South Africa (SA) has a two-tiered healthcare system comprising a large public health service and a rapidly growing private for-profit sector. In 2015/16, hospital services accounted for an estimated ZAR87 billion (57%) of the total public health expenditure in SA, of which more than half was used for general regional hospitals (ZAR24 billion), central hospitals (ZAR18 billion) and tertiary hospitals (ZAR10 billion). Expenditure at these hospitals was mainly driven by personnel, laboratory tests, medicines and medical supplies. In the province of KwaZulu-Natal, regional and tertiary hospitals and central hospitals accounted for 27% and 12%, respectively, of the total provincial health expenditure in the public sector in 2015/16. Regional hospitals provide access to high care and short-term ventilation, while tertiary hospitals offer services that are more specialised and have intensive care units (ICUs). Central hospitals deliver highly specialised services, often in subspecialties that require skilled personnel and unique and expensive technologies, and have specialised ICUs.

In 2008/09, there was a total of 4 719 ICU beds in the healthcare sector in SA, with 75% (3 533) in the private sector and 25% (1 186) in the public sector. The majority of ICU beds were located in three provinces: Gauteng (49%), KwaZulu-Natal (14%) and Western Cape (15%). KwaZulu-Natal had a total of 224 ICU beds in the public sector, translating to 1 bed per 45 000 population. ICUs function differently in the two sectors. In public hospitals ICUs are closed units run by a specialist clinician, usually an intensivist, whereas in the private sector the ICUs are open units and any clinician can admit and manage a patient in the ICU. Medical advances, together with increasing life expectancy, have increased the proportion of patients with multiple morbidities, thereby increasing demands for intensive care beds. The need for ICU services often exceeds the availability of ICU beds. In the public sector, the development of new hospitals with ICUs has been constrained owing to the increasing focus on making primary healthcare accessible to the population. As a result, the growth in private sector ICUs has outstripped that in the public sector. Although ICUs comprise <10% of all hospital beds, the cost of admissions in an ICU is significant. In the USA, intensive care costs have increased from ~13% to nearly a third of inpatient costs over the past two decades. In SA, intensive care services, like all other health services in the public sector, are provided at no cost to patients who are unemployed. Previously, if a patient required intensive care services and there was no available ICU bed in the public sector, the KwaZulu-Natal Department of Health would ‘buy’ this service from the private sector. This arrangement met the healthcare needs of the patients, but presented challenges in terms of who took responsibility for the care of the patient, and the surrounding costs associated with private healthcare. It is therefore important for both managers and clinicians to be aware of the cost of patient stays in an ICU.

Objectives

Previous research has analysed the cost of primary healthcare services, district hospital services and specific health programmes, but there has not been an analysis of the costs incurred in ICUs in the SA public sector. The objective of this research was to conduct a
cost analysis of intensive care services in the public sector from the perspective of the health service provider.

Methods

The study was conducted at an 846-bed central hospital in the eThekwini Health District in KwaZulu-Natal. This hospital has a trauma ICU (10 beds), a combined neurosurgical, medical and surgical ICU (6 beds per discipline), a cardiothoracic ICU (8 beds), a burns ICU (4 - 7 beds) and a transplant ICU (2 beds). We included the trauma and combined neurosurgical, medical and surgical ICUs in this study. A retrospective cost analysis for the 2015/16 financial year (1 April 2015 - 31 March 2016) was conducted.

We used a mixed-methods costing approach based on the availability of data for the ICUs under consideration. The cost components utilised are outlined in Table 1. Land and building costs were excluded owing to unavailability of data. The equipment at the facility attracts a monthly usage charge that is reimbursed to the private managing agent, and depreciation was therefore not calculated. The bottom-up approach was used to calculate the cost of clinical support, and pharmaceuticals and consumables. These costs were assigned to each ICU based on resource utilisation. The hospital uses cost-centre accounting, and we were therefore able to obtain the total costs for equipment, goods, and services for the ICUs. The top-down approach was used to allocate equipment and goods and services per ICU based on the proportion of patient days per ICU.

