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Outcome of ICUs using APACHE, SAPS and MPM Scoring Systems

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Abstract
Now a day's price of health protection for a care unit patient has been three times more as compared to general word patient. Monitoring the care unit improvement is a major criteria with respect to control the major hospital expenses. To predict the outcome in an ICU the common illness severity scores are generally used which characterize the severity of diseases, depend on the rate of organ disorder and assessment of resources used for this purpose. Primarily, the separate types of scoring systems are used necessarily for the treatment purpose. Their compound uses provide a more correct symptom of disease intensity and prophecy to the doctor regarding duration of rest and mortality for the ICU patient. This paper gives brief overview of the generally used scoring system, examines the details regarding their development, qualified information concerning their execution. It is important and also necessary for all these marking approach will be modernize accordingly with times as care unit community increases, change in heterogeneity of diseases and new symptomatic, remedial and anticipating strategy become available day by day.

Keywords: *Simplified Acute Physiology Score* ***(SAPS),*** *Mortality Probability Model* ***(MPM),*** *Acute Physiology and Chronic Health Evaluation* ***(APACHE),*** *Organ System Failure (****OSF****), Sequential Organ Failure Assessment (****SOFA****), Intensive Care Unit (****ICU****), length of stay (****LOS****).*

Introduction

Medical care depends on the evaluation of quality that requires effectiveness of treatment provided to the patients so that recovery takes place within a minimum amount of time. Although ICU admission policies generally not strictly follow any norms and there are many situations when a patients shifted from a general word into an ICU on emergency. Before the treatment is given a proper evaluation of the sick people's condition must be defined to do the valid evaluation of the treatment process. Medical care unit utilizes seriousness of parameter recording systems to evaluate the patient condition. In the ICU medical treatments standard can be measured by differentiating the correct death rate with predicted mortality with respect to used criteria into consideration for patient seriousness.

Intensity of ranking systems divided into two portions, based on individual system used for collecting the data from the ICU. The first category includes the well known techniques like MPM model, Simplified Acute Physiology Score and Acute Physiology and Chronic Health Evaluation (**APACHE**), all of these techniques use the time periods of whole day of care unit

admission to calculate starting position of the patient. The second category focuses on the different kinds of organ related issues like Sequential Organ Failure Assessment, Organ System Failure (**OSF**), Organ Dysfunction and Infection System (**ODIN**) and Multiple Organ Dysfunction Score (**MODS**), all of which specially look into the measurement of patient status continuously all over the entry period.

APACHE, SAPS and MPM among these severity scoring system, that use most of the times in ICUs are evaluates the starting patient status while the quantification of parameters used by theses systems were initially chosen according to the subject, all have chooses statistically according to the significant variables thereby enhancing their performances[1].

Critically ill patients classified into two broad categories. First category deals with specifically pointed for an organ or diseases where Glasgow Comma Scale (**GCS**) are used to find out nature and depth of an organ failure. In second category deals with patients for all ICUs that are generic in nature. Overall these scores separated into count that measures disease intensity on entrance and use it to forecast results (like **APACHE**, **SAPS** and **MPM**), outcome that assess the relevance and speed of organ deterioration (like **MODS**, **SOFA**) and scores which giving the importance with nursing workload use for this purpose like Therapeutic Intervention Scoring System (**TISS**), Nine Equivalents of Nursing Manpower use Score (**NEMS**)) etc.

This observation is looking into intensity parameter systems like APACHE, SAPS and MPM are analyzed for this purpose to find which structure best executes data according to the seriousness of critical care unit sick peoples. Purpose of this evaluation is to give knowledge to the critical care doctors without any particular experience.[2].

