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A Study of the After-Effects of COVID-19 with an Emphasis on Potential Cardio-Thoracic Diseases through a Machine Learning Outlook

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Abstract– ***The COVID-19 pandemic has shaken the world rigorously. As of now, people have learned to live with it. In this situation, after-effects of the pandemic have begun to surface rapidly. From recent studies and research works, it has been noted that after being affected by COVID-19, the patient may suffer with chest diseases, heart problems, epilepsy, or neural problems. This paper focuses on the above said perception to study and deduce the after-effects of the pandemic on the Cardio-Thoracic systems and the diseases that might surface in the future. Analysis of the data from 100+ patients from a hospital in Visakhapatnam, Andhra Pradesh, India, suggests that some patients might suffer cardiovascular problems and/or chest problems in their near future. Patients who have been exposed to the pandemic did suffer heart damage, and such risk is greater for those who already possess respiratory and cardiac problems. According to the results, those over the age of 35 are more likely to be affected by COVID-19 and are most likely to face cardio-related complications such as clots, cardiac arrest, and admission to intensive care unit (ICU) or in the worst case, death. For studying this hypothesis, the Machine Learning algorithms of K-Nearest Neighbour and Naïve Bayes have been identified for utilization in the future works of the above-said data.***

Keywords- COVID-19, After-effects of COVID-19, Machine Learning, Naïve Bayes, KNN

1. INTRODUCTION

COVID-19 is caused by a virus called SARS-CoV-2. It is part of the coronavirus family, which includes common viruses that cause a variety of diseases from head/chest colds to more severe but rare diseases like severe acute respiratory syndrome (SARS) and the Middle East respiratory syndrome (MERS) [4]. Like many other respiratory viruses, coronavirus spreads quickly through droplets that project out of the patient's mouth or nose when they breathe, cough, sneeze, or speak.

As genetic changes to the virus take place, the SARS-CoV-2 virus begins to form genetic lineages. Just as a family has a family tree, the SARS-CoV-2 virus can be similarly mapped out in different ways. The branches of that tree have different attributes that depict how fast the virus spreads, or the severity of illness it causes, or the effectiveness of treatments for it. Such viruses with these changes are called "variants". They are still SARS-CoV-2 but may

act contrarily. The main effect of this SARS-CoV-2 has an increase in cardiovascular risks [4]. Cardiac damage has been noted in patients who have been previously affected by the pandemic. Chances for damage are more for patients who already have respiratory and cardiac problems [5]. Through this work, it is being aimed to predict the percentage of patients that are most likely to be affected by cardiothoracic diseases [Fig. 1].

PATIENT CATEGORIES:

*FIRST CATEGORY***:** These individuals are infected by the virus, but act as carriers but may not exhibit the symptoms. These individuals are at a higher risk of spreading the virus as they might be oblivious to its presence.

*SECOND CATEGORY***:** Individuals with mild fever, cough, headache, or possible conjunctivitis. This is due to an infection in the upper respiratory tract.

*THIRD CATEGORY***:** Similar to the second category, the symptoms here are more pronounced and might require hospitalization. Immediate treatment can help alleviate the symptoms and prevent a fatality.

*FOURTH CATEGORY***:** Severe cases of COVID-19, might lead to ARDS and pneumonia. At this stage, it is fatal.

	Category 1	Category 2	Category 3
Clinical urgency	High	Moderate	Low
Time-frame	• Emergency surgery needed within 24-72hours	• Elective surgery needed within 4-6 weeks	• Elective surgery can be delayed for 10-12 weeks
Rationale	• Life threatening condition requiring emergency life saving surgery*	• Potentially curative surgery required because of severity of symptoms, or biological priority Or • Palliative surgery required because of the severity of symptoms in the setting of failed medical therapy with a life expectancy> 12 months **	• Surgery in patients with low or moderate biological priority and low risk of complications in the interim
Patient cohort ***	• SI NENs complicated by small bowel obstruction or perforation, mesenteric ischaemia or hydronephrosis • Bronchial carcinoid complicated by life threatening haemoptysis • Acute duodenal perforation due to a gastrin secreting NEN	• Symptomatic catecholamine secreting PPGL • Secretory pNENs (localised or metastatic) inadequately controlled by medical therapy** • Primary SI NENs causing intermittent obstruction • Thymic NEN	• Symptomatically well controlled primary G1/G2 GEP NENs • Non-secretory PPGL • Elective valve surgery for CHD • Primary asymptomatic bronchial carcinoid
Additional considerations	• Intra-operative i.v. SSA prophylaxis for emergency SI NEN surgery • COVID-19 screening for emergency surgery should follow local guidance	• The need for ICU/HDU admission post-operation • Other co-morbidities which may place patients at risk if they develop COVID-19 ****	

