Bedside Critical Care Guide

Edited by
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Chapter: Critical Care Scoring Systems and Checklists

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Critical Care Scoring Systems and Checklists

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Abstract

Scoring systems are widely used in the ICU to predict outcome, characterize disease severity and degree of organ dysfunction, assess resource use, evaluate new therapies, compare ICU care across various settings, and demonstrate equivalence of study and control patients in clinical research. In this article, we will review the most commonly used scoring systems in the ICU, briefly examine the history of their development and address when and how to use these systems. We also note the fact, that the different scoring systems should be seen as complementary and not as mutually exclusive and emphasize the fact, that scoring systems should not replace individualized care and/or decision making in the ICU.

Introduction

Scoring systems are necessary in the ICU for several reasons – to predict outcome and prognosis, guide the clinical decision making process, monitor and assess new therapies, compare care between different centers, standardize medical research and perform cost-benefit analysis with regard to resource utilization. While not specifically designed for individual patient care, scoring systems may guide (but will NOT replace) clinical decision making regarding withdrawal of treatment and/or futility of continued aggressive care. This latter reason will become progressively more important as families become more involved in medical decision making in the ICU.

A good scoring system should meet some basic requirements (Table 1). First, it should assess an important, relevant and easily determined outcome. Most ICU scoring systems assess mortality while others predict long-term morbidity and functional status. Next, it should be simple, reliable, easy to use, and in-put data should be readily obtainable. A good scoring system should also have wide patient applicability, high sensitivity and specificity, and be able to perform well across a wide range of predicted mortalities.

Discrimination and calibration are two characteristics used to judge a scoring system. Discrimination refers to the accuracy of a given prediction – e.g., if a scoring system predicts a mortality of 90%, discrimination is perfect if the observed mortality is 90%. Calibration describes how an instrument performs over a wide range of predicted mortalities. An instrument would be highly calibrated if it were accurate at mortalities of 90%, 50% and 20%. Unfortunately however, there is no ideal score. Several scores used in conjunction would be complementary although potentially more time consuming and labor intensive.

It should be noted, that scoring systems are meant as a guide to clinical care and should not replace good clinical judgment, limit treatment of individual patients or result in nihilistic, depersonalized care.

Table 1: The ideal scoring system [40].

| 1. Based on easily/routinely recordable variables |
| 2. Well calibrated |
| 3. A high level of discrimination |
| 4. Applicable to all patient populations |
| 5. Can be used in different countries |
| 6. The ability to predict functional status or quality of life after ICU discharge |

No scoring system currently incorporates all these features

Classification of Scoring Systems

There is no agreed method of classification of scoring systems used in critically ill patients. Several methods of classification have been suggested as shown below [1]:

- Anatomical scoring – these depend on the anatomical area involved and are mainly used for trauma patients [e.g. Abbreviated Injury Score (AIS) and Injury Severity Score (ISS)]
- Disease specific – based on the ongoing disease process [e.g. Ranson’s criteria for acute pancreatitis, subarachnoid hemorrhage assessment using the World Federation of Neurosurgeons score, and liver failure assessment using Child-Pugh or Model for End-Stage Liver Disease (MELD) scoring]
- Physiological assessment - based on the degree of derangement of routinely measured physiological variables [e.g. Acute Physiology and Chronic Health Evaluation (APACHE) and Simplified Acute Physiology Score (SAPS)].
- **Organ-specific scoring** - The underlying premise here is that the sicker a patient is, the more organ systems will be involved (ranging from organ dysfunction to failure) and the poorer the expected outcome will be [e.g., Sepsis-Related Organ Failure Assessment (SOFA)].

- **Therapeutic weighted scores** - These are based on the assumption that very ill patients require a greater number of interventions and procedures that are more complex than patients who are less ill. Examples include the Therapeutic Intervention Scoring System (TISS).

- **Simple scales** - based on clinical judgment (e.g., survive or succumb)

For the purpose of simplicity and ease of understanding, we will simplify the scoring systems into 3 broad functional categories:

- **Disease-specific scores** - specific for an organ or disease (for example, the Glasgow Coma Scale (GCS), the Ransons's Criteria for acute pancreatitis, the Intra Cranial Hemorrhage (ICH) score or the Maddrey's discriminant function for alcoholic hepatitis etc.)

- **Generic ICU score** – these are generic and applicable to a very wide range of ICU patients independent of their disease specifics. This category will include the physiologic assessment scores, the organ dysfunction scores and the therapeutic weighted scores.

- **Scores and check lists** used to assess everyday care in the ICU including adequacy of pain control, depth of sedation/degree of agitation or presence or absence of delirium and adherence to infection prevention.

In this chapter, we focus on the latter 2 broad groups. The objective of this review chapter is to give the ICU provider without any particular knowledge or expertise in this area an overview of the current status of these instruments and their possible applications.

### Generic ICU scores

Generic ICU scores may further sub-categorized into:

- **Outcome prediction scores** - based on disease severity on admission (e.g. Acute Physiology and Chronic Health Evaluation (APACHE), Simplified Acute Physiology Score (SAPS), Mortality Probability Model (MPM))

- **Organ dysfunction scores** - assess the presence and severity of organ dysfunction (e.g. Multiple Organ Dysfunction Score (MODS), Sequential Organ Failure Assessment (SOFA)).

- **Scores that assess nursing workload use** (e.g. Therapeutic Intervention Scoring System (TISS), Nine Equivalents of Nursing Manpower Use Score (NEMS)).

### Outcome prediction scores

The original outcome prediction scores were developed over 25 years ago to provide an indication of the risk of death in groups of ICU patients. They were not designed for individual prognostication. They have all undergone recent updates to account for the changing patient demographics, disease severity and intensive care practices to ensure continued accuracy in today’s ICU.

