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Intensive care use in a developing country: a comparison between a Tunisian and a French unit

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Abstract *Objectives:* To compare the variations in intensive care (ICU) outcome in relation to variations in resources utilization and costs between a developed and a developing country with different medical and economical conditions.
Design and setting: Prospective comparison between a 26-bed French ICU and an 8-bed Tunisian ICU, both in university hospitals.
Patients: Four hundred thirty and 534 consecutive admissions, respectively, in the French and Tunisian ICUs.
Measurements: We prospectively recorded demographic, physiologic, and treatment information for all patients, and collected data on the two ICU structures and facilities. Costs and ICU outcome were compared in the overall population, in three groups of severity indexes and among selected diagnostic groups.
Results: Tunisian patients were significantly younger, were in better health previously and were less severely ill at ICU admission ($p < 0.01$). French patients had a lower overall mortality rate (17.2 vs 22.5 %; $p < 0.01$) and received more treatment ($p < 0.01$). In the low severity range, the outcome and costs were similar in the two countries. In the highest severity range, Tunisian and French patients had similar mortality rates, while the former received less therapy throughout their ICU stays ($p < 0.05$). Conversely, in the mid-range of severity, mortality was higher among Tunisian patients, and a difference in management was identified in COPD patients.
Conclusion: Although the Tunisian ICU might appear more cost-effective than the French one in the highest severity group of patients, most of this difference appeared in relation to shorter lengths of ICU stay, and a poorer efficiency and cost-effectiveness was suggested in the mid-range severity group. Differences in economical constraints may partly explain differences in ICU performances. These results indicate where resource allocation could be directed to improve the efficiency of ICU care.

Key words Simplified Acute Physiology Score · Omega system · Severity of illness index · Workload · Outcome assessment · Intensive care unit comparison · Cost-effectiveness analysis · Evaluation studies · Organization · Quality of care

Introduction

The escalation in health care costs over the past 25 years has paralleled the increase in the number of ICU beds, which account for approximately 10–20 % of hospital expenses in western countries, and up to 1 % of the total gross national product (GNP) in the USA [1]. While economic constraints increase the need for outcome evaluation and guidance regarding efficient utilization in developed countries, similar concerns are arising in developing countries, where conditions are different [2].

Severity scoring systems have gained universal acceptance and most large-scale clinical trials involving ICU patients are now using severity scores, either as an enrollment criterion or as a descriptive variable [3, 4]. Combined with outcome information and workload scores, such as the therapeutic intervention scoring system (TISS) [5] or Omega score [6], these instruments have been used to measure the effectiveness and cost profiles of critical care units [7–9]. The comparison between predicted and actual mortality (standardized mortality ratio or SMR) is also increasingly used to assess ICU performance [10]. A strong relationship was found between workload, as described by the TISS score, and total ICU charges, thus allowing the indirect assessment of ICUs' resources utilization [11].

Although most ICU comparisons have been undertaken in industrialized countries that share similar medical and economical conditions [10–13], a few comparisons of ICU performance between industrialized and developing countries have been published [14, 15]. These reports concluded that the lower performance observed in developing countries was related to the reduced technology available and a shortage of ICU beds resulting in delayed ICU admission [14, 15].

In this report, we compared the variations in intensive care utilization and outcome in relation to variations of costs in two large university hospitals, in France and Tunisia. These countries differ in the share of GNP devoted to health care (9.4 % and 5.9 % in 1994, respectively) [16]. The GNPs themselves are markedly different with £ 1,000 billion in France and £ 10 billion in Tunisia. Since the Tunisian ICU medical staff have received post-doctoral training in the French unit, differences in therapeutic approach are expected to be due mainly to factors external to medical knowledge and therapeutic attitude, such as resource limitations. Under these circumstances, we sought to evaluate how country-specific conditions may influence utilization patterns and performance of ICUs and whether resource limitation results in a different use of intensive care facilities and outcome.

