Research Article

Economic analysis of costs associated with a Respiratory Intensive Care Unit in a tertiary care teaching hospital in Northern India

Kumari Shweta, Sachin Kumar[1], Anil Kumar Gupta[2], Surinder Kumar Jindal[2], Ashok Kumar[2]

Abstract

Background: There is a paucity of cost analytical studies from resource constrained developing countries defining intensive care costs and their containment. **Objective:** Economic analysis of costs in a Respiratory Intensive Care Unit (RICU) of a tertiary care teaching hospital in northern India. **Materials and Methods:** A prospective study was conducted in 74 patients admitted in the RICU. Costs were segregated into fixed and variable costs. Total and categorized costs averaged per day and costs incurred on the first day of the RICU stay were calculated. Correlation of the costs was performed with the length of stay, length of mechanical ventilation, survival, and therapeutic intervention scoring system-28 (TISS-28). **Results:** The total cost per day was Indian rupees (INR) 10,364 (US $ 222). 46.4% of the total cost was borne by hospital and rest by patients. The mean cost represented 36.8% of the total cost and 69.8% of the variable cost. Expenditure on personnel salary constituted 37% of the total costs and 86% of the fixed cost. Length of stay in RICU was significantly higher in nonsurvivors (14.73 ± 13.6 days) vs. survivors (8.3 ± 7.8 days) ($P < 0.05$). The TISS-28 score points in survivors was 30.6 vs. nonsurvivors 69.2 per nurse ($P < 0.05$) correlating strongly with the total cost ($r = 0.91$). **Conclusion:** Although considerably less expensive than in economically developed countries, intensive care in India remains expensive relative to the cost of living. The cost block methodology provides a framework for cost estimation, aids resource allocation and allows international comparisons of economic models.

Keywords: Cost analysis, economic analysis, intensive care

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Introduction

Intensive Care Unit (ICU) is the most expensive area where intensive nursing and medical care are provided round the clock in a hospital. Intensive care beds account for at least 10% of the hospital beds and 20-40% of all hospital costs.[1]

Cost calculation is necessary to enhance conceptual uniformity and to optimize resource consumption. Despite the high costs associated with ICU stays, to date there is a relative dearth of information relating to the daily cost of ICU care in India. Also, we cannot extrapolate findings from abroad to India. The average Indian income being much lower than that in the developed world makes intensive care unaffordable by the majority. In the absence of comprehensive insurance cover, more than 80% of patients have to pay out of their pocket for healthcare services.[2] Based on the National Sample Survey (60th round), in 2004, 63 million individuals or 12 million households fell below poverty line due to health expenditures (6.2% of all households).[3] Even more disconcerting is the fact that more than 40% of those admitted to an ICU had to borrow money or sell assets.[2,4] In addition, the staffing patterns and their salaries are different in India from

From:
Departments of Hospital Administration, All India Institute of Medical Sciences, New Delhi, [2]Post Graduate Institute of Medical Education and Research, Chandigarh, [1]Department of Pulmonary Medicine, Institute of Liver and Biliary Sciences, New Delhi, India

Correspondence:
Dr. Kumari Shweta, C-15, Delhi Government Residential Complex, D-2 Pocket, Vasant Kunj, New Delhi - 110 070, India.
E-mail: drkumarishweta@gmail.com

the developed countries. Because of these reasons, cost analytic studies are needed for better knowledge of the costs and economics involved in intensive care of a developing country like India. It is in this background that the present prospective observational study was conducted with an aim to perform a cost analysis of a Respiratory ICU (RICU) in a tertiary care hospital.

Materials and Methods

This study was conducted in RICU of a tertiary care teaching hospital in northern India. The study was reviewed and approved by both the institution thesis review committee and ethics committee.

The RICU is a closed unit with eight intensive care beds, six in open-plan units, and two in separate isolation cubicles. A doctor to patient ratio of 1:4 and a nurse to patient ratio of 1:2 are maintained round the clock. All patients admitted to the RICU were prospectively studied during 3 month study period. The data on demographic, clinical, physiologic parameters, location of patient before ICU admission, and specific reason for ICU admission (elective or emergency); were collected and analyzed. This study is an observational study and written consent was taken from each patient/attendants. All patients with duration of stay >24 h, irrespective of the underlying diagnosis were included in the study.