We will limit our discussion to the three most common outcome prediction scores:

- **Acute Physiology and Chronic Health Evaluation Score (APACHE, APACHE II, APACHE III, APACHE IV)**

- **Simplified Acute Physiology Score (SAPS, SAPS II, SAPS III)**

- **Mortality Prediction Model (MPM, MPM II, MPM III)**

### Acute Physiology and Chronic Health Evaluation (APACHE) score

The original APACHE score was developed in 1981 to classify groups of patients according to severity of illness so as to compare outcomes, evaluate new therapies and study the utilization of ICU’s [2]. It was not designed to assist in making individual treatment decisions. It was divided into two sections: a physiology score to assess the degree of acute illness; and a premorbid evaluation to determine the chronic health status of the patient before acute illness. A composite numerical physiological score was obtained by using the worst value from 34 possible physiological measurements obtained in the first 32-hours of ICU admission, reflecting the degree of derangement of one or more of the body’s 7 major physiological systems [2]. The pre-admission health status was assigned a letter score of A (excellent health) through D (severe chronic organ system dysfunction) for details concerning functional status, productivity and medical attention approximately 6 months before admission. The patients complete APACHE classification was indicated by the numerical sum of the weights for physiological measurements and a letter reflecting chronic health evaluation. Thus designations such as 13-A or 33-D reflect patients with different levels of acute illness and preadmission health status, while designations 13-A and 13-D would reflect patients with same level of acute illness but differing levels of preadmission health status.

In 1985, the original model was revised and simplified to create APACHE II by using 12 physiological variables instead of 34 and incorporating age and chronic health status directly into the model to give a single point score with a maximum score of 71 [3]. The worst value recorded during the first 24 hours of a patient’s admission to the ICU is used for each physiological variable. The principal diagnosis leading to ICU admission was added as a category weight so that the predicted mortality is computed based on the patient’s APACHE II score and their principal diagnosis at admission [1,3].Although the original APACHE system was not primarily developed to be used for individual patient treatment decisions, APACHE II can provide the clinician with a systematic evaluation and an improved understanding of how an individual patient’s severity of disease influences his outcome [3]. The APACHE II scoring system is now the world’s most widely used severity of illness score (1,3). APACHE II score calculators are widely available online.

The APACHE III prognostic system was developed in 1991 and was validated and further updated in 1998 [1,4,5]. It consists of two options: (i) an APACHE III score, which can provide initial risk stratification for severely ill hospitalized patients within homogeneous independently defined patient groups; and (ii) an APACHE III predictive equation, which uses APACHE III score and reference data on major disease categories and treatment location immediately prior to ICU admission to provide risk estimates for hospital mortality for individual ICU patients [4]. APACHE III uses 17 physiological variables with a different weighting system assigned to the original 12 from the APACHE II scoring system. It provides a composite score with a range of 0 to 299 and accounts for any selection bias
that may result from the location of a patient prior to ICU care. ICU readmissions, transfers from other ICUs and admissions from the hospital wards have marginally increased risk of death relative to patients admitted directly to the ICU from the emergency room. Like its predecessors, the APACHE III uses the worst physiological variable in the first 24-hours of ICU admissions to obtain a 1-day score. It can be updated daily to provide a daily risk estimate, which may be used to calculate individual risk estimates over time. Commercially available APACHE III calculators are available for purchase.

APACHE IV was developed in 2006 using a database of over 110,000 patients admitted to 104 ICUs in 45 hospitals in the USA in 2002/2003, and remodeling APACHE III with the same physiological variables and weights but different predictor variables and refined statistical methods [6]. A recent study out of 3 medical-surgical Brazilian Intensive Care Units showed that the APACHE IV and the SAPS III had good discrimination but poor calibration.

**Simplified Acute Physiology Score (SAPS)**

The Simplified Acute Physiology Score was developed and validated in 679 consecutive patients admitted to 8 multi-disciplinary referral ICUs in France in 1983 using 13 weighted physiological variable and age to predict the risk of death in ICU patients [7] (Table 2). Like the APACHE scores, SAPS used the worst values obtained during the first 24 hours of ICU admission. The Simplified Acute Physiology Score performed comparably to the APACHE score and is lauded as being simpler and less time-consuming to compute. Like the APACHE score, it is used to predict mortality for patient subgroups and should not be used for individual prognosis or treatment decisions.

<table>
<thead>
<tr>
<th>Variable SAPS Scale</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
<th>0</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>≥45</td>
<td>46-55</td>
<td>55-65</td>
<td>65-75</td>
<td>&gt;75</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>≥180</td>
<td>140-179</td>
<td>110-139</td>
<td>70-109</td>
<td>55-69</td>
<td>40-54</td>
<td>&lt;40</td>
<td></td>
</tr>
<tr>
<td>Systolic BP</td>
<td>≥190</td>
<td>150-189</td>
<td>100-149</td>
<td>80-149</td>
<td>55-79</td>
<td>&lt;55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>≥39</td>
<td>35.9-39</td>
<td>36.8-39</td>
<td>34-35.9</td>
<td>32-33.9</td>
<td>30-31.9</td>
<td>&lt;30</td>
<td></td>
</tr>
<tr>
<td>Respiratory rate (breaths/min)</td>
<td>≥50</td>
<td>35-49</td>
<td>25-34</td>
<td>12-24</td>
<td>10-11</td>
<td>6-9</td>
<td>&lt;6</td>
<td></td>
</tr>
<tr>
<td>Urine output (L/24h)</td>
<td>&gt;5.0</td>
<td>3.5-4.9</td>
<td>0.7-3.4</td>
<td>0.5-0.6</td>
<td>0.20-0.49</td>
<td>&lt;0.20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood urea (mMol/L)</td>
<td>≥55</td>
<td>54.9-29</td>
<td>39.9-25</td>
<td>35-29</td>
<td>20-29.9</td>
<td>&lt;20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hematocrit (%)</td>
<td>≥50</td>
<td>50-59.9</td>
<td>46-49.9</td>
<td>30-45.9</td>
<td>20-29.9</td>
<td>&lt;20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White blood cell count</td>
<td>≥40</td>
<td>20-39.9</td>
<td>15-19.9</td>
<td>10-14.9</td>
<td>10-2.9</td>
<td>&lt;1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Serum glucose (mMol/L)</td>
<td>≥44.5</td>
<td>28-44</td>
<td>14-27.7</td>
<td>9-13.9</td>
<td>2.8-3.8</td>
<td>1.6-2.7</td>
<td>&lt;1.6</td>
<td></td>
</tr>
<tr>
<td>Serum potassium (mEq/L)</td>
<td>≥7</td>
<td>6-6.9</td>
<td>0.5-5.9</td>
<td>3.5-5.4</td>
<td>3.0-3.4</td>
<td>2.5-2.9</td>
<td>&lt;2.5</td>
<td></td>
</tr>
<tr>
<td>Serum sodium (mEq/L)</td>
<td>≥180</td>
<td>161-179</td>
<td>156-160</td>
<td>151-155</td>
<td>130-150</td>
<td>120-129</td>
<td>110-119</td>
<td>&lt;110</td>
</tr>
<tr>
<td>Serum HCO3 (mEq/L)</td>
<td>≥40</td>
<td>30-39.9</td>
<td>20-29.9</td>
<td>10-10.9</td>
<td>5-9.9</td>
<td>&lt;5.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glasgow coma scale</td>
<td>1-13</td>
<td>12-10</td>
<td>9-7</td>
<td>6-4</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2:** Scoring Values for the 14 Variables of SAPS.

