

**RISK STRATIFICATION OF COVID -19 PATIENTS USING THE ACUTE  
PHYSIOLOGY AND CHRONIC HEALTH EVALUATION II SCORE**Deepan Karthick<sup>1</sup>, M. Divahar<sup>2</sup>, Sathik<sup>3</sup>, Rajmohan<sup>4</sup> and J. A. Jayalal\*<sup>5</sup><sup>1,3,4</sup>Assistant Professors Department of Surgery Tirunelveli Medical College, TN.<sup>2</sup>Postgraduate resident, Department of Surgery Tirunelveli Medical College, TN.<sup>5</sup>Professor of Surgery, Tirunelveli Medical College.**\*Corresponding Author: Prof. Dr. J. A. Jayalal MS, FRCS, PHD**

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**ABSTRACT**

SARS-COV-2 disease 2019 has emerged as a major global health threat with a great number of deaths in the world amounting to nearly 8 lakhs. In this study we looked for the association between Acute Physiology and Chronic Health Evaluation II score and hospital mortality in patients with coronavirus disease 2019, and to assess the predictive ability of Acute Physiology and Chronic Health Evaluation II score. It is a Retrospective observational cohort study carried out in a teaching hospital Tirunelveli medical college COVID care ward. 100 Confirmed patients with coronavirus disease 2019 as decided by the RTPCR testing and hospitalized in the COVID care unit with moderate to severe infection were included in the study. Of these 100 potentially eligible patients with symptoms of coronavirus disease 2019, 14 patients died and with intensive care all others were cured. The Mean Acute Physiology and Chronic Health Evaluation II score ( $22.21 \pm 6.05$ ) calculated was relatively higher in patients who were succumbed to death with the mean Acute Physiology and Chronic Health Evaluation II score of  $9.87 \pm 4.40$  in patients who have survived the infections ( $p < 0.001$ ). Acute Physiology and Chronic Health Evaluation II score has shown independent association with the resultant hospital mortality (adjusted hazard ratio, 1.07; 95% CI, 1.01-1.13) and have demonstrated better discriminative ability (area under the curve, 0.966; 95% CI, 0.942-0.990). The cut-off value of above 17, Acute Physiology and Chronic Health Evaluation score could predict the death of the patients with COVID -19 with a sensitivity of 96.15% and specificity of 86.27%. The survivor probability of patients with coronavirus disease 2019 with Acute Physiology and Chronic Health Evaluation II score less than 17 was notably higher and in patients with Acute Physiology and Chronic Health Evaluation II score lesser than 17, they were survived ( $p < 0.001$ ). Conclusions: For effective clinical prediction of hospital mortality in patients with coronavirus disease 2019, Acute Physiology and Chronic Health Evaluation II score can be used and when the score is greater than or equal to 17, it is an early warning indicator of death and will prompt the physicians to upgrade the treatment protocol.

**KEYWORDS:** SARS-CoV-2, APACHE-11 Score, hospital mortality.**INTRODUCTION**

Global world-wide pandemic was declared following the wide spread outbreak of coronavirus disease 2019 (COVID-19) caused by severe acute respiratory coronavirus 2 (SARS-CoV-2) by the WHO.<sup>[1]</sup> From its origin from the WUHAN, the disease has spread as on the date 19 August 2020, there have been 21,938,207 confirmed cases of COVID-19, including 775,582 deaths, reported to WHO.<sup>[2]</sup> Multivariant trial therapies, such as remdesivir and favipiravir, are under investigation and use, but the antiviral efficacy of these drugs is not yet fully known. The high grade of infection and the available limited treatment strategies caused one of the major characters of COVID-19, that is resulting in a rapid progression from sole pulmonary infection to multiple organ dysfunction

(shock, acute respiratory distress syndrome [ARDS], cardiac injury, and acute kidney injury [AKI]), which manifest as extraordinary high mortality in such critically ill COVID-19 patients.

Several descriptive cohort studies have previously reported citing the epidemiological, demographic, and clinical characteristics of COVID-19 patients, as well as severe cases. The advanced age, dyspnea, anorexia, and underlying comorbidities are more common in critically ill patients,<sup>[3][4]</sup> the risk factors contributing to the mortality of critically ill COVID-19 have not been fully identified.

As the COVID 19 is gripping the world with its rapid spread, it is imperative to have a scoring system to

categorize the patients on the basis of severity to prevent the mortality in a densely populated country like INDIA.

#### METHOD OF COLLECTION OF DATA

This Retrospective study from May 2020 to July 2020 involved 100 cases who were randomly selected by using Purposive Sampling technique. For the enrolled patients the demographic profile, clinical symptoms and presentation details were collected on the day of admission using standard format. The laboratory values were obtained and APACHE-11 scoring done within 24 hours. The associated comorbid conditions and treatment history were collected from the patients and validated with the records and attenders. The length of hospital stay, treatments offered and outcome were recorded.