Cost estimation of healthcare activity can be carried out using either microcosting (bottom-up) or macrocosting (top-down) methods. In the former method, costs are derived for each element of intervention: Staff time, supplies and medications, diagnostic and laboratory examinations, and so on. In the latter, there is no detail available on the cost of every component of the inpatient stay.[5] This study used the bottom-up costing method. The cost calculation was categorized as: (a) Fixed costs and (b) variable costs. These costs were calculated every day for all the patients.

Fixed costs

Electricity and water

The hospital's expenditure on electricity and water was calculated as per the number of electric sockets and water taps present in the RICU.

Staff salaries

The numerous staff working in the ICU includes doctors, nurses, and other supporting staffs. Per dime costs to the institute for each of these categories was calculated taking the median of their salary scales in relation to the estimated proportion of their time devoted to the ICU.

These fixed costs was taken as a whole and then calculated as fixed costs per bed per day.

Variable costs

Drugs, fluids, and disposables

The price at which the hospital purchases these things was taken as the hospital costs.

Costs of equipment

Equipment costs were calculated by adding the purchase price of the equipment with its Annual Comprehensive Maintenance Contract (ACMC) charges. The average life span of the equipment was taken as installation + 2 years of warranty + 5 years of ACMC giving a total of 7 years. From these data, the costs of each equipment per day is calculated by, CPD = (PP + ACMC)/(7 × 365). Where; CPD is cost per day, PP is purchase price, and ACMC is the total ACMC costs for 7 years. The usage of these equipments was calculated on a day to day basis.

Patient costs

A nominal amount is collected from patients towards hospital charges, that is, INR 385 per day in RICU for bed, routine investigations, and diet. A limited amount of drugs and consumables are provided by the hospital. Rest is purchased by the patient. The copies of prescriptions given to the patient were collected every day.

Since this was a central government funded autonomous tertiary care center, these charges are subsidized and fixed arbitrarily without any intention of profit or recovery of running cost.

Actual expense of the hospital on patient, that is, total cost of care in RICU:

Fixed cost (infrastructure costs + salaries of the staff + hospital costs) = A

Total variable cost (patient cost) = B

The difference in these two will determine the degree to which the cost is subsidized, that is:

$(A + B) - (B)/(A + B) \times 100$.

All patients were scored for severity of illness using the Sequential Organ Failure Assessment (SOFA) score. The SOFA score was calculated every 24 h until discharge. The maximum SOFA (max SOFA) score was determined as the highest SOFA value during the ICU stay and delta (Δ) SOFA was calculated by subtracting admission SOFA value from max SOFA value during the stay days.

The therapeutic intervention scoring system (TISS) was used to objectively quantify the intensive care services

provided in the ICU. This system assigns scores to all monitoring and therapeutic interventions performed in the ICU, and points for each patient are added to obtain an estimate of the workload and quantity of intensive care provided.[6] TISS points was assessed daily until discharge or death for each patient admitted during the 3 month period.

On the basis of bed occupancy, length of stay, TISS points per patient, and outcome; ICU cost-related variables were calculated. These include cost per patient, daily cost per ICU bed, cost per TISS point, and cost per survivor and this will be obtained in Indian rupees (INR) and converted to US dollars (US $ 1 = INR 46.71)* for comparison with other studies (*as on 20.12.2009).

Data was analyzed using commercial Statistical Package for Social Sciences (SPSS, version 10, SPSS Inc., Chicago, IL) for MS-Windows. Differences between categorical and continuous variables were analyzed using Chi-square and Mann-Whitney U test, respectively. Descriptive analysis of cost was done under the following categories: Total and categorized costs averaged per day and total and categorized costs incurred on the first day of the ICU stay. Correlation of these costs to the length of stay, SOFA score, and TISS score was done.

Results

In this prospective study, 85 patients were admitted in RICU from December 2008 to February 2009. Bottom-up cost analysis was done in 74 patients admitted in our ICU and 11 patients were excluded as their duration of stay was <24 h. Patient characteristics are shown in Table 1.

Nonsurvivors had a statistically higher length of stay in RICU as compared to the survivors ($P = 0.046$) [Table 2].

The overall cost incurred in treating these 74 patients during the 3 month study period was INR 71,89,608 (US $ 154,003.74). The cost per patient was INR 97,156 (US $ 2,081.10). The total cost per survivor was INR 74,677 (US $ 1,599.6).