SAPS II was developed in 1993 to provide a method of converting the obtained score to a probability of hospital mortality [8]. It is the most widely used version and like its predecessor, calculates a severity score using the worst values measured during the initial 24 hours of ICU admission for 17 variables (12 physiologic variable, age, type of admission (scheduled surgical, unscheduled surgical, or medical) and 3 underlying dichotomous disease variables (AIDS, metastatic cancer and hematologic malignancy). The physiological variables are continuous variables that have been made categorical by assigning points to a range of values. SAPS II was developed and validated using data from 13,125 patients admitted to 137 adult ICUs in 12 countries. It excluded patients younger than 18 years, burns patients, coronary care unit patients and cardiac surgery [8]. It did however perform well for patients with cardiovascular disease as the primary reason for admission and may be applied to these patients [9]. SAPS II can be entered into a mathematical formula, which predicts hospital mortality. It has excellent discrimination and calibration and may be suitable for use in the intermediate care unit settings [10,11]. Like the APACHE II calculators, SAPS II calculators are freely available online and an example is shown below.

The most updated model – the SAPS III was created in 2005 using complex statistical methods to select and weight variables using a database of 16,784 patients from 303 ICU’s in 35 countries [12]. It includes 20 variables divided into 3 sub-scores related to – patient characteristics prior to ICU admission (age, co-morbidities, use of vasoactive drugs before ICU admission, intra-hospital location and length of hospital stay before ICU admission), circumstances related to ICU admission (reason(s) for ICU admission, planned/unplanned ICU admission, surgical status at ICU admission, anatomic site of surgery and presence of infection at ICU admission) and the degree of physiologic derangement within 1 hour before or after of ICU admission. This is in contrast to all prior models that utilized a 24-hour time window [12]. The total score can range from 0 to 217. Unlike other scores, SAPS 3 includes customized equations for the prediction of hospital mortality in 7 geographical regions – but the sample size in some of the regions was relatively small thus compromising prognostic accuracy. A subsequent study of over 28,000 patients in 147 ICUS in Italy found that the SAPS III has good discrimination but poor calibration [13,14].

**Mortality Prediction Model (MPM)**

In 1985, Lemeshow et al created the first MPM based on multiple logistic regressions modelling of data from 755 patients in 1 ICU over a period of 7 months (Feb 1 to August 15th, 1983) [15]. The goal was to create a predictive model that would be useful for making triage decisions as well as determining aggressiveness of care so as to determine patients who would benefit the most in a world with limited resources. Unlike the APACHE and SAPS scores the weights for the various variables were obtained using Multiple Logistic Regression (MLR) models instead of based off decisions made by a team of experts and the results are therefore expressed as a probability rather than as a score. There were two MLR models – the first based only on admission data and one used at 24 hours when more information is available and response to initial therapy can be incorporated. Each of the models used 7-variables. There were seven-atriac intervention dependent and seven 24-hour variables reflecting treatments and patient’s condition in the ICU. Coronary care, cardiac surgery and burn patients were excluded from the study, as were patients under 14 years of age.
The MPM II was developed in 1993 based off a much larger dataset of 19,124 ICU patients in 12 different countries (Table 3). Like its predecessor, it used logistic regression techniques and consists of 2 scores: MPM\textsuperscript{0}, the admission model, which was expanded to 15 variables; and MPM\textsuperscript{24} the 24-hour model, which contains 5 of the admission variables and 8 additional variables and is designed for patients who stay in the ICU for more than 24 hours. It is to be noted, that in MPM II each variable (except age, which is entered as the actual age in years), is designated as present or absent and given a score of 1 or 0 accordingly. MPM II is the most common version of the MPM. An advantage of the MPMII\textsuperscript{24} is that it can be compared to the SAPS and the APACHE, since all three are determined after the first 24-hours of admission. The MPM II has excellent calibration and discrimination \cite{10,16,17}. More recently, MPM III has been developed using a database of 124,885 patients from 135 ICUs in 98 hospitals (all in North America except for one in Brazil) collected from 2001 to 2004 \cite{18}. MPM\textsuperscript{0}-III uses 16 variables, including 3 physiological parameters obtained within 1 hour of ICU admission to estimate mortality probability at hospital discharge. The MPM24 III is unchanged from the MPM\textsuperscript{24}.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Response</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patient age*</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Medical or unscheduled surgical admission?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Cardiopulmonary resuscitation prior to admission?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Coma (Glasgow coma scale 3-5)?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Heart rate ≥150 bpm?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Systolic blood pressure ≤90 mmHg?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Mechanical ventilation?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Acute renal failure? (Does not include pre-renal azotemia)</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Cardiac dysrhythmias?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Cerebrovascular accident?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Intracranial mass effect?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Gastrointestinal bleeding?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Metastatic carcinoma? (Distant metastases only; does not include local lymph node involvement)</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Cirrhosis?</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td>Chronic renal insufficiency? (Creatinine &gt;2 mg/dL chronically)</td>
<td>Yes</td>
<td>1</td>
</tr>
</tbody>
</table>

*Patient age does not receive points when calculating the severity score; however, it is used in the formula to calculate predicted mortality.

