandemic phase (Robert *et al*., 2020: 1). Similar aspects have been highlighted by McGuire *et al*. (2020: 15), wherein it has been affirmed that ethical issues emerged not only within the healthcare system but also in society.

Particularly, ethical issues can be evident while defining the benefits, handling informed consent, understanding the special needs of other patients, mitigating discrimination, identifying structural inequalities, and engaging communities (McGuire *et al*., 2020: 15). Besides, ethical issues have also been found to emerge at the time of resetting healthcare services after the outbreak (Baines, 2020: 715). Contextually, it has been affirmed in the study of Laudanski *et al*. (2020: 5) that "numerous predictive models of COVID-19 prognosis in various individuals based on AI-driven algorithms have been designed and published. Their ability to distinguish between favourable outcomes and demise is significantly accurate. A few of them were implemented to test their suggestions in real life, a fact that leaves unaddressed concerns about dataset impartiality and concomitant ethical concerns about the implication of AI-driven decisions". This indicates that in the post-pandemic era, ethical concerns have been prominent, especially at the time of implementing AI-driven decisions (Laudanski *et al*., 2020: 5).

Contribution of AI in Accelerating COVID-19 Vaccine Discovery

The latest technology has been of utmost importance during the pandemic. This is because AI is found to be effective not only in detecting but also in responding and recovering from COVID-19. According to a report presented by OECD (2020), AI systems had predicted an outbreak of pneumonia in China before coronavirus became the worldwide threat. Hence the need to understand the effectiveness of this technology. AI technologies and tools can be incorporated for supporting the efforts of medical communities, policymakers, and societies. This can enable the concerned authorities to manage activities at all stages of the pandemic, including the acceleration of research, detection, response, prevention, and recovery. AI can be effective in enhancing research for the discovery of proper

solutions such as vaccines and drugs through distributed computing and open data projects (OECD, 2020: 2). Similar opinions have been provided by Arora, Banerjee, and Narasu (2020:1) wherein AI largely contributed to developing several types of vaccines to date. It seemed that there is a race between the virus and vaccine developers. Therefore, for the betterment of mankind and to improve the situation created by the pandemic, AI's ability was found to be vital. This was because "the pace of the discovery can be accelerated manifold by harnessing the power of AI." (Arora, Banerjee, and Narasu, 2020: 4).

To win in the race, several biotechnology companies are depending on AI such as Blue Dot for speeding up ways to find a cure for the virus. This technology has the potential to identify changes and spot patterns so that the process of vaccine development does not get hampered. In this context, several successful trials have been made. For instance, the 'Deep Learning-Based Drug Screening' method was created using DenseNet for predicting the interactions between ligands and proteins, which further helped in determining the drug combination that worked well in responding to COVID-19. DeepMind has used the AlphaFold library for understanding the protein structure of the virus. Furthermore, Machine Learning (ML) models were developed by the AI scientists of Wuhan for identifying the infection intensity, with the help of factors such as gender and age (Kannan, Subbaram, Ali, and Kannan, 2020: 2).

As a result of such initiatives, an 'AI-based flu vaccine' has been developed in the US for which the clinical trials are being sponsored by the National Institute of Allergy and Infectious Diseases. Herein, the scientists of Flinders University used 'synthetic chemist', which is an AI program that generated numerous synthetic compounds. They also used the Search Algorithm for Ligands (SAM), which is an AI program that assisted the scientists to determine good candidates for vaccine trials. This program has shortened the development process of vaccines. This indicates that AI can contribute not only to examine the drugs that are currently available but also helps in accelerating the antivirus development procedure (Ahuja, Reddy, and Marques, 2020: 1). Additionally, the Human Vaccines Project, as well as the Harvard T.H. Chan School of Public Health, has started the 'Human Immunomics Initiative', which made use of AI models to speed up the process of vaccine and therapeutic development, thereby understanding effective immunity concerning old-aged populations (Kaushik, and Raj, 2020: 1).

Implications and Lessons Learned from the Pandemic

The pandemic has also taught that with cooperation at local, national, and global levels communities can thrive in the wake of the crisis (Snower, 2021). It has also been understood that at the time of a pandemic, without effective control and prevention measures, the healthcare systems become restricted to the consideration of general measures such as limited travel, social contact, hygiene and sanitary measures, usage of PPE, isolation, and quarantine (Mijović, 2020: 1; Brannen 2020). The ongoing carnage experienced by this population is not only despicable but also confirms the degree of incompetence and lackadaisical efforts of institutions – both government and private.

As counterfactuals, there are compelling needs to know if these gruesome and unacceptable mortality rates could have been avoided if:

- Effective oversights were in place.
- Periodic reports were produced and submitted to the relevant parties and at different levels of institutions.
- Relevant and appropriate feedback was part of the process.
- Monitoring, evaluation, and learning was in place.

- Role of AI and related technology in developing vaccines and drugs.
- Effective operating strategies were in place and more.

The memories of this pandemic in these communities will be long-lasting and tenuous, especially between the affected families and institutions.

Additionally, it must also be noted that communities need to prioritise and appreciate essential values along with their needs so that the true importance of healthcare professionals and frontline workers, in maintaining the wellbeing of people, can be understood. Even the businesses require focusing on values and fulfilling the needs of the people. Piccialli *et al*. (2021) affirmed that AI technology has the potential to be successfully used in the healthcare systems so that society can benefit in future pandemic situations.