The costs of ICU bed, anti-bedsore mattresses, monitors, water and electricity, and the staff were added to get total fixed costs per patient per day. These amounted to INR 4878 per patient per ICU day. Salaries of the ICU staff amounted to INR 3853; out of this 86% of fixed costs and 37% of total costs [Figure 1].

The costs for investigations and consumables were significantly higher for the first day in the present study. In our study the mean day one variable cost was INR 6,859 as compared to mean daily total variable cost of INR 5,486. The mean daily drug cost in our study was INR 3,824 which represented 36.9% of the total cost and 69.7% of the variable cost.

The total cost of RICU stay was sum total of the total variable cost and the total fixed cost. In our study, the total cost per day was INR 10,364 (US $ 222). Other types

Table 1: Patient characteristics

Variable	Value - *n*
Age	54.2+17.9 yrs
Gender (male)	39 (52.7%)
Primary diagnosis group	
Sepsis/septic shock	14
COPD	13
Asthma	4
Pneumonia	19
Tuberculosis	5
Interstitial lung disease	2
Malignancy	5
Acute pancreatitis	3
OSA	4
Post transplant	5
Admission source	
Emergency	23
General Ward	44
Private ward	5
Private hospital	2

Table 2: Length of stay and total equipment days in RICU (mean ± SD)

	All patients	Survivors	Non survivors	*P*
ICU days	9.6 + 9.5	8.3 + 7.8	14.73 + 13.6	0.046
Ventilator days	9.5 + 10.2	16.25 + 14.3	6.52 + 5.9	0.018
Infusion days	1.08 + 1.9	3.33 + 2.7	0.51 + 1.2	0.0

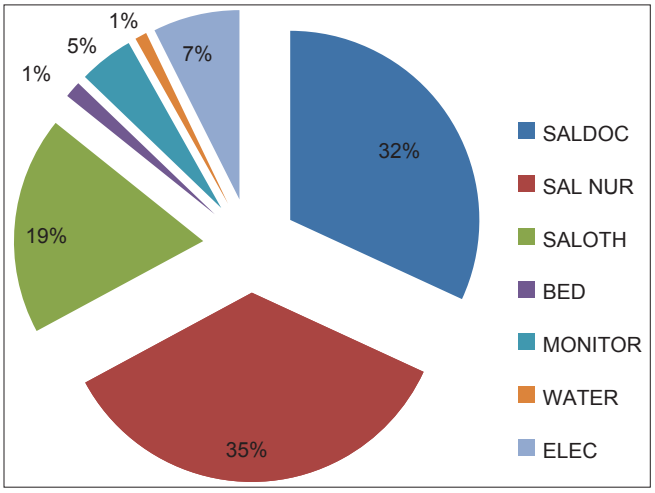

Figure 1: Contribution of different categories to the total fixed costs

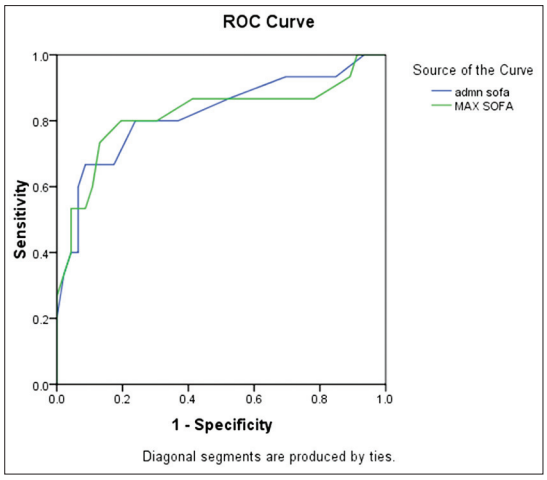

Figure 2: Receiver operating characteristic (ROC) curve of Sequential Organ Failure Assessment (SOFA) score for predicting in-hospital mortality

of costs for the different subgroups of patients are shown in Table 3.

The daily total cost for nonventilated patient was INR 6,585 ± 932, whereas that for mechanically ventilated group was INR 12,429 ± 9,720.

SOFA score

The mean admission (admn) SOFA score was 5.5 ± 4.4 points and max SOFA was 6.8 ± 4.3 points. The area under the receiver operating characteristic curve (ROC) of SOFA for predicting in-hospital mortality at admn SOFA was 0.82 (95% confidence interval (CI) =0.68-0.96) and at max SOFA was 0.81 (95% CI 0.66-0.96). [Figure 2] The delta SOFA was found to have a positive relationship with in-hospital mortality.

