Intensive Care Med (1998) 24: 582–589

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Estimation of direct cost and resource allocation in intensive care: correlation with Omega system

Received: 10 February 1997
Accepted: 3 March 1998

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Abstract *Objective:* An instrument able to estimate the direct costs of stays in Intensive Care Units (ICUs) simply would be very useful for resource allocation inside a hospital, through a global budget system. The aim of this study was to propose such a tool.
Design: Since 1991, a region-wide common data base has collected standard data of intensive care such as the Omega Score, Simplified Acute Physiologic Score, length of stay, length of ventilation, main diagnosis and procedures. The Omega Score, developed in France in 1986 and proved to be related to the workload, was recorded on each patient of the study.
Setting: Eighteen ICUs of Assistance Publique-Hôpitaux de Paris (AP-HP) and suburbs.
Patients: 1) Hundred twenty-one randomly selected ICU patients; 2) 12,000 consecutive ICU stays collected in the common data base in 1993.
Measurements: 1) On the sample of 121 patients, medical expenditure and nursing time associated with interventions were measured through a prospective study. The correlation between Omega points and direct costs was calculated, and regression equations were applied to the 12,000 stays of the data base, leading to estimated costs. 2) From the analytic accounting of AP-HP, the mean direct cost per stay and per unit was calculated, and compared with the mean associated Omega score from the data base. In both methods a comparison of actual and estimated costs was made.
Results: The Omega Score is strongly correlated to total direct costs, medical direct costs and nursing requirements. This correlation is observed both in the random sample of 121 stays and on the data base' stays. The discrepancy of estimated costs through Omega Score and actual costs may result from drugs, blood product underestimation and therapeutic procedures not involved in the Omega Score.
Conclusions: The Omega system appears to be a simple and relevant indicator with which to estimate the direct costs of each stay, and then to organise nursing requirements and resource allocation.

Key words Intensive care costs · Omega system · Resource allocation

Introduction

Intensive care medicine is particularly concerned with the rise of hospital costs. As in the USA, it is supposed to account for about 15 % of total hospital costs in France [1, 2]. This can be justified by the severity of diseases, technological progress and expected outcome [3–5]. However, the methods of costing and resource allocation remain a major issue [6–8]. This report concerns ICU direct costs in 18 Ile-de-France teaching hospitals (Assistance Publique-Hôpitaux de Paris, AP-HP).

Until now, each admission cost in AP-HP has been assessed through a fixed weighting system. The Financial Department (FD) of AP-HP attributed an annual coefficient to each speciality, calculated from the average costs of internal medicine stays, as reference by analytic accounting. The weight of internal medicine was 1, intensive care was 5.33 in 1992 and 7 in 1993, whatever the disease, workload or length of stay (LS). Most of the allocated resources were calculated annually from the weighted number of admissions in every department. A marginal, variable part (less than 10%) could be negotiated with respect to medical expenditure. But within each speciality wide disparities could be observed, which were particularly obvious in ICU stays with regard to case-mix, severity, workload, LS and resource utilization [9]. This procedure did not take into account this variability, and so could not assess actual hospital output.

Because of the economic recession, new costing analyses have been made, and more relevant management tools using more sensitive data have been proposed. A prospective payment system (Programme de Médicalisation des Systèmes d'Information, P.M.S.I.) [10] has been developed since the late 1980s to break down every hospital stay into a French version of Fetter's Diagnosis Related Groups (DRG) [11]. DRG have been used since 1996, with a regional weighted value to support resource allocation at the hospital level [12]. However DRG have been criticized in their present version, for they reflect ICU stays poorly [13]. Morever they cannot settle financial discussions between units within hospitals, otherwise the ICU might be heavily underestimated an penalized [14].

For several years, intensivists have designed and validated tools of activity assessment, which are sometimes used to estimate expended resources or needs for nursing staff [15–17]. The objective of this study, performed in the AP-HP ICUs, was to propose simple and reliable indicators of intensive care direct costs, and specially to to evaluate whether the Omega system is a good one for that purpose. This has been achieved by recording all ICU stays and available data concerning patients' requirements, in a common data base since 1991. Two component parts: medical expenditure and staff costs, have been analysed in the same way.