1.1 ICU and care unit Patients

Distinguishing feature of the care unit patients is its significant diverseness of diseases, which attending a provocation in controlling type of care unit patient is. Dissimilarity contains in the age group, gender of victims, trajectory or direction, length of the disease process, co morbidities and manner of difficulties. These features are very important can directly influence the outcomes of ICU as can the source of patient entrance. Care offers a quality tracking, interference, important organ assistance that is not easily available in a general word. Sick peoples entry from the general words, sometimes have poor outcome as compared to those admitted from the emergency word or operating theatre. Patients transferred from other hospitals are very difficult situations than those shifted within the same health centre. The critical care interaction among illness intensity, length of stay in other hospitals, and lead time means that if patients admitted earlier with severe multiple organ failure when the degree of severity was moderate value or lower, their possibility of viability would be improved and affect the outcomes of the hospitals. Further outcomes of care unit also depends on administration, patient's stay in the care unit before and after, quality of physician or nurses, supporting staff working in the care unit are more required for assessment of care unit.[3]. Major difference could be made between care units (i.e. intensive therapy in care unit) and critical care (i.e. intensive care enlarge to parts of the hospital) for better outcomes regarding hospitals services. It is also expected in the medical crisis outreach teams work simultaneously within critical care without any barrier. There has been a traditional separation in many nations between patients needing surgical and medical treatment due to ancient and regional distinction. Patients in pharmaceutical and surgical care units have same problems like infection, cardio respiratory uncertainty, fluid variance, basic consumption rate fluctuation and digestive problems**.** Difference is that patients in pharmaceutical care unit's higher mortality rates as compared to surgical care units[4]. Nevertheless this disconnection might carry on within health centers for financial or administrative reason. Principally whatever are the

differences like infection, trauma or internal hemorrhage the general destination for several patients is in the care unit treated similar as different organ failure. Below Table1 describe the common reasons for against of care units into different surgical and pharmaceutical blocks.

Table 1: Reasons for Separation of Medical and Surgical ICUs

Advantages	**Disadvantages**
For financial budgets surgical and medical ICUs are separate	Most of the time prescribed intensive care medicines are same, ignoring the main purpose of sickness.
Specialized ability and mastery regarding development for pharmaceutical and care staff for the specific analytical domain	Increased costs for treatment as more separate equipment are needed
For homogeneous group of patients it is more helpful for medical diagnosis	Increased cost for hospitals due staffing needs
Surgical ICUs are located near to the operating theater which is a major advantage	Critically sick peoples who are not fall into these usual category get reduced ability to care

1.2 Materials and Methods

Technological advances make severe pharmaceutical development and life expectancy also grow universally, as earth community continued to increase with, unprecedentedly old age population. High currency of age related *disease and several co-occurring conditions* requires establishment of several intensive care unit. Availability of care unit beds exclusively depends on the financial conditions and increment of human resources are increase on the *high-income Nations (**HINs**)* but for others like lower-income and middle- income countries facing a great challenge due to economic disparities during the pandemic situations[5]. General intensive care units face several issues related to death rate of the sick peoples. Maximum research have found that second genesis outcome like APACHE III,SAPS II, sepsis-related organ collapse evaluation, logistic organ deterioration structure which were grow in mid 1990s are need to updated accordingly and includes more variables for *mortality prediction and duration of rest* in care unit in terms of number of days. Further recent genesis of care unit scoring systems like SAPS III, APACHE IV and MPM III are more powerful and represents updated model. *These models are maintaining the scoring systems by categorizing the ICU patients based on admission types*[6]. After assess the improvement of the scoring systems and check for the mortality, next is to specify the duration of rest based on the evaluated score. Below **Figure 1**show the details.