The mean TISS score in our study was 39 TISS points per nurse. The TISS score points in survivors was 30.6 and that in nonsurvivors were 69.2 per nurse ($P < 0.00$). Nonsurvivors had a higher mean TISS-28 score than survivors.

Correlation was also performed between total costs, length of stay, and TISS score. This analysis showed that there was strong correlation between the TISS 28 score and total cost and length of stay in our study [Table 4]. Positive correlation was also found between day 1 cost and TISS score ($P = 0.069$).

Difference between the costs spent by the hospital and patient gives the degree to which the cost is subsidized. Of the total ICU costs, 46.4% was borne by the hospital and 53.6% was borne by the patients [Table 5].

Table 3: Cost of RICU care for different subgroups

Costs	All patients INR ($) mean
Total cost per patient per day	INR.10364 (U.S. $ 222)
Total fixed cost per patient per day	INR4878 (U.S. $ 104.43)
Total variable cost per patient per day	INR 5,486 (U.S. $ 117.44)
Day 1 variable cost per patient per day	INR.6, 859 (U.S. $ 146.84)
Total Drug cost per patient per day	INR.3, 824 (U.S. $ 81.87)
Total cost per patient	INR.97,156 (U.S. $ 2,081.10)
Total cost per survivor	INR74,677 (U.S. $ 1,599.6)
Total cost for non ventilated patient per day	INR.6,585 (U.S. $ 140.98)
Total cost for ventilated patient per day	INR 12,429 (U.S. $ 266.09)

Table 4: Correlation between total costs and length of stay and TISS score

	Total costs
Length of stay	0.89
TISS score	0.91

Table 5: Degree of subsidy of ICU hospitalisation costs

	Total costs	Hospital costs	Degree of subsidy
All patients	INR.71,89,608	INR.33,60,621	46.4%

Discussion

Critical care in hospitals is expensive. Despite of accounting for <10% of the beds in hospitals, it forms nearly a third of total inpatient costs.[1,7] In India, there being a paucity of cost analytical studies it is essential to perform cost calculations in intensive care in order to plan containment measures.

In this prospective study, during the 3 month study period, 15 patients died in the RICU amounting to an observed mortality rate of 18.98% comparable to a study from Italy in which a national survey of 26 RICUs showed an observed mortality of 16%.[8] In contrast, in a study by Parikh and Karnad from Mumbai, higher mortality rate of 36.2% was reported.[9] The case mix in our RICU and those observed in these studies might account for the disparity observed. The advancement in intensive care management over the past decade might also have contributed to overall better survival noted in our study.

The maximum numbers of patients were in the age group of 50-70 years (36.5%). The age group above 70 constituted 18.9% of total patients admitted to RICU during the study period. The lower percentage of elderly patient observed in our study may reflect the fact that as per census 2001, only 7.2% of Indian population are above 65 years and older and life expectancy at birth is still 62.4 years, much lower than other developed

countries like US. The other social reason for low admission of elderly patient may be the reluctance on the part of families to spend on older patients and an ICU admission bias in favor of younger patients given the scarcity of ICU beds in India.[9]

In our study, the length of stay in ICU was found to be significantly higher in nonsurvivors (14.73 ± 13.6 days) as compared to survivors (8.3 ± 7.8 days). Moran *et al*., also reported that the survivors and nonsurvivors in Australian ICUs had significantly different variances of the total overhead costs and length of ICU stay.[10]

In our study the mean variable cost was significantly higher for the first day (INR 6,859 as compared to mean daily total variable cost of INR 5,458.) As a routine, certain investigations are performed and consumables are purchased as a onetime expenditure on the first day of ICU admission and are not usually repeated later. In a study by Dasta *et al*., ICU costs were greatest on the first ICU day, decreasing by approximately 50% by day 2, and becoming stable after day 3, averaging approximately $ 3,500/day.[11]

The mean daily drug cost in our study was INR 3,824 which represents 36.8% of the total cost and 69.8% of the variable cost. In a study by Moerer *et al*., medication cost accounted for 18.7% of the total costs.[1] The daily total cost for nonventilated patient was INR 6,585 ± 932, whereas that for mechanically ventilated group was INR 12,429 ± 9,720. Moerer *et al*., concluded that in all levels of care, the most expensive patients were those needing mechanical ventilation, or with high severity of illness, or severe sepsis and in nonsurvivors.[1]