#### Statistical Analysis

The data for the people who recovered and who succumbed to infections were separated and checked for significance using chi-square and Fisher's exact test. Cox regression analysis was used with both mono and multivariate data to assess the predictability of APACHE-11 score in early identification for the potential sick patients. ROC curve and Kaplan-Meier method were used to study the difference in the survival.

#### APACHE II Score

The patients were divided into two groups based on the cut-off point value of APACHE II score with the low risk values as less than 17 and the high risk values as greater than or equal to 17.

## RESULTS

#### Demographic and clinical factors

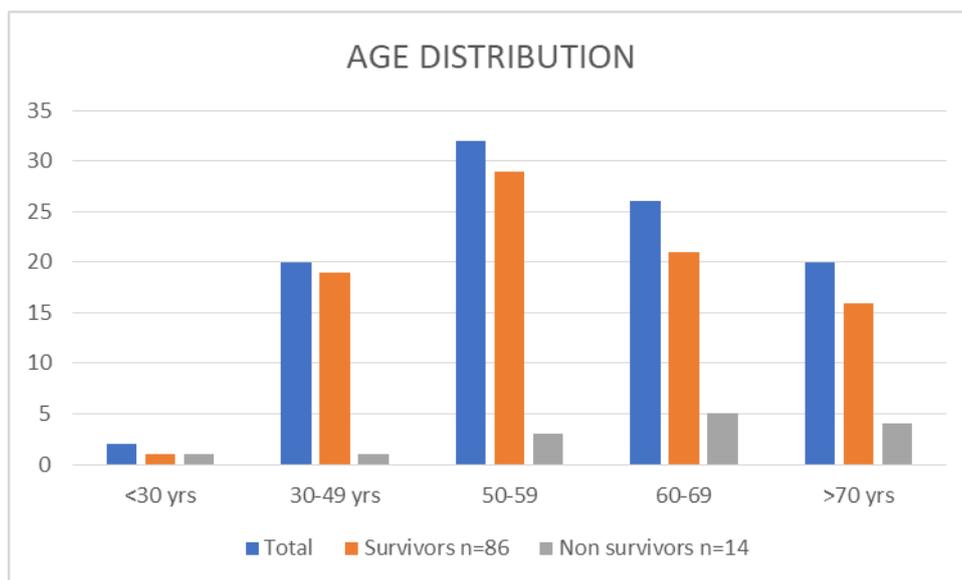
The study population included a total of 100 admitted patients with confirmed COVID-19 infection from April to June 2020. The median age was 58.7(+15.67) years. In those who recovered from the infection it was 56.3+14.567 and in those who have succumbed it was 62.42+16.163, it was statistically significant.  $P < 0.014$ .

The majority of the patients 74% were male. In the study 13(92.8%) of the deceased patients were male, and 25 (29.0%) of the non-severe patients were female. Out of 26 female 25 patients (96%) survived. The numbers of patients with COVID-19 below the age of 30 years, between 30-49 years, 50-59 years, 60-69 years and above 70 years were 2 (2%), 20 (29%), 32(32%), 26 (26%) and 20 (20%) respectively. Of these patients, 22(22%) were severe patients and 78(78%) patients were non-severe (Table 1).

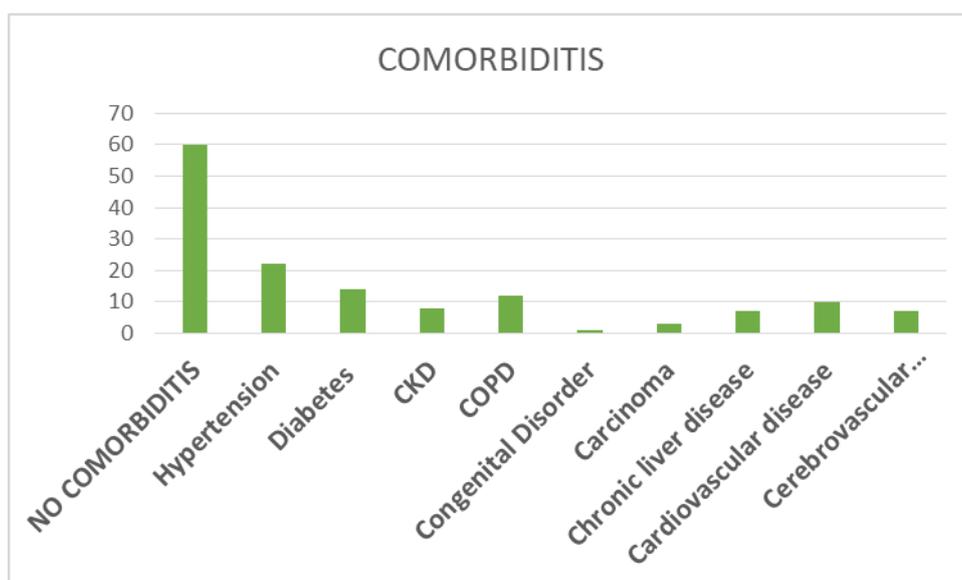
In total, 40 (40%) patients had 1 or more chronic comorbidities, including hypertension 22 [22%], diabetes 14 [14.0%], cardiovascular disease 10 [10.0%], cerebrovascular disease 7 [7%], chronic obstructive pulmonary disease (COPD) 12 [12%], chronic kidney disease (CKD) 8 [8%], chronic liver disease 7 [7%], Cardiovascular disease 10(10%), malignancy 3 [3%] and patients with Congenital disorder (1 [1%]) (Table 1).

