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RESEARCHARTICLE

COST EVALUATION IN ADULT ICU: A TWO-YEAR STUDY IN A GREEK STATE HOSPITAL

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Abstract

Background: During the last decades the combination of international economic and healthcare crisis has led to pressure on healthcare systems and has made financial evaluations particularly important.

Aim: To measure the total cost in ICUs, to analyze its components, and their changes during the study period.

Method and Material: All cost components in four cost categories (direct-variable, direct-fixed, indirect-variable, and indirect-fixed) of all patients admitted in a 6-bed mixed type adult ICU in a general (non-university) hospital of northern Greece in two consecutive periods, with total duration 2 years was measured. The direct-variable cost (medications, consumables, and diagnostic tests) was assessed with bottom-up (micro-costing) method while for the cost components of rest three categories the top-down (attributable costing) was used.

Results: In a 331 patients' sample with 2823 total patient days, the sum cost was 2,417,788€ (1,370,420€ and 1,047,368€ in 1st and 2nd period respectively). The direct variable cost was 897,866.07€ (37.14%), the direct-fixed 1,049,068.6€ (43.39%), the indirect-variable 45,210.6€ (1.87%), and the indirect-fixed 425,643.0€ (17.60%). The mean daily cost per patient was 835.62€ and 885.35€, and the total cost per patient was 7,967.6€ and 6,587.2€ in the two periods of study respectively. The total cost of all non-survivors' patients (N=85, 25.7%) was 595,009.1€ and the efficiency cost per survivor 9,828.4€. The mean daily cost and the total cost per survivor was 840.8€ and 7,409.7€ while for non-survivors was και 908.4€ and 7,000.1€ respectively. During the second study period, a reduction in total costs was observed and especially in direct-variable category attributed mainly to the prices of medicines consumables, and staff gradual costs reductions.

Conclusions: Changes in cost categories vary over time due to social and financial factors while the variables as the ICU environment or patient's characteristics as severity of disease are the main cost drivers. Monitoring and recording of cost components variance would help with valuable information to healthcare managers, doctors, or nursing leaders. Extending this study with a multicenter to more ICUs could provide clearer conclusions about cost variability.

Keywords: Cost evaluation, economic analysis, intensive care unit.

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INTRODUCTION

Many healthcare professionals have the belief that they should not be interested in economics and financial management, without though realizing that they already actively participating in the financial healthcare system, since the role of patient care is closely associated with economic powers such as cost, revenue, and profit. Doctor and nursing leaders at Intensive Care Units (ICUs) are increasingly obligated to know, manage, and prepare budget and business plans to secure their sources required for providing and improving care in their units.[1]

Patient care in (ICUs) is becoming increasingly expensive yet; cost analysis studies of ICUs are rare.[2] In previous decades costs in the health sector and particular in ICUs have shown rates greater than inflation, making the cost of these services unsustainable for many countries. In Greece from 2010 - 2015 due to the economic crisis in-situ, health spending shrank by 1.2% GDP (i.e., from 9.56% to 8.38%), while public funding for health spending fell by 6.2 billion Euros (i.e. from 14.9 to 8.7 billion).[3] The cost of intensive care is now 'substantial' not only for the state budgets, but also for the citizens who are ultimately indirectly carrying the corresponding financial burden via taxes for this expenditure. As with an increasing aging population, resources for caring for patients in need of intensive care will become increasingly scarce.

In addition, the survivors of intensive care, will subsequently present with increased co-morbidity and disability, i.e. continuing to use high-rate healthcare resources.[4] On the other hand, many patients who have little or minimal life expectancy are still admitted to an ICU and thus, 'consume' significant resources, burdening further overall operating costs.[5] Inevitably, questions arise as to whether society is prepared to pay for these costs and whether this high cost of ICU care is 'worth the price'. Such dilemmas are being raised more often due to increasing pressure from hospitals to measure and justify their costs, particularly for care with special reference to cost-quality and cost-effectiveness.[6]

Analytical methods for calculating total costs, although useful, are often time-consuming and laborious, and precise data are often not available.[7,8] Alternatively, cost estimates are performed with gross estimates or are attributed by representative measures such as on the basis of Diagnostic Related Groups (DRGs)[9,10] length of stay[11], disease severity[12] or nursing workload.[13] These methods, while dealing with a certain number of difficulties and representing cost to a semi-satisfactory extent do not, however, represent actual costing which requires greater precision.

In an analysis of cost factors, a two-tier classification is customarily used, i.e., fixed, and variable costs. Fixed costs are those that remain relatively unchanged, i.e., they are independent of the number of patients (staff salaries, capital depreciation, maintenance costs, etc.) while the variable costs are those that change depending on the number of patients and the procedures performed on them (medicines, materials, diagnostic tests, etc.). An additional classification proposed is that of direct and indirect costs. The direct cost is that of the patient's proper care and depends on the amount on the patient per se, and the indirect cost is the administrative or fixed costs related to all other fixed expenditures.[7,13] The combination of these two gives rise to four different cost categories that can be measured and analyzed separately.