The daily expenditure on personnel salary constituted 37% of the total costs and 86% of the fixed cost in our study. In an Indian cost analysis in the neonatal intensive care unit by Narang *et al*., the personnel salary constituted 55% of the running costs.[12] Moerer *et al*., also found the cost of staffing to be the highest expenditure of intensive care.[1] Similarly, a French study found that 62% of the ICU budget was consumed by staff cost.[13]

The total cost of RICU stay was sum total of the total variable cost and total fixed cost. In our study the total cost per day was INR 10,364 (US $ 222) (total variable cost/day (INR 5,486) + the total fixed cost/day (INR 4, 878)). The overall cost incurred in treating these 74 patients during the 3 month study period was INR 7,189,608 (US $ 154,003.74). The cost per patient was INR 97,156 (US $ 2,081.10). The total cost per survivor was INR 74,677 (US $ 1,599.6). In the study by Parikh and Karnad, it was shown that overall cost of treating 993 patients was INR 10,779,209 and cost per patient per day was INR 1,973. The cost per survivor was INR 17,029 and cost per TISS point was INR 90.14.[9] Several other studies have also compared costs of intensive care, although few of these are from developing countries. In a study by Dasta *et al*., mean intensive care unit cost and length of stay were $ 31,574 ± 42,570 and 14.4 days ± 15.8 for patients requiring mechanical ventilation and $ 12,931 ± 20,569 and 8.5 ± 10.5 days for those not requiring mechanical ventilation, respectively. The mean ICU cost per day was $ 3500/day.[11] Secondarily in our study, of the total ICU costs, only 46.4% was borne by the hospital and 53.6% was borne by the patients as against the developed world, where insurance cover and government contribution is much more.[14] Hence, there is a great disparity in the intensive care costs in the western world and a developing country like India. However, even after correcting for the lower cost of living in India, intensive care in India is considerably less expensive than in economically developed countries. Similar findings were reported in the study by Parikh *et al*.[9]

The TISS-28 has been found to be a useful tool showing a good correlation with the severity of illness and as an indicator of nursing workload in the ICU.[15] Keene and Cullen recommend that an accomplished ICU nurse be able to manage 40 TISS points.[16] The mean TISS score in our study was 39 TISS points per nurse. The TISS score points in survivors was 30.6 and that in nonsurvivors were 69.2 per nurse ($P < 0.00$) Higher TISS-28 scores among nonsurvivors have also been reported in many studies.[17-19] In a study by Parikh and Karnad, the mean TISS score was 64.2, indicating the increased work load per nurse.[9]

In our study there was strong correlation between the TISS 28 score and total cost (r = 0.91). Similar results have been reported in a study by Dickie *et al*.[20] The correlation of total TISS score to variable cost confirms that there is a strong linear relationship for TISS 28 and costs.

To the best of our knowledge, ours is the first prospective study specifically addressing the issue of cost analysis of care in a RICU unit in India. Although findings of our study is not generalizable to represent the cost of intensive care in entire India, still it can serve as a reference for future studies in this area. Though we did not perform any cost-effectiveness or cost-utility analysis, this could help in planning further cost-minimization trials.

There are significant limitations pertaining to this study. This study reflects the ICU costs of a single teaching tertiary hospital and findings are not generalizable to all

settings. More so, in an environment where intensive care bed availability is skewed in favor of private institutions the actual cost incurred by patients might be higher. However, this study has shed some light on the provision of critical care and the related costs from a developing country like India. As a teaching and public tertiary care institution, this study provides a model for cost analysis of intensive care in India. It also reflects the current trends and status. This study suggests improving trends in intensive care survival in India and also significantly less cost as compared to the West. However, the study does not control for differences in case mix with respect to previous studies or factor in cost of living indices for accurate comparisons to be made. [4,9] A small sample size and only a limited period of evaluation also are important weaknesses of this study. Majority of patients were transferred to RICU after receiving medical care for a variable period outside the RICU. The costs incurred during these treatments were not included in this study. Also the previous level of care might have affected the overall patient outcome.

This study provides break-up of costs incurred by the patients admitted to the RICU. This could be useful for future research into the economics of intensive care in a developing country like India. It is hoped that similar cost analyses will be integrated into healthcare policy and decision making.