**Table 1: The Demographic and Clinical characteristics.**

Variable	Total	Survivors n=86	Non survivors n=14	P value
Age (Years)	58.3	56.3+14.567	62.42+16.163	0.014
<30 yrs	2	1	1	
30-49 yrs	20	19	1	
50-59	32	29	3	
60-69	26	21	5	
>70 yrs	20	16	4	0.006
SEX				
Male	74	61	13	
Female	26	25	1	0.08282
<b>COMORBIDITIES</b>				
No comorbidities	60	59	1	0.0001
Hypertension	22	12	10	< 0.00001
Diabetes	14	12	2	.160542
CKD	8	0	8	< 0.00001
COPD	12	4	8	< 0.00001
Congenital disorder	1	0	1	< 0.00001
Carcinoma	3	2	1	.171995
Chronic liver disease	7	4	3	.000013
Cardiovascular disease	10	6	4	.00022
Cerebrovascular accidents	7	4	3	.000013



**Figure 1: Age Distribution.**



**Figure 2: Associated co morbidities.**

The most common symptoms were

- fever -90 [90%],
- fatigue -76 [76 %],
- cough -61 [61%],
- anorexia -36[36%]
- dyspnoea -29 29.0%].
- anosmia -18(18%)
- loss of taste 17(17%).
- diarrhoea 11 [11. %],
- Sore throat -10[10.0%],
- headache (7 [7.7%])
- abdominal pain (5 [5%]),

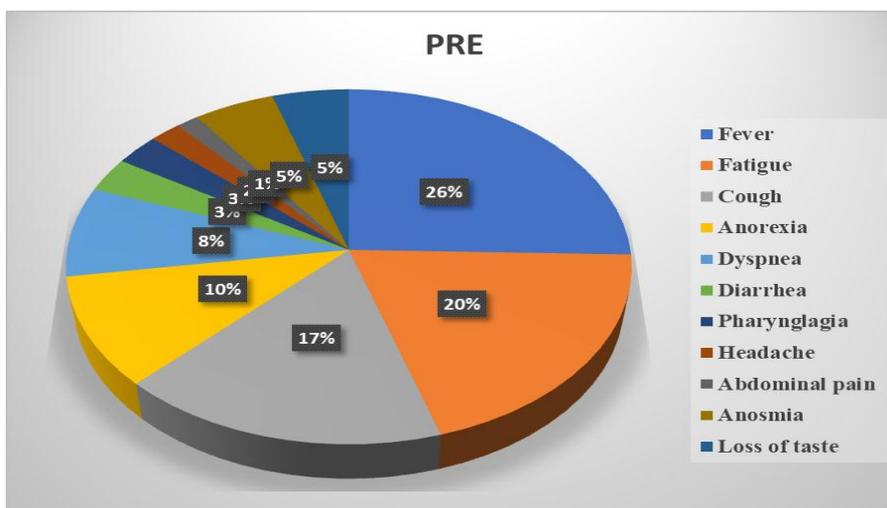


Figure 3: Presenting Symptoms.

From onset of symptoms to hospital admission the average time taken was 6.0 days (IQR, 4.0-10.0), time taken to develop dyspnoea was 8.0 days (IQR, 4.0-11.0), and for ICU admission was 10.0 days (IQR, 7.0-13.0).

The comorbidities among the patients who were grouped under severe or mild diseases were noted. The severe patients had more underlying comorbidities (17 [77.7%] vs 23 [29.48%] in the mild category and it was statistically significant;  $P < 0.001$ ).

The patients received high flow nasal canula supplementation of oxygen, non-invasive mechanical ventilation and few were on mechanical ventilation and each category number of people recovered and succumbed to the infections were noted and tabulated in table 2.

Table 2: The various treatments given.

Treatment	Total Patients	Recovered	Deceased patient	P value
High flow nasal canula	42	41	1	.078962.
Mechanical ventilation non invasive	12	9	3	0.3338.
Invasive ventilation	12	4	10	< 0.00001.

For all patients admitted were assessed for ACUTE PHYSIOLOGY AND CHRONIC HEALTH EVALUATION II SCORE and it was tabulated .The

data for the patients who have expired are shown in table 3.

Table 3: APACHE-11 Score of deceased patients.