In addition, two main approaches have been proposed for detailed measurement of the overall costs of an ICU: the 'top down' or 'attributable costing' and the 'bottom-up' or micro-costing approach. The top-down method is approximate, i.e., costs are recorded overall and then distributed proportionally per patient, usually based on his or her length of hospitalization.[13] It is understandable that other costs such as the fixed costs of an ICU or staffing costs are almost impossible to measure per patient and therefore in such cases the top-down method is more appropriate.

The bottom-up method records the cost of each material or activity and then adds-up to the overall cost (usually per patient). The bottom-up method, although it can only be applied to the calculation of certain cost elements (e.g. medicines, materials and patient diagnostics), is a precision tool and is an option for specific financial assessments.[7,8] Tan et al. proposed a mixed cost-accounting approach, i.e. the combination of the two above methods for cost calculation in seven ICUs in four

European countries (Germany, Italy, the Netherlands and the United Kingdom).[7] In accordance with this technique, direct-variable costs can be measured using the micro-costing method and for all other categories the costing methodology. This mixed approach appears to be gaining ground in the literature as many cost-accounting analyzes are increasingly turning to this practice.[14]

Nevertheless, to date there are insufficient cost analytical data for ICUs, and those available are based either on indirect approaches, using a relatively short time measurement, or on measurements of limited cost categories.

AIM

The aim of the present study was to measure the total cost in ICUs, to analyze its components, and their changes during the study periods.

MATERIAL AND METHOD

Design, sample, and study duration

In this study a mixed approach with full and detailed cost data, in a 6-bed ICU non-university state hospital in northern Greece with 399 total beds, was used. The type and design of the study was a prospective observational study with a target population of all type adult ICU patients (non-cardiology) and a sample of all adult patients admitted in ICU. The duration of data collection was two consecutive years i.e., 2014 - 2016 (from 1/7/2014 to 30/6/2016) and for analysis it was divided into two corresponding periods: from 1/7/2014 to 30/6/2015 (1st period) and from 1/7/2015 to 30/6/2016 (2nd period).

Cost calculation categories and modalities

During the two study periods, all relevant economic data from successive admissions into the ICU were recorded, with a breakdown of four different cost categories as follows:

(a) Direct-Variable cost, which is concerned with expenses concerning direct patient care and is dependent on the number of ICU inpatients. This category included all expenditure on health equipment (consumables), diagnostic tests (imaging, microbiology, hematology, and biochemical laboratory tests) and medication (drugs and fluids) per patient.

(b) Direct-Fixed cost, i.e., costs relating to the direct care of patients, which are independent of the number of patients treated. This category included the gross costs of staff remuneration (doctors, nurses, and other ICU staff), the costs of purchasing new, and the maintenance of existing medical equipment and training of ICU staff. For the costs of training, these were calculated indirectly (by the days of absence of the staff on educational leave) and were not included in the final totals as these costs were included in the salary received by the staff without working on the days of the training leave.

(c) Indirect - variable cost, i.e. costs not related to the direct care of patients but dependent on the number of patients treated. This category included the various ICU common-use materials (reagents, cleaning materials, clothing, technical materials, maintenance of common equipment and stationery).

(d) Indirect Fixed cost, i.e., costs not related to the direct care of patients and independent of the number of patients treated. In this category, the individual cost components were calculated using the analytical method of accounting by an employee at the hospital, specialized in this area. This category included inter alia the proportional allocation of costs of other sections and costs borne by the ICU, the depreciation of fixed capital (equipment) of the ICU, the proportional allocation of costs of the hospital support services (administrative, technical, hospital care, etc.), heating, maintenance, and cleanliness of premises (building infrastructure), energy consumption and water use. Also, some of these (e.g., cleaning, electricity, water consumption, etc.) were calculated based on the ratio of the ICU square meters (2.39%) to the square meters of the whole hospital.

In the first category (direct-variable cost) the calculation was made using the bottom-up method, i.e., the analytical recording of all individual cost components for each individual patient (medication, materials, diagnostic tests, etc.). In the remaining three categories (direct-fixed, indirect-variable, and indirect-fixed costs), calculations were made per cost component in detail but the total resulting amounts were allocated to patients according to their treatment days.

For all the individual cost components and the above categories, the total amounts, the corresponding amounts per ICU day and per patient, were calculated for the two periods and in total. In addition, the efficiency index per survivor (effective cost per survivor: ECPS) corresponding to the cost of all patients (cost of treating patients) and the indirect-variable cost of the surviving and non-surviving patients were also calculated.

