Outcomes of paediatric patients ventilated in a high-care area outside an intensive care unit

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Background. Limited availability of paediatric intensive care beds in the public sector is a major challenge in South Africa. It often results in patients being ventilated in a high-care area (HCA) outside an intensive care setting. The outcomes of paediatric patients ventilated outside a paediatric intensive care unit (ICU) are not well documented.
Objectives. To describe characteristics and outcomes of patients ventilated in a paediatric HCA.
Methods. A retrospective chart review of children (0 - 16 years) requiring mechanical ventilation in the HCA at Chris Hani Baragwanath Academic Hospital, Johannesburg, between 1 February and 31 October 2015 was performed.
Results. A total of 214 patients required mechanical ventilation during the study period. Fifty-four percent were male and 91.1% were HIV-negative. The most common diagnoses were acute lower respiratory tract infections (59.3% of the post-neonatal group, 28.8% of the neonatal group) and sepsis (6.8% of the post-neonatal group, 28.8% of the neonatal group). The ultimate rate of acceptance to an ICU was 69.0%. Only 41.6% of cases referred to an ICU were initially accepted, with limited bed availability being the main reason for refusal. Patients with respiratory illnesses were more likely and those with neurological illness less likely to be accepted to an ICU. Patients with low-risk diagnoses were more likely to be accepted than those with very high-risk diagnoses. The overall mortality rate was 32.2%, with 52.2% of these deaths occurring in the HCA. Patients aged 1 - 5 years had the highest mortality rate (48.0%). Lower respiratory tract infections (36.8%) and sepsis (20.6%) were the main causes of death. The mortality rate of suitable ICU candidates in the HCA was higher than that in an ICU (33.3% v. 24.3%). The standardised mortality ratio (SMR), as predicted by the Paediatric Index of Mortality 3 score, for all patients who died in the HCA was 3.3, while the SMR for patients who died in an ICU was 1.3. The odds ratio for mortality of suitable candidates ventilated in the HCA v. patients who were ventilated in an ICU was 1.80 (95% confidence interval 1.39 - 6.03).
Conclusions. Although a reasonable number of paediatric patients ventilated in an HCA survive, survival is lower than in those ventilated in an ICU. However, offering life-supporting therapies in an HCA may offer benefit where ICU care is unavailable. Emphasis needs to be placed on improving access to ICU care as well as optimising the use of available resources.

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Intensive care has become an integral aspect of medical care, with ongoing development of medical strategies to treat medical conditions and prolong life.[1] Studies have demonstrated that intensive care in low- and middle-income countries (LMICs) is not always equitable, with some children not having access to an intensive care unit (ICU) while others are kept alive at great cost when the chance of a good outcome is low.[2] South Africa (SA), an LMIC, has a high burden of disease but limited availability of paediatric critical care beds. The high cost of trained healthcare workers and limited resources have limited development of our ICUs, preventing paediatric patients from having access to critical care when they need it.[3] Many paediatric ICUs (PICUs) use scoring systems, such as the Paediatric Index of Mortality 3 (PIM3) score, to prognosticate mortality and identify patients admitted to the PICU who have an increased risk of poor outcome.[4,5] However, no scores exist to analyse patients with regard to prioritising PICU admission in resource-limited settings. The limited number of PICU beds often results in paediatric patients who require mechanical ventilation being managed in a general paediatric ward rather than in a PICU, even though this practice has been shown to increase morbidity and mortality.[2,6] At Chris Hani Baragwanath Academic Hospital (CHBAH) in Soweto, Johannesburg, temporary ventilation for paediatric patients can be offered in a paediatric high-care area (HCA) while awaiting an ICU bed. However, patients ventilated outside PICUs are often managed by nurses who are not trained in critical care and by general paediatricians who are not intensivists.

Objectives

No studies have assessed whether the practice of ventilating in an HCA outside a PICU rather than in a ward carries the same morbidity and mortality as management in a PICU. The objective of the present study was to describe the characteristics and outcomes of paediatric patients receiving mechanical ventilation in a paediatric HCA outside a PICU and to compare their mortality rates with those for patients who were ventilated in a PICU.