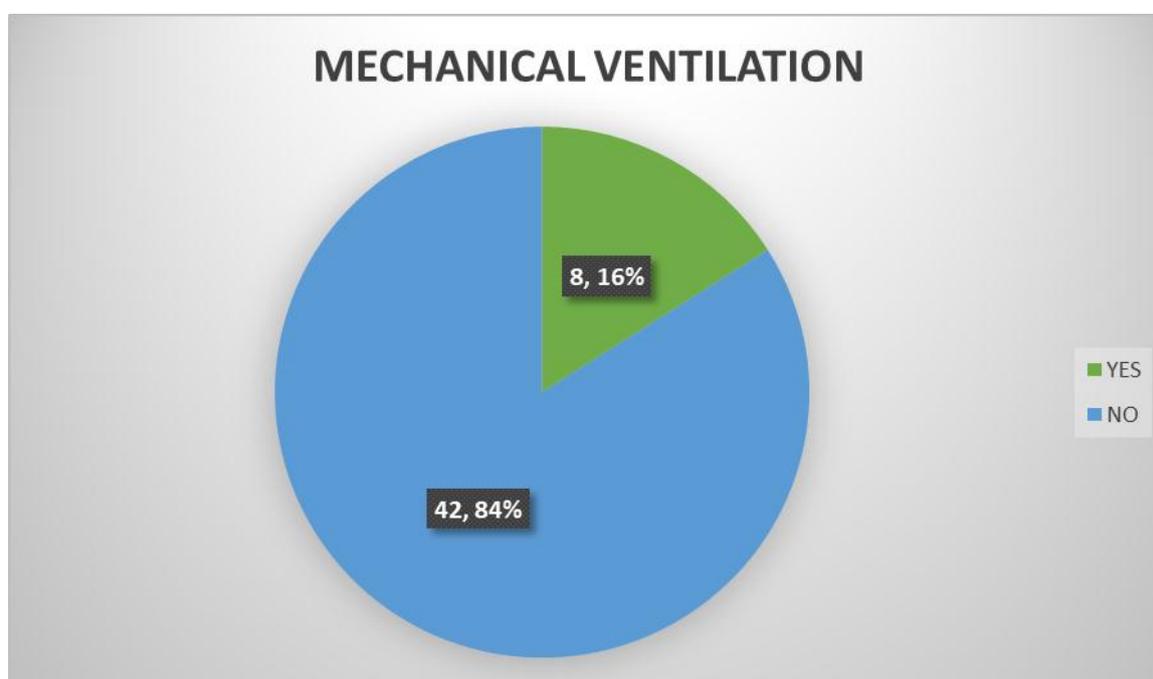
SN	GENDER	AGE	Physiological variables												Age	Chronic health points	Total	
			TEMP	MAP	HR	RR	O2	pH	Sr Na	Sr.K	Sr.Cr	Hct	WBC	GCS				
1.	MALE	24	1	0	0	1	1	1	1	1	3	4	0	1	5	0	0	18
2.	MALE	32	3	0	2	1	0	2	1	1	3	0	1	2	0	5	21	
3.	MALE	52	3	0	2	1	1	1	1	2	2	0	1	1	2	0	17	
4.	MALE	52	1	0	3	1	1	2	0	1	2	0	1	1	2	5	20	
5.	MALE	55	3	0	2	1	1	2	0	2	2	1	1	2	3	5	25	
6.	MALE	60	3	2	2	1	1	1	0	1	2	0	1	0	3	0	17	
7.	MALE	70	3	2	2	3	1	1	0	1	3	0	1	3	5	0	25	
8.	FEMALE	80	3	2	2	1	0	1	0	1	2	1	2	0	6	0	21	
9.	MALE	62	1	0	0	1	1	1	1	3	4	0	1	5	0	0	18	
10.	MALE	65	3	0	2	1	0	2	1	1	3	0	1	2	0	5	21	
11.	MALE	67	3	0	2	1	1	1	1	2	2	0	1	1	2	0	17	
12.	MALE	60	1	0	3	1	1	2	0	1	2	0	1	1	2	5	20	
13.	MALE	72	3	0	2	1	1	2	0	2	2	1	1	2	3	5	25	
14.	MALE	75	3	2	2	1	1	1	0	1	2	0	1	2	3	0	19	

The associated comorbid condition, number days of hospital stay, nature of mechanical ventilation were tabulated in Table 4.