Strategic Post-Pandemic Requirements

Irrespective of several positive achievements evident during the pandemic due to lockdowns and less human intentions on social, business, and environmental aspects, it has posed significant adverse impacts. To minimise or mitigate the negative consequences of the COVID-19 pandemic, certain strategic decisions need to be undertaken by the nations at the post-pandemic stage. Innovation has been one of the widely used strategic initiatives to be undertaken by several countries, especially to revive the healthcare systems and gain economic stability (Khetrapal and Bhatia, 2020). On the other hand, a recent Organisation for Economic Co-operation and Development (OECD) (2020:2) report highlighted that the social economy has been playing an essential role in addressing or minimising the impacts of the pandemic. This indicates that nations must focus on strengthening their social economies so that both long-term and short-term impacts can be eliminated during the post-pandemic phase. This is because social economic firms have the potential to reshape the national economy, thereby encouraging sustainable economic growth along with inclusive models. This, in turn, can facilitate social innovation, which will help the economy to improve in the future (Organisation for Economic Co-operation and Development 2020: 13). It has also been suggested by Piccialli *et al*. (2021) that in the post-pandemic era, careful application of AI technologies must be enabled for managing complex situations like COVID-19 in the future, thereby involving research, healthcare, and society.

Future Implications

As we go through these trying times, there is a need to regularly remind ourselves that while the vulnerable groups on the front lines specifically continue to subject themselves to this devastating virus, their motivation and dedication to respond to this professional call of duty requires special recognition, empathy, and compassion at all levels. This applies specifically to health professionals who continue to expose themselves daily to alleviate the suffering of victims of the pandemic. Institutional support remains inadequate and yet its involvement is a *sine qua non* that cannot be adequately emphasised. Institutional support needs to be strengthened, especially concerning individual risks and supply chain coordination. In the future, it will be important to take effective public interventions so that new cases of COVID-19 can be prevented along with mitigating community transmission. Innovation must be taken into consideration for tracing cases, along with online learning and telemedicine for managing the second wave of the COVID-19 outbreak more effectively than the earlier one (Khanna *et al*. 2020: 708). Since the second wave has been phased out, recommendations for the third wave must be taken into consideration. Vigilant monitoring of the cases must be maintained for tracking the new variants to control the cases at the earliest (Salyer

et al. 2021: 1273). Moreover, disparities evident during the pandemic must also be eliminated cooperatively to ensure that future pandemics and similar issues can be averted effectively.

Additionally, the health issues such as anxiety and stress must be evaluated as well as addressed immediately among the healthcare staff (Stiles-Shields *et al*., 2020: 720). It has also been understood that elderly people have higher risks of transmission, which suggests that in the future, healthcare requirements of older citizens must be taken into high consideration so that their safety and wellbeing can be ensured (Brannen, 2020). The importance of AI technology has also been found to be immense, as it has been estimated to play a vital role in tackling COVID-19. AI can contribute not only to pacing up the vaccine development procedures but also in identifying future threats posed by viruses beforehand. It also helps in diagnosing, predicting infections, surveillance, gathering information, delivering materials, deploying services, and tracking the recovery process. However, evidence of these implications has not been evident to date, which can be highly effective in tackling COVID-19 in the future (OECD, 2020: 2). Additionally, Al-Hashimi and Hamdan (2021: 830) asserted that AI has been showing positive results in detecting conditions such as diseases. It must also be effectively used in the healthcare sector. This is owing to the reason that due to its usage; healthcare organisations can track the progress of any situation at a quick pace. With more advancement in AI-driven technologies, higher-quality healthcare services can be delivered for the betterment of society (Al-Hashimi and Hamdan, 2021: 830).

Conclusions

Based on the findings gathered in the above sections, it has been understood that COVID-19 has significantly affected the world both positively and negatively. It can be concluded that the pandemic has facilitated global transformations, especially by deteriorating the quality of life of millions of people. Additionally, the public, along with healthcare workers, were also found to be adversely affected due to COVID-19. Hence, it became highly important on the part of the healthcare workers that their health and safety are maintained to serve as frontline workers effectively. However, on a positive note, COVID-19 has made the best use of AI-driven technologies for aiding and responding to the pandemic. Hence, it has been suggested that its full potential needs to be explored in the future. This can help in providing better quality healthcare services in pandemic situations in the future both efficiently and effectively. This proves that the objective of the research study has been met effectively. Additionally, an exploratory review of COVID-19 has been conducted by emphasising the theme of pandemic morbidity and considering the dynamics of AI and Quality of Life (QOL).

The pandemic also made us realise the importance of cooperation among people along with values. It is also understood that healthcare workers and other frontline workers are important in responding to the pandemic. Additionally, innovative approaches and effective health interventions are found to be essential in addressing the adverse consequences of the crisis. This further indicates the lessons that must be learned from the pandemic so that new waves and future epidemics can be handled as effectively as possible. One of such future implications is to ensure the health and wellbeing of elderly people. Another important future implication is to optimally utilise AI capabilities to tackle the pandemic throughout its different stages.

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