Fig. 1: Categories of COVID-19 w.r.t Time-frame, Rationale, patient cohort and additional consideration [12]

2. MACHINE LEARNING

Coined in 1959 by Arthur Samuel, Machine Learning (ML) has the power to make extraordinary improvements in the sector of the healthcare system due to the reduction of subjectivity and variability in clinical diagnosis [1]. It has shown promising results in helping clinicians diagnose cancer, tumours, rare diseases, and pathologies. ML-based systems can even outperform humans in certain tasks.

Using Machine Learning for Disease Prediction provides precise results. It can help leverage patients' health information to find correlations between patients' symptoms with suspected diseases. These correlations can help forecast possible health outcomes before any health conditions occur and give doctors an idea of underlying patterns of disease. By using Machine Learning algorithms on the patients' past history, smoking or drinking, and the COVID-19 data we can predict the post-COVID issues through it [1]. This study aims to discover a pattern that would be useful to proclaim various Machine Learning algorithms and predict the patient's future with utmost accuracy.

3. DATA COLLECTION

The collected information includes demographic data, i.e., gender, age, height, weight, and past illnesses. Symptoms like fever, loss of taste, breathlessness, cough, body pains, loss of smell, muscle and joint pain, weakness, chest discomfort, fatigue, nausea and vomiting, sore throat diarrhoea, and unconsciousness. Results of laboratory tests on admission are TLC, platelets, serum bilirubin, absolute lymphatic count, ALP, AST, D-Dimer, serum creatinine, RBS, C-Reactive protein, serum ferritin, s-electrolysis, chest X-ray, ECG, ultrasound, ABG and urine analysis. Treatments include nasal catheter oxygen therapy, non-invasive ventilation, mechanical ventilation, extracorporeal membrane oxygenation (ECMO), intravenous antibiotics/antifungal drugs, antiviral drugs, systemic glucocorticoid therapy, gamma globulin, and continuous renal replacement therapy (CRRT), and clinical outcomes are length of hospital stay, intensive care unit (ICU) admission, discharge, or death [3].

In this retrospective cardio thoracic case study, data was acquired from the medical records of 100+ patients with laboratory-confirmed COVID-19. Data was compiled for hospitalized patients and noted readings of each patient's tests. COVID-19 was confirmed through a positive result on high-throughput sequencing or real-time data. From the observation of collected data of patients with COVID-19, the youngest was 6 years old, while the eldest was over 80 years. For this study, no patients were directly involved in our study design, the setting of the research questions, or the outcome measures.

4. IMPORTANCE OF HEALTH DATA

Medical data is one of the most transactionally generated data types. Obviously, there was a gradual increase in the number of health cases registered during the pandemic period. This data can be regarded as the most difficult dataset to collect and can be used to uncover interesting and hidden patterns. Mining health data and predicting future conditions help medicos to improve their quality of care in treating patients and predicting future ailments.

The medical data is collected concerning holistic views of patients, personalized treatments, advanced treatment strategies, communication between doctors and patients, and outcomes. The discovery from health data aids in the identification of common diseases in a specific geographical area at a given period, allowing for a better understanding of the root cause of the

complaint. This provides researchers with a clear picture and allows them to identify different factors that are causing the disease, allowing them to eradicate it from its source. If this is done, proper vaccines and medicines can be used, and public awareness about taking necessary precautions to prevent diseases can be created.

5. SECTORS OF DATA

The medical data that we have obtained covers various topics, parts, and tests related to COVID-19[3]. Amongst these, we have obtained information regarding two tests mainly: Biochemistry & Haematology [8]. We have collected the results and reference ranges for the test items/components as shown in the sample.