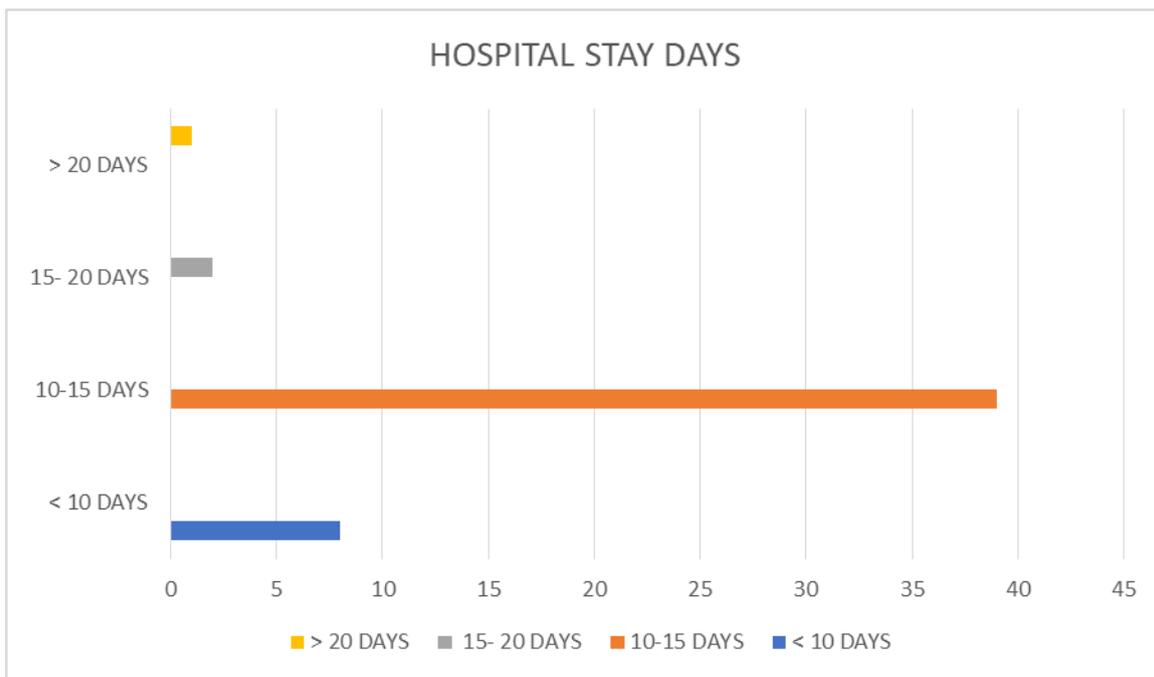
**Table 4: Various parameters of deceased patients.**

S NO	AGE	SEX	COMORBIDITY	MECHANICAL VENTILATION	DURATION	OUTCOME	APACHE 2
1.	24	MALE	MUSCULAR DYSTROPHY	YES	2 DAYS	EXPIRED	18
2.	32	MALE	SHTN, COPD, CKD	YES	7 DAYS	EXPIRED	21
3.	52	MALE	COPD, SHTN	NO	5 DAYS	EXPIRED	17
4.	52	MALE	CKD	YES	4 DAYS	EXPIRED	20
5.	55	MALE	COPD, CKD	YES	2 DAYS	EXPIRED	25
6.	60	MALE	COPD, CKD	NO	6 DAYS	EXPIRED	17
7.	70	MALE	T2DM, SHTN, CKD	YES	2 DAYS	EXPIRED	25
8.	80	FEMALE	SHTN	YES	3 DAYS	EXPIRED	21
9.	32	MALE	CAD,DM,CKD	YES	5 DAYS	EXPIRED	18
10.	65	MALE	CKD,CAD,CLD	YES	4 DAYS	EXPIRED	21
11.	67	MALE	MALIGNANCY	YES	2 DAYS	EXPIRED	17
12.	60	MALE	COPD, CKD	YES	6 DAYS	EXPIRED	20
13.	72	MALE	T2DM, SHTN	NO	2 DAYS	EXPIRED	25
14.	75	MALE	CKD,CAD,CLD	NO	3 DAYS	EXPIRED	19

Number of patients received ventilatory support is shown in figure 4 and duration of hospital stay in Figure 5.