Log Tool

A relational electronic database designed specifically for the purpose of this study was used to analyze all economic data. This database ('Care Unit Quality Management Registry' or 'ICU-QMR') also included patient demographics and analytical clinical data on medical and nursing procedures. In order to monitor the variance of ICU costs, all economic parameters by cost category, the recording of which was based on the above-described mixed approach, were included in detail. The application included, among other things, the ability to directly access the view of multiple aggregated charts related to the time variance of all economic parameters.[16]

RESULTS

Out of a total 338 patients enrolled during the study in the ICU, seven cases (extravagant inflows of very short duration of minor patients) were excluded and the final analysis sample was 331 adult (>=18 years) patients (172 and 159 in period 1 and 2, respectively). The total ICU time (days) were 2823 (1640 and 1183 (in periods 1 and 2, respectively). Table 1 and 2 show the main sample characteristics.

The total cost of all categories in the two years was 2,417,788€ (1,370,420€ and 1,047,368€ in period 1 and period 2 respectively). The average total cost per patient was 7,304€ and the average daily cost of 856€. The total direct-variable cost was 897,866€ or 2,712€ average cost per patient or 318€ per ICU day. Direct-variable costs accounted for 41.7% (period 1) to 31.1% (period 2) of total costs. The total direct-fixed cost was 1,049,069€. The average cost per patient was 3,169€ or 371€ per ICU day. Direct-fixed costs accounted for 40.4% (period 1) to 47.3% (period 2) of total costs. The indirect variable cost was 45,210€. The average cost per patient was 137€ or 16€ per ICU patient day. Indirect variable costs accounted for 1.7% (period 1) to 2.1% (period 2) of total costs. The indirect-fixed cost was 425,643€. The total average cost per patient was 1,286€ or 150€ per ICU patient day, accounting for 16.2% (period 1) to 19.4% (period 2) of the total ICU costs (Table 3).

In surviving patients (N=246) APACHE II Score was 18.28±7.36, the mean LOS was 8.81±10.15 days and the total cost of all categories throughout the study was 182,279.6€ or 7,409.7€ per patient or 840.8€ per ICU day. In the patients who died (N=85) APACHE II Score was 25.54±6.98, the mean ICU time was 7.71±9.47 days, and the total cost was 595,009.1€ or 7,000.1€ per patient or 908.4€ per ICU day. The average cost of efficiency per surviving patient was 9,828.4€. Finally, the total direct-variable cost in surviving patients was 655,513€ or 2,664.7€ per patient or €302.4 per ICU day, whereas the cost of non survivors was 242,352.7€ or 2,851.2€ per patient or 370.0€ per ICU patient day.

The tables below show the totals (Table 4), the mean daily and the mean total cost per patient (Table 5) for each combined category in 2 study periods.

The percentages of patients who developed multi-resistant micros (Carbapenem-Resistant Acinetobacter baumannii - CRAB, Klebsiella pneumoniae, Carbapenem-Resistant Pseudomonas aeruginosa - CRPA, Methicillin-Resistant Staphylococcus aureus - MRSA, και Vancomycin-Resistant Enterococcus - VRE) during the ICU stay, varied between the first (11.04%, N=19) and the second study-period (10.06%, N=16). This factor was associated ($p<0.05$) with the mean ICU stay (22.80±14.6 versus 6.84±7.72 days), the mean MV duration (14.82±9.4 versus 4.56±5.94 days) and all other cost components. The average total direct-variable cost per patient with multi-resistant microbes was 8230.8€ versus 2,060.1€ per patient without development of multi-resistant microbes. The cost of consumables, medicines, laboratory, and imaging tests in patients with multi-resistant microbes was 2121.73€, 5394.5€, 579.9€ and 89.3€ versus 640.8€, 1,181.4€, 205.6€ and 23.5€, respectively, of patients who did not develop a multi-resistant microbe.

In the direct-fixed cost category, the reduction in the number of staff (by about three points in total) from the first to the second study-period, (Table 6) resulted in an absolute reduction in total costs of 13.46% (from 547,293.0€ to 473,594.4€). However, due to the decrease in the number of total ICU days from the first to the second study-period (-27.9%), expenditure per ICU day for staff remuneration increased by 19.9% (from 333.7€ in the first to 400.3€ to the second study-period). Thus, while the overall average cost per patient fell from 7,967.6€ to 6,587.2€ from the first to the second study-period, the average daily cost per patient increased from 835.62€ to 885.35€. In other words, although there was a reduction in the cost due to the reduction in staff number, the cost increasement per ICU day due to LOS reduction (from 9.53±11.54 to 7.44±7.38 days), was more significant. This increase in the average daily cost per patient, except for a reduction in the mean ICU LOS, can be attributed to the difference in patient severity (APACHE II score: 19.88±7.8 versus 20.56±8.02, $p<0.05$) as well as those patients who developed multi-resistant infections as reported above.

