Journal of Critical Care (2007) **22**, 184–190

ELSEVIER

Journal of Critical Care

# Methodological approach for the evaluation of the performances of medical intensive care units

**Hervé Hubert PhD[a,*], Comlavi Guinhouya PhD[a], Laurent Castra MSc[a], Stéphane Soubrier MD, MSc[a,b], Christian Vilhelm PhD[a], Pierre Ravaux PhD[a], Mohamed Lemdani PhD[a], Alain Durocher MD, PhD[a,b], Fabienne Saulnier MD, PhD[a,b]**

[a]*EA 3614 LEM-MOSCADES, Institute of Engineering in Health of Lille (ILIS), University of Lille 2, 59120 Loos, France*
[b]*Emergency Respiratory, Medical Intensive Care and Hyperbaric Unit, Calmette Hospital, 59037 LILLE cedex, France*

**Keywords:**
Intensive care units;
Economic performance;
Resource consumption;
Simplified Acute Physiology Score version 2

**Abstract**

**Purpose:** The purpose of the study was to present a methodological approach enabling the comparison of clinical and economic performances of intensive care units and a graphical visualization based on these 2 dimensions.

**Patients and Methods:** A retrospective analysis of a database of 666 patients admitted in intensive care units over a period of 2 consecutive months.

**Results:** Calculation of clinical performance is based on the difference between the mortality observed and forecast from the Simplified Acute Physiology Score version 2. The evaluation of resource consumption is carried out from the measure of medical and paramedical care workload. These 2 scores are modeled on the basis of the length of stay and the severity state of the patient. The economic performance is calculated on the basis of the difference between the resource consumption observed and forecast. The graphs are constructed by taking up as coordinates the values of the clinical and economic performances of each center.

**Conclusion:** These graphs enable the identification of the most deviating intensive care units to study, for example, their organizational, technical, or human resource setup accounting for their position.


## 1. Introduction

*Intensive care* can be defined as the medical speciality that brings into operation the set of techniques making it possible to compensate for the failure of many vital functions. Therefore, intensive care can be designed as the subject dealing with the maintenance of patients' lives. Taking into care the "most serious" patients requires the use of substantial resources in terms of structures, technical platforms, and personnel. Indeed, it is estimated that personnel costs account for more than 70% of the total costs. The corollary to patients' severity state is a relatively high mortality rate observed in these units.

The significant specificity of intensive care, from the viewpoint of evaluating its activity, is that it is one of the rare medical areas where mortality seems to be a good indicator for assessing its outcome. At least, it is coherent as regards the objective of this activity of maintaining life.

* Corresponding author. Tel.: +33 03 20623737; fax: +33 03 20623738.
*E-mail address:* herve.hubert@univ-lille2.fr (H. Hubert).

0883-9441/$ – see front matter © 2007 Elsevier Inc. All rights reserved.
doi:10.1016/j.jcrc.2006.11.007

Capturing this triple aspect—patients' characteristics, resource consumption, and outcome obtained—is the necessary condition for moving from the evaluation of the "outcome" to the comparison of performances.

The idea of clinical performance in intensive care has been largely explored, especially by works dealing with the calculation of the forecast mortality rate based on severity score [1-3] and with the comparison between the mortality forecast and the mortality observed [4-7]. However, we cannot appreciate global performances solely from the ratio of mortality forecast to observed. We cannot ignore the resources harnessed [8]. Some authors [9,10] have related mortality (evaluated by the Acute Physiology and Chronic Health Evaluation severity index) to the length of stay (LOS). Moreover, Stanley Lemeshow's [11] team has proposed to graphically relate a Standardized Clinical Performances Index (SCPI), based on the calculation of the difference between the forecast and observed mortality, to a Standardized Resource Consumption Index, calculated solely from the LOS in hospital. However, considering the LOS as the main determinant of resources harnessed is probably very inappropriate. This is why we propose to complete these first approaches by using medical and paramedical care workload to evaluate resources harnessed. Moreover, we propose to introduce the idea of economic performance by modeling the resource consumption and comparing the level of resources forecast with the one observed. The idea is to create a Standardized Resource Performance Index (SRPI) that we will relate to the SCPI.

The aim of this study was to provide a methodological framework enabling the creation of a graphical system for the comparison of performances of intensive care units (ICUs). We will comment on the way those graphs could be used. Therefore, our objective is to lay the basis for an evaluative approach to intensive care. However, the resulting models should not be generalized.

## 2. Patients and methods

### 2.1. Study population

For this study, we used past data from a Clinical Research Hospital Programme (CRHP 1994 no. 5366 [12]) whose patients' inclusion phase spanned from December 1994 to September 1995. The advantage of this database is that it provides us with all the information required for our project. The information was collected at that time in a prospective and multicentric manner. During 2 consecutive months within that period, all patients admitted in the participating units were included. Patients from burns unit and cardiac surgery and those younger than 18 years were excluded.

Thus, 10 French ICUs from the following hospitals participated in this study: Béthune, Boulogne, Dunkerque, Lens, Roubaix, Saint Omer, Valenciennes, St Philibert in Lomme, Calmette in Lille, and Salengro in Lille.

### 2.2. Evaluation criteria

For each patient, the following were collected: age, sex, LOS, main diagnostic based on the thesaurus of diagnostics established by the Société de Réanimation de Langue Française (SRLF) [13].

The Simplified Acute Physiology Score version 2 (SAPS II) [3,14] was calculated for each patient. This index enables the evaluation of the initial severity state of a patient by taking into account 12 physiological variables, age, underlying chronic diseases, and type of patient admission. Moreover, it enables the calculation of the probability of hospital mortality [14,15]. The probability of mortality is provided by the following equation:

$$\text{probability of mortality} = e^{\text{logit}}/\left(1 + e^{\text{logit}}\right)$$

$$\text{with logit} = -7.7331 + 0.0737(\text{SAPS II}) + 0.9971[\ln(\text{SAPS II} + 1)]$$

The evaluation of medical resource consumption for each stay was made through the use of the OMEGA system [14,16]. This system is a scale of measure of medical activity elaborated by the SRLF Evaluation Commission at the request of the French referent authority. It is based on the census of 47 intensive care actions (with a weight assigned) distributed into 3 groups. This score is calculated at the end of the patient's stay by adding up the values of the 3 above-mentioned groups.

For the evaluation of paramedical resources, we used the PRNrea [17], which is a tool for measuring paramedical care workload specific to intensive care. Elaborated from the Canadian Project of Research in Nursing (PRN) index [18], it is based on the daily census of 35 care actions. A fixed value is attributed to each action, which enables the calculation of the PRNrea score corresponding to the daily paramedical patient care workload. This score is measured by a point system; each point is equivalent to 5 minutes of nursing work. This time is the time "required" to carry out the action as per "good practice."

### 2.3. Statistical methods

Analyses were performed using SPSS 11 software (SPSS Inc, Chicago, Ill).

#### 2.3.1. General description

A general description of the population was carried out based on the calculation of mean and standard deviation values of the evaluation criteria. These calculations were made for the entire population set and for each participating center.

The search for a relationship between total OMEGA and total PRNrea was carried out by studying the linear correlation.