Original Article

Factors Increasing Hospitalization Cost in Adult Patients Post Cardiac Surgery

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Abstract

Background: The hospitalization of patients post cardiac surgery ICU constitutes a complex mixture of procedures affected by a variety of clinical, administrational and technical aspects of care. The respective cost may drastically increase due to these patients' increased clinical needs, including also the clinical state of delirium which is a quite common complication following this type of operation.
Objective: We are aiming to address the gaps in literature about healthcare costing in Cardiac Surgery ICU. and try to calculate any costs that may occur during hospitalization post cardiac surgery in the ICU
Methodology: The study included 179 consecutive patients who underwent open heart operation with cardiopulmonary bypass. Perioperative time intervals, hospitalization outcomes, along with the delirium complication were studied. Updated cost prices of DRGs (Diagnosis Related Groups) were applied on every case specifically. Hospitalization costs were built up on top of these DRGs, using the micro-costing method as well.
Results: The delirium complication was recorded in 20 out of 179 patients of the study (11.2%). Bivariate analysis revealed that prolonged intraoperative time in cardiopulmonary bypass (p<0,001), prolonged sedation time (p=0,005) and prolonged length of stay with endotracheal tube (p<0,001) were significantly correlated with increased total health care cost. Multivariate analysis showed that the complexity of surgical operation (p<0,001), the delirium complications (p<0,001) and the prolonged in-hospital length of stay (p<0,001), formulated altogether a group of factors contributing on hospitalization cost increase.
Conclusions: The independent variables of complexity of operation, cardiopulmonary bypass time, and prolonged in-hospital length of stay, are potentially responsible for hospitalization cost increase and may also jeopardize quality of care and health outcomes.

Keywords: Hospitalization cost increase, Diagnosis Related Groups, delirium complication.

Introduction

It is widely known that some of the costliest clinical procedures are implemented in the Intensive Care Units (ICUs). These clinical departments are also characterized by an increased number of medical prescriptions and treatments that need to be completed. They also require a substantial number of human resources in order to operate properly and assure patients' safety. More analytically, the process of hospitalizing ICU patients contains a wide mixture of clinical procedures affected by a wide variety of clinical, administrational and technical aspects of care. In addition, the respective costs may drastically increase due to those patients' hospitalization needs.

Background: Numerous studies exist which highlight the necessity of analytical identification of factors increasing cost in healthcare services, in general, and Intensive Care Units and Cardiac Surgery ICUs more specifically (Seidel,Whiting & Edbrooke, 2006, Weinrebe et al, 2016, Mistichelli, 2001, Mogyorosy, Smith, 2005).

In fact, methodologies of cost calculation may vary among studies and surveys, which in turn lead to different calculated results finally (Seidel et al, 2006). Another reason for such a discrepancy among studies regarding factors increasing healthcare cost in the ICUs could be found at the complications which might also exist as long as those treatments were taking place. Our method of identifying factors increasing hospitalization cost was based on the implementation of DRGs (Diagnosis Related Groups), a costing method that was put in practice since '80s in Medicare System of the United States. The pay rate of reimbursement was calculated and structured upon on those groups' classification. The DRGs' classification ranges up to 467 illness categories in total, as identified in the International Classification of Diseases (Mistichelli, 2001). In this study we are trying to address the gaps and inconsistencies in the existing literature about healthcare costing in Cardiac Surgery ICU. The purpose of our study is to calculate any costs that may occur during hospitalization post cardiac surgery in the ICU. This procedure will take place by conducting the micro-costing method on top of implementation of the relevant DRGs upon those cases. Our study included the Diagnosis Related Groups relative to cardiac surgical cases and their post-operative processes and any accompanying complications as well. In parallel, given the fact of a wide variation of recording ways to document the resources spent in an Intensive Care Unit we had to bear in mind those different options of treating patients, which in turn would lead to a mixed variation of potential costs added to the final budget of the unit (Vozikis et al, 2016, Moerer et al, 2007, Tan et al, 2012). We used the micro-costing method in order to determine the factors increasing hospitalization cost. As this methodology was applied in detail, all cost components that were used on patients were analytically registered. In addition, this method has been used quite commonly in the past (Mogyorosy, Smith, 2005, Tan et al, 2012). One of the most common complications among cardiac surgery patients is the post-operative delirium state which is recorded up to 72% among study populations (Gummert, Walther, Doll, 1996, Smulter et al, 2013, Theologou, Giakoumidakis & Charitos., 2018, Norkiene et al, 2007, Chang et al, 2008). We included this specific complication in our study, as it appears to play a critical role to the outcomes and their financial consequences regarding hospitalization of ICU patients (Weinrebe et al, 2016). The aim of our study was to estimate and analyze the cost of hospitalization of cardiac-surgical patients and its correlation with demographic and anthropometric characteristics, the type of the intervention, the multitude of intra-operative and post-operative risk factors and outcomes, with a focus on the induction and occurrence of post-operative delirium as well.