Patients and methods

Hospital ICU setting

Data were collected in the Henri Mondor Hospital (Créteil, France), a 1,006-bed tertiary care referral center, and the 550-bed Hospital of Monastir (Tunisia), both university teaching hospitals. Most of the health care delivery system in Tunisia is provided by the public or government health service which has primary, secondary and tertiary levels. Tertiary care is provided nationwide by university teaching hospitals were ICUs are located. All of these facilities are readily available and accessible to a large proportion of the Tunisian population, including those in rural locations living in poor conditions. The French unit studied, one of the eight ICUs of the hospital, is a 26-bed closed medical ICU. The Tunisian ICU is the only medical ICU in Monastir and includes eight beds; both are run under the direction of one full-time physician. Physicians running the ICU in Monastir had received 1–3 years post-doctoral training in ICUs of the Paris area, thus limiting practice pattern differences between the two ICUs.

The data collection protocol and study were approved by the Institutional Review Boards of the respective hospitals.

Structural characteristics

The ICU data analyzed included information about medical staff, physician coverage, the type and number of ICU beds, occupancy rate, technology and equipment, nurse/patient ratio and other personnel availability including physiotherapists, secretaries and auxiliaries.

Patients

All consecutive patients admitted to the French ICU from January 1st to June 30th, 1993 ($n = 430$) were included. Tunisian patients were 534 consecutive ICU admissions over 15 months (January 1993–March 1994). Clinical data recorded included age, sex, location before ICU admission, prior state of health using Mac Cabe classification [17], operative status, ICU length of stay (LOS) and discharge status. Each patient was assigned a specific diagnostic category using ICD-9 codes [18]. The severity of illness was assessed in the first 24 h of ICU admission, using the simplified acute physiology score (SAPS) [19]. Mortality in the ICU was taken into account.

Resource utilization and cost estimation

The total amount of therapy received was evaluated at discharge from ICU by the Omega score (Ω) which is a simplified version of the TISS [6]. Costs were computed from the viewpoint of the ICUs, and did not include hospital indirect costs and societal costs. Medical costs, including drugs, blood products, supplies and tests, were computed using a simple linear model that relates costs to length of stay (LOS) and total therapeutic used in the ICU (Ω) as follows: medical cost = $139 \times (\text{LOS} + 14\,\Omega) - 122$.

This model of cost estimation was established and validated for all the ICUs in the Paris area. Because the medical costs described above depend on purchase prices rather than on salaries, we used the same coefficients for the French and the Tunisian ICUs. In addition to medical costs, we computed the total direct costs, including nursing and physicians costs. These personnel costs were computed on a per diem basis, using the total payroll of the ICUs and dividing it by the total number of patient days. We did not adjust for differential workload. Overhead costs were not included as they would emphasize differences in hospital structures that are not related to the differences in ICU practices. Since the level of salaries (both for doctors and nurses) is 7 times lower in Tunisia than in France, we computed an adjusted cost for the Tunisian ICU, using French salary values, in order to facilitate cost comparisons; thus, the remaining differences in costs between the two units were due to differences in patient management, i. e. LOS and resource utilization. Cost estimation was computed in each group of severity indexes and diagnostic category described below.

To compare the efficiency of each ICU, the outcome analysis was performed first on the overall patient population, and then stratified in three groups of severity indexes ($\text{SAPS} \leq 5$;

Table 1 Description of ICU characteristics

	French ICU	Tunisian ICU
Total number of ICU admissions in 1993	814	397
Number of beds		
Acute care	13	4
Intermediate	13	4
Average occupancy rate	73 %	83 %
Physician staffing		
Full-time medical director	1	1
Full-time seniors	6	2
Residents	4	1
Nurse staffing		
Nurse manager	1	1
Head nurses	3	2
Registered nurses	49	12
Nurse assistants	18	3
Mean nurse/patient ratio		
Acute care beds	1/3	1/3
Intermediate care beds	1/6	1/4
Other professionals		
Physiotherapists	2	1
Secretaries	3	1
Social workers	1	0
Housekeeping personnel	4	3
Monitoring and therapeutic facilities		
Ventilators	16	6
EKG monitors	20	8
Pulse oxymeters	10	4
Hemodialysis	1	0
Echocardiograph	1	0
Bronchoscope	1	0
Nurses monthly salary (Br. £)	1,400	150