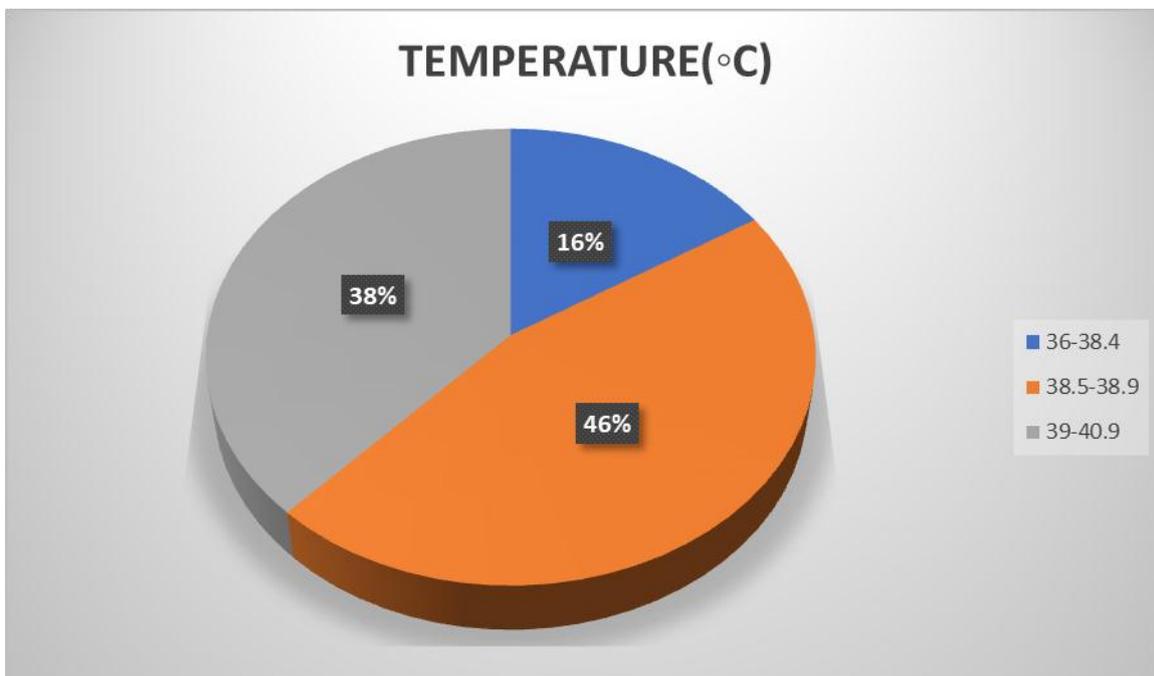


**Figure 4: Number of people on ventilation.**

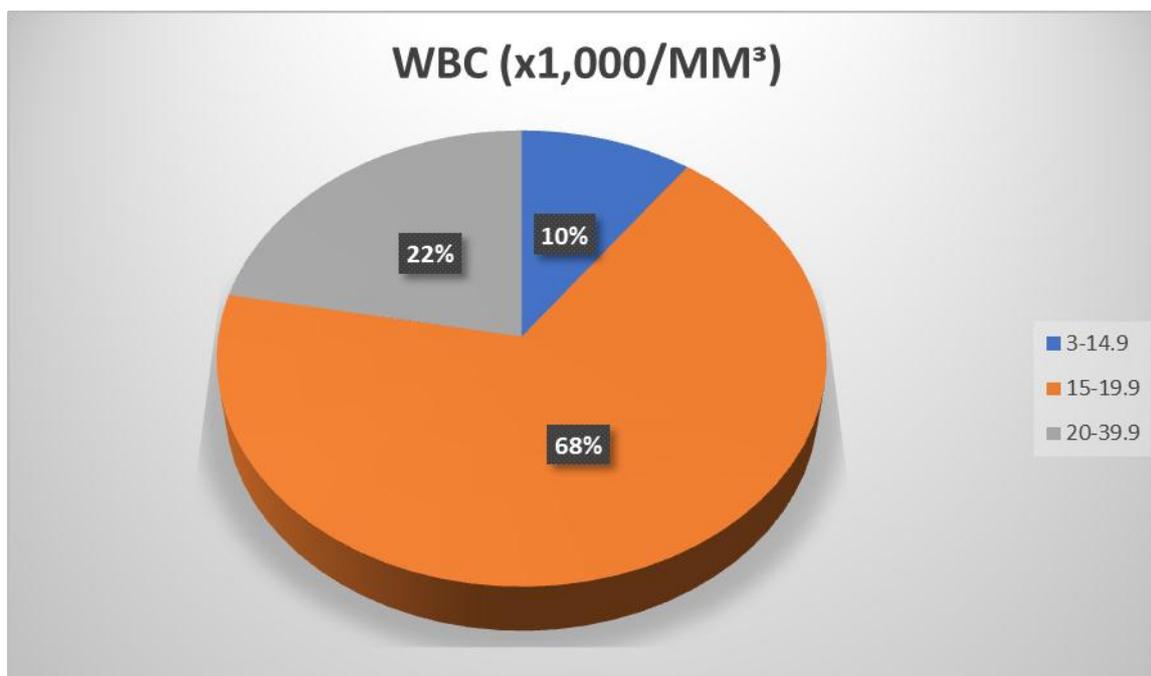


**Figure 5: Duration of hospital stay.**

The various physiological variables were observed as part of APACHE-11 scoring and the temperature and WBC COUNTS ARE SHOWN IN figure 7 AND 8.



**Figure: 6. The fever chart.**



**Figure 7: The Wbc Count Of The Patients.**

## DISCUSSIONS

In our study out of 100 COVID-19 positive patients, 86 patients responded to treatment and 14 patient died due to associated comorbid conditions and aggressive progression of the disease. Among them, 44 patients were complicated with ARDS, and 16 required mechanical ventilation. Our data showed that the patients aged >70 years, with treatment delay, severe lymphopenia and thrombocytopenia, elevated interleukin 6, with acute kidney injury, cardiac injury, and arrhythmia, were at high risk of death. Among these factors, being over 70 years of age, with comorbidities of Cardiovascular disease and APACHE -11 score above 17 were identified as independent risk factors for mortality of patients in multi-variant regression analysis.

The treatment protocols are evolving with more clear understanding of the varied pathogenesis of corona manifestations and mainly it is subjective and symptomatic. Various drugs are proposed to counteract the effects of intussusceptive angiogenesis resulting in microthrombi and hypoxia, features due to hyper immunoinflammatory syndrome and viral effects on producing lymphocytopenia and viral symptoms are treated appropriately with steroid, low molecular weight heparin, monoclonal antibodies and antiviral drugs like lopinavir or remdesivir.