Methodology

Study population: A cross-sectional study involving patients who underwent open heart operation with cardiopulmonary bypass was conducted (prospective data collection) over a 12-month period at a Greek Public General Hospital. The study population consisted of 179 patients, 20 of whom (11.2%) presented delirium complication, being diagnosed with the Confusion Assessment Method (Ely et al, 2015) (Adamis et al, 2012) (CAM-ICU). Due to the inclusion of the complication of delirium postoperatively, patients a) with poor knowledge/understanding of the Greek language, b) with speech-hearing disorders, c) who had GCS <13 (Glascow Coma Scale) or mental and/or behavioral disorders postoperatively, addiction to alcohol/psychotropic abuse, d) who had experienced respiratory and/or cardiac arrest postoperatively and underwent CPR, were all excluded. Data were collected from patient medical and administrative files and from the Hospital Pharmacy as well.

Measures: We used the *Confusion Assessment Method (CAM-ICU)* as the delirium diagnostic tool, weighted and translated into the Greek language (Adamis et al, 2012).

In addition, the data collection form included fields about the sample's demographic and anthropometric characteristics, the type of the intervention that patients underwent and other perioperative risk factors and outcomes (such as the induction and occurrence of post-operative delirium, the duration of anesthesia, patient's discharge time intervals, the length of stay in the ICU and in the Ward as well).

Statistical analysis: Categorical variables are presented as absolute (n) and relative (%) frequencies; quantitative variables are presented as mean (standard deviation) or as median (inter-quartile range). The Kolmogorov-Smirnov test and normality box plots were used to test the normal distribution assumption for quantitative variables. Student's t-test was used in order to investigate the relationship between a quantitative variable and a dichotomous variable. The Pearson's correlation coefficient was used to investigate the relationship between two quantitative variables following the normal distribution, and the Spearman's correlation coefficient was used to investigate the relationship between a quantitative variable and an ordinal variable. In the case, where > 2 independent variables were statistically significant at the level of 0.2 (p <0.2) in the bivariate analysis, multivariate linear regression (backward stepwise linear regression) was applied (coefficients' beta values, the corresponding 95% confidence intervals and p-values are presented). The two-sided level of statistical significance was set at 0.05. Data analysis was performed using the IBM SPSS 20.0 statistical package software.

Ethics: Permission for the study implementation was issued by the Scientific Board of the author's institute. In addition, the participants of the study gave their informed consent in order to be included in the study and to be screened for delirium in the ICU. The study was carried out in line with the ethical standards of the responsible institutional committee for human experimentation and preceded in line with the tenets of the Helsinki Declaration of 1975, as revised in 2013. Privacy and confidentiality of the patients' personal data was assured, in order to maintain their dignity at all times throughout the study period.

