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# NURSING CONSIDERATIONS OF SCORING SYSTEMS IN THE CRITICALLY ILL PATIENTS

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**Abstract:**

General illness severity scores are widely used in the ICU to predict outcome, characterize disease severity and degree of organ dysfunction, and assess resource use. In this article we review the most commonly used scoring systems in each of these three groups. We examine the history of the development of the initial major systems in each group, discuss the construction of subsequent versions, and, when available, provide recent comparative data regarding their performance. Importantly, the different types of scores should be seen as complementary, rather than competitive and mutually exclusive. It is possible that their combined use could provide a more accurate indication of disease severity and prognosis. All these scoring systems will need to be updated with time as ICU populations change and new diagnostic, therapeutic and prognostic techniques become available.

**Keywords:** Sequential Organ Failure, Assessment Sequential Organ Failure, Assessment Score Simplify, Acute Physiology Score Nursing, Workload Therapeutic Intervention Scoring System

**Introduction:**

Scoring systems used in critically ill patients can be broadly divided into those that are specific for an organ or disease (for example, the Glasgow Coma Scale (GCS)) and those that are generic for all ICU patients. In this article, we focus on the generic scores, which can broadly be divided into scores that assess disease severity on admission and use it to predict outcome (for example, Acute Physiology and Chronic Health Evaluation (APACHE), Simplified Acute Physiology Score (SAPS), Mortality Probability Model (MPM)), scores that assess the presence and severity of organ dysfunction (for example, Multiple Organ Dysfunction Score (MODS), Sequential Organ Failure Assessment (SOFA)), and scores that assess nursing workload use (for example, Therapeutic Intervention Scoring System (TISS), Nine Equivalents of Nursing Manpower Use Score (NEMS)). The objective of this review is to give the intensivist without any particular knowledge or expertise in this area an overview of the current status of these instruments and their possible applications. For a more detailed explanation of the development, application and limitations of these models, the reader is referred to a recent review [1].

The healthcare industry recognizing the need for communication between information technology personnel and healthcare practitioners in order to address the issues of patient care, created nurse informatics specialist positions. Nurse informatics specialists are an integral part of the healthcare delivery process and a deciding factor in the selection, implementation and evaluation of healthcare, which supports safe, high-quality and patient-centered care. Nursing informatics is a specialty that integrates nursing science and computer science to manage and communicate data, information and knowledge in nursing practice. Nursing informatics can also be defined as any use of information technology by nurses for the purpose of enhanced patient outcomes, the management of healthcare facilities, nurse education and nursing research [2].

**2. Outcome prediction scores**

The original outcome prediction scores were developed more than 25 years ago to provide an indication of the risk of death of groups of ICU patients; they were not designed for individual prognostication. Patient demographics, disease prevalence, and intensive care practice have changed considerably since [2], and statistical and computational techniques have also progressed. As a result, all three of the major scores in this category have been recently updated to ensure their continued accuracy in today's ICU[3]**.**

**3. Acute Physiology and Chronic Health Evaluation**

The original APACHE score was developed in 1981 to classify groups of patients according to severity of illness and was divided into two sections: a physiology score to assess the degree of acute illness; and a preadmission evaluation to determine the chronic health status of the patient [3]. In 1985, the original model was revised and simplified to create APACHE II [4], now the world's most widely used severity of illness score. In APACHE II, there are just 12 physiological variables, compared to 34 in the original score. The effects of age and chronic health status are incorporated directly into the model, weighted according to their relative impact, to give a single score with a maximum of 71. 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 is 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. The reason for ICU admission is, therefore, an important variable in predicting mortality, even when previous health status and the degree of acute physiological dysfunction are similar [4].

APACHE III was developed in 1991 [5] and was validated and further updated in 1998 [6]. Equations for predicting risk-adjusted ICU length of stay were also developed using the APACHE III model [7]. Most recently, APACHE IV was developed using a database of over 100,000 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 [8]. APACHE IV again provides ICU length of stay prediction equations, which can provide benchmarks for the assessment and comparison of ICU efficiency and resource use [9].

**4. Simplified Acute Physiology Score**

SAPS, developed and validated in France in 1984, used 13 weighted physiological variables and age to predict risk of death in ICU patients [10]. Like the APACHE scores, SAPS was calculated from the worst values obtained during the first 24 hours of ICU admission. In 1993, Le Gall and colleagues [11] used logistic regression analysis to develop SAPS II, which includes 17 variables: 12 physiological variables, age, type of admission, and 3 variables related to underlying disease. The SAPS II score was validated using data from consecutive admissions to 137 ICUs in 12 countries[11].

