International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

A Systematic Review: Forecasting Post-Pandemic Health Trends with Machine Learning Methods

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Submitted: 28/12/2023 **Revised**: 04/02/2024 **Accepted**: 12/02/2024

Abstract*: Purpose* Over the last few months, the spread of Coronavirus has become a global concern, affecting every corner of the world. While scientists are working tirelessly to discover a cure, the exact cause of this outbreak remains unclear. With the surge in the number of cases requiring testing for Coronavirus, conventional methods are becoming increasingly challenging due to constraints in time and resources. In recent times, machine learning has proven to be highly effective in the field of medicine. Implementing machine learning techniques to predict COVID-19 in patients could significantly accelerate the process of obtaining test results. This would enable healthcare workers to promptly administer appropriate medical care, thus improving the management of the pandemic.

Objectives: The primary objective of this thesis is to create a machine learning model capable of predicting COVID-19 infection in patients. This involves conducting a comprehensive literature review to determine the most appropriate algorithm. Additionally, the study aims to evaluate the various factors that influence the effectiveness of the prediction model.

Methods: A thorough Systematic Literature Review was conducted to pinpoint the optimal algorithms for the predictive model. Following this, a review was constructed based on the insights gained from the literature review, specifically for predicting COVID-19. This review also aims to ascertain the key features that influence its predictive accuracy.

Proposed Results: The literature review identified several algorithms suitable for prediction, including SVM, Random Forests, and ANNs. To determine the most accurate technique, a performance comparison was conducted among these algorithms. Additionally, feature importance values were calculated to assess their influence on the predictive outcomes.

Conclusions: Applying Machine Learning to forecast the aftermath of COVID-19 has the potential to expedite illness detection, leading to a decrease in fatality rate. Upon analyzing the findings acquired from studies, it was determined that algorithms exhibited superior responsiveness.

Keywords: *COVID-19, Pandemic, Machine Learning, Prediction.*

1. Introduction

As of January 14, 2022, there have been over 318 million infections and 5.5 million fatalities worldwide due to the COVID-19 pandemic. March 3, 2020 was the first reported incidence of COVID-19 in the medRxiv database [1]. To reduce the spread of the virus, countries have implemented various measures such as imposing border restrictions, isolating those who are ill, quarantining people who have come into contact with the virus, and enforcing social distancing in public areas. Disruptions to everyday living caused by these constraints led to less physical activity, more mental stress, and a decline in quality of life (QoL). According to studies, people's social, psychological, and mental health might take a hit when they're confined to their homes for an extended period of time. This can lead to things like emotional distress, memory loss, and trouble focusing. Numerous studies have underscored these consequences, highlighting the detrimental effects of the COVID-19 outbreak on mental health [2]. Globally, there's a pressing need for suitable and scientifically backed actions to address the COVID-19 crisis. Predictive modelling is crucial in efficiently distributing human security resources and fortifying the preparedness of relevant systems. In this vein, we surveyed 1,000 people from various age groups and professions. The field of machine learning, particularly its branch of deep learning, has experienced significant advancements. This technology, essential for tasks like data prediction, learns and evolves from experience without the need for manual programming. Such progress has revolutionized technologies used by millions. It also opens up possibilities for fine-tuning these models for more precise outcomes in the future. Deep learning models provide instant insights, aiding healthcare professionals in more rapid and accurate patient diagnoses, thereby reducing the likelihood of medical and diagnostic errors [3]. These models are also invaluable for governments, offering forecasts of potential future outbreaks and informing decisions about necessary precautions to manage and reduce the spread of the virus. The transmission of COVID-19 primarily occurs through person-to-person contact, making AI-enabled electronic devices key in halting its spread. The

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scope of healthcare epidemiology has broadened alongside the growth in electronic health data availability [4]. This surge in accessible electronic health records offers significant prospects in the healthcare sector, both for ground breaking discoveries and practical applications aimed at healthcare enhancement. Such data is invaluable for training machine learning models, enhancing their ability in disease prediction and decision-making processes.