Results

Effectiveness and safety indicators: As we mentioned above, the delirium outcome was analyzed thoroughly as a key role for increased hospitalization cost as there was expected that significant findings would occur. And it was done so, as differences of clinical significance were noted among delirium and non-delirium patients, i.e. delirium patients stayed longer in cardiopulmonary bypass and presented ischemia for longer than non-delirium patients (140min stay vs. 118 min, p=0.113 and 90min vs. 75min, p=0.155, respectively) (Table 3). Additionally, statistically significant differences were found among delirium and non-delirium regarding length of stay at the cardiac surgery unit (p<0.001), length of stay in hospital (p=0.028) and endotracheal tube time interval (p=0.001) (Table 3).

Hospitalization Cost: The mean hospitalization cost for patients who underwent CABG was €9,219.9 euro (SD=2,568.7), for patients who underwent AVR or MVR was €11,199.1 (SD=1,986.5) and for patients who underwent Bentall / Ascending Aortic Arch Replacement (+ -AVR), it amounted to €13,756.9 (SD=5,544.1). In addition, the mean hospitalization cost for patients who underwent AVR & MVR & CABG / TVR interventions reached the highest observed level (mean=€16,989.2, SD=2,781.2). In contrast, the lowest mean hospitalization cost, among all interventions was observed for ASD / VSD interventions (mean=€4,592.1, SD=1,863.7)

Correlations (with hospitalization cost as the dependent variable):Bivariate analyses' results between sample demographics and other characteristics and total hospitalization cost are shown in Table 5. According to the results of the multivariate linear regression analysis, patients who underwent AVR & MVR (+ - CABG + -TVR) had the higher mean hospitalization cost (= €16,989.2) than those who had not undergone AVR & MVR (+ - CABG + -TVR) (p<0.001). Also, increased time duration in Cardiopulmonary Bypass, ischemia time duration while cardiopulmonary bypass, anesthesia time interval during patients' stay in the Unit, endotracheal tube time interval, length of stay at the Cardiac Surgery Unit and length of stay in the hospital were related with increased hospitalization cost (p<0.05). Finally, delirium patients had higher hospitalization cost than non-delirium patients (p<0.001).

According to multivariate linear regression analysis (Table 6), patients who underwent CABG had a lower mean hospitalization cost (by €2,138.3) than those who had not undergone CABG (p<0.001). In addition, the group of ASD / VSD patients had the lowest mean hospitalization cost (by € 6,103.5) compared to those who had not undergone ASD / VSD (p<0.001). In contrast, patients who underwent Bentall / Ascending Aortic Arch Replacement had a higher mean total hospitalization cost (by €1,855.8) than those who had not undergone

Bentall / Ascending Aortic Arch Replacement (p=0.046).Moreover, patients who underwent AVR & MVR (+ -CABG + -TVR) had a higher mean hospitalization cost (by €5,418.2) than those who had not undergone AVR & MVR (+ -CABG + -TVR) (p<0.001).

Table 1. Demographic and anthropometric characteristics

Characteristic	TOTAL SAMPLE N (%)	Delirium		P-value
		No	Yes	
Age (years)[a]	**63.3 (12.7)**	62.5 (12.6)	69.6 (11.9)	**0.020**[b]
Gender				0.202[c]
Male	**129 (72.1)**	117 (73.6)	12 (60.0)	
Female	**50 (27.9)**	42 (26.4)	8 (40.0)	
Body Mass Index (BMI)[a]	**28.1 (5.1)**	27.9 (5.2)	29.2 (4.2)	0.226[b]

Values are expressed as absolute frequencies (n) and relative frequencies (%) unless otherwise stated.
[a]Mean value (standard deviation) [b]Student's t test

