Cost of critical care in South Africa

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Objective. To evaluate the cost of critical care in a respiratory intensive care unit (RICU).

Design. A prospective cost-utility analysis of all admissions over a 4-week period.

Setting. A 13-bed RICU admitting all categories of medical, surgical and trauma patients in a teaching hospital.

Patients. All patients who were treated in the ICU over the 4-week period were included in the cost analysis.

Outcome measures. The total cost of patient care, including all investigative and therapeutic modalities and medical, paramedical and ancillary staff salaries.

Results. The total cost for the month was R549 705, including R197 222 for staff, R135 369 for special investigations, and R110 088 for intermittent positive-pressure ventilation and continuous positive airway pressure by face mask. The average daily cost per patient was R1 566, with conditions such as drug overdose, where supportive treatment only was needed, averaging R1 077 per patient per day compared with multiple injury from motor accidents, which cost R2 112 per patient per day. Increased severity of illness and ultimate death also significantly increased costs.

Conclusion. Careful evaluation of the need for each high-cost item, particularly those used routinely, and each therapeutic intervention, and use of guidelines for drug therapy, special investigations and patient care, which help to improve both outcome and resource utilisation, may result in lower costs per survivor. In order to achieve optimum cost efficiency, an effective training programme in critical care incorporating experienced teachers from all disciplines, together with ongoing critical evaluation of the quality of care, are needed.

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The contribution of critical care to the successful treatment of severe illness with return to a fully functional life has been well demonstrated in a number of studies, both locally and internationally.[1-7] More recent application of severity of illness scoring systems has made it possible to compare outcome in different intensive care units (ICUs) and thus evaluate the efficacy of care given in different institutions.[2,8,9] It has been mooted that as the cost of medical care continues to increase in Western societies the hospitals of the future are likely to become exclusive ICUs, with all other patients being treated as day cases. The current economic climate with the recognised high costs associated with high technology and intensive staffing requirements of critical care, has resulted in closer questioning of the cost efficacy of providing this type of care, with the associated ethical dilemmas that this provokes.[6]

Although the cost of critical care is known to be high it has seldom been accurately evaluated, and this is essential in determining its role in future health care planning. We considered that now all aspects of social services provided to our community are under scrutiny it would be useful to perform a careful audit of the day-to-day costs of running an ICU, to assess which areas were the most expensive, whether such expenses were justified, and whether costs in any areas could be reduced.

Patients and methods

The respiratory ICU (RICU) at Groote Schuur Hospital has 13 beds, 10 in two open-plan units and 3 in separate isolation cubicles, and admits all categories of medical, surgical, obstetric and gynaecological and trauma patients (neurosurgical, coronary care and cardiothoracic cases are treated in specialised units). Criteria for admission include the need for intensive nursing care as well as ventilatory support, and because of a shortage of beds admission is frequently determined by bed availability rather than clinical need; many patients are initially treated in the general wards when the severity of their illness actually warrants ICU admission. The unit is staffed by 2 registrars in internal medicine and 2 in anaesthetics, 3 full-time specialists, 2 of whom have critical care subspecialty accreditation, 3 respiratory/critical care technologists, 2 physiotherapists, a half-day pharmacist, 30 professional nurses (11 of whom have a diploma in critical care nursing), 4 enrolled nurses (2 years' training), 24 nursing assistants, 5 general cleaning staff and a secretary.

Costing for this study was determined by measuring the actual costs of all aspects of maintaining the unit for 1 month, excluding the hire of floor space, telephone costs, laundry, stationery, water and electricity. The cost of all categories of staff was the actual salaries, obtained from the personnel office, plus 40%, which is considered the value of additional benefits to staff. Allowance was also made for additional cover during periods of leave, and, for those not working full-time in the unit, this was calculated according to the estimated percentage of their day that was spent in the ICU on a regular basis. The cost of drugs, oxygen and other gases, and disposable items of equipment was calculated according to hospital and government tender prices. The cost of radiological, microbiological, biochemical and haematological investigations was determined according to the medical aid Scale of Benefits tariff, and the use of ventilators was calculated according to private hospital rates.