$6 \leq$ SAPS ≤ 15; and SAPS ≥ 16) referring, respectively, to low, intermediate and high severity groups with expected mortality rates of less than 10 %, 10–35 % and more than 35 % [19]. In addition, we selected four diagnostic categories representing over 25 % of all admission diagnoses, and a wide spectrum of severity scores, to compare actual ICU mortality to expected mortality (SMR) for each specific diagnostic category. Septic shock patients were selected for the high severity category; patients presenting with spontaneous pneumothorax represented the low severity category, and we selected patients with acute asthma and acute exacerbation of COPD as representative of the intermediate range of severity. To compute SMRs in the three groups of severity indexes and in the specific diagnostic groups, and because SAPS I does not provide individual estimates of mortality, a conversion formulae derived from the SAPS II validation cohort (J R. Le Gall, S. Lemeshow, personnal communication) was used to estimate SAPS II from SAPS I as follows: SAPS II = 0.49 + 2.6 SAPS I.

The mean total and per day Omega per survivor (Omega points accumulated by survivors/number of survivors), per non-survivor (Omega points accumulated by non-survivors/number of non-survivors) and effective Omega per survivor (Omega accumulated by all patients/number of survivors) were used as indicators of effectiveness [20]. This analysis was performed for the entire population and for each sub-group of severity.

Statistical analysis

All variables are expressed by their means and standard deviation. Univariate comparisons of French and Tunisian patients were performed using chi-square statistic for qualitative variables, and a Student's t-test was used to compare quantitative variables. A p value less than 0.05 was considered significant.

Results

ICU characteristics and staffing

Although the mean physician- and nurse- to- patient ratios were similar in the two ICUs, there were substantial differences between the two ICUs regarding organisational setting, staffing and technological equipment (Table 1). Night coverage was performed by a senior physician and a resident in the French ICU, and by a resident (or a postgraduate medical student) with a senior physician on call in the Tunisian ICU.

Patient characteristics

The demographic and clinical data of the 430 French and 534 Tunisian patients along with treatment facilities are listed in Table 2. Significant differences were observed for age, prior health status and co-morbidities. The mean severity of illness (SAPS I) was significantly higher in the French group ($p < 0.01$).

Outcome and relationship to workload measurements

The overall ICU mortality rate was significantly higher in the Tunisian cohort than in the French one (Table 3). The total amount of therapy administered to patients in the French ICU was significantly higher than that in the Tunisian ICU ($p < 0.01$). Both Omega per non-survivor and effective Omega per survivor were significantly lower in the Tunisian group. However, the amount of intensive therapy remained higher in non-survivors than in survivors in both countries. The mean LOS was significantly longer in the French group compared to the Tunisian one ($p < 0.01$).

Figure 1 shows the distribution of the French and Tunisian populations in the three groups of severity along with their respective mortality rates and Omega scores. The mortality rates, SMR, LOS and the workload stratified by increasing severity are presented in Table 4. In the low SAPS group, no significant difference was found between the two ICUs. In the highest SAPS group, although mortality was not significantly different, Omega scores and especially Omega per survivor and effective Omega per survivor were significantly lower in Tunisia, associated with a lower LOS recorded both in survivors

Table 2 Demographic and clinical characteristics of French and Tunisian ICU admission (*MV* mechanical ventilation)