Methods
Study setting
The study was conducted at CHBAH, a tertiary hospital that admits an average of 15 - 30 paediatric patients daily, with an average of 7 000 paediatric admissions per year.[7] The hospital conducts ~22 000 births per year and caters for neonatal admissions from ~8 000 births from the surrounding midwife-operated units. In total, the neonatal unit has ~4 000 admissions per year. A small

percentage of paediatric patients may require mechanical ventilation and intensive care services at some point during their admission. These patients are admitted to the HCA in the paediatric admissions ward at the discretion of the admitting paediatrician while a request is being made to the ICU for an intensive care bed. The paediatric department is supported by a PICU and a neonatal intensive care unit (NICU). The PICU has the capacity for 9 paediatric beds, which are managed by paediatric intensivists with a nurse-to-patient ratio of 1:1. The NICU has the capacity for 18 beds and is run by neonatologists, with a nurse-to-patient ratio of 1:2. While patients are awaiting an ICU bed, the HCA has capacity to ventilate 2 patients at a time and can accommodate up to 10 non-ventilated patients. One qualified nursing sister manages the unit, with 2 - 3 enrolled nurses assisting her. Paediatric patients requiring ICU admission outnumber the beds available, resulting in many patients being denied ICU admission. These patients are then ventilated in the HCA until clinical improvement occurs and the patient is extubated, an ICU bed becomes available and the patient is transferred, the decision is taken to withdraw intensive care support, or the patient dies. Such decisions are made at the discretion of the attending paediatrician. The protocol guiding the admission of ventilated patients in the HCA states that the period of ventilation should not exceed 48 - 72 hours. However, the limited number of ICU beds available, coupled with the ICU admission criteria, often result in patients being ventilated for longer than the stipulated 48 - 72 hours, or in some instances in more than 2 patients being ventilated in the HCA at a time. Principles guiding patient selection for PICU admission at CHBAH (unpublished) are based on allowing as many patients for whom demonstrable benefit is likely as possible to be admitted. Patients selected should be those for whom intensive care is necessary for a severe reversible disease process, with reasonable potential for the patient to return to an independent, functional state. Patients considered to be poor PICU candidates include those with end-stage organ failure, advanced neoplastic disease, neurological devastation, severe malnutrition, genetic syndromes and malformations, or congenital heart lesions not amenable to surgical correction. HIV *per se* is not an exclusion criterion, but HIV stage, associated illness and potential for recovery should be considered.

Study design

This retrospective chart review was carried out in the paediatric HCA at CHBAH from 1 February 2015 to 31 October 2015. Patients aged <16 years who required invasive mechanical ventilation were identified using the HCA database. Data collected included baseline characteristics and outcomes, including survival to discharge from the ICU, which was collected using the REDCap electronic data capture tool hosted at the University of the Witwatersrand.[8] Baseline characteristics included age, gender, anthropometric indices, HIV status, admission diagnosis, and indication for ventilation and parameters required to calculate the PIM3 score. Outcomes data included assessment of ICU suitability as specified above, acceptance to the ICU, transfer to the ICU and in-hospital mortality.

When grouping patients according to indication for ventilation, an arterial oxygen partial pressure to fractional inspired oxygen (P/F) ratio ≤300 was used to define type 1 respiratory failure. An arterial carbon dioxide partial pressure ≥60 mmHg was used to define type 2 respiratory failure.

PIM3 data were used to compare weighted risk diagnoses of suitable v. unsuitable ICU candidates. The PIM3 score groups diagnoses into very high-risk, high-risk and low-risk diagnoses. Very

high-risk diagnoses include cardiac arrest prior to ICU admission, severe combined immune deficiency, leukaemia or lymphoma, post-bone marrow transplant, liver failure and necrotising enterocolitis. High-risk diagnoses include spontaneous cerebral haemorrhage, cardiomyopathy or myocarditis, hypoplastic left heart syndrome, neurodegenerative disorders and septic shock. Low-risk diagnoses include asthma, bronchiolitis, croup, obstructive sleep apnoea, diabetic ketoacidosis and seizures.[4]