The unit costs of laboratory and radiography investigations, consumables, and goods and services were obtained from hospital administrative databases. Human resource costs were obtained from the hospital human resource database and included all nurses, doctors, and managers employed full-time at each of the ICUs.

The clinical costs for the medical, surgical, and neurosurgical ICU were disaggregated to the medical/surgical and neurosurgical sections using the bottom-up approach. The remaining costs were allocated to the medical and surgical and neurosurgical sections based on the number of inpatient days. All costs were based on SA rands at the average exchange rates for 2015: ZAR13.48 = USD1.00, ZAR14.85 = EUR1.00. A sensitivity test based on including land and building costs at a rate of ZAR10 000.00 per square metre and varying inpatient days was conducted.

Permission to conduct the study was obtained from the hospital management and the KwaZulu-Natal Department of Health Research Committee. The study was approved by the Biomedical Research and Ethics Committee of the University of KwaZulu-Natal Research Committee. The study was conducted at an 846-bed central hospital in the eThekwini Health District in KwaZulu-Natal. This hospital has a trauma ICU (10 beds), a combined neurosurgical, medical and surgical ICU (6 beds per discipline), a cardiothoracic ICU (8 beds), a burns ICU (4 - 7 beds) and a transplant ICU (2 beds).

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Results

Cost per admission

During the 2015/16 financial year there were 544 admissions in the two ICUs with a total cost of ZAR114 055 104, which is equivalent to 5.3% of the total hospital expenditure for the financial year (Table 2). The 323 admissions to the combined ICU accounted for 59.4% of admissions, of which 215 (39.5%) were to the neurosurgical section and 108 (19.8%) to the medical and surgical section. The combined ICU accounted for more than two-thirds of the cost (ZAR79 162 985). The mean cost per admission for both ICUs was ZAR209 660. The mean cost per admission was ZAR157 883 in the trauma ICU, ZAR201 347 in the neurosurgical section and ZAR332 161 in the medical and surgical section of the combined ICU.

Estimated cost per patient day

The cost per patient day in the two ICUs was ZAR22 870. The cost per patient day was 58% higher in the combined ICU (ZAR26 954) than the trauma ICU (ZAR17 021). Of the 2 937 inpatient days in the combined ICU, 1 636 were in the neurosurgical section of the combined ICU and 1 301 in the medical and surgical section. The cost per patient day in the neurosurgical section of the ICU and the medical and surgical section showed a very slight difference (ZAR26 461 v. ZAR27 574) despite the fewer inpatient days in the medical and surgical section.

Component costs

Human resources costs were the highest ICU cost driver (55%). Other direct patient activity costs (clinical support, consumables and pharmaceuticals) accounted for 24% of the total ICU costs. A fixed cost driver at this specific facility is the equipment cost, which accounts for 14% of the ICU cost (Fig. 1). The cost per day, excluding direct patient activity costs and clinician costs, was ZAR13 433.

![Fig. 1. Contribution of the different components to ICU costs, 2015/16. (ICU = intensive care unit.)](image-url)

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human resources</td>
<td>55%</td>
</tr>
<tr>
<td>Equipment</td>
<td>7%</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>8%</td>
</tr>
<tr>
<td>Goods and services</td>
<td>8%</td>
</tr>
<tr>
<td>Clinical support</td>
<td>14%</td>
</tr>
</tbody>
</table>

Table 1. Cost components included in the analysis of ICU services

<table>
<thead>
<tr>
<th>Human resources</th>
<th>Clinical support</th>
<th>Consumables</th>
<th>Equipment</th>
<th>Goods and services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational manager</td>
<td>Radiography</td>
<td>Intravenous fluids</td>
<td>Medical equipment</td>
<td>Utilities</td>
</tr>
<tr>
<td>Clinicians</td>
<td>Laboratory</td>
<td>Drugs</td>
<td>General equipment</td>
<td>Patient catering</td>
</tr>
<tr>
<td>Nurses</td>
<td></td>
<td>Total parenteral nutrition</td>
<td>Information technology</td>
<td>Security</td>
</tr>
<tr>
<td>Ward clerk</td>
<td></td>
<td>Blood and blood products</td>
<td></td>
<td>Cleaning</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Disposables</td>
<td></td>
<td>Waste management</td>
</tr>
</tbody>
</table>