DISCUSSION

The highest cost rates were observed at the direct-variable and direct-fixed costs but differentiated in the two study periods (Graph 1). In period 1, 41.7% ranked direct-variable costs first among the categories with direct-fixed costs followed by 40.4%. This finding is not consistent with the international literature, in which, by a large majority, staff costs usually account for the highest proportion of the costs of all categories.[17-20] In the second study period, a reversal of these rates (Graph 1) was observed, the first percent being direct-fixed costs (47.3%) with direct-variable followed by 31.1%. This reversal is mainly due to a reduction in the direct-variable costs (-20.9% per ICU day), consumables (-25.9%) and medicines (-20.4%) and was found to be at a statistically significant level ($p<0.05$). At the same time, there was a relative increase in the share of total direct-fixed costs (mainly in staff costs). These changes can be explained by the following factors:

First, the economic crisis in Greece, which has obviously gradually brought about both better financial control and lower prices for medicines and consumables. It is well known that since 2010 Greece was under austerity and one of the measures taken to deal with it was to reduce the cost of hospital supplies (pharmaceuticals, medical supplies, orthopedic devices, chemical reagents, etc.). Hospital fees accounted for 68% of the total operating costs of hospitals (excluding salaries) and with measures such as simplifying procedures, commissions, implementing reforms in pharmaceutical policy and horizontal cuts decided by the Ministry of Health, a reduction of around 38.2% was achieved. In the pharmaceutical policy in particular, the promotion of the use of generic medicines in the public health system and policies such as the introduction of a national electronic prescription system, the prescription of the active substance rather than the commercial equivalent, the mandatory 50% rate in the use of generic medicines and the imposition of the limit on the maximum price of generic medicines (up to 60% of the price of labeled medicines) have led to an increase use of generic medicines representing 26% of total pharmaceutical costs in public hospitals in 2011. With similar policies, spending in 2011 on medical supplies, pharmaceutical and chemical reagents fell by 38.5%, 29% and 30.5%, respectively.[21] These policies were continued during the study period, resulting in gradual reductions in the costs of both pharmaceutical and ICU medical materials.

Another reason was the decrease in the mean mechanical ventilation (MV) duration (from 6.31±8.12 during the first, to 4.89±5.74 days in the second study-period, respectively). However, the percentage of patients' time in MV relative to their total ICU LOS between 1st and 2nd (64.9% and 65.7% respectively) did not differ ($p>0.05$) statistically and the above difference should be attributed to the shorter mean LOS in the second study-period. It is documented in the literature that MV is associated with significantly higher daily costs for patients in the ICU and interventions related to the reduction in MV duration lead to significant reductions in the total patient cost.[22] In addition, it is proven that prolonged LOS in combination with MV predisposes a patient to greater risk of infections and death which also increase costs.[23]

The average total direct-variable cost per patient with multi-resistant microbes was about fourfold greater than per patient without development of multi-resistant microbes. These results are confirmed in the international literature. In the study by Jia et al., it was found that the increase in the cost of hospitalization in patients with multi-resistant microbes (6,127.65€ versus 2,274.02€ of the control group) was statistically significant ($p<0.01$) and was mainly due to additional pharmaceutical costs.[24] In the systematic review of Tansarli et al. it was also found that in 17 of the 24 studies, researchers had reached the same conclusion, i.e. the correlation between multi-resistant microbial infections and increased patient care costs, regardless of the range of micro-organisms, the type of infection, the patient population and healthcare systems.[25]

Although it cannot be confirmed, an impact by the ICU management is likely, as they have gradually shown increasing interest in reducing waste during the study period contributing significantly to the reduction of costs (Hawthorne effect).[26] These results are partly comparable with the international literature. For example, Lefrant et al., (2009) estimated the staff cost rate to be of 43% and the total direct cost of 59%. The average direct cost per patient was 842±521€ while direct-variable costs (staff costs) were 607€ (versus 333.7€ to 412.8€ in the present study) and the indirect-fixed (administrative) costs of 326€ (versus 135€ to 171€ in this study).[12] The above variances can be attributed to the difference in average staff-cost (the difference between the 2009 GDP of France and that of Greece in 2016 was 13,700€) as well as the difference related to staffing mainly of doctors and nurses between the two countries.[27]

The average direct-variable cost (318.1€ in the present study), although it showed a significant downward trend between study periods, (from 348.6€ in the first to 275.7€ in second study-period), is still far from the corresponding cost (130€ per ICU day) in the Lefrant et al. study.