Methods

Omega scoring system

The Omega system was created by the SRLF (French language intensivists' society) assessment committee, at the Department of Health's request, to measure the concentration of therapy in intensive care. The 1990 version was validated by a multicentric study (Omega versus PRN) and is now currently used in European ICUs [18, 19]. It encompasses 47 diagnostic and therapeutic items which are weighted from 1 to 10 points according to the required workload, and divided into three categories of tasks (Table 1):

- Omega 1: 28 items, recorded only once during a stay (even if they have been performed several times)
- Omega 2: 11 items, recorded every time they are performed
- Omega 3: 8 items, recorded every day

The total score is obtained by adding all Omega points on the last ICU day.

ICU regional data base

In 1991, the concept of a common ICU data base was suggested to collect the standard indicators: simplified acute physiological score (SAPS) [20], Omega score, length of mechanical ventilation (LV), length of stay (LS). This data base, which involves all AP-HP ICUs and three additional units in Paris suburbs, contained almost 20,000 stays at the end of 1993, and feeds the national intensive care data base of SRLF.

The same data base software (Fusion F-Rea) runs in each unit, collecting homogenous data. Methods of coding are harmonized through regular meetings. Automatic procedures ("coherence tests") are used to check the data's reliability, and are applied both to local data within units and to data in the common data base.

Study on 121 ICU stays: measurement of direct costs

Costs are defined from the hospital perspective, to allow comparisons between the costs of different stays. Direct costs are attributed to patients'care; they can be divided into variable costs and fixed costs. Variable costs depend on the workload level, such as nursing staff requirements, and medical expenditures, such as supplies, pharmacy, blood products, various tests and procedures. Fixed costs are independent of the workload level: medical staff, secretaries, equipment amortization.

Indirect costs do not concern the actual patients'care: maintenance staff, hostelry, heating, ligthing, overheads, building amortization. Medical and non-medical staff salaries are generally considered as fixed or semi-fixed charges in the French hospital system; so medical expenditures and nursing staff requirements contribute more to estimating the variable direct costs of a stay, for they may vary substantially from one patient to another [14, 21].

In 1992, FD of AP-HP undertook a study with the aim of measuring the direct costs of ICU stays, and finding clinical factors related to cost [22]. A sample of 121 patients was randomly drawn from five representative AP-HP ICUs, through a former typological multivariate study which took into account several parameters:

- available means: the number of available beds, medical and nursing staff
- medical activity: admissions, mean LS, procedures, medical expenditure.
- total direct costs and medical costs.

For each stay the total direct costs, composed of medical costs and staff costs, were computed:

- medical costs: drugs, blood products, supplies, tests and procedures, equipment; prices were taken from the national list of

Table 1 The Omega system

Omega 1	Points		
Tracheotomy*	6		
Intubation*	6		
Thoracic or pericardic drains*	6		
Training for home respiratory assistance	3		
Central line or introducer*	3		
Pulmonary artery line*	6		
Arterial line*	3		
Pacemaker*	3		
Intra-aortic balloon*	10		
Cardioversion	3		
Circulatory arrest	10		
Vasoactive drugs	6		
Fibrinolytic drugs	10		
Blood infusion: more than 1/2 volemia per day	10		
Gastric lavage	1		
Parenteral feeding: more than 34 Kcal/kg/day for more than 9 days	6		
Enteral feeding: more than 34 Kcal/kg/day for more than 9 days	3		
Ascitis reinjection	10		
Esophageal varices tamponade*	3		
Arteriovenous fistula*	10		
Ureteral catheter*	3		
Supra pubic drainage*	1		
Complex orthopedic tract	6		
Intensive neurologic monitoring	1		
Lumbar drainage	1		
Intracranial pressure monitoring	3		
More than 1 day anesthesia and/or analgesia	6		
Lavage-punction	3		
* Performed or only monitored in the unit			
Omega 2	**Points**	**Number**	**Total**
Hemodialysis or extracorporeal circulation	10		
Plasmapheresis	10		
Bronchio-endoscopy (bronchio-alveolar lavage included)	3		
Digestive endoscopy	3		
Hyperbaric oxygen	10		
Ultrasonic procedure	3		
Isotopic procedure for diagnosis	6		
Radiography with contrast product (angiography)	10		
Operating room (preparation, transport or reception)	6		
Preparation transport with continuous intensive care	1		
Other transports out of the unit	3		
Omega 3	**Points**	**Number of days**	**Total**
CPAP	10		
Mechanical ventilation	10		
Peritoneal dialysis, hemofiltration	10		
Complex surgical dressing	10		
Digestive reinfusion	6		
Patient isolation (sterile room)	10		
Continuous monitoring in ICU	4		
Infant under incubator	1		
TOTAL OMEGA 1:	TOTAL OMEGA 2:	TOTAL OMEGA 3:	TOTAL OMEGA:

Table 2 Case mix of 121 stays and database

	121 stays	Data base
Diagnosis (%)		
Respiratory diseases	38.7%	29%
Heart and vascular diseases	15.3%	15.3%
Infectious diseases	10.5%	10.9%
Intoxications	10%	10.3%
Metabolic diseases	5%	5.5%
Neurologic diseases	5%	7.3%
Nephrologic diseases	4%	3.9%
Digestive diseases	1.5%	6.7%
Hematologic diseases	1%	3.2%
Main parameters (mean values ± standard deviation (median))		
Age (years)	62 ± 20	52.6
SAPS 1	11 ± 6 (10)	10.6
Length of stay (days)	7 ± 2.1 (5.5)	6.5
Total Omega	75 ± 17.6 (28.5)	80.1
Deaths (%)	10.5%	16.3%

blood products and from the AP-HP central pharmacy; the variable direct part of tests and procedures' costs was estimated to be as much as 30%, so a unitary direct cost of each procedure could be calculated.

- staffcosts: nursing and auxiliary nursing costs were estimated in assessing the mean length of each care, through interviewing a nurse and a head nurse in each unit, and weighting it with per diem staff salaries according to the rank.
  The total staff cost of each stay can be calculated by adding all the care required during the stay. The mean direct cost per stay was 16335 ± 23929 French francs (FF) or 3260 US $ (1 US $ = 5 FF) in 1992.

Direct costs measured in that way amounted to about 60% of the overall costs. The aim of the study was to define the burden of variable direct costs in ICUs, so fixed direct costs and indirect costs were not involved: salaries of physicians, head nurses and secretaries, hostelry and overheads.

Three groups of patients, could be distinguished according to severity, LS and costs:

1- group 1: moderately severe patients, with long LS and high total costs.
2- group 2: most severe patients, with middle LS but high daily costs
3- group 3: less severe patients, short LS and low mean costs.

121 stays were randomly drawn from the units as a whole, after stratification for severity. No major differences could be observed between the sample and the whole data base (Table 2).

AP-HP analytic accounting: calculation of mean direct costs

Every year, FD of AP-HP publishes the overall costs of hospital departments: staff supplies, pharmacy, diagnostic and therapeutic procedures, infrastructure and amortization. From these data an average direct cost per stay could be calculated for each unit on 12,000 intensive care stays in 1993.

Statistical methods

Two levels of analysis have been conducted: analysis per stay, based on 121 patients; analysis per ICU, based on a common data base. At the individual level of an ICU stay, multiple linear regression equations, using the least squares method, were developed to predict direct costs, from the variables Omega, LS and LV of the 121 stays. Most of the relevant equations were applied to the 1993 common data, and the predicted costs per stay were compared to the mean direct costs per stay calculated from 1993 analytic accounting (method 1).

At the aggregated level of 1993 ICU stays, the mean values of Omega score, LV and LS computed from the common data base, were used as predictors of the mean direct costs per stay from the 1993 analytic accounting, using multiple regression (method 2). Two of the 18 ICUs were excluded from analysis as their economic data were not available for the survey's period.

Three separate analyses were performed, intended to predict respectively:

- total direct costs
- medical direct costs
- nursing staff requirements

Probability values less than 0.05 were considered as statistically significant. The coefficient of determination r^2 was used as a measure of predictive performance of the equations. Development of the regression models included a search for non-linear effects and possible transformation of data in order to gain normality and homoscedasticity. The paired t-test was used to compare estimated and actual costs.