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Costing was performed by the nursing staff using a data sheet which was kept at each patient's bedside and filled out on a daily basis as equipment was used and care provided. Data collection was reinforced by one of the investigators checking several times a day to ensure that all aspects were entered correctly.

Data were stored on Lotus 1-2-3 (Lotus Development Corp., Cambridge, Mass.) and the analysis was done using the statistical programme 'Statcalc' of Epi-Info (Version 5) (Centers for Disease Control and Prevention, Atlanta, Ga, USA). Continuous variables are reported as means ± standard deviation (SD), with significance testing using Student's *t*-test.

Results

Forty-six patients were treated in the ICU during the month-long study period; the entire ICU stay was documented for 35. Patients' ages and admitting diagnoses, as well as severity of illness scores calculated by the Acute Physiology and Chronic Health Evaluation (APACHE II) and injury severity scoring systems, and mortality, are set out in Table I. The mean duration of ICU admission was 5,17 ± 3,29 days for the 35 patients whose entire ICU stay was documented, and the duration of ventilation in the 30 patients who required intermittent positive-pressure ventilation (IPPV) was 3,43 ± 2,7 days. Overall 80% of patients were treated with IPPV, 6 with continuous positive airway pressure (CPAP) by face mask, and 4 with oxygen alone.

Table I. Spectrum of diseases, patient ages, severity of illness or injury and outcome

Diagnosis	No.	Age (yrs)	APACHE II	ISS	Mortality (%)
Pneumonia	9	46,8 ± 13,79	12,2 ± 5,87	–	22
COAD	3	67,7 ± 2,31	18 ± 13,53	–	0
Asthma	2	48 ± 17	6,5 ± 7,79	–	0
Overdose	4	36 ± 9,66	8,8 ± 6,13	–	0
Neurological	6	25,5 ± 13,35	7,3 ± 4,8	–	0
Cardiac	3	40,7 ± 6,66	10 ± 12,5	–	0
Other	5	32,6 ± 10,2	13,8 ± 7,6	–	0
Surgical	7	52 ± 24,54	8,3 ± 6,6	–	0
Trauma	7	30,3 ± 14,65	4,29 ± 3,5	21,4 ± 9,6	0
Total	46	40,8 ± 17,9	9,63 ± 7,35	–	6

COAD = chronic obstructive airways disease; ISS = injury severity score.

Bed occupancy during the 4-week study period was 100%, beds only being unoccupied for brief periods during patient change-over. The total cost of ICU care and staffing was R549 705, an average of R1 566 per patient per day. Further detailed analysis of the daily cost is shown in Table II.

Special investigations included radiographic, haematological, biochemical, immunological and microbiological investigations, which together accounted for more than a third of the total cost and are detailed in Fig. 1. Chest radiographs were done daily on all ventilated patients; otherwise radiological investigations were performed when clinically indicated. Biochemical investigation included measurement of serum electrolytes and renal and hepatic function tests, which were performed on admission, routinely twice weekly and when clinically indicated; these amounted to R103 per patient per day. Arterial blood gases were measured daily in ventilated patients and when clinically indicated at a cost of R109 per patient per day. Microbiological investigations were done when clinically indicated (26% of patients were considered to be infected on admission), and surveillance cultures of tracheal aspirates and urine were done twice weekly for all intubated or bladder-catheterised patients, and cost an average of R9 per patient per day.

Table II. Costs of different aspects of ICU practice and therapy

Item	Cost/patient/day (R)	Monthly cost (R)
Staff	541	197 222
Special investigations	372	135 369
Ventilation	314	110 088
Drugs	75	26 216
Consumables	74	25 813
IV fluids + lines	71	24 836
Blood products	59	21 004
Feeds (oral + TPN)	26	9 157

TPN = total parenteral nutrition.