1.1 Selecting Digital Libraries

The research involved an extensive search across five major digital databases as detailed in Table 1: Google Scholar, ACM, IEEE, Springer, and PubMed. This search utilized keywords, titles, and abstracts, with Google Scholar also allowing for full-text searches, to identify pertinent primary studies. These databases were chosen for their comprehensive coverage of significant scholarly works. Additionally, to ensure thoroughness, a manual search was conducted. This involved reviewing relevant academic journals and identifying additional relevant articles cited in both primary and secondary studies.

Table 1: Digital Library

Name	URL
Springer	https://springer.com
ACM	https://dl.acm.org
Google	https://scholar.google.com
PubMed	https://pubmed.ncbi.nlm.nih.gov

1.2 Machine Learning and Sentiment Analysis

In parallel, sentiment analysis is performed on textual data related to the disease. Natural language processing (NLP) techniques are used to analyse the sentiment expressed in text. Sentiment analysis can classify text as positive, negative, or neutral based on the emotions, opinions, and attitudes expressed. Sentiment analysis results can be integrated into the disease prediction model [5]. For example, if sentiment analysis of social media data reveals a surge in negative sentiment related to specific symptoms of a disease, this information can be considered as an additional feature in the disease prediction model. By incorporating sentiment analysis, the disease prediction model becomes more holistic. It not only relies on traditional medical data but also takes into accounts the public's sentiment and perception of the disease. This can lead to more accurate predictions and early detection of disease outbreaks. The insights from sentiment analysis can also be valuable for healthcare providers and policymakers. They can gain a better understanding of how patients perceive the disease, healthcare services, and treatments, leading to improvements in patient care and healthcare policies. In summary, combining machine learning and sentiment analysis in disease prediction enhances the predictive capabilities by considering both medical data and public sentiment. This approach can lead to more accurate predictions, early detection of disease trends, and improved healthcare decision-making.

2. Problem Statement

In the post-pandemic period following the COVID-19 outbreak, there is a critical need to utilize machine learning techniques to predict and understand the potential health conditions, both physical and mental, that individuals and communities may face. This predictive modelling aims to leverage electronic health records, healthcare surveys, pandemic-related data, demographic information, and historical health data to develop accurate models for forecasting post-pandemic health conditions [6]. These models should be interpretable, ethically sound, and continuously updated to assist in proactive healthcare planning and resource allocation in the evolving healthcare landscape. Classifiers are widely used in various fields like business, decision-making, clinical research, and education, with primary methods including decision tree, Bayesian, artificial neural network, and K-Nearest Neighbor classification. It highlights the consequences or implications of the problem, emphasizing why it needs to be resolved and the potential benefits of doing so.

2.1 Enhance Lung (Respiratory health) Infection Prevention and Treatment Strategies

Sentiment analysis in the context of research on lung infections entails the application of machine learning methods to examine and comprehend the emotions, opinions, and attitudes conveyed in text or social media content related to lung infections. This analytical approach holds significant value in healthcare and research for various compelling reasons. Firstly, sentiment analysis allows researchers to assess the public's perception and awareness regarding lung infections such as COVID-19, pneumonia, or tuberculosis. By scrutinizing social media posts, news articles, or online discussions, researchers gain insights into how individuals are discussing these infections, whether they exhibit concern, possess adequate information, or are misinformed, and how these sentiments evolve over time [7]. Moreover, sentiment analysis serves as a valuable tool for monitoring online dialogues and identifying early indicators of outbreaks or emerging lung infections. An upswing in negative sentiments or discussions concerning symptoms can serve as a precursor or early alert for healthcare authorities. Furthermore, the analysis of sentiment within patient reviews and feedback offers valuable insights into their experiences with treatments for lung infections, hospitals, or healthcare providers. Utilizing this data may improve care and treatment results [8]. Sentiment analysis classifies text as good, negative, or neutral. This effort is made easier by NLP libraries and pre-trained sentiment analysis algorithms. Lastly, sentiment analysis holds promise as an early warning system for

identifying outbreaks or surges in lung infections. An abrupt increase in unfavorable emotion about symptoms or the availability of healthcare may indicate a developing problem that needs treatment [9]. There are several respiratory disorders, and their common symptoms are clearly similar. Accurately identifying the kind of illness only based on medical history and physical examination is challenging. Misdiagnosis of these diseases may result in improper therapy, leading to longer recovery time and possibly worsening of the condition. Conducting chest CT scans on all patients for a conclusive diagnosis may lead to an unnecessary depletion of medical resources. Hence, the creation of an artificial intelligence-based model for diagnosing respiratory diseases can enable accurate diagnosis and prediction of such diseases. This model can offer diagnostic information to outpatient physicians as a reference, thereby enhancing the efficiency of medical resource allocation.