Conclusions

ICU treatments are particularly expensive and the related costs are not distributed evenly among the different types of patients. There is a great disparity in the intensive care costs in the developed as compared to a developing country like India. However, even after correcting for the lower cost of living in India, intensive care is considerably less expensive than in developed countries. The cost block methodology used in this study may be a useful tool for analyzing the costs and for optimal resource allocation in a resource constrained environment. It could also facilitate comparisons of international financial models for intensive care services.

References

1. Moerer O, Plock E, Mgbor U, Schmid A, Schneider H, Wischnewsky MB, *et al*. A German national prevalence study on the cost of intensive care: An evaluation from 51 intensive care units. Crit Care 2007;11:R69.
2. Berman PA. A prescription to revitalize india's health system. The World Bank 2007. Available from: http://go.worldbank.org/ZCBHV7YYJ0 [Last cited on 2007 Apr 17].
3. Challenges and World Bank Support for India's Health Sector. The World Bank 2007. Available from: http://go.worldbank.org/I5URN7VSO0 [Last cited on 2007 May 09].
4. Jayaram R, Ramakrishnan N. Cost of intensive care in India. Indian J Crit Care Med 2008;12:55-61.
5. Geitona M, Androutsou L, Theodoratou D. Cost estimation of patients admitted to the intensive care unit: A case study of the Teaching University Hospital of Thessaly. J Med Econ 2010;13:179-84.
6. Beck DH, McQuillan P, Smith GB. Waiting for the break of dawn? The effects of discharge time, discharge TISS score and discharge facility on hospital mortality after intensive care. Intensive Care Med 2002;28:1287-93.
7. Reis Miranda D, Jegers M. Monitoring costs in the ICU: A search for a pertinent methodology. Acta Anaesthesiol Scand 2012;56:1104-13.
8. Confalonieri M, Gorini M, Ambrosino N, Mollica C, Corrado A. Scientific Group on Respiratory Intensive Care of the Italian Association of Hospital Pneumonologists. Respiratory intensive care units in Italy: A national census and prospective cohort study. Thorax 2001;56:373-8.
9. Parikh CR, Karnad DR. Quality, cost, and outcome of intensive care in a public hospital in Bombay, India. Crit Care Med 1999;27:1754-9.
10. Moran JL, Peisach AR, Solomon PJ, Martin J. Cost calculation and prediction in adult intensive care: A ground-up utilization study. Anaesth Intensive Care 2004;32:787-97.
11. Dasta JF, McLaughlin TP, Mody SH, Piech CT. Daily cost of an intensive care unit day: The contribution of mechanical ventilation. Crit Care Med 2005;33:1266-71.
12. Narang A, Kiran PS, Kumar P. Cost of neonatal intensive care in a tertiary care center. Indian Pediatr 2005;42:989-97.
13. Guidet B, Harari A, Hodée C. Cost assessment of 21 intensive care units in the Paris area. Intensive Care Med 2003;29:A522.
14. Fowler RA, Adhikari NK, Bhagwanjee S. Clinical review: Critical care in the global context: Disparities in burden of illness, access, and economics. Crit Care 2008;12:225.
15. Padilha KG, Sousa RM, Kimura M, Miyadahira AM, da Cruz DA, Vattimo Mde F, *et al*. Nursing workload in intensive care units: A study using the Therapeutic Intervention Scoring System-28 (TISS-28). Intensive Crit Care Nurs 2007;23:162-9.
16. Keene AR, Cullen DJ. Therapeutic intervention scoring system: Update 1983. Crit Care Med 1983;11:1-3.
17. Lefering R, Zart M, Neugebauner EA. Retrospective evaluation of the simplified Therapeutic Intervention Scoring System (TISS-28) in a surgical intensive care unit. Intensive Care Med 2002;26:1794-802.
18. Miranda DR. Outcome assessment--TISS as a tool to evaluate cost-effectiveness of immunological treatment. Eur J Surg Suppl 1999:51-5.
19. Miranda DR, de Rijk A, Schaufeli W. Simplified therapeutic intervention scoring system: The TISS-28 items: Results from a multicenter study. Crit Care Med 1996;24:64-73.
20. Dickie H, Vedio A, Dundas R, Treacher DF, Leach RM. Relationship between TISS and ICU cost. Intensive Care Med 1998;24:1009-17.

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