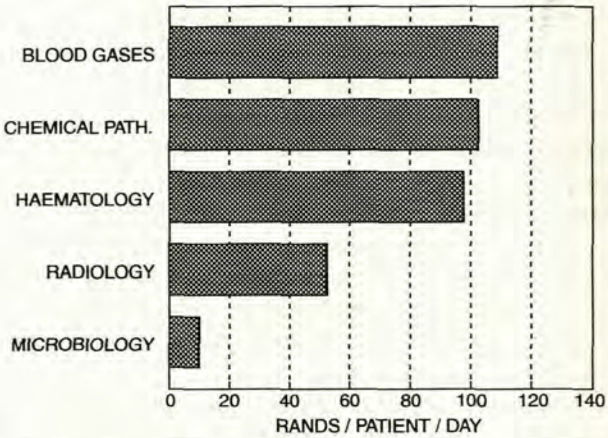

Fig. 1. Cost per patient per day of different special investigations.

Detailed staffing costs, which included the entire complement of staff needed to allow for periods off duty and annual vacations, are illustrated in Fig. 2. During the study period the staffing complement (other than nursing staff, where a ratio of only 1 nurse to 1,8 patients was achieved) was considered optimal.

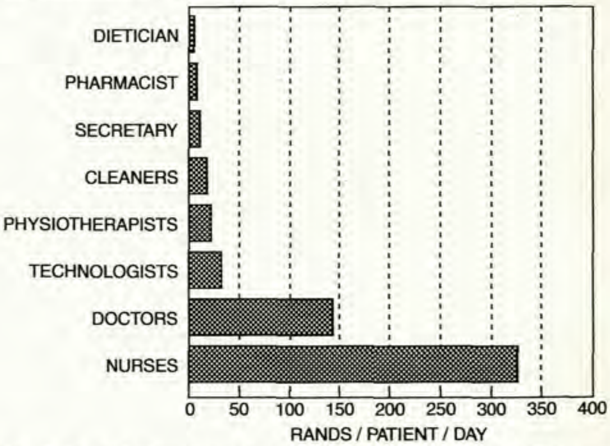

Fig. 2. Detailed costs of staff, shown as cost per patient per day.

The costs of the various procedures, in which were included the cost of consumable items, differed considerably and depended largely on the cost of sophisticated disposable equipment, e.g. arterial blood pressure monitoring, which required a transducer (R83,56), intravenous cannula (R27,59), extension set (R8,15), 3-way tap (R1,30), 200 ml heparinised normal saline (R6,00), gloves (R1,38) and a sterile pack and cleaning solution, local analgesic and dressing (R6,60); this amounted to R134,58 for the procedure. The costs of frequently performed procedures are illustrated in Table III.

Table III. Costs of consumable items used in a number of individual procedures in the ICU

Procedure	Cost/procedure (R)
Pulmonary artery catheterisation	996,30
Triple-lumen CVP catheterisation	300,20
Radial artery catheterisation	134,58
Chest drain	49,16
Stericath tracheal suction*	152,16
Regular tracheal suction†	17,14

* Stericath Portex (UK) 1 used daily.
† Daily cost with 16 suction procedures per day.
CVP = central venous pressure.

Drug therapy was the fourth major cost and totalled R26 216,00 for the study period or R75 per patient per day. The costs of the various drugs are detailed in Fig. 3.

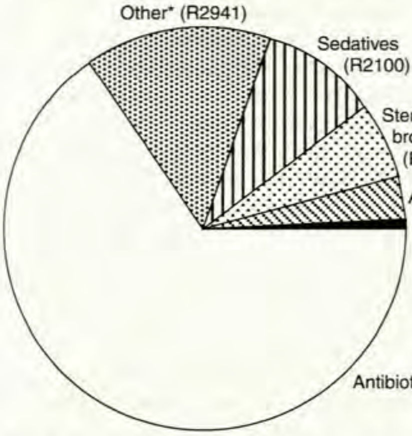

Fig. 3. Total drug bill for the study month, showing the cost of the main groups of drugs.
***Other drugs included cardiac agents, immunosuppressive agents, H_2 antagonists and sucralfate.**
† Bronchodilators included intravenous and inhaled salbutamol, inhaled ipratropium and intravenous and oral theophylline preparations.