### Table 3: Mortality Prediction Model II (MPM II).

### Comparison of ICU general prediction models

A table summarizing the 3 outcome prediction models is shown below:

<table>
<thead>
<tr>
<th>Score</th>
<th>APACHE</th>
<th>SAPS</th>
<th>APACHEII</th>
<th>MPM</th>
<th>APACHEIII</th>
<th>SAPSII</th>
<th>SAPSIII</th>
<th>APACHEIV</th>
<th>MPMIII</th>
<th>SAPS IV</th>
<th>APACHE V</th>
<th>MPM III</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICUs</td>
<td>2</td>
<td>8</td>
<td>13</td>
<td>1</td>
<td>40</td>
<td>137</td>
<td>140</td>
<td>303</td>
<td>104</td>
<td>135</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients</td>
<td>705</td>
<td>679</td>
<td>5,815</td>
<td>2,783</td>
<td>17,440</td>
<td>12,997</td>
<td>19,124</td>
<td>16,784</td>
<td>110,558</td>
<td>124,855</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variable selection &amp; Weights</td>
<td>Expert panel</td>
<td>Expert Panel</td>
<td>Expert Panel</td>
<td>MLR</td>
<td>MLR</td>
<td>MLR</td>
<td>MLR</td>
<td>MLR</td>
<td>MLR</td>
<td>MLR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Variables</td>
<td>34</td>
<td>14</td>
<td>17</td>
<td>11</td>
<td>26</td>
<td>17</td>
<td>15</td>
<td>20</td>
<td>142</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mortality Prediction</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

There have been a number of studies examining the difference in accuracy between various second-generation ICU mortality prediction models (Table 4). A summary of four prospective, large, multicenter studies is shown in table 5 below. Discrimination refers to the ability of the model to separate those patients predicted to live from those patients predicted to die and is measured using the area under the receiving operating characteristic curve. Tossing a coin to classify patients as dead or alive would produce an area under the receiver operating characteristic curve (AUC ROC) of 0.50. As a general rule, the greater the AUC ROC, the better the discriminatory capability of the model. A model is considered to discriminate well when this area is >0.8. The AUC ROC also measures the specificity and sensitivity of a prediction method, with an AUC of 1.0 being perfectly sensitive and specific. Calibration refers to the ability of a model to describe the mortality pattern in the data is evaluated based on goodness-of-fit by the Hosmer-Lemeshow chi-square statistic. Lower
The LODS was developed in 1996, using a database of 13,152 admissions to 137 ICUs in 12 countries [26]. Using multiple logistic regressions, 12 variables were selected to represent the function of six organ systems (neurologic, cardiovascular, renal, hepatic, hematologic, and hepatic). The worst value for each variable in the first 24 hours of admission is recorded, and for each system, a score of 0 (no dysfunction) to 5 (maximum dysfunction) is awarded. Unlike the MODS and SOFA scores, LODS is a weighted system: for the respiratory and coagulation systems, the maximum score allowed is 3, and for the liver (neurologic, cardiovascular, renal, pulmonary, hematologic, and hepatic). The worst value for each variable in the first 24 hours of admission is recorded, and for each system, a score of 0 (no dysfunction) to 5 (maximum dysfunction) is awarded. Unlike the MODS and SOFA scores, LODS is a weighted system: for the respiratory and coagulation systems, the maximum score allowed is 3, and for the liver the maximum score is 1. LODS values, therefore, can range from 0 to 22. The LODS lies somewhere between a mortality prediction score and an organ failure score as it combines a global score summarizing the total degree of organ dysfunction across the organ systems, and a logistic regression equation that can be used to convert the score into a probability of mortality. Within organ systems, greater severity of organ dysfunction varies widely among individuals and within an individual over time. Organ failure scores must therefore be able to take both time and severity into account [1]. Many organ dysfunction scores have been developed over the past few decades, but we will limit our discussion to three of the scores most commonly used in general ICU patients:

1. Logistic Organ Dysfunction System (LODS) [26]
2. Multiple Organ Dysfunction Score (MODS) [27]
3. Sequential Organ Failure Assessment (SOFA) [28]

**Logistic Organ Dysfunction Score (LODS):** The LODS was developed in 1996, using a database of 13,152 admissions to 137 ICUs in 12 countries [26]. Using multiple logistic regressions, 12 variables were selected to represent the function of six organ systems (neurologic, cardiovascular, renal, pulmonary, hematologic, and hepatic). The worst value for each variable in the first 24 hours of admission is recorded, and for each system, a score of 0 (no dysfunction) to 5 (maximum dysfunction) is awarded. Unlike the MODS and SOFA scores, LODS is a weighted system: for the respiratory and coagulation systems, the maximum score allowed is 3, and for the liver the maximum score is 1. LODS values, therefore, can range from 0 to 22. The LODS lies somewhere between a mortality prediction score and an organ failure score as it combines a global score summarizing the total degree of organ dysfunction across the organ systems, and a logistic regression equation that can be used to convert the score into a probability of mortality. Within organ systems, greater severity of organ dysfunction was consistently associated with higher mortality [1,29], and a LODS of 22 was associated with a mortality of 99.7% [26]. The LODS was not initially validated for repeated use during the ICU stay, but in a study of 1,685 patients in French ICUs, the LODS of organ dysfunction was consistently associated with higher mortality [1,29], and a LODS of 22 was associated with a mortality of 99.7% [26]. The LODS was not initially validated for repeated use during the ICU stay, but in a study of 1,685 patients in French ICUs, the LODS was accurate in characterizing the progression of organ dysfunction during the first week of ICU stay [30].

**Multiple Organ Dysfunction Score (MODS):** The development of the MODS in 1995 was based on a literature review of 30 publications that had characterized organ dysfunction [27,31]. Seven organ systems were then selected for further consideration (respiratory, cardiovascular, renal, hepatic, hematologic, central nervous system, gastrointestinal), and variables for each organ system were chosen according to a set of ‘ideal descriptor’ criteria (Table 4). No accurate descriptor of gastrointestinal function could be identified, so this system was not included in the final model. For the cardiovascular system, Marshall and colleagues [27] created a composite variable, the pressure-adjusted heart rate (heart rate × central venous pressure/mean arterial pressure); in patients without a central line, this variable is assumed to be normal. For each of the six organs, the first parameters of the day are used to calculate the score and a score of 0 (normal) to 4 (most dysfunction) is awarded, giving a total maximum score of 24. The score was developed in 336 patients admitted to one surgical ICU and validated in 356 patients admitted to the same ICU [27]. Although not designed to predict ICU mortality, increasing MODS values do correlate with ICU outcome. ICU mortality also increases with increasing numbers of failing organ systems [27,32]. The delta MODS, defined as the difference between the MODS at admission and the maximum score, may be more predictive of outcome than individual scores [27]. Tables 6 show the variables for the MODS score.
Table 6: The Multiple Organ Dysfunction Score (MODS) score.