	French ICU $n = 430$	Tunisian ICU $n = 534$
Sex (% of male)	58	56
Age (years)	51 ± 19	44 ± 21 §§
Age distribution (%)		
< 45 years	42	54 §§
> 65 years	28	23 §
SAPS (mean ± SD)	10 ± 7	8 ± 6 §§
Respective % of patients		
SAPS ≤ 5	33	43
6 ≤ SAPS ≤ 15	50	48
SAPS ≥ 16	17	9
Severity of underlying disease (%)		
Non-fatal	65	82 §
Ultimately fatal	25	13
Rapidly fatal	10	5
Co-morbidities (%)		
AIDS	4.6	0.5 §
Hematologic malignancies	10.8	0.5 §
Location prior to ICU admission (%)		
Emergency room	45	48
Hospital floor	29	21
Transfer from another hospital	26	31
Medical patients (%)	90	95
Active treatment and monitoring (%)		
MV > 24 h	34.6	38.6
Dialysis*	8.8	2.4 §
Pulmonary artery chatheterization	20	1.8 §

§ $p < 0.05$; §§ $p < 0.01$: refers to the difference between the two ICUs
* hemodialysis is performed outside the ICU for Tunisian patients

Table 3 Comparisons of mortality rate, length of stay (LOS) and amount of treatment among the entire population (* see the text for definitions)

	French ICU patients $n = 430$	Tunisian ICU patients $n = 534$	*p* value
Mortality rate (%)	17.2	22.5	< 0.01
Length of ICU stay (days ± SD)	8.1 ± 3	6.6 ± 2.8	< 0.01
Omega score	84 ± 12	63 ± 10	< 0.01
Omega per survivor*	70 ± 11 §	60 ± 9 §	ns
Omega per non-survivor*	147 ± 12	118 ± 12	< 0.05
Effective Omega per survivor*	101	81	< 0.05

§ $p < 0.01$ for difference beween survivors and non-survivors in each country
All values are means ± SD

and non-survivors. However, no difference was observed when Ω per day was considered for survivors and non-survivors. In contrast, in the middle range of severity, the mortality rate was significantly higher in Tunisia and SMRs differed. In that group, the total and

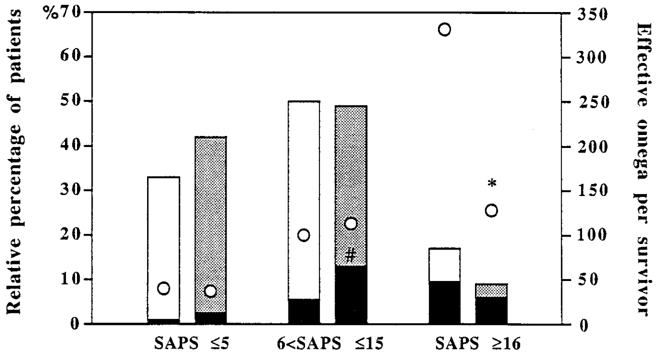

Fig. 1 Relative distribution of the French *(white bars)* and the Tunisian *(grey bars)* populations in the three groups of increasing severity (Y axis). The *black part of each bar* represents the % mortality in each category. *Open circles* refer to the effective omega score per survivor (Z axis) in each category
#: $p < 0.05$ for the difference in mortality rate between French and Tunisian ICUs in the corresponding group of severity
*: $p < 0.05$ for the difference in workload measurements (Omega) between French and Tunisian ICUs in the corresponding severity group

per day Omega and the effective Omega per survivor were not different. No difference in mean LOS was observed, although non-survivors had a lower LOS and mean Omega score in the Tunisian ICU.

Outcome measurements for selected diagnostic categories

Patients with spontaneous pneumothorax, a subset of the low severity group, had remarkably similar SAPS and Omega scores, and had comparable ICU mortality rates (Table 5). In contrast, in the subgroup of patients with septic shock (the high severity group), French patients were more severely ill and received significantly more therapy than Tunisian patients ($p < 0.05$), while ICU survival and SMR were not significantly different.

Compared to corresponding Tunisian patients, French patients admitted with severe acute asthma had significantly higher SAPS, workload score and a longer LOS along with a trend to a lower mortality ($p = 0.06$) and a lower SMR ($p < 0.01$). Tunisian patients admitted with acute COPD decompensation were less severely ill at admission and received the same amount of therapy as French patients, but had a higher mortality rate ($p < 0.01$) and a 4 times higher SMR ($p = 0.03$); they more often received endotracheal intubation and mechanical ventilation than their French counterparts (66% versus 25%; $p < 0.01$), whereas 75% of the latter and none of the Tunisian patients received non-invasive ventilation (NIV).