In 2005, a completely new SAPS model, the SAPS 3, was created. Complex statistical techniques were used to select and weight variables using a database of 16,784 patients from 303 ICUs in 35 countries [12]. The SAPS 3 score includes

20 variables divided into three sub-scores related to patient characteristics prior to admission, the circumstance of the admission, and the degree of physiological derangement within 1 hour (in contrast to the 24-hour time window in the SAPS II model) before or after ICU admission. The total score can range from 0 to 217. Unlike the other scores, SAPS 3 includes customized equations for prediction of hospital mortality in seven geographical regions: Australasia; Central, South America; Central, Western Europe; Eastern Europe; North Europe; Southern Europe, Mediterranean; and North America. It should be noted that the sample size for development of some of these equations was relatively small, which may compromise their prognostic accuracy. The SAPS 3 score has been shown to exhibit good discrimination, calibration, and goodness of fit [12]. SAPS 3 has also been used to examine variability in resource use between ICUs using the standardized resource use parameter based on the length of stay in the ICU adjusted for severity of acute illness [13].

**5. Mortality Probability Model**

The first MPM, developed from data from patients in one ICU, consisted of an admission model using seven admission variables, and a 24-hour model using seven 24-hour variables [14]. A revised MPM, MPM II, was developed in 1993 using logistic regression techniques on a large database of 12,610 ICU patients from 12 countries [15]. MPM II also consists of two scores: MPM0, the admission model, which contains 15 variables; and MPM24 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. Unlike the APACHE and SAPS systems where variables are weighted, 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. A logistic regression equation is then used to provide a probability of hospital mortality. The authors also developed a Weighted Hospital Days scale (WHD-94) by subjectively assigning weights to days in the ICU and to hospital days after ICU discharge from the first ICU stay, and an equation to predict an ICU's mean WHD-94, thus providing an index of resource utilization [16].

MPM0 has recently been updated using a database of 124,885 patients from 135 ICUs in 98 hospitals (all in North America except for one in Brazil) collected in 2001 to 2004 [17]. MPM0-III uses 16 variables, including 3 physiological parameters, obtained within 1 hour of ICU admission to estimate mortality probability at hospital discharge; the MPM0 characterization is, therefore, based on patient condition largely before ICU care begins. The WHD-94 predictive equation has also been updated [18].

**6. Organ dysfunction scores**

Organ failure scores are primarily designed to describe the degree of organ dysfunction rather than to predict survival. The severity of organ dysfunction varies widely among individuals and within an individual over time and organ failure scores must be able to take both time and severity into account. 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: the Logistic Organ Dysfunction System (LODS) [19], MODS [20], and SOFA[21]

**7. Logistic Organ Dysfunction Score**

The LODS was developed using a database of 13,152 admissions to 137 ICUs in 12 countries [22]. Using multiple logistic regression, 12 variables were selected to represent the function of six organ systems (neurologic, cardiovascular, renal, pulmonary, hematologic, 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 [23], and a LODS of 22 was associated with a mortality of 99.7% [24]. 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 [25].

**8. Multiple Organ Dysfunction Score**

The development of the MODS was based on a literature review of 30 publications that had characterized organ dysfunction [26]. Seven organ systems were then selected for further consideration (respiratory, cardiovascular, renal, hepatic, hematological, central nervous system, gastrointestinal), and variables for each organ system were chosen according to a set of 'ideal descriptor' criteria. No accurate descriptor of gastrointestinal function could be identified, so this system was not included in the final model. For the cardiovascular system, 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 [28]. ICU mortality also increases with increasing numbers of failing organ systems [29]. 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 [30].

**5. Conclusion**

General illness severity scores are widely used in the ICU to assess resource use, predict outcome, and characterize disease severity and degree of organ dysfunction. All the scores were developed to be used in mixed groups of ICU patients and their accuracy in subgroups of patients can be questioned; disease-specific scoring systems are increasingly being developed. As ICU populations change and new diagnostic, therapeutic and prognostic techniques become available, all the scoring systems will need to be updated. Importantly, the different scoring systems have different purposes and measure different parameters; we believe they 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. When used together, these three approaches could provide a more accurate indication of disease severity and prognosis, which could be of help both to the clinician in charge of the patient and to the manager involved in resource allocation and performance assessment.

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