Sequential Organ Failure Assessment (SOFA): The SOFA system (Table 7) was developed in a consensus meeting of the European Society of Intensive Care Medicine in 1994 [33] and further revised in 1999. The SOFA is a six-organ dysfunction/failure score measuring multiple organ failure daily. The Six organ systems (respiratory, coagulation, cardiovascular, renal, hepatic, CNS) were selected based on a review of the literature. The function of each organ system is scored from 0 (normal function) to 4 (most abnormal), giving a possible score of 0 to 24. The objective in the development of the SOFA was to create a simple, reliable and continuous easily obtainable score that would be used to describe a sequence of complications in the critically ill and NOT primarily to predict outcome.

Table 7: The Sequential Organ Failure Assessment (SOFA) Score.

Unlike the MODS score in which the first value of each day is used, the SOFA uses the worst value on each day. In addition, for the cardiovascular component, the SOFA uses a treatment-related variable (dose of vasopressor agents) instead of a calculated composite variable. This is not ideal, as treatment protocols vary among institutions and among patients and over time, but it is difficult to avoid, especially for the cardiovascular system [1]. The Mean total maximum SOFA score presented a very good correlation to ICU outcome, with mortality rates ranging from 3.2% in patients without organ failure to 91.3% in patients with failure of all the six organs analyzed [34]. The total maximum SOFA score (AUROC=0.847) and the delta SOFA score (AUROC = 0.742) can be used to quantify the cumulative insult suffered by the patient by comparing the degree of dysfunction/organ failure present on ICU admission to that developing while in the ICU [35,36]. In a prospective analysis of 1,449 patients, a maximum total SOFA score greater than 15 correlated with a mortality rate of 90% [34]. In a prospective study of 352 ICU patients, an increase in SOFA score by about 30% during the first 48 hours in the ICU, predicted a mortality rate of at least 50%, while a decrease was associated with an ICU mortality rate of just 27% [35] The SOFA scores are calculated 24 hours after admission to the ICU and every 48 hours thereafter. The mean and highest scores are most predictive of mortality [36]. Several online SOFA calculators are available.

Comparison of the three organ dysfunction scores

A table (Table 8) comparing the characteristics of the 3-major organ dysfunction scores are shown below.

Table 8: Comparing the characteristics of the major Organ Dysfunction Scores.

Several studies have directly compared the performance the various organ dysfunction scoring systems. Pettì and colleagues [37] reported comparable discriminative power of LDS, SOFA, and MODS to predict hospital mortality in a single centre study. Peres Bota and colleagues [38] reported no significant differences between MODS and SOFA for mortality prediction in 949 general ICU patients. In a multicenter study, Timsit and colleagues [30] reported good accuracy and internal consistency for both the SOFA and LODS. However, in a more recent Canadian study of 1,436 ICU patients [39,40], SOFA and MODS had only a modest ability to predict hospital and ICU mortality. Table 9 outlining these studies is shown below.
### Severity assessment based on nursing workload use

Scoring systems based on nursing workload are used mainly to assess nurse staffing and changing nursing needs in the ICU. Although higher scores are associated with worse outcomes, they are neither prognostic nor mortality scores. All the scores are limited by the items included and can be prone to subjective interpretation and influenced by patient case-mix, local admission and discharge policies, and local management protocols. A recent position statement by the European Federation of Critical Care Nursing Associations recommends that all units use such a system on a regular basis to monitor the efficiency of the use of nursing manpower and they have been included in this chapter for this reason.

### Therapeutic Intervention Scoring System (TISS)

TISS was originally developed in 1974 to assess severity of illness and compare patient care based on the measurement of nursing workload [1,41–49]. The original score included 57 therapeutic activities with points assigned for each activity conducted during a 24-hour period. Higher values were given for more specialized or time-consuming activities. In 1983, the score was updated and expanded to include 76 items (TISS-76) but this was criticized for being too time-consuming and cumbersome [42]. TISS-28 was devised in 1996 using advanced statistical analysis and only 28 items, divided into 7 groups: basic activities, ventilatory support, cardiovascular support, renal support, neurological support, metabolic support, and specific interventions [43]. The scoring is weighted to give a total score of 78. TISS-28 was validated in 22 Dutch ICUs and in 19 ICUs in Portugal [42,43]. According to this system, each nurse can provide care for 46.35 TISS-28 points per shift, with each TISS-28 point requiring 10.6 minutes of each nurse’s shift. This information can be useful for planning the allocation of nursing manpower, to evaluate the efficacy in the use of nursing workload use and to objectively classify ICUs based on the amount (and not only the complexity) of care provided [44].

### Nine Equivalents of Nursing Manpower Use Score (NEMS)

In 1997, NEMS was created from the TISS-28 with the aim of creating a simpler system that would be more widely used [1,45]. Nursing activities are separated into nine categories: basic monitoring, intravenous medication, mechanical ventilatory support, supplementary ventilatory care, single vasoactive medication, multiple vasoactive medication, dialysis techniques, specific interventions in the ICU and specific interventions outside the ICU (Table 10). Each of these is awarded weighted points, giving a maximum score of 56. NEMS has been validated in large cohorts of ICU patients and is easy to use with almost no inter-rater variability [46]. Again, this system can be used to evaluate the efficacy of the use of nursing manpower and they have been included in this chapter for this reason.