PIM3 data were used to calculate standardised mortality ratios (SMRs) by dividing the number of observed deaths by the number of expected deaths as predicted by the PIM3 score. The SMR is used as a surrogate marker for the quality of ICU care, with a result of 1 being normal or expected. A ratio >1 indicates that the ICU is faring worse than expected in terms of mortality outcomes, and a ratio of <1 that it is faring better than expected.[4]

Data analysis

Descriptive statistics were used to report the data. Categorical variables were described using frequencies and percentages. Continuous variables were described using medians, interquartile ranges and ranges, as the data were not normally distributed. Calculations were performed using Statistica version 12 software (StatSoft, USA).

Ethics approval

Ethical clearance was obtained from the University of the Witwatersrand Human Research Ethics Committee (Medical) (ref. no. M150821).

Results

During the 9-month study period, 20 821 patients were seen in the paediatric outpatient department, of whom 4 718 (22.7%) required admission to the general paediatric wards and 969 (20.5% of admissions) were admitted to the HCA. A total of 214 (4.5%) of all patients admitted required invasive mechanical ventilation.

Characteristics of all patients ventilated in the paediatric HCA

Gender distribution was fairly equal, with male patients accounting for 115 cases (53.7%). The majority of patients (*n*=195; 91.1%) were HIV-negative. The majority (*n*=169; 79.0%) were aged <1 year, with the median (range) age being 2.4 months (1 day - 15.4 years). There were 52 neonates (24.3%), of whom 14 (26.9%) were preterm. The median (range) age of neonates at admission was 15 (1 - 28) days. The median (range) age of all other paediatric patients excluding neonates was 4 months (29 days - 15.6 years). Further characteristics of patients are outlined in Table 1. HIV status was confirmed with an age-appropriate serological test.

The most common diagnosis in the neonatal group (*n*=19 patients; 36.5%) was sepsis. The most common diagnosis in the post-neonatal group (*n*=96 patients; 59.3%) was lower respiratory tract infection (Table 2). While type 1 respiratory failure was the most common indication for invasive mechanical ventilation in the post-neonatal group (*n*=73 patients; 45.1%), neonates were most frequently ventilated for apnoeas, with 16 neonates (30.7%) having this indication for ventilation (Table 3). Seventy-seven patients (36.0%) overall required vasoactive support.

ICU referral

Among the 214 patients who required ventilation in the HCA, an ICU bed was not requested for 17 (7.9%). Nine of these patients were deemed to be poor candidates for intensive care by the attending

Table 1. Baseline characteristics of paediatric patients requiring invasive mechanical ventilation in a high-care area

	Neonatal age group (N=52)	Post-neonatal age group (N=162)
Gender, *n* (%)		
Male	31 (59.6)	84 (51.9)
Female	21 (40.4)	78 (48.1)
Age (months), *n* (%)		
0 - 1	52 (100)	0
>1 - 12	0	117 (72.2)
>12 - 60	0	24 (14.8)
>60	0	21 (13.0)
Anthropometric indices, median (range)		
Weight (kg)	2.9 (2.2 - 3.4)	5.0 (3.7 - 9.9)
Height (cm)	50.0 (47.8 - 52.0)	58.0 (52.0 - 73.0)
Weight for age (*z*-score)	−1.5 (−3.4 - −0.8)	−1.9 (−3.4 - −0.5)
Height for age (*z*-score)	−1.0 (−2.2 - 0.3)	−1.7 (−2.9 - 0.4)
Weight for height (*z*-score)	−2.0 (−3.6 - −0.1)	−0.9 (−2.5 - 0.7)
HIV status, *n* (%)		
Negative	52 (100)	143 (88.3)
Unexposed, uninfected	27 (51.9)	93 (65.0)
Exposed, uninfected	25 (48.1)	50 (35.0)
Positive	0	19 (11.7)
Positive, on HAART	0	3 (15.8)
Positive, not on HAART	0	16 (84.2)

HAART = highly active antiretroviral therapy.