[Biochemistry: rbs, serum creatinine, serum total bilirubin, s.bilirum (direct), sgot (ast), sgpt (alt), alkaline phosphatase, serum albumin, serum protein]

[Haematology: twbc, plymorphs, lymphocytes, eosinophils, monocytes, basophils, platelets count, trbc, pcv, mcv, mch, mchc)

Admitted on 12-8-20 as per GO 62 pateints is asymptomatic for 3 days & is being discharged

Department of biochemistry:

Cpmponents/test item	results	units	Reference range
RBS	*150	Mg/dl	70.00-140
BLOOD UREA	24	Mg/dl	15-45
SERUM CREATININE	0.9	Mg/dl	0.50-1.40
SERUM TOTAL BILIRUM	0.7	Mg/dl	0.10-1.20
S.BILIRUBIN(DIRECT)	0.1	Mg/dl	0.00-0.40
SGOT (AST)	*42	U/L	0.00-40
SGPT (ALT)	36	U/L	0.00-40.00
ALKALINE PHOSPHATASE	74	U/L	0-40
SERUM ALBUMIN	3.6	Gm/dl	15-115
SERUM PROTEIN	6.7	Gm/dl	3.20-5.00

Department of heamatology:

components	result	units	reference
Heamoglobin	13.9	gm %	11-16
Twbc	7000	Cells/cumm	4000-11000
Plymorphs	70	%	40-75
Lymphocytes	24	%	20-50
Eosinophils	03	%	1-6
Monocytes	03	%	0-5
Basophils	00	%	0-5
Platelets counts	3.0	Lakhs/cumm	1.50-4
Trbc	5.5	Millions/cumm	3.50-5.50
Pcv	52.4	%	34-55
mcv	86.9	Fl	80-100
mch	*23.1	Pg	27-34
mchc	*26.5	g/dl	32-36

Fig. 2: Dataset Details

The medical data obtained manually was later converted to computerized data, the data presented here are various factors of a single patient as a sample.

6. ATTRIBUTE INFORMATION

Only 43 rows are taken into consideration

- Person number(represented with P1,P2….Pn)
- Age
- DOA(date of admission)
- DOD(date of discharge)
- Diagnosis(1=present,0=absent)
- Fever(1=present,0=absent)
- Cough(1=present,0=absent)
- Breathlessness(1=present,0=absent)
- Cold(1=present,0=absent)
- Sore Throat(1=present,0=absent)
- Loss of Smell and Taste(1=present,0=absent)
- Body pains(1=present,0=absent)
- Asymptomatic(1=present,0=absent)
- Fatigue(1=present,0=absent)
- Chest Discomfort(1=present,0=absent)
- Vomiting(1=present,0=absent)
- Loss of Appetite(1=present,0=absent)
- Diarrheal(1=present,0=absent)
- Head Ache(1=present,0=absent)
- Gastritis(1=present,0=absent)
- Nausea(1=present,0=absent)
- Hyperthyroid(1=present,0=absent)
- Cerebral Palsy(1=present,0=absent)
- Contact History(1=present,0=absent)
- PR(at DOA and DOD, 0=normal,1=high)
- BP(at DOA and DOD, 0=normal,1=high,2=low)
- RR(at DOA and DOD, 0=normal,1=high)
- Temperature(at DOA and DOD)
- Spo2 (82%-87%(0),88%-93%(1),94%-99%(2))
- Spo2(after 5 min walk, 82%-87%(0),88%-93%(1),94%-99%(2))
- D-Dimer
- Serum Ferritine
- Troponin
- Chest X-Ray
- ECG
- Ultra Sound

A significantly higher proportion of patients with COVID-19 were treated with antifungal medication systemic corticosteroids, oxygen therapy, non-invasive ventilation, invasive mechanical ventilation, CRRT, and intravenous immunoglobulin [6].

7. ACUTE RESPIRATORY DISTRESS SYNDROME (ARDS)

According to the gathered data, there are higher possibilities of getting affected by various chronic diseases. From the analysis found that there is another important aspect in understanding COVID-19 is its long-lasting effect on the body system, especially the lungs.

There is a direct correlation between COVID-19 and *ARDS*. Severe cases of COVID-19 infection lead to ARDS and pneumonia, which can prove to be fatal for the infected individual. Acute Respiratory Distress Syndrome (ARDS) causes dry cough, heavy breathing, breathing difficulties, and increased heart rate. In most of the healthy individuals, who do not have underlying morbidities, COVID-19 can be treated with normal medications. In severe cases, where the infected person has impaired immunity due to underlying health conditions, an infection due to COVID-19 can progress to severe ARDS. Once the patient progresses to ARDS, it eventually leads to pneumonia.