#### Table 9: Comparison of the hospital mortality prediction Performance of the organ dysfunction scores.

<table>
<thead>
<tr>
<th>Citation</th>
<th>Type of Study</th>
<th>Enrollment Period/Time period</th>
<th># of Patients</th>
<th># of ICU</th>
<th>Country</th>
<th>Setting</th>
<th>AUC ROC (Hospital Mortality Prediction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pettila2002 [37]</td>
<td>Prospective</td>
<td>NA</td>
<td>520</td>
<td>1</td>
<td>Finland</td>
<td>10-bed medical-surgical ICU in tertiary care hospital</td>
<td>0.805</td>
</tr>
<tr>
<td>Peres 2002 [38]</td>
<td>Prospective</td>
<td>Apr-Jul 1999 – Oct-Nov 1999</td>
<td>949</td>
<td>1</td>
<td>Belgium</td>
<td>31-bed University hospital ICU</td>
<td>0.856*</td>
</tr>
<tr>
<td>Timisit 2002 [30]</td>
<td>Prospective</td>
<td>24-months</td>
<td>1685</td>
<td>6</td>
<td>France</td>
<td>Medical/Surgical ICUs</td>
<td>0.728*</td>
</tr>
<tr>
<td>Zygun2005 [39]</td>
<td>Prospective</td>
<td>May 2000 to April 2001</td>
<td>1436</td>
<td>3</td>
<td>Calgary, Canada</td>
<td>3-multi-system ICUs</td>
<td>0.62*</td>
</tr>
</tbody>
</table>

*Initial  
**maximum  
*ICU Day 7

*Please note that Pettilla et al – calculated the MOD score for each day using the worst single value of the day, contrary to the original MOD score as described by Marshall et al [27].

#### Table 10: Nine Equivalents of Nursing Manpower use Score.

<table>
<thead>
<tr>
<th>Item</th>
<th>B coefficients</th>
<th>Points*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basic monitoring: hourly vital signs, regular record and calculation of fluid balance</td>
<td>8.928</td>
<td>9</td>
</tr>
<tr>
<td>2. Intravenous medication: bolus or continuously, not including vasoactive drugs</td>
<td>5.545</td>
<td>6</td>
</tr>
<tr>
<td>3. Mechanical ventilatory support: any form of mechanical/assisted ventilation, with or without PEEP (e.g., continuous positive airway pressure), with or without muscle relaxants</td>
<td>11.559</td>
<td>12</td>
</tr>
<tr>
<td>4. Supplementary ventilatory care: breathingspontaneously through endotracheal tube; supplementary oxygen any method, except if (3)applies</td>
<td>3.415</td>
<td>3</td>
</tr>
<tr>
<td>5. Single vasoactive medication: any vasoactive drug</td>
<td>7.304</td>
<td>7</td>
</tr>
<tr>
<td>6. Multiple vasoactive medication: more than one vasoactive drug, regardless of type and dose</td>
<td>11.664</td>
<td>12</td>
</tr>
<tr>
<td>7. Dialysis techniques: all</td>
<td>5.962</td>
<td>6</td>
</tr>
<tr>
<td>8. Specific interventions in the ICU: such as endotracheal intubation, introduction of pacemaker, cardioversion, endoscopy, emergency operation in the past 24 h, gastric lavage, routine interventions such as X-rays, echocardiography, electrocardiography, dressings, introduction of venous or arterial lines, are not included</td>
<td>5.163</td>
<td>5</td>
</tr>
<tr>
<td>9. Specific interventions outside the ICU: such as surgical intervention or diagnostic procedure; the intervention/procedure is related to the severity of illness of the patient and makes an extra demand upon manpower efforts in the ICU</td>
<td>5.826</td>
<td>6</td>
</tr>
</tbody>
</table>

* Coefficients are rounded off to the nearest integer.

### Nursing Activities Score (NAS)

In 2003, the Nursing Activities Score (NAS) was created from the TISS-28 to reflect nursing work-load in an intensive care unit as a function of average time consumption instead of severity of illness [47]. It includes a total of five new items and 14 sub items describing...
nursing activities in the ICU (e.g. monitoring, care of relatives, administrative tasks) [47]. The list of items was developed by consensus and the average time consumption of the activities was determined from a 1-week observational cross-sectional study in a cohort of 99 ICUs in 15 countries. The new activities accounted for 60% of the average nursing time; and in the development study, NAS activities accounted for 81% of the nursing time (versus 43% in TISS-28) [47].

**Pain, Agitation/Sedation Delirium (PAD) care bundle scores and ICU checklists**

Everyday care in ICU can be daunting, challenging and labor intensive. Majority of the patients are intubated, sedated and otherwise unable to communicate their needs. Scoring systems and checklists are therefore needed to be sure that our patients are comfortable, adequately sedated, pain free and meeting treatment goals. The PAD Care bundle refers to the Pain, Agitation and Delirium care bundle that was created to facilitate proper implementation of the PAD care Guidelines [50]. The central tenet of the bundle is to emphasize the importance of the prompt and proper management of pain, agitation/sedation and delirium in the ICU in an integrated and interdisciplinary fashion. The PAD bundle links appropriate detection, management and prevention of pain, agitation/sedation and delirium to the success of other evidence-based ICU practices such as Spontaneous Awakening Trials (SAT), Spontaneous Breathing Trials (SBTs), Early Mobility Protocols ad ICU sleep hygiene programs. The guideline provides strong recommendations for the following:

1. Use valid and reliable tools for detecting pain, depth of sedation/agitation and presence or absence of delirium in critically ill patients.
2. Screen all ICU patients routinely (at least four times per shift or every 2 to 3 hours minimum) for Pain, agitation/sedation and for delirium.
3. Adopt a stepwise approach, beginning with assessment, treatment and then prevention.
4. Assess and treat pain first before giving sedatives.
5. Maintain a light level of sedation that allows the ICU patient to interact in a meaningful way with the environment without agitation.
6. Prevent and treat delirium using both non-pharmacologic and pharmacologic strategies.

**Pain**

Most ICU patients experience significant pain at some point in their ICU stay and it can be a great source of stress and distress. Pain in the ICU can trigger a significant stress response leading to hemodynamic instability, impaired wound healing, poor glycemic control and increased risk of infection. Pain also has significant short and long term psychological consequences in the ICU including sleep deprivation, higher likelihood of developing chronic pain, Post Traumatic Stress Disease syndromes and lower health-related Quality of Life post ICU discharge. ICU procedures can be a significant source of pain and patients should receive routine pre-procedural analgesia. Patient self-reporting of pain using a Numerical Rating Scale (NRS such as a Likert scale as shown) is the goal standard for pain assessment (Table 11). The majority of ICU patients are however unable to self-report and need to be actively accessed for pain using behavioral pain scales (BPSs). It is to be noted, that although often used, reliance on vital signs is not sufficient to detect the presence of or the absence of pain [50,51]. A rigorous psychometric analysis of six BPSs included in the PAD guidelines found that the BPS (Table 11) and the Critical-Care Pain Observation Tool (CPOT) (Table 12) are the most valid and reliable for use in ICU patients who are unable to self-report [51]. A recently updated psychometric analysis of eight BPSs, including studies published since 2010, came to a similar conclusion [52]. The BPS uses three domains (facial expression, posture of the upper limbs and compliance with ventilation) to assess pain in critically ill intubated patients who are unable to self-report [53]. The CPOT uses four domains with a potential score of 0 to 2 in each domain (Table 12).