3. Review of Literature

Using a combination of ANNs, a subset of RNNs, and Long Short-Term Memory (LSTM) models, we were able to predict the number of COVID-19 cases in the five nations with the greatest infection rates [10]. This study examines how COVID-19 has changed online education and learning [11].Indian researchers are studying the epidemiology of Delta variation and its dynamics during the COVID-19 pandemic using many datasets. They used various machine learning algorithms, such as Decision Tree Regression, Polynomial Regression (PR), and Random Forest (RF) Regression, to predict the number of patients recovering and fatalities in each state [12]. To capture the illness curve and anticipate pandemic trends, an AI-based time series prediction technique was developed, using methods like random forests, multi-layer perceptrons, and support vector machines (SVMs). The study also investigated recurrent neural network architectures like (LSTM), bidirectional LSTM, and encoder-decoder LSTM models as potential short-term COVID-19 infection predictors in several Indian states [13]. A modified SEIRD (Susceptible-Exposed-Infectious-Recovered-Dead) model is suggested for the purpose of evaluating the COVID-19 trend and peak in India and its four states that were most severely impacted. Results are based on a population that has been exposed to the infectious illness but is not showing any symptoms, according to this version of the SEIRD model. In order to assess epidemiological datasets that include positive and negative COVID-19 cases in Mexico, supervised machine learning models are built. This family of methods includes naive Bayes, SVM, decision trees, and ANNs [14]. The COVID-19 epidemic has led to a dramatic spike in cases of mental health issues. It is necessary to conduct more comprehensive research that includes disadvantaged populations from other nations impacted by the epidemic. An investigation examines the knowledge, attitudes, anxiety experiences, and perceived need for mental healthcare among adult Indians during the COVID-19 pandemic, employing an internet survey with a semi-structured questionnaire. The objective of this study is to ascertain the prevalence rates of stress, anxiety, and depression among individuals in India during the COVID-19 lockdown, along with their socio-demographic correlations. An electronic questionnaire is used to perform a cross-sectional survey, which involves a random convenience sample of 354 persons. Finally, the article discusses the significant impacts of COVID-19 on Higher Education Institutions (HEIs) in India [15]. It examines the actions taken by HEIs and educational authorities in India to provide consistent educational support during the crisis. Researchers gathered data from various publications on the COVID-19 outbreak from national and international organizations for this on-going review. Nayak et al. [16] also examined current studies on machine learning (ML) and deep learning (DL) models used for detecting and analyzing COVID-19. By using specific search terms, they amassed a grand total of 795 articles pertaining to COVID-19. Subsequently, they eliminated 672 papers that were considered irrelevant. The presentation began with a comprehensive elucidation of viruses that have inflicted grave illnesses in the last century. Subsequently, the focus shifted towards coronaviruses and their impact, including the impacts of COVID-19 on both humans and other animal species. The individuals provided an account of the facts on mortality rates, rates of recovery, and the number of active cases in various countries. They also discussed the factors contributing to the spread of the illness, the benefits of machine learning models for detecting, visualizing, analyzing, and predicting diseases, and the constraints of the currently available machine learning techniques. They then discussed using deep learning (DL) models to overcome ML model challenges. This method simplifies and speeds up sickness detection, medical image analysis, disease diagnosis, medicine and vaccine production, and other tasks. **(Narin A et al. 2021),** focuses on ML and DL approaches for COVID-19 and other medical image anomaly analysis. Deep learning models (RNN, GAN, and CNN) and their practical applications were covered, along with the history and present status of COVID-19, the worth of deep learning methods, the relevance of supervised, unsupervised, and semi-supervised machine learning concepts. Their talk centered on medical image analysis, which covered a wide range of subjects including registration, anomaly detection, classification, localization, and segmentation utilizing different types of medical pictures. Predicting outbreaks, tracking the spread, diagnosing, treating, and comprehending the limitations of COVID-19 were all topics covered in the debate, as were the applications of ML and DL models. In table 2, we have presented the common issues accepted by various experts. The provided table seems to be a summary of various studies or expert opinions (referenced by numbers like [18], etc.) on