In a similar study by Karabatsou et al. in 138 ICU patients in a Greek hospital in Athens with a LOS of >24 hours, the variable cost was 573.18€ per patient day versus 334.06€ (sum of direct and indirect variable costs) in the present study. These differences may be due to the different methodology (e.g. in this study, all the materials, drugs and tests of all patients enrolled into the ICU were calculated), the mean ICU LOS (8 versus 8.5 days in the present study), patient severity (APACHE II score 18.64±0.61 versus 20.20±7.92 in this study) and other possible factors that cannot easily be determined.[28]

In general, however, it is understood that there has been a gradual reduction in the variable costs due to the factors discussed above, the reduction in the price of medicines and materials for the ICU, but also the reduction in staff remuneration costs.

Cost studies in the ICU have traditionally focused on variable on direct-variable costs that differ from one patient to another as they are the costs affected by policies and interventions to reduce the LOS in the ICU. However, it has been reported that up to almost 80% of the cost of an ICU is in fact stable.[29] Direct-variable costs contribute little to the total cost of an ICU and therefore the modification of ICU LOS may not result in significant cost differences. In contrast, it has been reported that greater cost savings can be achieved through changes in fixed costs, such as improved appropriate use of beds or appropriate staffing in the ICU.[30]

In our study, the fixed cost rate reached 66.7% (second study-period) with nursing and medical staff costs being the greatest. The remaining 33.3%, which was the variable cost (second study-period) although not negligible, was relatively low compared to other studies and this can be attributed to the reduced staffing of medical staff, but also to the relatively low salaries in general of hospital staff in Greece.

Regarding indirect-fixed costs, the reduction observed by 8.47% (from 22,233.1€ in the first to 203,409.9€ in the second study-period) can be attributed mostly to the shorter treatment duration since the calculation of these costs was proportional to the patient's LOS and less to the reduction in actual costs. In a similar study in India over the same period, indirect costs accounted for 19.4% of total costs (compared to 19.5% in the present study).[31]

The Efficiency Cost Per Survivor (ECPS) and the financial loss per patient are useful measures to reimburse costs to the ICU. As more resources are spent on non-survivors, the ECPS increases significantly. In the study of Kulkarni at al., for example, it was found that cost efficiency could be improved in a group of post-operative cancer patients when they were hospitalized in a ward and not in the ICU, concluding that care limits should be set in patients who may have a poor outcome.[32] In our study, the direct-variable daily cost (Table 7) was 22.37% higher in the non survivors than in the survivors. In a corresponding study in the US in 2003-2005 in 572 patients in five ICUs with a total of 88 beds, direct-variable costs represented 20% of total cost, direct-fixed costs 45% and the remaining indirect costs 34% versus 38.3%, 42.6% and 19 1% respectively in this present study (Graph 2).[33] Although the difference in direct-variable costs between the two patient groups was non-statistically significant ($p>0.05$), the non survivors had higher consumption of medicines and materials (Graph 3), which can be attributed mainly to the higher disease severity when entering the ICU at a statistically significant level ($p<0.05$). As a result, the average cost per patient day for non survivors was significantly higher. However, the lower average ICU LOS by about one day resulted in reduced costs (directly-fixed and indirectly-fixed costs) and ultimately lower average total costs per non survivor than the corresponding survivor. The cost savings attributable to the reduced LOS were only 5.4% of the total cost per patient and would probably have been lower considering that the average daily cost was used in the calculation of the costs rather than the actual costs per ICU patient day (which may have been significantly lower in the last few days).[11,22,34]

Limitations

All costs were calculated based on the values of the start year of the study in the current European common currency (euro). For convenience reasons no change in discount or adjustment of price harmonization was made between the two study periods. Although the concepts of cost and expenditure are not identical, in this study they have been used with the same meaning as the amount spent on the running of the ICU. Finally, the cost calculation of the diagnostic examinations, was based on charges taken of the Greek National Agency for Health Services' (NAHS) list of applicable compensation prices based on a national agreement established by a Greek law in 2015.[35]

CONCLUSIONS

The recording and analysis of all cost in the ICU for two consecutive years showed the variation of cost between the two study periods. Cost categories in the first period showed an unexpected dominance of direct-variable costs with direct-fixed costs following. This was reversed in the second period and the changes observed were in the reduction in prices for medicines and materials and in the reduction in staff costs. The severity and presence of multi-resistant microbes and by extension, and duration of mechanical ventilation also appear to have affected the duration of hospitalization and changes in both the immediate and the other cost categories. The differences in cost between survivors and non survivors were mainly attributed to the difference in the amount of medicines and materials used but the overall average cost per patient between these two patient categories was relatively small. The extension of this study by a multifactorial analysis method to several ICUs could identify independent factors for cost variability.

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ANNEX

Table 1. Main characteristics of study sample.