Medical costs per diagnostic category are presented in Table 5. These costs were lower in Tunisia than in

Table 4 Comparison of mortality rate, length of stay (LOS) and amount of treatment according to three classes of severity indexes (Total cost includes medical + personnel costs. Costs are adjusted using French price of labour to price the personnel costs in Tunisia. *SMR* standardized mortality ratio, refers to the comparison between predicted and observed ICU mortality rate according to the SAPS II model)

	SAPS ≤ 5			6 ≤ SAPS ≤ 15			SAPS ≥ 16		
	France (n = 141)	Tunisia (n = 229)	p* value	France (n = 216)	Tunisia (n = 257)	p* value	France (n = 73)	Tunisia (n = 48)	p* value
Percentage of the population: %	33	42		50	49		17	9	
Mortality rate (%)	2	6	ns	11	26	< 0.01	56	64	ns
SMR	2.9	5.8	ns	1.3	3.7	< 0.01	0.9	1.2	ns
LOS (days)	6.0 ± 5.3	5.0 ± 4.2	ns	9.0 ± 7.9	8.3 ± 6.8	ns	9.1 ± 7.6	5.6 ± 4.6	0.01
LOS/survivors	5.9 ± 4.8	4.6 ± 3.6	ns	8.6 ± 6.7	9.3 ± 7.5	ns	13.4 ± 5.6	9.6 ± 8.1	0.01
LOS/deceased	9.7 ± 7.1	9.8 ± 8.9 §	ns	12.5 ± 8.4 §	8.3 ± 6.6	0.01	5.8 ± 3.8	3.7 ± 3.3	0.02
Total Ω/survivor	37 ± 9	29 ± 8	ns	77 ± 11	72 ± 14	ns	153 ± 18	94 ± 15	0.04
Ω/day/survivor	6 ± 10	6 ± 8	ns	9 ± 12	8 ± 16	ns	12 ± 19	10 ± 14	ns
Total Ω/deceased	84 ± 22	111 ± 34	ns	184 ± 28	115 ± 12	0.02	136 ± 26	69 ± 28	0.01
Ω/day/deceased	9 ± 23	11 ± 35	ns	15 ± 29	14 ± 13	ns	23 ± 26	19 ± 28	ns
Effective Ω per survivor	40	37	ns	99	113	ns	331	228	0.02
Average cost per survivor (£)									
Medical cost	1210	919	ns	2135	2165	ns	3848	2508	0.04
Total cost #	2088	1015	ns	3394	2360	ns	5809	2709	0.04
Adjusted cost #	2088	1592	ns	3394	3526	ns	5809	3913	0.04

Ω: omega
* refers to the comparison between France and Tunisia
§ refers to the comparison of LOS between survivors and non-survivors in each country ($p < 0.01$)

Table 5 Severity, mean amount of treatment and cost per patient and outcome in four selected diagnostic categories (Average costs per patient in French and Tunisian ICUs. All costs are computed over the total duration and hospital stay and are expressed in Br. £. Medical costs represent the costs of: drugs, blood products, supplies, test. Total costs are medical costs plus medical and non-medical personnel costs. Adjusted costs were computed by adjusting the personnel costs in the Tunisian ICU to French hospital salaries. *SMR* standardized mortality ratio, refers to the comparison between predicted and observed mortality rate according to the SAPS II model.)