Results

Estimated total costs per stay

Method 1: relations between total direct costs and clinical descriptions on 121 stays

Seven linear regression equations give precise estimations of the total direct cost per stay ($0.81 < r^2 < 0.94$)

Table 3 Seven regression equations with total costs and predictors on 121 stays

1)	–226 + 265 total Omega – 1285 LV	$r^2 = 0.91$*
2)	–957 + 1274 LS + 150 Omega 3	$r^2 = 0.91$
3)	–1772 + 1156 LS + 140 Omega total	$r^2 = 0.92$
4)	211.68 total Omega + 1191.5	$r^2 = 0.90$
5)	–4474 + 2969 LS	$r^2 = 0.85$
6)	–1780 + 302 total Omega – 1953 LV	$r^2 = 0.94$ if ventilation > 48 h
	–1834 + 1871 LV + 87 Omega 3	$r^2 = 0.82$ other patients
7)	–3845 + 224 total Omega	$r^2 = 0.90$ if ventilation > 48 h
	–1555 + 2251 LS	$r^2 = 0.81$ other patients

* all equations are significant at $p < 0.001$

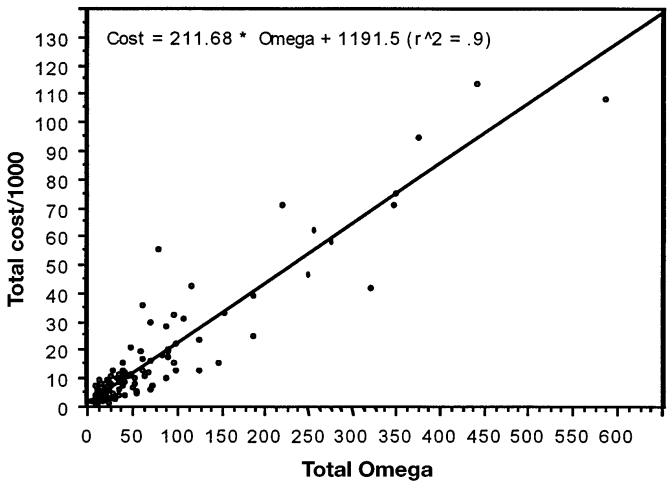


Fig. 1 Relation between total cost and total Omega on 121 stays

(Table 3). There was no quadratic or higher degree effect. Although both distributions of cost and Omega looked close to a log normal one, the equations involving log transformation of data appeared less predictive and led to greater residuals than the equations on raw data. The simples equation with total Omega is equation n° 4 in Table 3 (shown in Fig. 1):

Total direct cost per stay = 211.68 total Omega + 1191.5; $r^2 = 0.90$ ($p < 0.001$)

When applying the former equation on the 1993 data of common data base, the comparison between each stay's predicted costs by Omega and the mean direct costs calculated from analytic accounting show that the relation is quite close (Fig. 2).

Method 2: relations between average calculated direct costs of each unit's stays, and predictors of the actual stays

When predicting 1993 average costs per stay with average values of total Omega from the common data base, the results are superimposed on those of the first method (Fig. 2).

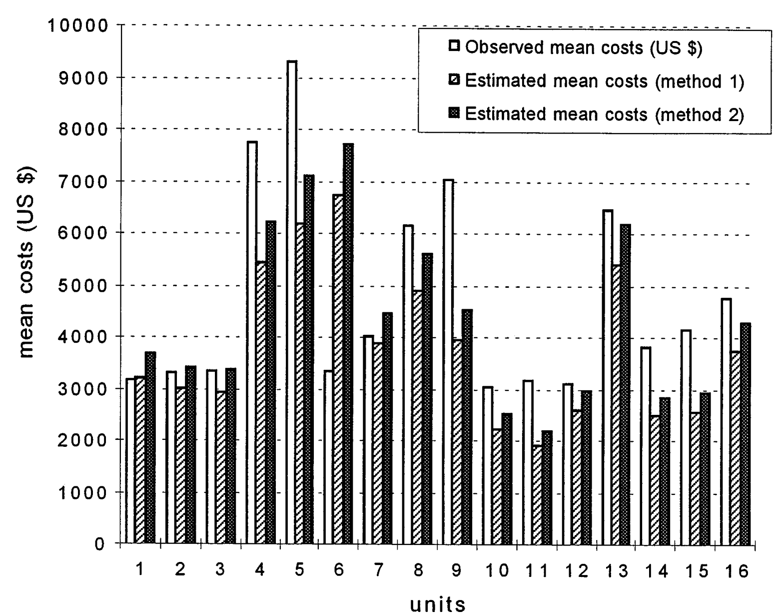
The most simple equation is:
Estimated total cost per stay = 248.6 total Omega
$r^2 = 0.894$ ($p < 0.001$)