the effectiveness of different factors or methods in the fields of Machine Learning (ML), Deep Learning (DL), Hybrid approaches (combining ML and DL), Transfer Learning (TL), and their applications to medical images, specifically COVID images. It also includes references to techniques like denoising, normalizing, first-order statistical features, and principal component analysis. In each cell, a '+' or '-' sign indicates whether the referenced study/expert opinion supports (+) or does not support (-) the effectiveness of the given factor in that context. For example, "In [19]" suggests that the first reference supports the use of ML and DL in medical and COVID images, denoising, normalizing, first-order statistical features, and PCA, but does not mention the effectiveness of ML, DL, and TL combined. This table 3 is likely used to summarize and compare different studies or opinions on these topics, showing areas of agreement or disagreement among various experts or research findings.

Table 2: Commonly Accepted Parameters by various Experts

Sr No	Effective Factors → / References ↓	ML DL Hybrid	ML DL TL	Medical images COVID images	Denoising, and normalizing	first-order statistical features	Principal component analysis
1.	In [1]	-	+	+	+	+	+
2.	In [2]	+	+	+	+	-	-
3.	In [3]	+	-	+	+	+	+
4.	In [5]	+	+	-	+	+	+
5.	In [7]	+	+	+	+	+	-
6.	In [9]	+	+	+	-	+	+
7.	In [10]	+	+	+	+	+	+
8.	In [11]	-	+	-	+	+	+
9.	In [13]	+	+	+	+	-	+
10.	In [12]	+	-	+	+	+	-
11.	In [14]	+	+	+	-	+	+
12.	In [15]	+	+	+	+	+	+
13.	In [16]	+	+	+	+	+	+
14.	In [17]	+	+	+	+	+	+

Table 3: Review on Machine learning Based Approach

References	Behaviour	Approach	Dataset	Quantify terms	Total Instances
In [18]	Detection Classification	CNN, SVM	Covid-19	MSE, F1 score	14
In [19]		ANN	Covid-19	RMSE, Accuracy	16
In [20]		kNN	Covid-19	Accuracy, RMSE	12
In [21]		SVM	Covid-19	Data Structure	11
In [22]		SVM, kNN	Covid-19	Accuracy, Confusion matrix	13
In [23]		Tree	Covid-19	Feature Selection	14
In [24]		SVM ANN	Covid-19	Accuracy, MSE, RMSE	8

The pandemic has significantly impacted health, with far-reaching consequences:

- The pandemic has caused significant distress, resulting in increased levels of anxiety and other mental health concerns. Factors such as social isolation, unpredictability, and the bereavement of close individuals may have enduring impacts on mental well-being.
- There has been a tendency to delay routine healthcare and screenings during the pandemic, potentially resulting in late detection of various medical conditions **(Wang et al. 2023).** Such delays might cause diseases to progress further and complicate treatment.
- Due to lockdowns and stay-at-home orders, people have become less active, which might lead to health problems including obesity and muscle loss.
- The pandemic has led to an increase in substance abuse and addiction rates due to the stress and solitude experienced.
- COVID-19 itself can lead to chronic health problems, including issues related to the respiratory, cardiovascular, and nervous systems. These effects might continue well beyond the pandemic's conclusion **(Wang et al. 2023).**
- The pandemic has had a disproportionate impact on marginalized groups, leading to long-term consequences for their health outcomes **(Hvide and Johnsen 2022).**