Sample Characteristics	1st period	2nd period	Total
Patients (N, %)	172 (51.95%)	159 (48.04%)	331 (100%)
Male (N,%)	125 (72.7%)	98 (61.6%)	223 (67.4%)
Female (N,%)	47 (32.3%)	61 (38.4%)	108 (32.6%)
Age (mean, SD)	61,7±16.37	59.53±17.67	331 (60.66±17.02)
LOS days (mean, SD)	9.53±11.54	7.44±7.83	7.49±9.94
LOS (days)	1640	1183	2823
MV days (mean, SD)	6.31±8.12	4.89±5.74	5.63±7.1
Pathological patients	73 (42.44%)	69 (43.40%)	142 (42.90%)
Surgical patients	99 (57.56%)	90 (56.60%)	189 (57.10%)
Ventilator Utilization Ratio (mean, SD)	0.77±0.23	0.79±0.23	0.78±0.23
APACHE II Score (mean, SD)	19.88±7.86	20.57±8.02	20.20±7.92
APACHE II PDR (mean, SD)	38.00±22.22	39.56±22.60	38.72±22.36
SAPS II Score (mean, SD)	50.12±17.81	49.84±17.96	49.98±17.94
SAPS II PDR (mean, SD)	45.95±29.14	45.36±29.61	45.67±29.30
ISS Score (mean, SD)	24.03±15.46	26.80±16.23	25.50±15.83
RTS Score (mean, SD)	5.28±1.56	5.40±1.53	5.34±1.53
Survivors (N,%)	131 (76.16%)	115 (72.33%)	246 (74.3%)
Non-Survivors (N,%)	41 (23.84%)	44 (27.87%)	85 (25.7%)
ECPS (Efficiency Cost Per Survivor):	9,828.4€		
Occupancy rate (%)	74.88%	53.99%	64.43%
SMR	0.6779 (95% CI 0.48–0.95)		

LOS=Length Of Stay, MV=Mechanical Ventilation, APACHE II=Acute Physiology And Chronic Health Evaluation II, SAPS= Simplified Acute Physiology Score, ISS=Injury Severity Score, RTS=Revised Trauma Score, SMR= Standardised Mortality Ratio.

Table 2. Reasons for patient admission.

Reasons of admission	N, (%)
Respiratory failure	54 (16.3%)
Multiple trauma	27 (8.2%)
Head injury	23 (6.9%)
Craniotomy, neoplasm	22 (6.6%)
Multiple organ dysfunction	20 (6.0%)
Craniotomy, ICD/SDH/SAH	18 (5.4%)
Craniotomy, head injury	12 (3.6%)
Brain Hemorrhage	11 (3.3%)
Coma / depressed LOC	10 (3.0%)
Situation after cardiac arrest	10 (3.0%)
Septic shock	9 (2.7%)
Poisoning	8 (2.4%)
Bronchoscopy under sedation	7 (2.1%)
GI surgery, bleeding	7 (2.1%)
GI surgery, neoplasm	7 (2.1%)
Other	86 (25.98%)

Table 3. Cost per component analyses of all categories cost in the 2 study periods. *Training costs were calculated indirectly (from the days of absence of staff on leave) and are not included in the final totals.

Cost Category	**Cost components**	**(1st period)**	**(2nd period)**	**Total (€, %)**
Direct Variable				
Cost1	Medical care materials	171987.4 (12.5%)	91974.0 (8.8%)	263961.4 (10.92%)
Cost2	Medical imagining (X-ray, echo, U/s, MRI, CT e.t.c)	6166.8 (0.4%)	3924.8 (0.4%)	10091.6 (0.42%)
Cost3	Lab tests (Microbiology, Hematology Biochemistry)	48976.95 (3.6%)	32198.42 (3.1%)	81175.37 (3.36%)
Cost4	Medications - Fluids (Including TPN)	342172.6 (25.0%)	196356.1 (18.7%)	538528.7 (22.27%)
Cost5	Enteral feeding. (Including per os diet)	2462.0 (0.2%)	1647.0 (0.2%)	41090.0 (0.17%)
Subtotal of Direct Variable		571765,75 (41,7%)	326100.32 (31.1%)	897866.07 (37.14%)
Direct Fixed				
Cost6	Labor (ICU specialists)	198561.0 (14.5%)	169775.1 (16.2%)	368336.1 (15.23%)
Cost7	Labor (ICU nursing staff)	310473.0 (22.7%)	283368.9 (27.1%)	593841.9 (24.56%)
Cost 8,9,10	Labor (ICU specialists)	38259.0 (2.8%)	35170.5 (3.4%)	73429.5 (3.04%)
Cost11	Investment in new equipment (medical)	0 (0.0%)	4650.0 (0.4%)	4650.0 (0.19%)
Cost11	Equipment maintenance (medical)	6226.2 (0.5%)	2584.9 (0.2%)	8811.1 (0.36%)
Cost12	Staff continuing education*	331,2	1135,6	1466,8
Subtotal of Direct Fixed		**553519,2 (40.4%)**	**495549.4 (47.3%)**	**1049068.6 (43.39%)**
Indirect Variable				
Cost13-18	Miscellaneous, non-medical disposables (included, cleaning materials, clothing, technical materials, maintenance of common – non medical, stationery)	21116.43 (1.5%)	19340.39 (1.8%)	40456.82 (1.67%)
Cost19	Miscellaneous, medical disposable materials (including antiseptics, – disinfection agents etc.)	1480.3 (0.1%)	2647.29 (0.3%)	4127.59 (0.17%)
Cost21	Other miscellaneous, non-medical disposables for common use	305.1 (0.02%)	321.09 (0.02%)	626.19 (0.03%)
Subtotal of Indirect Variable		**22901,83 (1.7%)**	**22308.77 (2.1%)**	**45210.6 (1.87%)**
Indirect Fixed				
Cost23	ROI (Return Of Investment) for ICU	69270.8 (5.1%)	69413.5 (6.6%)	138684.3 (5.74%)