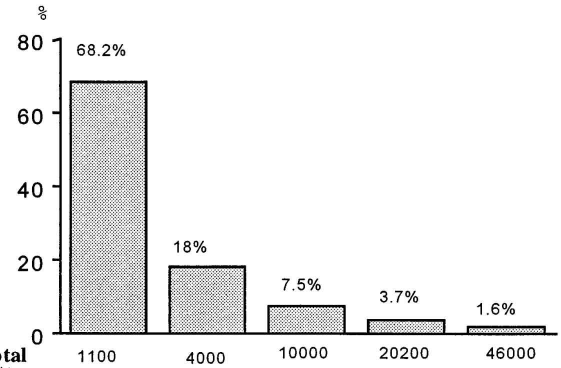
In spite of overestimations or underestimations in each unit, an overall analysis comparing predicted and calculated and/or measured costs in the aggregate does not show a statistically significant difference between the methods:

Method 1
mean difference: 3900.77 FF (780 US $)
paired t-test: NS

Method 2
mean difference: 1827.38 FF (365 US $)
paired t-test: NS

Fig. 2 Comparison between observed and estimated mean costs by stay on 16 ICUs





average total cost (US $)

Fig. 3 Range of total costs (in US $). Distribution of stays (%) according to their total cost; each group has the same economic weight

Estimated medical costs per stay

Relations between medical direct costs and clinical descriptions on 121 stays

Most relevant regressions between the measured medical direct costs of 121 stays and related variables are applied to the 1993 data from the common data base. The most simple and relevant equation is:
Estimated medical cost per stay = 124.4 total Omega $r^2 = 0.90$ ($p < 0.001$)

Relations between calculated average medical costs of each stay and predictors of the related stays

Results of the correlations between the mean values of total Omega from the data base and the average medical costs from analytic accounting show that the estimation is as good as with the first method. The most relevant equation is:
Estimated medical cost per stay = 112.36 total Omega $r^2 = 0.85$ ($p < 0.001$)

The results are superimposed on those of total costs with more marked variations in some units.

Estimated nursing staff costs

Relations between nursing staff costs and clinical descriptions on 121 stays

The most relevant regression equation between nursing and auxiliary nursing staff costs of 121 stays and related variables is:
Estimated staff costs per stay = 67 total Omega $r^2 = 0.88$ ($p < 0.001$)

Correlations between average staff costs from analytic accounting and predictors of the related stays

Estimated staff costs per stay = 147.1 total Omega $r^2 = 0.93$ ($p < 0.001$)

Range of costs

Using predictors for estimating direct cost, the frequency distribution of 1993 stays did not clearly show homogenous subgroups of costs. We decided to split the stays over five groups whose overall costs were equal (Fig. 3). The breakdown of the patients into cost range is different according to the ICUs. On average, 70 % of the patients are to be found in the lowest cost group, less than 12,000 FF (2400 US $). The total costs of one patient can vary by as much as fifty times. The range of medical costs, designed in the same way, are superimposed on the total costs. The medical costs of each patient can be vary by as much as 80 times.

Discussion

The costs of ICU are generally high. About 5 % of short stays in France concern ICUs [14]. In the United States 7 % of hospital beds concern intensive care, and amount to 15–20 % of hospital charges and 1 % of the Gross National Product; but the patient turn-over is much higher than in western Europe [23, 24].