	SAPS	Omega	Average cost per patient			Length of stay (days)	Mortality n (%)	SMR
			Medical	Total	Adjusted			
Septic shock								
French ICU (n = 29)	20 ± 6 §	180 ± 14 §	3,020	4,143	4,143	9.2 ± 8.8 §	23 (79)	1.50
Tunisian ICU (n = 18)	16 ± 7	73 ± 8	1,349	1,442	1,996	5.3 ± 5.3	13 (72)	1.70
COPD exacerbation								
French ICU (n = 32)	11.3 ± 4.5 §§	66 ± 8	1,735	2,870	2,870	9.3 ± 7.8	3 (9.4)	0.55
Tunisian ICU (n = 65)	8.9 ± 3.9	70 ± 8	1,664	1,810	2,677	8.3 ± 6.5	21 (32) §§	2.13
Severe acute asthma								
French ICU (n = 39)	7.5 ± 4.3 §§	50 ± 9 §§	1,460	2,496	2,496	8.5 ± 9.4 §§	1 (2.5)	0.62
Tunisian ICU (n = 33)	4.9 ± 2.0	31 ± 7	835	922	1,445	5.0 ± 3.4	3 (9)	3.00
Spontaneous pneumothorax								
French ICU (n = 23)	3.4 ± 3	28 ± 4	905	1,625	1,625	5.9 ± 3.4	0 (0)	0
Tunisian ICU (n = 32)	3.3 ± 6	30 ± 4	928	1,031	1,648	5.9 ± 3.8	0 (0)	0

§ $p < 0.05$; §§ $p < 0.01$: refers to the difference between French and Tunisian ICUs

France for patients treated for septic shock and severe acute asthma, and comparable for COPD decompensation and spontaneous pneumothorax. When personnel costs were added, the Tunisian costs were lower in all patient categories, as expected, because of the large differences in personnel salaries. The adjustment of Tunisian salaries to French levels re-established the grading found previously for medical costs. A twofold difference in costs was observed for the most severe patients (septic shock), explained by the longer LOS and higher severity, in addition to higher unit costs, in France. For less severe patients, when the difference in LOS was near zero and Omega scores did not differ, the only cost difference was due to the difference in salaries.

Discussion

This study shows that Tunisian patients received less treatment during a shorter LOS, leading to overall lower costs than French patients, but that their ICU mortality rate was higher (22.5 % vs 17.2 %; $p < 0.01$). However, cost-effectiveness profiles were different across the sub-groups of severity indexes and diagnoses. Cost-effectiveness was similar in the low range severity group for the two ICUs. In the middle range of severity, ICU outcome was significantly poorer in Tunisia than in France, with no difference in Ω and costs. In the highest severity range, the Tunisian ICU could be viewed as more efficient, at least from an economical point of view, although there was a trend toward increased mortality and SMR.

The younger average age and the better prior health status of Tunisian ICU patients may reflect, in part, differences in the age distribution of the population between the two countries and/or each hospital's environment. Nevertheless, these differences may also result from a Tunisian policy of actively restricting the admission. The smaller percentage of ICU beds in Tunisian hospitals, which account for approximately 2 % of hospital beds, compared to 3.3 % in France [21] and to about 10 % at Henri Mondor hospital, places a greater triage pressure on Tunisian physicians. As a result, elderly patients or patients with serious chronic health problems may be commonly denied ICU admission in Tunisia. Accordingly, as shown in Table 2, there was a marked difference between the two units in the proportion of patients admitted with high severity scores, AIDS or hematologic malignancies.

Tunisian patients had a shorter ICU stay and consumed fewer resources than French patients. Besides differing admission policies, this could be partly due to the significantly higher mortality rate observed in the Tunisian ICU, associated with a decreasing LOS among non-survivors as SAPS increases (Table 4). However, a difference in the pattern of resources use between Tunisian and French physicians may also explain these findings, at least in part. The financial shortage in Tunisia could possibly encourage Tunisian physicians towards more efficient utilization of scarcer resources. For example, patients with high severity indexes, such as septic shock patients, had a similarly poor outcome in the Tunisian and French ICUs, despite a much higher LOS and resource consumption in the latter, even after adjusting for differences in salaries (Table 5). This could reflect quicker consideration given by the Tunisian ICU physicians to withdrawing active treatment in the sickest patients for whom no additional benefit would be expected from ICU care, whatever the available new technologies provided [22–24]. In this group of patients, lower effective Omega per survivor in Tunisian patients might be considered as an indicator of a better cost-containment strategy [25]. However, when considering Ω per day in survivors and non-survivors, there was no difference between the two ICUs. Therefore, differences in total Ω and costs mostly reflect the shorter LOS in Tunisia. It is, then, difficult to know whether such a difference is actually due to a more efficient use of intensive care resources or related to resource limitations.