Table 2. Interventions'characteristics

Characteristic	Total Sample N (%)	Delirium		P-value
		No	Yes	
Type of intervention				
CABG				**0.032**[a]
No		71 (44.7)	14 (70.0)	
Yes	**94 (52.5)**	88 (55.3)	6 (30.0)	
AVR/MVR				0.267[α]
No		117 (73.6)	17 (85.0)	
Yes	**45 (25.1)**	42 (26.4)	3 (15.0)	
Bentall-AscAort-Arch Replcmnt (& +-AVR)				0.746[a]
No		148 (93.1)	19 (95.0)	
Yes	**12 (6.7)**	11 (6.9)	1 (5.0)	
AVR & MVR (& + -CABG/TVR)				**<0.001**[a]
No		146 (91.8)	10 (50.0)	
Yes	**23 (12.8)**	13 (8.2)	10 (50.0)	
ASD/VSD				0.549[a]
No		154 (96.9)	20 (100.0)	
Yes	**5 (2.8)**	5 (3.1)	0 (0.0)	
Transfer to the High Dependency Unit				0.321[c]
No	**158 (88.3)**	139 (87.4)	19 (95.0)	
Yes	**21 (11.7)**	20 (12.6)	1 (5.0)	
Bloodtransfusion				0.157[a]
No	**166 (92.7)**	149 (93.7)	17 (85.0)	
Yes	**13 (7.3)**	10 (6.3)	3 (15.0)	
EuroSCORE II (European System for Cardiac Operative Risk Evaluation) [b/c]	**6.2 (8.9) / 1.1 (13.7)**	5.8 (8.9) / 10.2 (12.9)	9.8 (24.9) / 18.5 (17.2)	**0.006**[d]

Values are expressed as absolute frequencies (n) and relative frequencies (%) unless otherwise stated.
[a]Chi-square test [b] Median (interquartile range) [c] Mean value (standard deviation) [d]Mann-Whitney test
Intervention abbreviations;CABG: Coronary Artery Bypass Graft, AVR: Aortic Valve Replacement, MVR: Mitral Valve Replacement, TVR: Tricuspid Valve Replacement,Bentall :operation'Bentall' , Ascending Aorta / Aortic Arch Replacement, ASD: Atrial Septal Defect, VSD: Ventricular Septal Defect.

Table 3. Effectiveness and safety indicators

Characteristic	TOTAL SAMPLE Mean value (standard deviation)	Delirium		P-value
		No	Yes	
Time duration in Cardiopulmonary Bypass (in minutes)	121.2 (42.6)	118.8 (40.2)	140.2 (56.0)	0.113[a]
Ischemia time duration while cardiopulmonary bypass (in minutes)	77.4 (31.5)	75.8 (29.7)	90.1 (42.0)	0.155[a]
Length of stay at the Cardiac Surgery Unit	1.6 (1.8)	1.5 (0.7)	2.4 (1.6)	**<0.001**[b]
Length of stay in hospital (in days)	7.4 (2.9)	7.3 (2.7)	8.8 (4.6)	**0.028**[b]
Length of stay in the Cardiac Surgery Unit (in hours)	35.1 (19.8)	32.6 (14.5)	55.9 (37.7)	**<0.001**[b]
Anesthesia time interval during patients' stay in the Unit (in hours)	7.2 (8.4)	6.5 (5.0)	13.2 (20.7)	0.189[b]
Endotracheal tube time interval (in hours)	10.7 (11.4)	9.7 (8.1)	19.5 (24.1)	**0.001**[b]

Values are expressed as mean value (standard deviation) unless otherwise stated. [a]Student's t test [b]Mann-Whitney test

Table 4. Basic descriptive measures for the hospitalization cost and hospitalization cost per type of intervention

Characteristic	Mean value	Standard deviation	Median value	Minimum value	Maximum value
Hospitalization cost	10,890.6	3,915.2	9,586	2,169	28,555.5
Hospitalization cost per type of intervention					
CABG	9,219.9	2,568.7	8,816.1	7,276	26,377.9
AVR/MVR	11,199.1	1,986.5	10,415.6	9,328	17,162.6
Bentall-AscAort-Arch Replcmnt (&+- AVR)	13,756.9	5,544.1	12,714.9	8,480	28,555.5
AVR & MVR (&+- CABG/TVR)	16,989.2	2,781.2	17,739.7	8,934	20,030.1
ASD/VSD	4,592.1	1,863.7	5,835.6	2,169	6,026.2

Table 5. Bivariate analyses between sample demographics and other characteristics and total hospitalization cost