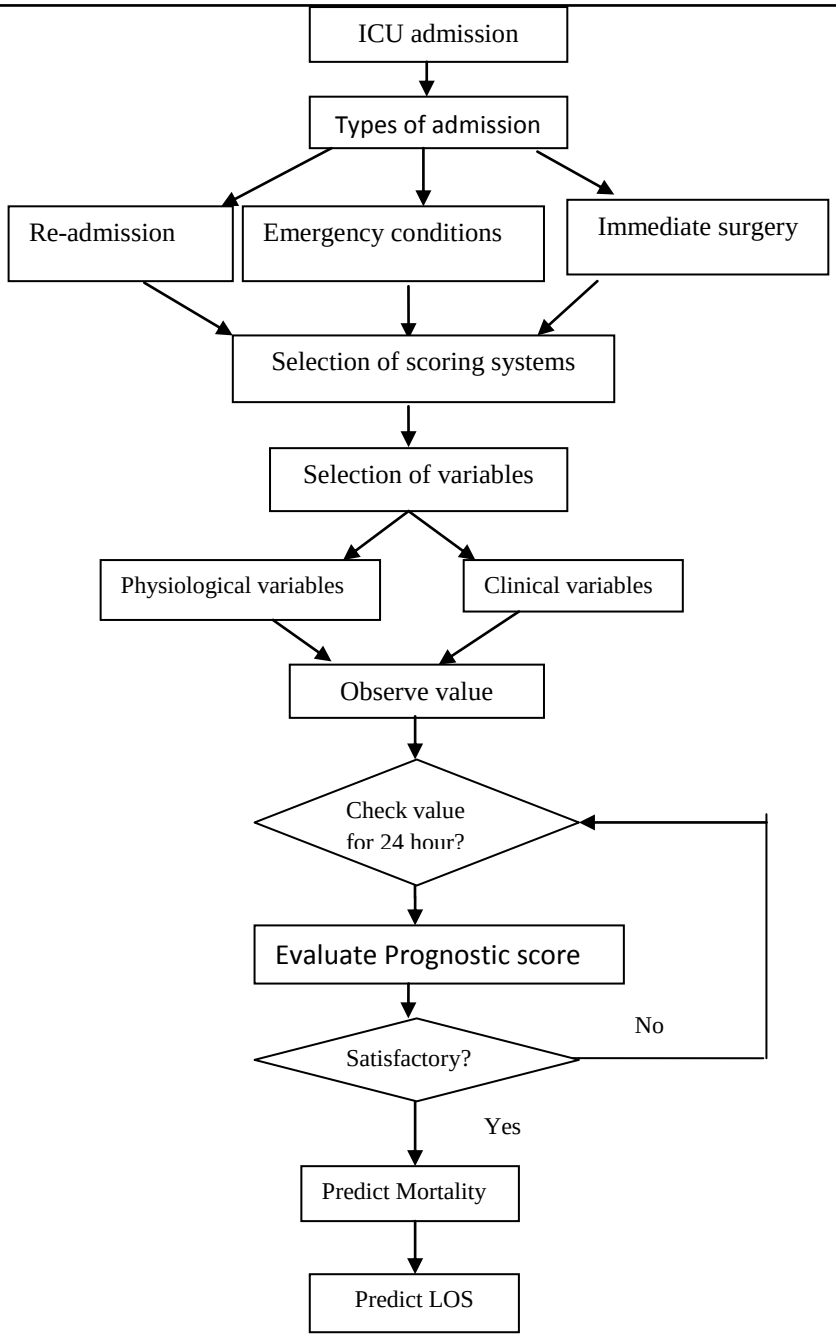

Figure 1: care unit life cycle of a patient

1.3 Prediction Scores and Outcome

Several results for forecast scores were developed forty years before provide marking regarding the possibility of death for groups of care unit patients instead of plan for individual forecast or prophecy. Patient's population, spreading of disease, intensive care operating procedures has changed considerably and major progress in the statistical and computational techniques *changed the dimensionality of ICUs care unit facilities*[7]. As a result all the three of the major scoring system has been regularly up to date to ensure the good accuracy for the ICU patients below **Table 2** shows the importance of variables and its general outcome for scoring systems[8].

Table 2: General Outcomes of Different Scoring System

Characteristics	APACHE	SAPS	APACHE II	MPM	APACHE III	SAPS II	MPM II	SAPS 3	APACHE IV	MPM III
Period	1981	1984	1985	1985	1991	1993	1993	2005	2006	2007
Nations	1	1	1	1	1	12	12	35	1	1
Care units	2	8	13	1	40	137	140	303	104	135
Sick peoples	705	679	5815	2783	17440	12997	19124	16784	110558	124855
selection methods	Expert panel	Expert panel	Expert panel	Multiple logistic regression (MLR)	MLR	MLR	MLR	MLR	MLR	MLR
Parameters										
Life time (Age)	No	Yes	Yes	Yes	Ye	Yes	Yes	Yes	Yes	yes
Origination	No	No	No	No	Yes	No	No	Yes	Yes	No
Clinical status	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Continual health status of patients	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Anatomical status	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Critical issues	No	No	Yes	No	Yes	No	Yes	Yes	Yes	Yes
Parameters in considerations	34	14	17	11	26	17	15	20	142	16
Score in relevance	Yes	Yes	Yes	No	Yes	Yes	No	Yes	Yes	No
Mortality prediction	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

In the above table 2 shows that age has no impact in APACHE scoring systems which release on year 1981 though other subsequent version of APACHE and other scoring systems consider Age is an important variable to predict the mortality of the patient. Similarly consideration of number of variables is more (142) as compared to other scoring systems.