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial Expression</td>
<td>Relaxed</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Partially tightened (e.g. brow lowering)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Fully tightened (e.g. eyelid closing)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Grimacing</td>
<td>4</td>
</tr>
<tr>
<td>Upper Limbs</td>
<td>No movement</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Partially bent</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Fully Bent with finger flexion</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Permanently retracted</td>
<td>4</td>
</tr>
<tr>
<td>Compliance with ventilation</td>
<td>Tolerating movement</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Coughing but tolerating ventilation for most of the time</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Fighting ventilator</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Unable to control ventilation</td>
<td>4</td>
</tr>
</tbody>
</table>

Scores from each of the three domains are summed, with a total score of 3 to 12

**Table 11: Behavioral Pain Scale (BPS).**

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facial Expression</td>
<td>No muscular tension observed</td>
<td>Relaxed, neutral</td>
</tr>
<tr>
<td></td>
<td>Presence of frowning, brow lowering, orbit tightening, and levator contraction</td>
<td>Tense</td>
</tr>
<tr>
<td></td>
<td>All of the above facial movements plus eyelid tightly</td>
<td>Grimacing</td>
</tr>
<tr>
<td>Body Movements</td>
<td>Does not move at all (does not necessarily mean absence of pain)</td>
<td>Absence of movements</td>
</tr>
<tr>
<td></td>
<td>Slow, cautious movements, touching or rubbing the pain site, seeking attention through movements</td>
<td>Protection</td>
</tr>
<tr>
<td></td>
<td>Pulling tube, attempting to sit up, moving limbs/ thrashing, not following commands, striking at staff, trying to climb out of bed</td>
<td>Restlessness</td>
</tr>
</tbody>
</table>

The majority of ICU patients are however unable to self-report and need to be actively accessed for pain using behavioral pain scales (BPSs). It is to be noted, that although often used, reliance on vital signs is not sufficient to detect the presence of or the absence of pain [50,51]. A rigorous psychometric analysis of six BPSs included in the PAD guidelines found that the BPS (Table 11) and the Critical-Care Pain Observation Tool (CPOT) (Table 12) are the most valid and reliable for use in ICU patients who are unable to self-report [51]. A recently updated psychometric analysis of eight BPSs, including studies published since 2010, came to a similar conclusion [52]. The BPS uses three domains (facial expression, posture of the upper limbs and compliance with ventilation) to assess pain in critically ill intubated patients who are unable to self-report [53]. The CPOT uses four domains with a potential score of 0 to 2 in each domain (Table 12).
Agitation/Sedation

Agitation and anxiety occur frequently in critically ill patients and can lead to adverse outcomes [51,55-57]. Common causes of agitation and anxiety include pain, delirium, hypoxia, hypoglycemia, hypotension and withdrawal from alcohol and drugs [50,51,55-57]. Prompt identification and treatment of cause is of utmost importance although not often done. The PAD guidelines strongly recommend the use of a valid and reliable sedation scoring system to routinely assess depth of sedation and agitation in ICU patients, and the results of these sedation/agitation assessments should provide the basis for the use of sedatives in critically ill patients [50,51]. The PAD guidelines define pain as being present and needing to be addressed if:

1. Patients self report pain of four or more on the Numerical Rating Scale (NRS 0 to 10).
2. Six or more on the Behavioral Pain Scale (BPS 3-12 scale).
3. Three or more on the Critical Care Pain Observation Tool (CPOT 0-8 scale).

The PAD guidelines included a rigorous psychometric analysis of 10 sedation scales and concluded that the Richmond Agitation-Sedation Scale (RASS) and Sedation-Agitation Scale (SAS) are the most valid and reliable sedation assessment tools for measuring quality and depth of sedation in adult ICU patients. The Depth of sedation in patients using either of these Scales is defined in tables 13 and 14. The RASS scale uses 10 discrete levels to define depth of sedation and agitation, ranging from -5 (unarousable) to +4 (combative) [58]. The Sedation-Agitation Scale (SAS) has seven discrete levels ranging from 1 (unarousable) to 7 (dangerously agitated) [59]. Agitation is termed if the RASS is +1 to +4 or SAS = 5 to 7; awake and calm if RASS = 0 or SAS = 4; lightly sedated if RASS = –1 to –2 or SAS = 3; and deeply sedated if RASS = -3 or SAS = 1 to 2. The guidelines recommend that critically ill patients, who need sedation, be maintained in a state of light sedation where they can have meaningful interaction with the environment without any agitation.

<table>
<thead>
<tr>
<th>Score</th>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>+4</td>
<td>Combative</td>
<td>Overtly combative or violent, immediate danger to staff</td>
</tr>
<tr>
<td>+3</td>
<td>Very agitated</td>
<td>Pulls on or removes tubes or catheters; exhibits aggressive behavior to staff</td>
</tr>
<tr>
<td>+2</td>
<td>Agitated</td>
<td>Frequent non-purposeful movement or patient-ventilator dys-synchrony</td>
</tr>
<tr>
<td>+1</td>
<td>Restless</td>
<td>Anxious or apprehensive, but movements are not aggressive or vigorous</td>
</tr>
<tr>
<td>0</td>
<td>Alert, calm</td>
<td>Not fully alert, but has sustained awakening with eye contact to voice</td>
</tr>
<tr>
<td>-1</td>
<td>Drowsy</td>
<td>Briefly (&lt;10 seconds) awakens with eye contact to voice</td>
</tr>
<tr>
<td>-2</td>
<td>Light sedation</td>
<td>Any movement (no eye contact to voice)</td>
</tr>
<tr>
<td>-3</td>
<td>Moderate sedation</td>
<td>Any movement (no eye contact to voice)</td>
</tr>
<tr>
<td>-4</td>
<td>Deep sedation</td>
<td>No response to voice, but any movement on physical examination</td>
</tr>
<tr>
<td>-5</td>
<td>Unarousable</td>
<td>No response to voice or physical stimulation</td>
</tr>
</tbody>
</table>