Cost24	Hospital Supporting Services (administrative, technical, hospital security etc)	45348.8 (3.3%)	50986.5 (4.9%)	96335.3 (3.98%)
Cost25	Heating expenses	25419.1 (1.9%)	18256.6 (1.7%)	43675.7 (1.81%)
Cost26	ICU maintenance (Hotel infrastructure)	24067.4 (1.8%)	17309.3 (1.7%)	41376.7 (1.71%)
Cost27	Cleaning services	35843.0 (2.6%)	27774.8 (2.7%)	63617.8 (2.63%)
Cost28	Electricity expenses	19988.0 (1.5%)	16666.0 (1.6%)	36654.0 (1.52%)
Cost29	Water expenses	2296.0 (0.2%)	3003.2 (0.3%)	5299.2 (0.22%)
Subtotal of Indirect Fixed		**222233,1 (16.2%)**	**203409.9 (19.4%)**	**425643.0 (17.60%)**
TOTAL		**1370420**	**1047368**	**2417788.0 (100.00%)**

Table 4. Category and total costs in 2 study periods.

Cost category	**1st period (€, %)**	**2nd period (€, %)**	**Total (€, %)**
Sum of Direct cost	1125285.0 (82.1%)	821649.7 (78.4%)	1946934.7 (80.5%)
Sum of Indirect cost	245134.9 (17.9%)	225718.7 (21.6%)	470853.6 (19.5%)
Sum of Variable cost	594667.6 (43.4%)	348409.1 (33.3%)	943076.7 (39.0%)
Sum of Fixed cost	775752.3 (56.6%)	698959.3 (66.7%)	1474711.6 (61.0%)

Table 5. Mean daily cost and mean total cost per patient for each combined category in the 2 study periods.

	1st period (€)	**2nd period (€)**
Cost category	Mean daily cost / Mean total patient cost (€)	Mean daily cost / Mean total patient cost (€)
Direct-Variable	348.64 / 3324.2	275.66 / 2050.9
Direct-Fixed	337.51 / 3218.1	418.89 / 3116.7
Indirect-Variable	13.96 / 133.2	18.86 / 140.3
Indirect-Fixed	135.51 / 1292.1	171.94 / 1279.3
Total Sum	**835.62 / 7967.6**	**885.35 / 6587.2**

Graph 1. Category cost rate changes between the two periods of study.