Although basic costs such as staffing, electricity, water, equipment and floor space remain static, costs may vary considerably depending on a number of factors such as nature of the disease or injury, severity of illness, time after admission, duration of admission, and drug, fluid and other therapy needed. The cost of treating different diseases and injuries is shown in Table IV. Within the group of trauma there were also significant differences in cost, with gunshot wounds averaging R1 332 per patient per day and motor vehicle accident injuries R2 112 per patient per day (P = 0,159).

Table IV. Costs of treating different diseases in the ICU

Diagnosis	No.*	Cost/day (R)	Total cost/patient (R)
Asthma	2	1 236 ± 126	5 032 ± 2 251
COAD	3	1 632 ± 59	9 334 ± 4 017
Pneumonia	7	1 804 ± 469	12 699 ± 8 169
Neurological	5	1 344 ± 228	19 555 ± 9 409
Overdose	4	1 077 ± 157	3 451 ± 257
Elective surgical	4	1 410 ± 525	4 076 ± 1 526
Trauma	7	1 754 ± 636	14 205 ± 13 368

*Patients who completed their ICU course. Three patients each with different diseases not included.
COAD = chronic obstructive airways disease.

In patients who recover, the daily costs decrease progressively. Episodes of escalated therapy due to complications increase costs; this is demonstrated by a comparison of the daily costs for two individual patients (Fig. 4).

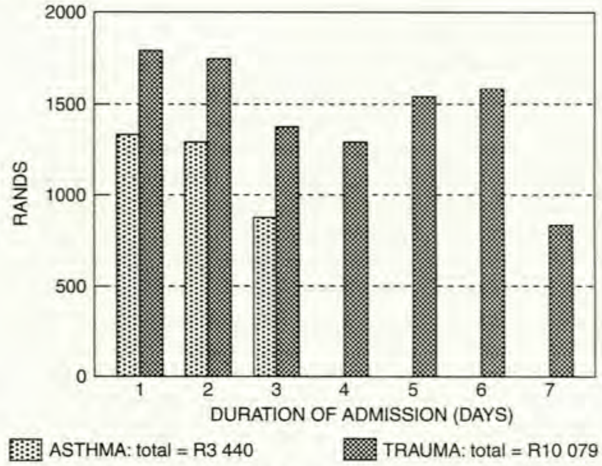

Fig. 4. Daily costs of treating a patient with asthma requiring IPPV compared with a patient with gunshot injury involving the arm and chest who developed complications on day 5 of admission.

The cost of 13 patients with an APACHE II score higher than 12 was R1 912 per patient per day, significantly more than treating 33 patients who had APACHE II scores of 12 or less (R1 456 per patient per day; P = 0,004). In the patients with pneumonia the cost per day for 5 survivors was R1 554 compared with R2 430 for 2 who died (P = 0,004).

Discussion

While prevention is better than cure, with the appropriate use of the ICU diseases 'which should have been prevented' and patients who are seemingly unsalvageable can sometimes be cured. This has created the demand for critical care, and has resulted in the ICU becoming an essential part of modern medical practice, even in less affluent societies. Its efficacy in treating otherwise fatal illness in many institutions has been proved in South Africa, as well as elsewhere in southern Africa, and the standard of care provided often compares very well with the best in the world.[2-4,10] In an audit of outcome in the RICU at Groote Schuur Hospital in Cape Town using the APACHE II scoring system to define the severity of illness and thus allow comparison, we were able to show that our results were comparable with the best ICUs in the USA.[2] These results were achieved at a cost (averaging R1 566 per patient per day in this study) which is lower than in Scotland (£1 980 per patient per day), and very much lower than in the USA ($24 886 per patient admission in a medical ICU).[11,12]

Despite these results it is important that every possible attempt be made to reduce unnecessary expenditure, and the aim of this study was to scrutinise and highlight areas where costs might be reduced further. The least expensive but most effective ways of managing patients without jeopardising outcome must be found, however, since expenditure on patients who die is totally wasted. In 1993, the year in which this study was completed, 483 patients with an average APACHE II score of 12,88 and a mortality rate of 18,2% were treated. If we extrapolate the annual cost of our ICU from these results the amount would have been approximately R6,5 million, or R16 373 per survivor for the year, which is a better reflection of value for money than the overall cost per patient per day.