Delirium

Delirium is characterized by the acute onset of cerebral dysfunction, with a change or fluctuation in baseline mental status, inattention,
and either disorganized thinking or an altered level of consciousness [59-64]. Patients with delirium may either be agitated (i.e., hyperactive delirium), calm or lethargic (i.e., hypoactive delirium), or may fluctuate between the two subtypes. Hyperactive delirium is more often associated with hallucinations and delusions, whereas hypoactive delirium is more often characterized by confusion and sedation and is often undetected [50]. Delirium occurs commonly in critically ill patients. It is estimated that up to 80% of critically ill patients develop delirium during their ICU stay [63,65,66]. The presence of delirium in ICU patients is associated with significant negative outcomes, including prolonged duration of mechanical ventilation [67], prolonged hospital LOS [63,66,68], post discharge institutionalization [69], long-term cognitive dysfunction [70,71], an increased risk of death [66], and higher costs of care [72]. Hypoactive delirium occurs much more commonly than hyperactive delirium in ICU patients and is associated with a longer duration of mechanical ventilation and ICU LOS and a higher mortality risk than hyperactive delirium [73-77]. Reliable detection and diagnosis of delirium is essential for delirium treatment and for improving delirium-related ICU outcomes. The PADD guidelines included a rigorous psychometric analysis of five delirium monitoring tools and concluded that the CAM-ICU [63] and the Intensive Care Delirium Screening Checklist (ICDSC) [64] are the most valid and reliable delirium monitoring tools for use in adult ICU patients (Figure 2). A patient is considered delirious if they are either CAM-ICU positive or their ICDSC score is greater than or equal to 4 (ICDSC Scale range = 0 to 8).

![Figure 2: Intensive Care Delirium Screening Checklist (ICDSC).](image)

**VAP and Ventilator Bundle Compliance Checklists**

Ventilator-associated pneumonia (VAP) continues to be a common and potentially fatal complication of mechanically ventilated patients in the ICU [78]. Intubation impedes the body’s natural defense against respiratory infections. The placement of an Endotracheal Tube (ETT) negates effective cough reflexes that protect the airway from invasive pathogens. An ETT also prevents mucociliary clearance of secretions and depresses epiglottic reflexes thus allowing the leakage of virulent bacteria (either from excess secretions or from aspirated esophageal or gastric contents) that pool around the inflated ETT cuff to infiltrate the lungs and cause pneumonia [79]. VAP is responsible for 90% of nosocomial infections in the ICU and is the leading cause of death amongst hospital-acquired infections, exceeding the rate of death from central line infections, severe sepsis and respiratory tract infections in non-intubated patients. VAP is a major health care burden in terms of mortality, escalating health care costs and increased length of ventilator, ICU and hospital days [78,79]. Hospital mortality of ventilated patients who develop VAP is 46% compared to 32% for ventilated patients who do not develop VAP [80,81]. VAP can occur early or late during a patient’s course of intubation and mechanical ventilation. Early onset VAP occurs within 48 to 96 hours of intubation [78,80] and the most common pathogens include *Streptococcus pneumoniae*, *Haemophilus influenzae*, and *Moraxella catarrhalis*. Late-onset VAP occurs 5 or more days after intubation and the common causative pathogens include *Staphylococcus aureus*, *Acinetobacter baumannii*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, and *Enterobacter* [80].

The Key components of the Institute for Healthcare Improvement (IHI) Ventilator Bundle are [82]:

1. Elevation of the head of the bed to 30 to 45 degrees
2. Daily sedation vacations and assessment of readiness to extubate
3. Peptic Ulcer disease prophylaxis
4. Deep Venous thrombosis prophylaxis
5. Daily oral Care with chlorhexidine

Implementation of these strategies has been shown in several studies to decrease the incidence of VAP. Other CDC recommended strategies for prevention of VAP that may be built into checklists for ease of bedside implementation include [83]:

- New ventilator circuits for each patient, with changes recommended only if the circuits become soiled or damaged. There is no indication for routine circuit changes.
- Use a closed endotracheal suctioning system (in-line suctioning system)
- Use of continuous sub-glottic suctioning in patients expected to be mechanically ventilated > 72 hours
- Washing of hands before and after contact with each patient.

Conclusions

General illness severity scores are widely used in the ICU to predict outcome, characterize disease severity, assess degree of organ dysfunction and evaluate resource use. They are also being increasingly used in clinical trials for case-mix comparisons and to ensure equivalence of control and intervention groups. An ideal scoring system should first measure an important outcome and in addition, should have excellent calibration and discrimination. Discrimination describes the accuracy of a given prediction and Calibration describes how an instrument performs over a wide range of predicted mortalities.

All the scoring systems were developed in mixed groups of adult ICU patients with exclusion of certain groups of patients including burns patients and post-cardiac surgery patients. Care should be taken not to apply these scores to patient groups not included in the development or validation cohorts. As ICU populations’ change and new diagnostic, therapeutic and prognostic techniques become available; the scoring systems do not perform as well and need to be updated. Different scoring systems have different purposes and measure different parameters and should be seen as complementing each other, rather than competing with one another. For example, outcome prediction models cannot be used to assess the severity of individual organ dysfunctions or to monitor patient progress over time. Although organ dysfunction scores correlate with outcomes, this is not what they were developed for and outcome prediction should be left to scores such as the APACHE and SAPS systems [1]. The workload scores complete the picture by offering information on how the patient’s disease will impact on staffing requirement and resource use.

It is to be emphasized that scoring systems were developed in groups of patients and should not replace individualized patient care and decision making in the ICU. Critical care checklists targeting pain control, depth of sedation and presence or absence of delirium is crucial to overall care and improved outcomes in critically ill patients.

References


82. Implement the IHI Ventilator Bundle (2011) Institute for Healthcare Improvement, USA.

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**UPCOMING TIF PUBLICATIONS**

- Community Awareness Booklets on α-thalassaemia, β-thalassaemia & Sickle Cell Disease (Greek) (Eleftheriou A)
- Sickle Cell Disease: A booklet for parents, patients and the community, 2nd Edition (Inati-Khoriaty A)

Please visit our website at [http://www.thalassaemia.org.cy/list-of-publications](http://www.thalassaemia.org.cy/list-of-publications)