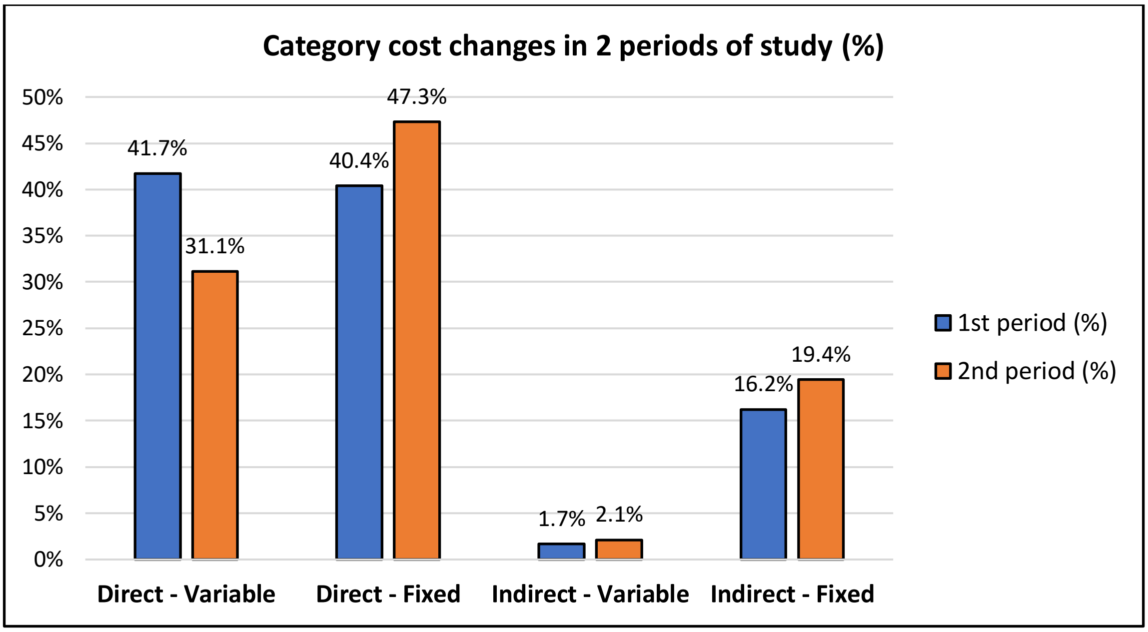


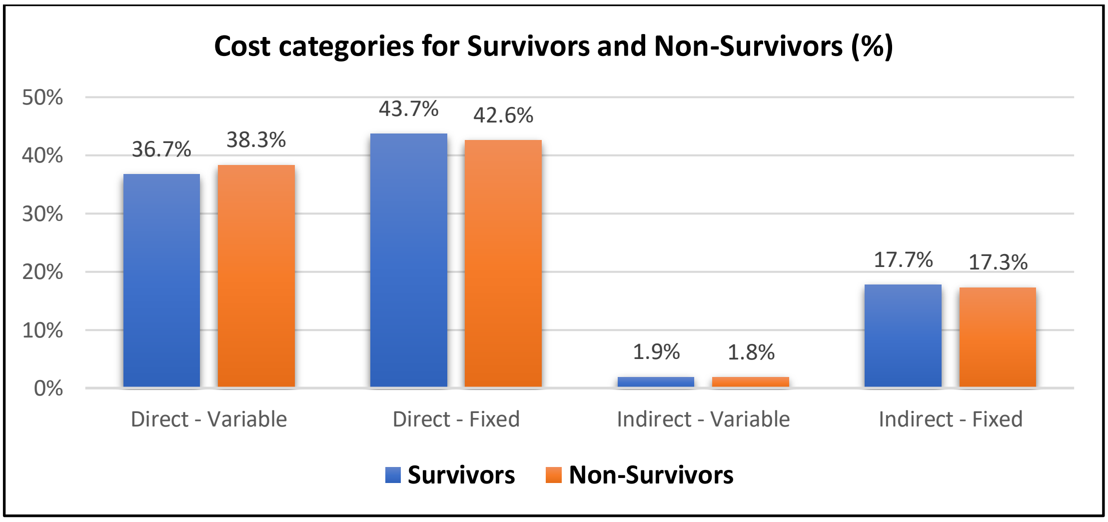
Table 6. Mean monthly and total gross salaries for each staff category in ICU (€). *Mean staff units per year.

Staff category	**1st period**			**2nd period**		
	N*	Mean monthly gross salary (€)	Total gross salary (€)	N*	Mean monthly gross salary (€)	Total gross salary (€)
Nurses	18.0	17248.5 (20.9%)	310473.0 (56.7%)	16.3	16448.2 (10.2%)	268648.8 (56.7%)
Physicians	5.0	39712.2 (48.1%)	198561.0 (36.3%)	4.0	42443.8 (49.5%)	169775.1 (35.8%)
Non-medical staff	1.3	17167.2 (20.8%)	21459.0 (3.9%)	1.0	18370.5 (21.4%)	18370.5 (3.9%)
Housekeeping	2.0	8400.0 (10.2%)	16800.0 (3.1%)	2.0	8400.0 (9.8%)	16800.0 (3.5%)
Total	**26.3**	**82527.9**	**547293.0**	**23.3**	**85662.5**	**473594.4**

Table 7. Total, mean daily and mean total patient cost analysis for each combined category cost of survivors and non survivors (€).

Cost categories	Total cost		Mean daily cost		Mean cost per patient	
	Survivors	Non-Survivors	Survivors	Non-Survivors	Survivors	Non-Survivors
Direct-Variable	667296.2	242352.72	302.4	370.0	2664.7	2851.2
Direct-Fixed	805660.9	243407.7	359.6	411.3	3275.0	2863.6
Indirect-Variable	34720.7	10489.9	15.5	17.7	141.1	123.4
Indirect-Fixed	326884.2	98758.8	145.9	166.9	1328.8	1161.9

Graph 2. Cost category rates of survivors and non survivors (%).



Graph 3. Direct-variable cost components for survivors and non-survivors: Mean cost per patient (€).