2. Scoring Systems

2.1 First scoring system APACHE

To categorized groups of sick peoples according to degree of illness the actual APACHE scores was developed in **1981**and was split into two parts:

- Degree of acute illness to assess a physiology score was provided and
- A pre entry equation helps to find out the critical health status of the patient.
- There are 34 physiological variables for severity of illness[9].

APACHE II

Original **APACHE** model was corrected and uncomplicated in the year **1985** to produce the **APACHE II** model; now the extensively used degree of illness scores in the ICUs[10]. In this model following characteristics are observed

- Twelve anatomical parameters as differentiate to thirty four parameters in the original score.
- Consequences of age and constant health position are directly incorporated.
- Weighted accordingly to check their corresponding effect to give a single score with a maximum of 71 for better management.
- Recorded unfavorable value for first 24 hours of an admitted sick people to the care unit is used for each anatomical variable.
- Principal diagnosis leading to ICU admission is added as a category weight so that computed predicted mortality is based on the patient's APACHE II score and their principal diagnosis at the time of entrance[11].

From the above discussions the problem for care unit admission it is found that observation of an principal parameter for forecasting death rate,

earlier health position and level of acute anatomical deterioration are same in nature.

APACHE III

- Evolved in the year **1991** and was validated accordingly for further updated in the year 1998 and 20 physiological variables initially selected for severity of disease.
- In this model additional features are added using the calculation for forecasting risk-adjusted care unit duration of stay.
- Below **Table 3**helps to evaluate the consequence on overall explanatory power of a variable describing preference for intensive care.

Table 3: Geographical attribute of Patients

Total patients		
26 arbitrary hospitals		10,941
14 participant hospitals		6,499
	Total	**17,440**
Non operative admissions		
Emergency space		6,199
Floor		2,860
Transfer from other hospital		423
Transfer from other ICU		581
	Total	**10,063**
	Percentage (%)	58
Postoperative admissions		
Elective surgery		5,811
Emergency surgery		1,566
	Total	**7,377**
	Percentage (%)	42
Average number of patients in each unit(range)		**425 (299-449)**
Age, year(mean, 59 year)		
<45	Values are percentage of total number of patients	23.2
45-54		10.8
55-64		18.0
65-74		25.5
75-84		17.2
>=85		5.3
Sex	Values are percentage of total number of patients	
Male		44.8
Female		55.2
Race		
colorless	Values are percentage of total number of patients	80.3
Black		14.1
American.		4.1
Asian		1.2
American Indian		0.3

APACHE- IV

Currently **APACHE-IV** was evolved consists of a database with 100000 sick peoples who are getting entry to more than one hundred and four care units in the USA 2002/2003 in 45 hospitals and also APACHE III was remodeled with the same anatomical parameters and influence but different determinant parameters which are purified accordingly available statistical models[12]. The new model **APACHE-IV** like APACHE III provides care unit length of stay forecast calculations, which provide benchmarks for the assessment and comparison of care unit productivity and usable resources. The current type of APACHE-IV scoring system is evaluated based on one hundred and twenty nine variables which are derived within the first whole day of care unit admission, and are evaluated over 110,588 patient's entry to more than 104 care units across the USA[13].

2.2 Simplified Acute Physiological Score (SAPS)

In the year **1984,** SAPS was developed and validated in the FRANCE which uses thirteen weighted physiological variables and include one important parameter **Age** which is used to forecast the risk of patient death in care units. SAPS were planned from the respective poor merits received during the first whole day of care unit entry, Like APACHE III scores. Further SPAS models has been refined to include more variables and released as SAPS II[14].

SAPS II

In the year **1993**, logistic regression analysis has been included to developed **SAPSII,** which consists of 17 variables like 12 anatomical parameters, Age, nature of entrance and 3 more parameters relevant to principal disease. Data received from consecutive admissions to 12 countries and 137 ICUs, the SAPS II scores were validated subsequently.

SAPS III

In the year **2005**, an entirely up to date SAPS model, the **SAPS-III** was generated which deals with composite analytical approach using a master database of 16,784 patients from the 35 nations and 303 care units to select and weight variables. Further 20 parameters are divided into three sub groups for maintaining the scores that are connected to patient's attributes prior to admissions, the circumstances of entry, and the level of anatomical insaneness within 1 hour as compared to SAPS II model which uses **24 hour** time window before or after ICU admission[15]. In this model aggregate score can range from 0 to 217 which is also a big range for monitoring the outcome. SAPS III uses regularized equations for hospital mortality prediction as compared to other scores in seven geographical regions. It is observed that for growth of these equations considering sample size that correspondingly small; in this case it may compromise the prediction accuracy. SAPS III scores pointed out three major things like correct *discrimination, proper calibration and goodness of fit*. SAPS III also been used for the following areas like

- Examine the classification of assets use between care units
- Uses the normalized assets utilize parameter for the **LOS** in the care unit and
- Parameters relevant to severity of acute illness are also adjusted[16].