It is also important to relate cost to both the ICU and hospital outcome as well as the quality of survival; by returning a patient to a non-independent quality of life, additional ongoing costs are demanded of the patient, the family and society. When one considers that more than 50% of survivors in the patient population from our ICU return to their pre-admission functional status,[1] the individual costs of this care cannot be considered excessively high. One of the most effective ways of getting the best value for money is to ensure that ICU care is of a standard that will achieve the optimal rate of survival. Compromising care by reducing funding in this area will almost certainly lead to a reduced standard of care with a consequent higher mortality, and add considerably to the cost per functional survivor.

This study has shown that the main contributors to expenditure are special investigations, staff and ventilation; however, it is important to recognise that the methods used to determine costs, particularly those used to determine the cost of biochemical, microbiological, and radiological investigation (Scale of Benefits tariffs) and ventilation (private hospital charges), will give these items a higher apparent cost than those where true state tender costs were used. In order to evaluate costs adequately, it is important to consider the methods used to determine the cost, as well as all aspects of care individually. Certain items such as blood products, which are used for very few patients, appear to be low-cost items when analysed as a cost per patient per day, as was done in this study; however, when considered separately they add considerably to total individual costs.

There are large differences in the cost of treatment for different types of diseases; with drug overdose, where supportive treatment only is usually required, being the lowest, and multiple injuries sustained in motor accidents, where numerous investigations, transfusions and intensive monitoring are needed, costing almost twice as much per day. There is also a significantly increased cost for patients with more severe disease, which is borne out in this study.[11] The cost of treatment also decreased with time following admission in those who recovered, while in those who died or who developed complications it usually escalated. We have shown the increased cost of treating non-survivors in a small comparable group of patients with community-acquired pneumonia. This confirms the increased cost of treating patients who ultimately die which has been seen in other studies.[11,12]

While there is little that can be done to reduce the cost of staffing, particularly as the major cost is nursing personnel (which during this study period fell short of what are considered optimal staffing norms), it might be possible to reduce other expensive aspects of the care. In spite of the probable over-inflation of the costs of special investigations in this study these remain an area of high expenditure, with the cost of frequent measurement of blood gases in ventilated patients being particularly high. Limiting the number of emergency and routine investigations could reduce costs without influencing outcome, and a recent study[13] has shown how this may be achieved by utilising specific orders for certain tests and limiting unnecessary routine tests by establishing a management committee to advise and control these issues.

The value of routine investigation has frequently been questioned, but unfortunately few scientific studies have evaluated these practices adequately. All routine investigations will in future need careful evaluation of cost-effectiveness to justify their continued use. The advent of the pulse oximeter has increased our ability to monitor adequacy of oxygen saturation and consequently should have reduced the number of blood gas analyses, but it has been shown that without the introduction of appropriate protocols, the number of arterial blood gas samples has not been reduced.[14] The value of pulmonary artery catheterisation (PAC) has also been questioned, and recent studies in patients following myocardial infarction have shown no benefit in outcome.[15,16] Studies in medical and surgical populations have shown the inaccuracy of haemodynamic parameters determined by clinical examination, and the accuracy of PAC in determining haemodynamic parameters which result in treatment modifications; however, these changes have not been shown to be translated into improved outcome.[17,18] Further evaluation of this high-cost procedure in other settings, such as their peri-operative use, manipulating haemodynamics and ventilation, and diagnostic use in differentiating cardiogenic from non-cardiogenic pulmonary oedema, is clearly warranted, as this procedure may be grossly over-used.[19] Other high-cost technology such as intra-arterial and pulmonary artery oximeters and blood gas analysis and in-line continuous cardiac output monitoring, which have been shown to function accurately, will also need evaluation of cost-effectiveness before being adopted into routine clinical practice.[20]

The use of routine chest radiographs in patients on IPPV as well as after central venous procedures has been questioned; however, a number of studies have shown that they are of benefit.[21,22] Nevertheless there may be a group of patients at low risk of complications in whom chest radiographs may be done less frequently without increasing risk to the patient. Careful planning of routine radiographs to coincide with post-procedural investigations will also reduce the number of investigations.