ICU = intensive care unit.
Sensitivity analysis

Two scenarios were modelled, taking into consideration the unique situation of the hospital. This hospital provides tertiary and quaternary levels of care, and patients are meant to be transferred back to the referring hospital once they are stable and no longer need specialised care. Owing to lack of availability of the patient transport system, patients may spend extra days in the ICU after they have been deemed fit for transfer. We therefore looked at the effect of inpatient days on the ICU costs by increasing and decreasing the inpatient days by 25%. We also estimated land and building costs to determine the effect these would have on the total costs.

The number of inpatient days has a major influence on the cost of managing patients in the ICU (Fig. 2). A 25% decrease in the number of inpatient days resulted in a 33% increase in the cost per inpatient day without adjusting any of the other fixed costs. Land and building costs increased the overall cost per inpatient day by ~ZAR2 000.

Discussion

A limited number of studies have been conducted on the cost of treatment of patients admitted to ICUs in low- to middle-income countries. Owing to the different types of ICUs, the wide spectrum of disease presentation and the availability of numerous diagnostic and treatment options, the cost of ICU admissions varies tremendously. The diversity of costing methodologies used to calculate ICU costs also makes comparative analyses a challenge.

In the USA, ICUs accounted for 13.5% of total hospital expenditure in 2005, while an earlier study in the Netherlands estimated that ICU costs represent ~20% of the total hospital budget. In contrast to these studies, our study showed that the cost of ICU admission at a public sector hospital in SA accounts for an estimated 5% of the total hospital expenditure. However, it must be noted that we included costs for only two ICUs in the hospital. If costs of the specialised and paediatric ICUs were included, the proportion of ICU costs would be higher. In SA the ratio of public sector ICU beds to the population varies across provinces from 1:20 000 in the Western Cape to 1:150 000 in Limpopo. The contribution of ICU costs to total public hospital expenditure is therefore likely to be lower in SA than in countries with higher ICU bed-to-patient ratios such as the USA, with an estimated 20 - 30 beds per 100 000 population.

The cost per ICU day (USD2 000/EUR1 815 in the trauma ICU and USD1 263/EUR1 146 in the combined ICU) in the current study is higher than the cost per day of USD193 in a medical ICU in a tertiary hospital in Sarajevo, and EUR144 across 13 ICUs in Hungary. Our cost per ICU day is also higher than the USD255
private sector cost data is extremely difficult owing to the competitive nature of the industry. Although we are unable to determine the cost drivers for ICUs in the private sector, this study provides an initial cost estimate that could be used to inform the debate on cost recovery in both sectors, as well as to reconsider the feasibility of ‘buying’ ICU beds during shortages in the public sector.

The costs of managing a patient are often not considered in the public sector, as hospitals seldom bill patients for services received. This is likely to change with the introduction of National Health Insurance, as hospitals will be expected to be competitive and efficient while recovering their costs through the insurance system. Costing of individual patient services in both the public and private sectors is therefore an important precursor to the implementation of National Health Insurance.

Study limitations

The mixed-methods approach to our cost analysis has limitations. Microcosting using the bottom-up approach with all costs calculated per patient activity is the best approach to costing health services, but this was not possible in the current study owing to the unavailability of disaggregated costing data for all components at the patient level. Costs were apportioned based on inpatient days and do not include the time spent on the activity. The costs in the current study were calculated as a cost per admission and cost per day, but we did not consider the fluctuations in the intensity of treatment provided during the patient’s ICU stay. Studies have shown a higher cost for the first day of admission in an ICU.[18,24]

Conclusions

Despite the limitations of this cost analysis, this study provides useful data that managers in the health sector could use in the planning and provision of intensive care services. These results may be of value when considering the financing and reimbursement model in National Health Insurance. Further research into the contribution of clinician costs in the private sector will provide a platform for the exploration of the use of closed ICUs, as in the public sector.

Declaration. None.

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Author contributions. SM conceptualised the research, collected and analysed the data, and wrote all versions of the manuscript. OM assisted with data analysis and reviewed all versions of the manuscript.

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