2.3 Mortality Probability Model (MPM):

The initial MPM prototype was developed in the year 1989-90 from data available from patient in single ICU which is considered as an input to an entry prototype using seven entry parameters. After that a whole day prototype using seven whole day parameters are used as an input to the model[17].

MPM II

A revised MPM, which is released as **MPM II** was developed in the year**1993** using large ICU database, consists of 12,610 patients from 12 countries using logistic regression statistical techniques. Above mentioned model depends on two scores $\mathbf{MPM_0}$ that uses fifteen parameters and $\mathbf{MPM_{24}}$ which is a whole day model having contains five of the entry parameters, eight extra variables and is specially originated regarding sick

peoples, can continue for care unit for whole day. As compared to scoring models like **APACHE** , **SAPS** where parameters are encumbered but in **MPM II** model every one (excepting **Age** that specified as real value in the system), marked as current or missing by specifying the value 1 or 0 subsequently. Computing the probability value for marking the hospital mortality based on equation for logistic regression is also used.

Further scale related to *Weighted Hospital Days* (WHD-94) are used by independently allocate weights to days in care unit and also to the hospital days after discharging from the care unit to the first care unit stays. Further an association is used to project care units mean for WHD-94 which also look into the mark *of wealth usage.* Now MPM_0 has upgraded using a master database which consists of **124,885** ill-patients from **135** care units in 98 health centre[18].

MPM_0 III

This model updated based on 2001-2004patient data that are acquire within sixty minutes of care unit entry by using sixteen variables including **three** major physiological parameters to calculate the value for mortality probability index at the time of health centre discharge. **MPM $_0$**describe which largely depends on the patient circumstances before ICU care begins. The anticipating calculation related to WHD -94 has also been updated accordingly[19].

3. Comparisons among Three Scoring Systems

The correctness of any grading system is highly depends on many factors out of which following criteria are most important like

- The quality of input provided to the system.
- Operating steps should be follow according to the specified instructions.
- Definitions properly maintained.
- Time of data collections
- Accuracy of data acquisition
- Rules specified for the missing data should be following properly and must match accordingly when developing the model.

Besides of that reported reliability of the systems also be taken into account including intra and inter-observer[20]. Below **Table 4** describes the different characteristics of three scoring system in terms of version, year of release and variables used.

Table 4: Characteristics of Three Scoring System

Scoring Systems	Version	Year of Release	Variables Used
APACHE	I	1981	34
	II	1985	12
	III	1991	20
	IV	2002	129
SAPS	I	1984	13
	II	1993	17
	III	2005	20
MPM	I	1989	7
	II	1993	15
	III	2001	16

When using this scoring system another important issues need to be remember regarding to local customization and daily updates with some limitation that also kept in mind are as follows

First, several obtained calculations which are used to anticipate mortality there are some inherent biases that are generated from a finite community of sick peoples from care units that concisely focused in estimating and enhancing care unit achievement[21, 22].

Second, in all the scoring systems during the time of health centre release the outcome used is the vital status. The status of the care unit release will neglect accuracy of the predictions due to the use of other outcome estimates. Regarding assessment of uses of resources, counted as risk adjusted, burdened ICU or hospital days for

further analysis some scoring system have additional equation also[23,24].

Third, different statistical techniques are helped to measures the calibration of a predictive model which is usually called as Hosmer-Lemeshow statistic, perhaps regulated by several criteria like n*umbers of independent variables are used, the strategy in which inspection of equal chances of outcomes are tabulated* and the selection such as both small and large are taken into consideration. Further interpretation of accuracy regarding prediction should comprise some uses of the statistical experiment.

Fourth, anticipating models have been prepared in consideration with sizeable population, but it is found when they are applied to new population in almost all cases it is observed that calibration deteriorates besides of that discrimination hardly changes[25,26].