Surveillance cultures of tracheal aspirates in intubated patients have not been formally evaluated, and studies on the diagnosis of ventilator-associated pneumonia suggest that they are of little value; however, in a recent study of selective decontamination of the digestive tract to reduce nosocomial infection, surveillance cultures were shown to be useful in determining the likely causes of ventilator-associated pneumonia, which allowed introduction of specific antibiotic therapy — invariably cheaper than the empirical therapy that would otherwise have been necessary.[23] The timing of microbiological sampling is also of critical importance, and it has been shown clearly that sampling before antibiotic therapy as well as avoiding delay in the processing of samples greatly increases the yield.[24]

Areas where the high costs are less apparent include various procedures where unnecessary use of disposable items may add considerably to overall cost. Many disposable items themselves appear to be excessively priced (e.g. disposable blood pressure transducers, which cost $15 in the USA, cost R83,86 ($23,60) in South Africa), and if more than one triple-lumen central venous pressure catheter is used because of initial failure of insertion, the additional catheter will add R96,80 to the cost of the procedure, or if an introducing set is used 'in case it may be needed' the additional cost is also R96,80. Limiting use of these items to more experienced operators only, or insisting on better supervision of these procedures, may reduce this unnecessary expenditure.

The pharmacy bill has always been thought to be one of the major costs in the ICU; however, this study has shown that the cost of drugs is relatively low compared with other items. This is probably largely due to strict control of the prescribing and use of drugs which has been introduced in our ICU to optimise drug therapy and to limit polypharmacy and drug interactions; this has been achieved without compromising the quality of care. A strict antibiotic policy is in place, with limitation of the use of all antibiotics, particularly new expensive broad-spectrum agents which are prescribed for specific indications only to limit the development of antimicrobial resistance and reduce costs. Other areas have also been targeted, particularly hypnotics, analgesics, and muscle relaxants, where again expensive short-acting agents are restricted for specific indications only. The introduction of intravenous adrenaline infusions as the primary inotropic agent unless specifically contraindicated, and limitation of routine ulcer prophylaxis, have also reduced the drug bill considerably without influencing outcome. The daily contribution of a clinical pharmacist has greatly assisted cost-effective and efficacious use of drugs, as has been suggested in other reports.[25]

This study has again suggested that the cost of care of non-survivors is much greater than that of survivors, although only 2 of the 46 patients died; however, this emphasises the importance of timely withdrawal of active supportive therapy and institution of appropriate terminal care in hopeless cases to limit unnecessary expenditure. Severity of illness scoring systems such as APACHE II and III and the Acute Physiological Score, measured during the first 24 hours of admission, have all contributed to evaluation of outcome and comparison of results in cohorts of patients, but none have accurately defined when care is hopeless in individuals.[26,27] Response over time with APACHE II, and in particular organ failure scoring and a number of mortality prediction models, have proved more useful in determining outcome in individuals and can be useful in supporting decisions made using clinical evaluation by experienced intensivists.[27-30] Further refining of these systems with disease-specific predictions and other relevant clinical data will be essential to help define hopeless cases in the future. This is particularly important with the development of new and more expensive therapies and drugs, particularly those used for severe sepsis and infections, where monoclonal antibodies to the inflammatory cascade and cytokines are showing promise, liposomal agents such as amphotericin B are less toxic and more effective than older preparations, and expensive prophylactic agents and vaccines are now becoming available for the management of HIV-infected patients.

Although it is difficult to determine the quality of care in individual ICUs without careful audit with severity of illness quantification, comparison of outcome using APACHE II scoring to equate different ICUs has shown that those with full-time direction by trained intensivists using appropriate protocols for therapy fare the best.[31] This high standard of ICU care should therefore be the goal for future funding and development in critical care. This will allow optimal use of this valuable national resource, and it should also be recognised that the value of critical care cannot be measured only in terms of patients saved, but also by its contribution to total health care. The teaching, training and research provided by these facilities, which impacts on all other areas of health care in society, makes critical care an indispensable part of the entire health care system in spite of its relatively high cost, and adequate funding will give the best returns and be of most benefit to all levels of society.[32]

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