4. Background of Machine Learning

AI or machine intelligence represents a field within computer science where machines are endowed with the ability to perform tasks that typically require human intelligence [1]. This is achieved through the utilization of AI techniques, wherein computers and machines are equipped with algorithms designed to comprehend, analyze, and learn from data **(S. Pokhrel et al., 2021).** Contemporary AI technologies enable various applications, including automatic face recognition by cameras, language translation by computers, efficient product search in e-commerce, and decision support for medical professionals, among others (**Dharani and Krishnan, 2021).** The roots of AI can be traced back to Alan Turing's development of Turing machines in the 1930s, which paved the way for automating intelligent mathematical calculations. Natural language processing, reasoning, knowledge representation, and machine learning are all parts of artificial intelligence (AI), which emerged as a topic of study in the 1950s and has since seen heavy development. Recent developments in AI have broadened its impact outside the realm of computer science, including ideas from several disciplines like philosophy, psychology, and language. As a result, AI is used in many different fields, such as gaming, marketing, education, healthcare, online shopping, agriculture, and robotics. Google, Netflix, and other recommendation systems, autonomous cars, and voice recognition systems like Alexa and Siri are some of the most prominent AI uses. The main

branches of artificial intelligence include robotics, machine learning, computer vision, NLP, and big data analytics. In AI and machine learning, classification and clustering are fundamental techniques. Both rely on various types of data, including numerical data, text, images, and videos **(Dhieb et al., 2020,).** Neural networks, decision trees, and Bayesian networks need large labeled training datasets. The algorithms may be supervised (using labeled training data) or unsupervised (without labels), however they may use class labels during testing. Unsupervised learning makes use of clustering methods, which aren't label dependent. In order to build forecasting models, prediction algorithms are taught using historical data. Classification, grouping, and prediction activities make use of a variety of methods **(Deist, 2020).**

5. Research Gap

The research gap in predicting post-pandemic health conditions using machine learning techniques lies in the need for a more comprehensive and multidisciplinary approach, the availability of long-term data, model interpretability, ethical considerations, and the impact on public health policies. Addressing these gaps can enhance our understanding of the long-term health effects of pandemics and contribute to better healthcare planning and decision-making. The potential gap in this study could be the need for more extensive validation and testing of the machine learning-based models on diverse and larger datasets. While the study mentions high accuracy rates for COVID-19 detection and classification, it is important to ensure that develop models generalize well to different populations and imaging conditions. Additionally, the study could benefit from discussing the practical implementation of these AI-based tools in clinical settings and addressing the challenges related to real-world deployment, such as interpretability, regulatory approval, and integration with existing healthcare systems.

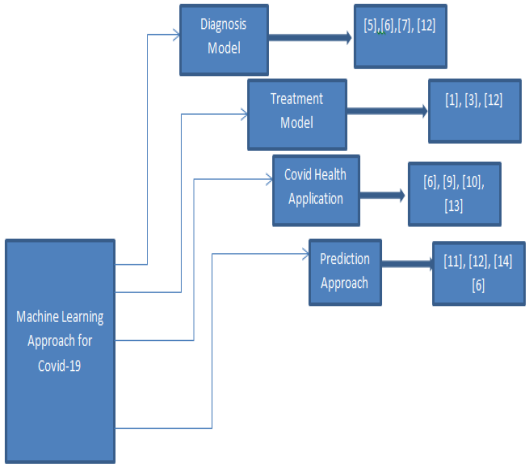

Fig 1: Machine Learning for COVID-19 Pandemic Response

5.1 Fish Bone Study

A Fishbone analysis, commonly known as an Ishikawa or cause-and-effect diagram, is a visual approach for identifying and analyzing issue factors. We have devised a Fishbone diagram to investigate many parameters that influence the use and efficacy of machine learning in forecasting pulmonary complications in COVID-19 patients. Figure 2, the Fishbone diagram, visually illustrates the different elements and obstacles related to the use of machine learning methods for predicting lung problems in Post COVID-19 individuals. It aids in discovering possible areas for improvement and resolving major challenges to increase the efficacy of machine learning in this crucial healthcare environment. In summary, the fishbone diagram is a suitable and versatile graphical approach for systematically examining and classifying the underlying factors that contribute to the development of technical advancements in applicable technology.