Fifth, below **Table 5** describe the impact of different scoring variables for well known scoring models (APACHE IV, SAPS 3 and MPM-III) and it is found MPM III uses less number scoring variable as compared to other scoring models. By replacing the selection rate for the anatomical variables in case of uses of mechanized patient data administration can change the accuracy of the model[27]. It is reported that data administration reporting as compared with the manual reporting for the respective scoring system like above mentioned models II where predicted mortality was greater.

Table 5: Important parameters related to scoring Model

SL No.	APACHE IV	SAPS 3	MPM -III
1	Maturity (level or Age)	Maturity (level or Age)	Maturity (level or Age)
2	Pulse Rate	Pulse Rate	Pulse Rate
3	Value of Mean (Arterial Pressure)	Value of Lowest Systolic BP	Value of Systolic BP
4	External Respiration	Ventilation Support / Oxygenation	External Respiration
5	Glasgow Comma Scale	Glasgow Comma Scale	Coma/stupor(GCS 3-4)
6	Creatinine and Burn	Creatinine	Chronic renal Failure
7	Urine Output	Chronic Heart Failure	Acute Renal Failure
8	Hepatic Failure	Cirrhosis	Cirrhosis
9	Various malignancies ,AIDS	Various malignancies ,AIDS	Metastatic neoplasm
10	Emergency Surgery	Unplanned / planned admit	Medical /unscheduled surgical
11	Bilirubin	Bilirubin	---
12	Temperature	Temperature	----
13	Serum pH/PCO_2	Lowest pH	----
14	Respiratory Rate	Use of vasoactive drugs	CPR before Admission
15	Oxygenation (AaDo2 or PaO2	Surgical status / anatomic site	Ageinteractionterms
16	Hematocrit	Thrombocytopenia	GI Bleeding
17	White Cell Count	White Cell Count	Cerebrovascular incident
18	Sodium , albumin,glucose	Presence of Infection	Absence of other risk factors
19	Admitting Diagnosis	Reason for ICU admission	Cardiac dysrhythmias
20	Pre-ICU Location and LOS	Pre-ICU Location and LOS	----
21	Origin /Readmission	Origin/Readmission	----
22	Non Operative / Postoperative	Non Operative / Postoperative	-----
23	Co morbidities	Co morbidities	------

Based on the scoring elements value for the APACHE IV scoring systems will provide the information regarding APACHE IV score with in the respective range, APS score, estimated percentage (%) of death rate and duration of rest in terms of number of days[28].

4. Quality Assessment of ICU Performance

Crude mortality data collected from different department in the hospital need some global guidance for measurement of ICU performance, adjustment of mortality rates according to disease severity and also calculated mortality ratio can also help to increase the quality assessment of

ICU outcome[29]. Regarding diversified groups of sick peoples suffering from sepsis or acute respiratory distress syndrome in that case using severity score like APACHE, SAPS can helps to find out level of sickness. In case of care unit schedule time or to differentiate with the available units severity adjusted indicators sometimes helps to assess the performances[30,31]. This technique has different restrictions which includes major consequences regarding pre-ICU entrance criteria, complexity of separate ICU release schemes, reaction of several mixed case patients and severity of illness at different times regarding between units or in the same units[32]. Risk regulated death rates among health units have large variations and repeated standard evaluation helps to determine the major reason for these differences and find out the measures to improved the performance[33,34].

5. Conclusion

Severity scores for general illness are widely used in the ICUs to assess the uses of ICU resource, anticipate the corresponding results and also classify the intensity of diseases. Time and mode of death are increasing due to several issues but most of the patients who are dying due to multiple organ failure even if so many development of ICUs. There is an urgent need of improved strategies to prevent death and improved recovery process. All the scores are mentioned above are advanced are used in combined groups of several patients and there is a need to continuously check there accuracy also. Although different scoring systems use several variables for organ dysfunction scores that correlate with outcomes but scores like APACHE and SAPS system are still used for the prediction outcome of ICU. When all these scoring system are used together give more correct information regarding disease severity, death rate and forecasting which could help doctors and nursing staff in resource utilization and performance assessment.

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c. Ethics

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d. Author's contributions

Two authors review by Prabhudutta Ray, Dr. Sachin Sharma who has read and accept the manuscript**.**

e. Declarations

The author(s) declared no potential conflicts of interest.

f. Availability of data and materials

Data sets will be provided on request from the consent of the hospital authority and guides also.

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