Independent variable	Mean hospitalization cost (standard deviation)	P-value
Age (years)[a]	0.107[a]	0.152[a]
Gender		0.614[b]
Male	10,798.3 (3,671.5)	
Female	11,128.8 (4,515.7)	
Body Mass Index (BMI)[a]	0.004[a]	0.954[a]
Type of intervention		
CABG		**<0.001**[b]
No	12,738.3 (4,312.6)	
Yes	9,219.9 (2,568.7)	
AVR/MVR		0.392[b]

No	10,787.0 (4,378.0)	
Yes	11,199.1 (1,986.5)	
Bentall-AscAort-Arch Replcmnt(+-AVR)		**0.008**[b]
No	10,684.7 (3,709.9)	
Yes	13,756.9 (5,544.1)	
AVR & MVR & CABG/TVR		**<0.001**[b]
No	9,991.5 (3,189.5)	
Yes	16,989.2 (2,781.2)	
ASD/VSD		**<0.001**[b]
No	11,071.6 (3,809.5)	
Yes	4,592.1 (1,863.7)	
Transfer to the High Dependency Unit		0.933[b]
No	10,881.6 (3,970.6)	
Yes	10,958.7 (3,558.3)	
Time duration in Cardiopulmonary Bypass (in minutes)[a]	0.469[a]	**<0.001**[a]
Ischemia time duration while cardiopulmonary bypass (in minutes)[a]	0.476[a]	**<0.001**[a]
Anesthesia time interval during patients' stay in the Unit (in hours)[c]	0.209[c]	**0.005**[c]
Endotracheal tube time interval (in hours)[c]	0.260[c]	**<0.001**[c]
Length of stay at the Cardiac Surgery Unit (in days)[c]	0.232[c]	**0.002**[c]
Length of stay in hospital (in days)[a]	0.379[a]	**<0.001**[a]
Length of stay at the Cardiac Surgery Unit (in hours)[c]	0.226[c]	**0.002**[c]
EuroSCORE I[c]	0.282[c]	**<0.001**[c]
EuroSCORE II[c]	0.277[c]	**<0.001**[c]
Delirium		**<0.001**[b]
No	10,494.3 (3,726.8)	
Yes	14,041.6 (4,042.2)	

Values are expressed as median value (interquartile range) unless otherwise stated.
[a]Pearson's correlation coefficient [b]Student's t test [c]Spearman's correlation coefficient

Table 6. Multivariate linear regression analysis with hospitalization cost as the dependent variable

Independent variable	Coefficient beta	95% confidence interval for coefficient beta	P-value
CABG	**-2,138.3**	-3,150.7 έως -1,125.9	**<0.001**
Bentall-AscAort-Arch Replcmnt(+-AVR)	**1,855.8**	32.9 έως 3,678.7	**0.046**
AVR&MVR (&+-CABG/TVR)	**5,418.2**	4,001.1 έως 6,835.4	**<0.001**
ASD/VSD	**-6,103.5**	-8,590.9 έως -3,616.1	**<0.001**
Time duration in Cardiopulmonary Bypass (in minutes)	**23.5**	1.1 έως 45.8	**0.039**
Length of stay in hospital (in days)	**250.2**	115.5 έως 385.0	**<0.001**

R^2=0,57

Multivariate linear regression analysis also revealed two very important postoperative outcomes from which useful conclusions are drawn towards a more effective financial management regarding patient care costs; These two outcomes were a) increased time duration in Cardiopulmonary Bypass and b) increased length of stay in hospital. They were both related with increased hospitalization cost (p=0.039 and p<0.001, respectively).