Before understanding the severity of COVID-19 infection, it is important to understand the different stages/categories of COVID-19 infection:

Person	AGE	DOA	DOD	DIAGNOSI	COMPLAIN	CONTACT	CONDITIO	PR/min	BP mm hg	TEMP/f	RR/min	SpO2	CONDITIO	PR/min	BP mm /	TEMP/f
P1	36	########	21-08-2020	1	FEVER,COI	1	nill	79	120/80	97.1	16	99 % with	nill	103	120/70	98.6
p2	34	########	20-08-2020	1	FEVER,COI	contact fr	nill	90	130/90	98.6	20	98 % with	nill	83	120/80	98.6

TEMP/f	RR/min	SpO2	SpO2	CHIEF COI	HISTORY C	PERSONA	TRAVEL AI	I-NAME	TLC cells/	ABSOLUTE	PLATELETS	Hb%&PCV	SERUM BI	ALP(SGPT)	AST(SGOT	SERUM CR	RBS mg/d
98.6	17	97 % with	96% after	fever-3da	nil	nil	nil	N-OF	5,500	3000	2.5	13 ,40%	0.5	29	30	0.3	100
98.6	17	99 % with	98% after	nill	nill	nill	nill	V-TEST	nill	nill	nill	nill	nill	nill	nill	nill	nill

PLATELETS	Hb%&PCV	SERUM BI	ALP(SGPT)	AST(SGOT	SERUM CR	RBS mg/d	D-DIMER	C-REACTIV	SERUM FE	TROP+AL1	S.ELECTRC
2.5	13 ,40%	0.5	29	30	0.3	100	nill	1	nill	nill	nat:125 m
nill	nill	nill	nill	nill	nill	nill	nill	nill	nill	nill	nill

CHEST X R	ECG	m	ULTRA SOI	ABG	URINE ANALYSIS
normal	nill	nill	nill	nill	nill
nill	nill	nill	nill	nill	nill

Fig. 3: Sample Dataset

EFFECT OF ARDS ON LUNGS

Post-COVID-19 syndrome involves a variety of new diseases, and returning or ongoing symptoms that people experience after getting COVID-19. In some people, post-COVID-19 syndrome severely impacts our respiratory, and cardio-thoracic organs [2]. This further impairs the oxygen intake by the lungs and hinders oxygen exchange. Due to the novelty of the COVID-19 strain, there is no immediate treatment to directly cure patients, and are mostly given supportive care [10].

8. PRIMARY OUTCOMES & CONCLUSION

The primary outcomes were composite endpoints determined by admission to an ICU, the use of mechanical ventilation, or death. The gathered information about the admission and confirmation of COVID-19 patients is through public and private contact, secondary contact, travel history with COVID positive patients, and family contacts. [9]

In this study, clinical characteristics and prognosis of 100 patients were analysed who were infected by COVID-19. Although all age groups are susceptible to infection by COVID-19, mostly older patients generally have more severe illness and poorer chances and recovery than younger ones. People with breathing issues were admitted into ICU and some were kept on mechanical ventilation if the patient's case is critical [7].

Some patients have more significant differences in their biochemistry and haematology test reports. Through this study, we have observed that the maximum number of patients who came with COVID complaints suffered from breathlessness, chest discomfort, and many other respiratory-related issues [7]. Many studies have reported that there is an increased risk of cardiothoracic events in patients after being attacked by COVID-19[11]. In this study, patients with COVID-19 showed a higher risk of admission to the ICU, and are a risk of experiencing cardiovascular and pulmonary diseases.

9. MACHINE LEARNING ALGORITHMS IN FUTURE WORK

K-Nearest Neighbour is the best bet in this type of data because it produces incredibly accurate predictions, and can compete with the most precise models. The distance measure affects how accurate the predictions are. Same goes with the Naïve Bayes algorithm, which predicts the class of the test data set, and is simple and quick. Additionally, it excels at multi-class prediction. Naive Bayes classifier performs better under the assumption of independence than other models, such as logistic regression, and requires fewer training data. So, we can conclude that these algorithms are the best algorithms for predicting the target for this unique dataset. The work on their usage on the discussed dataset has begun and the implementation, with results will be presented in due course.

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