In this study there were 43 (72.9%) patients treated with non-invasive Mechanical ventilation and 16 (16.0%) with invasive mechanical ventilation. Once the patients required the treatment with mechanical ventilation and/or vasoconstrictive agents, it reflected serious condition of patients, which predicted poor clinical outcomes of the patients.

As mentioned in previous studies, most patients (74, 74%) were men, and 26 patients were female.<sup>[3][4]</sup> Older age has been reported as an important independent predictor of mortality in SARS and MERS.<sup>[5][6]</sup> Twenty-(20 %) patients were aged over 70 years, which was an independent risk factor for death (HR=3.323, 95% CI=1.124–9.823).

SARS-CoV-2, has spike protein and it has a high degree of homology and have strong binding affinity to human angiotensin-converting enzyme 2 (ACE2).<sup>[6][7]</sup> Angiotensin-converting enzyme 2 (ACE2) is a homolog of ACE which plays an important role in counterbalancing the actions of angiotensin (AT)II and promotes vasodilatation. The ACE2 is the main portal of entry of the virus to invade the body and enhances increase viral replications and infection. Deng L, Li C *et al* in their studies demonstrated that ACE2 expression is relatively higher in young people than in elderly individuals and it is higher in females than in males.<sup>[8][9]</sup> ACE2 has a protective role in acute lung injury and when there is lack of functional ACE2 in the lung it will lead on to the pathogenesis of lung injury.<sup>[10][11]</sup> This is presumed to be a reason for the severe affection in the elderly male.

It is noted in the pathogenesis of SARS-CoV-2 infections, ACE2 catalyzes the angiotensin II conversion to angiotensin-(1–7), the resultant ACE2/angiotensin-(1–7)/MAS axis helps in counteracting the ill effects of the renin-angiotensin system (RAS), responsible for the balance between pathophysiology and physiology. The downregulation of ACE2 and the alteration in the balance between the Renin-angiotensin system and ACE2/angiotensin-(1–7)/MAS is the main contributory factor for the development of multiple organ injury in

COVID-19. Based on this fact many trials are on in the process of developing the drugs and vaccine based on this SARS-CoV-2 spike glycoprotein, which binds to ACE2. It is also reporting by ensuring and correcting this imbalance due to the infection between the RAS and ACE2/angiotensin-(1-7)/MAS will enable to attenuate organ injuries.

One more symptom which was seen to be present more on the non survivors were diarrhoea. The manifestation of diarrhoea was more frequent in the people who succumbed to the disease than people who recovered, though the difference was not statistically significant ( $P > 0.05$ ). Fen y et al have shown in their study, Diarrhoea can be common symptom in coronavirus infections, presenting in 30% of patients with MERS and 10.6% of patients with SARS.<sup>[12][13]</sup> It is also suggested as the ACE2 mRNA expression levels were high in the intestinal epithelium, faecal-oral transmission can acts as a super spreader.

SARS-CoV-2 can cause myocardial injury, as assessed by increased troponin I level accompanying increased cardiovascular symptoms in COVID-19 patients.<sup>[12][14]</sup> However there is dilemma in concluding whether cardiac injury is directly caused by viral infection or it is due to the secondary effects of hypoxia and associated systemic inflammation. The potent SARS-CoV-2 receptor, ACE2, is seen in cardiomyocytes and mural cells, particularly pericytes, which can induce Cardiac arrhythmias. It is also observed in our study due to this effect majority of COVID -19 patients had sinus tachycardia (72%) and sinus bradycardia in 14.9%. and the same thing was reported by Kochi AN in their study.<sup>[15][16]</sup> It is also observed in our study that arrhythmia is an independent risk factor for mortality of critically ill patients with COVID-19 pneumonia. However who will get arrhythmia and who will not be couldn't be predicted.

APACHE II score have been widely used to predict the outcome of many critically ill patients especially pancreatitis patients. APACHE II score can not only predict which patients are likely to develop sepsis but also to predict which patients can survive sepsis or not. This will guide the physicians to plan and execute augmented care to the potential patients.

After calculating and assessing the APACHE -II SCORE, based on that we could demonstrate that. APACHE II scores were significantly higher in non-survivors than survivors ( $P < 0.05$ ). X Zou in their study reported from china, Mean Acute Physiology and Chronic Health Evaluation II score ( $23.23 \pm 6.05$ ) was much higher in deaths compared with the mean Acute Physiology and Chronic Health Evaluation II score of  $10.87 \pm 4.40$  in survivors ( $p < 0.001$ ).<sup>[18]</sup>

### Limitations of the study

- Study had limited sample size, because only one hospital was included in this study.
- it was a retrospective study as a result all patients were not having all the desired laboratory testing
- There is no rigid rule of treatment protocol followed in all patients and there was varied delay in the time of presentation to the concerned unit.