In spite of rising costs in ICUs during recent years, it has been proved that the relative contribution of each cost section is quite stable [2, 21]: more than half of it concerns nursing and medical staff, while pharmacy, supplies and tests for 30 %, infrastructure and amortization for 15 %.

The most common characteristic of the ICU is to deal with severe diseases using high technology and very specialized staff. But it is of importance to point out the variability of stays, with regard to case-mix, specialization of some facilities, LS, intermediate or acute care patients, scheduled or non-scheduled surgery. Most of the severely ill patients are generally “high costs”, however with a bell-shaped relationship between cost and severity [16], the costs are better correlated with LS where patients with moderate severity are concerned [8]. This variability with regard to severity and resource utilization cannot be taken into account through the former fixed system of resource allocation.

The ICU is supposed to consume a large amount of hospital resources, although this weight is not precisely known in France. French DRG classification (2nd version, with about 500 DRG) still generates major difficulties in recognizing the specificity of ICU. Patient stay is described through a main diagnosis, the choice of which is a deciding factor for the classification into DRG. In multi-units stay more than half are classified into DRG not related to their main diagnosis in the ICU, which in itself remains a much debated question [25]. Mixing ICU and non-ICU stays in the same DRG probably undervalues the intensive care requirement, and so the budgets allocated.

Tools for assessment of intensive care activity seem to be relevant for a better estimation of the direct costs per stay. Among these tools, MPM, TISS or PRN have been studied and sometimes validated for resource allocation or need for nursing staff [15–17]. However these methods represent unwieldy procedures for systematic use for they are time-consuming. Omega is a simple, quick and available tool, its information being collected by medical staff at the end of the stay. It is not a good predictor of incremental daily cost, but it appears to be relevant for estimating the direct costs of each stay for current use.

Omega points take into account the LS, which is a very important cost predictor, but also involve ventilator days, main tests and procedures, so that the Omega system is more sensitive than LS in reflecting direct costs; it may therefore contribute more to resource allocation.

The present study shows that some units are systematically undervalued, probably because of the failure of the Omega system to account for drugs and blood products, or very specialized procedures. On the other hand patients with a long LS, such as neurologic ones, are overvalued for their marginal costs generally decrease after some days, while a fixed daily workload is computed through Omega 3 for ventilation. This is the case for unit 6. Moreover, for this unit with the largest discrepancy between estimated and actual costs, analytic accounting could not distinguish between the data from acute and intermediate dependency sections. Economic data from two units were not available and not included in the analyses (Fig. 2).

It must be noted that both the method used in the 121 stays and the analytic accounting method have flaws, for both use assumptions on some components of costs. The costs of 1992 and 1993 have been mixed, without discounting. Inflation at that time was less than 1 % a year, so the gap was very narrow.

A major criticism could be that using the Omega system, in which LS plays a major role, could lead to abuses. Some unscrupulous physicians indeed could artificially increase the LS, keeping patients longer than necessary. It is therefore important to consider other data in the base, such as diagnoses and severity. Another point of discussion is the method of measuring nursing time. A working group was designed for that purpose to harmonize estimations from different nurses and head nurses, for, at that time, a specific indicator such as PRN was not in current use in AP-HP ICUs.

A national survey in 50 French public hospitals has been undertaken by the Health Ministry with the aim of measuring the costs of hospital output and organising regional budgets [12]. The financial weight of Omega points has been calculated to estimate medical and nursing staff costs for intensive care. The Omega scoring system can then settle budgetary discussions between units and the financial board at a local level.

The Omega system appears relevant to estimate the direct costs of each stay, and to organise nursing requirements and resource allocation, on condition that the exhaustivity and quality of the computed data are controlled, using both prospective automated procedures and retrospective regular audits, which are cost-effective [26]. The aim of collecting Omega points and other variables through a common software and an operative ICU data base is not only economic, but also medical and epidemiologic: more homogenous groups of diseases will be sought, and performance will be assessed within each unit through systematic recording of SAPS II and comparing predicted and actual mortality [27]. The increasing number of recorded stays will allow wide multicentric surveys if the methods of collection and coding are standardized. A better description of casemix and severity will contribute to improving information proceedings.

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