Discussion

The study population consisted of cardiac surgical patients who were admitted in the ICU

postoperatively. The cardiac-surgical operations were broken down into 5 categories: 1. *Coronary Arterial Bypass Graft (CABG), 2. Aortic Valve Replacement/Mitral Valve Replacement/Tricuspid Valve Replacement (AVR/MVR/TVR), 3. Bentall-Ascending Aortic Arch Replacement (with or without Aortic Valve Replacement), 4. AVR & MVR (with or without CABG/TVR), and 5. Atrial Septal Defect/Ventricular Septal Defect (ASD/VSD),* and then the cardiac surgical DRGs were assigned on these groups of cases. In addition, we used the *micro-costing* method as we focused on the factors that were involved in increasing the hospitalization cost. This methodology applied analytically on all cost components that were used at the study population. In this way, we identified extra charges on those patients on top of those relevant DRGs which were applied. More specifically, we added on the costs the blood products of human albumin, thrombin, fibrinogen, specific colloid solutions (fluids necessary for intravascular volume expansion), specific antibiotics (specifically designed to treat chest infection & septic endocarditis), and levosimendan which is a specific vasodilative intravascular agent by this name. All these medications were not contained in the cardiac-surgical DRGs due to the fact that they don't get administered as routine drugs on every cardiac-surgical case in the ICU postoperatively. The findings of our study provide important information on the factors that might play a significant role on hospitalization cost increase of ICU patients post cardiac surgery. Our study unveiled that when this specific medication (which was not contained in the DRGs cost), was finally administered to patients, then the hospitalization cost would be increased, and this finding was consistent with similar findings noted in other studies elsewhere (Weinrebe et al, 2016). More analytically, in Weinrebe's study, the calculations of personnel and material costs and the extended length of stay of patients' hospitalization also increased altogether significantly the total costs. On Table 5 of our bivariate analysis, we identified certain perioperative outcomes that were correlated with increased hospitalization cost. From a financial point of view, there exist reports in literature about the augmented expenditure in patients' hospitalization because of the complication of delirium state (Weinrebe et al, 2016) (Lee E, & Kim J, 2014) (Awissi et al, 2012). Given this fact, a plethora of researchers focused on strategies to prevent and minimize delirium occurrence as it proved to be financially cost-efficient (Lee E, & Kim J, 2014) and money-saving per patient (Lee E, & Kim J, 2014) (Awissi et al, 2012). In that sense, we identified the outcome of delirium state on patient as a factor increasing the hospitalization cost. Delirium state of patient was documented and recorded by the use of Confusion Assessment Method (CAM-ICU) which was certified and validated on its Greek version (Adamis et al, 2012). Delirium assessment was carried out by 2 of the researchers and was being conducted twice in every shift, in order to document any alterations or fluctuations in the mental state of the patients. In addition, Delirium assessment is a standard of care for all postoperative cardiac surgical patients necessitated for optimization of their healthcare treatment.

Bivariate analysis showed that delirium state was associated with increased hospitalization cost ($p<0.001$). And from this point of view, our findings were going along with other sources where postoperative delirium frequency occurrence had been associated with multiple negative outcomes such as patient self-extubation, prolonged length of hospitalization, increased healthcare cost and also increased morbidity levels (Milbrandt et al, 2004).Similar findings were documented also in general surgical patients where the postoperative delirium had been associated with prolonged in-hospital length of stay and subsequent increase of healthcare cost (Franco et al, 2001).

In our bivariate analysis we identified also EuroSCORE II ($p<<0.001$), Cardiopulmonary Bypass time duration ($p<<0.001$), Ischemia time duration while in Cardiopulmonary Bypass ($p<<0.001$), Anesthesia time interval during patients' stay in the Unit ($p=0.005$), Endotracheal tube time interval ($p<<0.001$), Length of stay at the Cardiac Surgery Unit ($p<0.002$) and Length of stay in hospital as well ($p<0.001$) as statistically significant factors. Cheng et al from the very past already (1995) had also found that early weaning from anesthesia and early extubation could reduce the total length of stay in the ICU and total in-hospital length of stay. These findings would result in reducing healthcare cost up to 25% (Cheng D. C. H, 1995) (Cheng et al, 1996). Moreover, our findings regarding the endotracheal tube and anesthesia time interval are similar with those of Rajakaruna et al where it has been demonstrated that