In the groups of patients with low risk of mortality, such as spontaneous pneumothorax, no difference in mortality was observed, thus rendering any cost-effectiveness computation moot. A cost-minimization analysis would, then, indicate that the Tunisian ICU has a more efficient use of their resources for septic shock, and that the two ICUs are equally efficient for pneumothorax.

In contrast, results are clearly different in the mid-range risk category, illustrated by COPD exacerbation and acute asthma. While having a lower severity and inducing a similar workload, Tunisian COPD patients had a significantly higher mortality rate than their French counterparts, the costs being roughly equivalent. This indicates that, by comparison, the French maximized the efficacy of their ICU resources, the large difference in SMRs suggesting a substantial difference in the process of care between the two ICUs.

Differences in population studied may have affected our results [26] and reasons for systematic biases in ICU comparisons have been extensively listed [14, 15, 26]. Since the Monastir medical team had been trained in Créteil, definitions of disease, patient characteristics coding system, and the use of physiological variables were similar for the two ICUs, especially concerning the four selected diagnoses. However, even in developed countries, the relationship between severity scores and mortality has not always been found consistent [26]. The standardized mortality ratio (SMR), comparing actual and predicted mortality, has been proposed to allow for comparisons between different ICUs [27]. However, the use of SMR to compare ICUs from different countries has been recently questioned, especially since the equation used for predicting mortality – using APACHE, SAPS or MPM scoring systems – has not been validated in some of these countries [26]. However, we believe that the use of the SAPS prediction model within the context of this study remains valid; indeed, a recent validation of this severity score has been performed by our group in Monastir, showing good discrimination of the SAPS II model (area under the ROC curve: 0.84) [28]. It should be noted, however, that calibration was suboptimal, particularly in the mid-range severity index groups, which led us to ask whether such results were not related to quality of care problems and resource allocations in Tunisian ICUs.

These data are consistent with our findings of a different outcome in the mid-range severity group of patients. As noted above, this difference may reflect different processes of care. One possible explanation is that most French COPD patiens received non-invasive ventilation (NIV), which was recently shown to reduce mortality and morbidity in a multicenter study conducted by the Créteil group [29]. This technique was not used in Tunisia. It is worth noting that the mortality rate of COPD patients in Tunisia is similar to that found in the control group of the NIV study [29]. For patients of intermediate severity having severe acute asthma, the medical (and total) costs are higher in the French ICU, but the mortality was lower. The explanation for the highest mortality observed in Tunisian patients is not straightforward, since they demonstrated lower SAPS. It is possible that SAPS poorly reflects the severity of asthma per se and that the poorer outcome of Tunisian patients could reflect the impact of socio-economic status on the risk of death due to this disease [30, 31].

Some limitations to the costing approach used in this study should be mentioned. Personnel costs were average per diem costs and did not reflect actual workload. Likewise, we did not attempt to allocate overhead costs [32], which probably results in reducing the actual cost differences because overheads are higher in French hospitals due to higher amortization and depreciation costs and to other charges.

The Tunisian intensive care appeared less expensive than the French one, because patients had shorter LOS and received less intensive and expensive care. Tunisian intensivits may be selecting a population more likely to respond favourably to ICU care, hence maximizing the health benefits obtained from ICU. However, ICU resource utilization appeared less effective in Tunisia in the intermediate severity range. Our results suggest that if the resource allocation were to be increased in Tunisia, it should be devoted to this particular subset of patients first. This example also highlights the discrepancies between individual and aggregate outcomes, which mirror the potential conflicts between decisions at individual versus population levels.

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