### CONCLUSION

SARS-CoV infections is spreading fast to infects millions of people. The risk stratifications and early identifications of the vulnerable sick patients and ensuring appropriate treatment protocols for them will be the way to make death as an exception rather than rule. APACHE-11 score is a predictable and feasible scoring method to assess and segregate the potential severe grade patients. By calculating the APACHE-11 Score, when it is above 17, the patient will be a potential patient for aggressive management to prevent mortality.

### Disclosure

The authors declare that there is no conflict of interest.

### REFERENCES

1. World Health Organization. Coronavirus disease 2019 (COVID-19): situation report—89. Available from: [https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200418-sitrep-89-covid-19.pdf?sfvrsn=3643dd38\\_2](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200418-sitrep-89-covid-19.pdf?sfvrsn=3643dd38_2). Accessed April 18, 2020.
2. COVID-19 Worldwide Dashboard - WHO Live World Statistics <https://www.worldometers.info/coronavirus/>
3. Liu X, Zhou H, Zhou Y, et al. Risk factors associated with disease severity and length of hospital stay in COVID-19 patients. *J Infect*, 2020; 81(1): e95–e97. doi: 10.1016/j.jinf.2020.04.008
4. Huang C, Wang Y, Li X, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. *Lancet*, 2020; 395(10223): 497–506. doi: 10.1016/S0140-6736(20)30183-5.
5. Choi KW, Chau TN, Tsang O, et al. Outcomes and prognostic factors in 267 patients with severe acute respiratory syndrome in Hong Kong. *Ann Intern Med*, 2003; 139(9): 715–723. doi: 10.7326/0003-4819-139-9-200311040-00005
6. Ko JH, Park GE, Lee JY, et al. Predictive factors for pneumonia development and progression to respiratory failure in MERS-CoV infected patients. *J Infect*, 2016; 73(5): 468–475. doi: 10.1016/j.jinf.2016.08.005.
7. Li F, Li W, Farzan M, Harrison SC. Structure of SARS coronavirus Spike receptor-binding domain complexed with receptor. *Science*, 2005; 309(5742): 1864–1868. doi: 10.1126/science.1116480
8. Ni, W., Yang, X., Yang, D. *et al.* Role of angiotensin-converting enzyme 2 (ACE2) in

- COVID-19. *Crit Care* 24, 422 (2020). <https://doi.org/10.1186/s13054-020-03120-0>
9. Xie X, Chen J, Wang X, Zhang F, Liu Y. Age- and gender-related difference of ACE2 expression in rat lung. *Life Sci*, 2006; 78(19): 2166-2171. doi: 10.1016/j.lfs.2005.09.038
  10. Soro-Paavonen A, Gordin D, Forsblom C, et al. Circulating ACE2 activity is increased in patients with type 1 diabetes and vascular complications. *J Hypertens*, 2012; 30(2): 375-383. doi: 10.1097/HJH.0b013e32834f04b6
  11. Jia H. Pulmonary angiotensin-converting enzyme 2 (ACE2) and inflammatory lung disease. *Shock*, 2016; 46(3): 239-248. doi: 10.1097/SHK.0000000000000633
  12. Busse LW, Chow JH, McCurdy MT, Khanna AK. COVID-19 and the RAAS-a potential role for angiotensin II? *Crit Care*, 2020; 24(1): 136. doi: 10.1186/s13054-020-02862-1
  13. Chan JF, Yuan S, Kok KH, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet*, 2020; 395(10223): 514-523. doi: 10.1016/S0140-6736(20)30154-9
  14. Fan Y, Zhao K, Shi ZL, Zhou P. Bat coronaviruses in China. *Viruses*, 2019; 11(3): 210. doi: 10.3390/v11030210.
  15. Yu CM, Wong RS, Wu EB, et al. Cardiovascular complications of severe acute respiratory syndrome. *Postgrad Med J*, 2006; 82(964): 140-144. doi: 10.1136/pgmj.2005.037515.
  16. Kochi AN, Tagliari AP, Forleo GB, Fassini GM, Tondo C. Cardiac and arrhythmic complications in patients with COVID-19. *J Cardiovasc Electrophysiol*, 2020; 31(5): 1003-1008. doi: 10.1111/jce.14479.
  17. Basile-Filho A, Lago AF, Meneguetti MG, et al. The use of APACHE II, SOFA, SAPS 3, C-reactive protein/albumin ratio, and lactate to predict mortality of surgical critically ill patients: a retrospective cohort study. *Medicine (Baltimore)*, 2019; 98(26): e16204. doi: 10.1097/MD.00000000000016204
  18. X Zou, S Li, M Fang, M Hu, Y Bian, J Ling, S Yu, L Jing, D Li, J Huang. Acute Physiology and Chronic Health Evaluation II Score as a Predictor of Hospital Mortality in Patients of Coronavirus Disease 2019. *Crit. Care Med.* 2020 May 01; [Epub Ahead of Print],