prolonged stay in mechanical ventilation has been associated with increased in-hospital mortality and poor five-year survival (Rajakaruna et al, 2005). In addition, we identified EuroSCORE II as a potential indicator of the potential final limits that the total cost would reach. This conclusion came to surface as it had been recorded that EuroSCORE could predict in-hospital mortality, prolonged length of stay and other relevant cardiac surgical post-operative complications such as respiratory failure, sepsis, renal failure (Messaoudi et al, 2009). All these complications could result in augmented total costs and similar conclusions were also found in other studies as well (Nilsson et al, 2004). We also conducted multivariate analysis which revealed in Table 6 significant findings regarding hospitalization costs. The hospitalization cost was being increased up to 250.2 euros for every additional day of hospitalization on top of the respective DRG applied on every case. It was also found that hospitalization cost was being increased up to 23,5 euros for every additional minute of stay in total cardiopulmonary bypass. This result really makes sense in general for anyone looking at the "big picture" of prolonged intraoperative surgical time periods and the subsequent increased healthcare costs, and these facts can be also justified from a study of Lamy et al in 2006 regarding comparisons off pump versus on pump cardiac surgical operations (Lamy et al, 2006). Multivariate analysis revealed also that hospitalization cost was increased in analogy with the complexity of cardiac-surgical operation.

Patients who were operated for Bentall-Ascending Aortic-Arch Replacement (+ - AVR) or AVR & MVR & (+ - CABG/TVR) had higher total costs and were also statistically correlated with these numbers ($p=0.046$ and $p<0.001$ respectively). Mean hospitalization cost on these groups of cases was increased up to 1,855 euros for the first group and up to 5,418 for the latter. Shortage of qualified staff has been described in literature as a potential factor of healthcare cost increase. This happens when patients' healthcare service warrants qualified nursing skills and the absence of those has been associated with increased mortality as well (Kiekkas et al, 2008, Aiken et al, 2014, Aiken et al, 2015, Fagerström, Kinnunen, Saarela, 2018). With a closest view on this hot topic, Mazetas & Zakynthinos in 2014 reported that the total costs spent in an ICU form a substantial percentage of Gross National Product. The relevant wages of qualified staff working there occupy also a large share of this percentage and thus, they play a significant role in the final outcomes of those Units (Mazetas & Zakynthinos, 2014)

To sum up, the public debate about healthcare cost in the Intensive Care Unit (ICU) is of outmost importance and has been evolving as a very crucial subject in health economics for the last 40 years (Aisbett, 2010). Our team tried also to provide with a little share on this ongoing discussion.

Study Limitations: Our study focused on various intraoperative and postoperative factors which increase the hospitalization cost. There are certain limitations in our study. First of all, the relatively limited (though satisfactory for the research scope) sample of population was drawn from a single hospital only. We also restricted our study within the limits of patients who underwent cardiac surgery with cardiopulmonary bypass (those with off-pump operations were excluded from the study). In addition, we did not take into account the actual nurse-to-patient ratio which, if it was measured, could potentially unveil additional findings in our hospitalization cost analysis. Finally, the personal data of EuroSCORE were included only in our bivariate analysis as only at that point they were found as statistically significant (they were not included in the multivariate analysis as they were not found statistically significant due to fact of small sample of study population).

Conclusions: A plethora of factors seem to increase post cardiac surgery ICU patients' hospitalization cost and downgrade the quality of care in those patients and the health outcomes in general. An adequate resource management with close monitoring, analytical process of health care costing in the Cardiac ICU and Ward, and a substantial recruitment of nursing staff with advanced clinical and management skills might confront those adverse effects. More analytically, the study results showed that complexity of cardiac surgical operation, appearance of delirium state at patient, total cardiopulmonary bypass time and in-hospital total length of stay are significant factors increasing total hospitalization cost in general. The need for additional research on this topic on a larger sample is apparent. Such research should be based on multicenter data collection with larger

samples of population. Prospective studies with a much greater sample size would be needed in order to identify and focus on certain factors increasing the hospitalization cost.

Place in which tis study contacted: This study was carried out at 'Evangelismos' General Hospital of Athens, 45-47 Ipsilantou street, Athens, 106 76, Greece

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