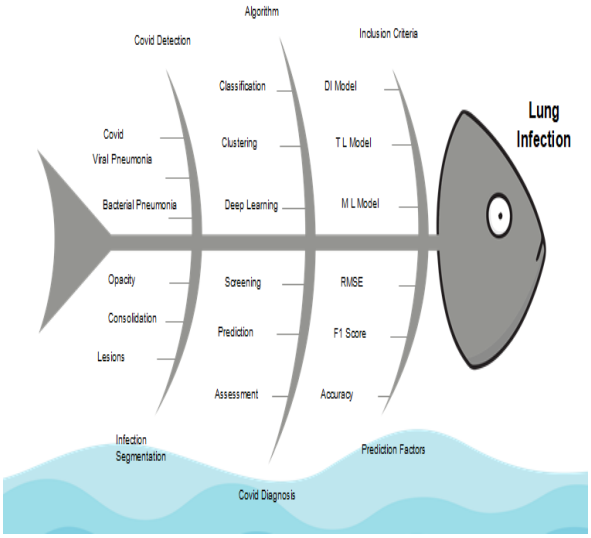

Fig 2: Fish Bone study for Prediction

5.2 Major Outcomes

The following are the most important contributions that the study made:

- **Recent studies using AI tools have focused on medical image-based research to understand and treat COVID-19:** The study provides a comprehensive summary and analysis of recent research in the field of COVID-19 medical image analysis using artificial intelligence (AI) tools. It aims to capture the state of the art in this domain.
- **Discussion of Basics of ML, DL, and TL Models:** Machine Learning, Deep Learning, and Transfer Learning models are explained in the paper. This explains the technological basis of COVID-19 medical image analysis AI technologies.

- **Introduction of Common Evaluation Metrics:** The study introduces common evaluation metrics relevant to the topic, helping researchers and practitioners assess the performance of AI models in analysing COVID-19 medical images. This ensures a standardized approach to evaluation.
- **Summary of Existing Literature Reviews:** The study summarizes existing literature reviews on the topic, providing an overview of the research directions and key findings in the field. This helps contextualize the paper's own contributions within the broader research landscape.
- **Literature Review on Recent AI Model-Based Researches:** The report summarizes the most up-to-date research on medical image analysis using COVID-19 models, focusing on important publications, methodology, datasets, and contributions.
- **Methods, Datasets, Data Types, Performances, and Contributions:** The study provides detailed information on the methods employed, datasets used, and types of data analysed, performance results, and the significant contributions of recent research in the field. This information serves as a valuable resource for researchers seeking insights into the latest developments.
- **Availability of COVID-19 Medical Image Databases:** The study offers necessary resources by listing available COVID-19 medical image databases. This aids researchers in accessing relevant data for their studies, facilitating further research in the domain.
- **Identification of Research Challenges:** The study identifies and discusses the challenges associated with COVID-19 medical image analysis using AI tools. These challenges can serve as a guide for future research directions and highlight areas that require further investigation.

6. Conclusion

This research aimed to predict lung disease occurrence in patients using ten prominent machine learning algorithms: KNN, K-Star, One-R, Logistic Regression, Naïve Bayes, AdaBoost, Bagging Algorithm, SVM, Random Forest, and MLP. The study involved an analysis of 38 research papers to discern prevalent trends in machine learning and deep learning methods, data sources, and the availability of tools. It offered a classification of ML methodologies and correlated them with existing primary research to pinpoint literature gaps. Both thematic and descriptive analyses of qualitative and quantitative data were carried out to address research queries and shed light on ML strategies. A comparative study was also conducted to examine the similarities and differences in performance metrics used in the primary research. The findings indicated a predominant focus on supervised learning techniques, particularly CNN, in the reviewed articles. Unsupervised learning methods were less commonly employed. The study highlighted the crucial role of tool development in transitioning academic findings to industrial application, noting the scarcity of publicly accessible tools. It was observed that most significant studies utilized academic datasets. Common performance evaluation metrics included accuracy, precision, F1 score, confusion matrix, and recall. This research is valuable for scholars, offering guidance on potential areas for impactful contributions in the field.

7. Conflicts of interest

The authors declare no conflicts of interest.

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