Table 2. Diagnoses of paediatric patients requiring invasive mechanical ventilation in a high-care area

Diagnosis	Neonatal age group (N=52), *n* (%)	Post-neonatal age group (N=162), *n* (%)
Respiratory	16 (30.8)	99 (61.1)
Lower respiratory tract infection	15 (93.8)	96 (97.0)
Upper airway obstruction	1 (6.2)	3 (3.0)
Cardiac	1 (1.9)	11 (6.8)
Congenital heart disease	1 (100)	4 (36.4)
Dilated cardiomyopathy/myocarditis	0	7 (63.6)
Renal	0	7 (4.3)
Nephrotic syndrome	0	4 (57.1)
Chronic kidney disease	0	3 (42.9)
Neurological	5 (9.6)	14 (8.6)
Seizures	0	7 (50.0)
Encephalopathy	0	3 (21.4)
Acute flaccid paralysis	0	1 (7.2)
Meningitis	5 (100)	3 (21.4)
Endocrine	0	1 (0.7)
Diabetic ketoacidosis	0	1 (100)
Infectious	25 (48.1)	15 (9.3)
Sepsis (including neonatal sepsis)	19 (76.0)	11 (73.3)
Acute gastroenteritis	6 (24.0)	4 (26.7)
Gastrointestinal/hepatic	4 (7.7)	2 (1.2)
NEC	2 (50.0)	0
Malrotation	0	1 (50.0)
Intussusception	0	1 (50.0)
Bilirubin encephalopathy	2 (50.0)	0
Other	1 (1.9)	13 (8.0)
Poisoning	0	7 (53.8)
Malignancy	0	5 (38.5)
Burns	1 (100)	0
Near-drowning	0	1 (7.7)

NEC = necrotising enterocolitis.

Table 3. Indications for ventilation of paediatric patients requiring invasive mechanical ventilation in a high-care area

Indication for ventilation	Neonatal age group (*N*=52), *n* (%)	Post-neonatal age group (*N*=162), *n* (%)
Respiratory	38 (73.1)	122 (75.3)
Type 1 respiratory failure	15 (39.5)	73 (59.8)
Type 2 respiratory failure	7 (18.4)	27 (22.1)
Apnoeas	16 (42.1)	18 (14.8)
Upper airway obstruction	0	4 (3.3)
Circulatory	14 (26.9)	23 (14.2)
Cardiorespiratory arrest	3 (21.4)	7 (30.4)
Cardiac failure	0	1 (4.4)
Shock, cardiogenic	0	3 (13.0)
Shock, septic	4 (28.6)	4 (17.4)
Shock, hypovolaemic	1 (7.1)	0
Severe metabolic acidosis	6 (42.9)	8 (34.8)
Neurological	0	13 (8.0)
Airway protection	0	13 (100)
Pre/post-surgery/intervention	0	4 (2.5)

paediatrician, 7 improved and were extubated soon after admission, and 1 died before an ICU bed could be requested. Of the 197 patients for whom consultation with the ICU took place, a total of 136 (69.0%) were accepted to the ICU, 82 (60.3%) on the day of consultation and the remainder at a point after the first day. Fig. 1 outlines the overall outcome of all 214 patients.

Analysis of ICU suitability

When an ICU bed is requested for a patient, that patient should be assessed regarding candidacy for admission to ICU. Of the 214 patients, 148 were assessed as being suitable candidates for ICU admission, notwithstanding bed status. Thirty-one patients were assessed as being poor or unsuitable candidates. Nine of these patients were deemed unsuitable ICU candidates by the attending paediatrician in the HCA and were among the 17 cases in which the ICU was not consulted. In 22 cases in which the ICU was consulted, the patient was initially refused an ICU bed on the grounds of being an unsuitable candidate (however, 4 of these patients were later reassessed with subsequent improvement and accepted to an ICU). The remaining 35 of the 214 patients were refused ICU admission owing to lack of bed availability with no assessment of ICU candidacy being made. An analysis was carried out to determine whether characteristics differed between the 148 patients assessed as being suitable candidates for ICU admission and the total of 31 patients initially assessed as being unsuitable candidates. The 35 patients for whom assessment of candidacy was not made were excluded from this analysis (Table 4).
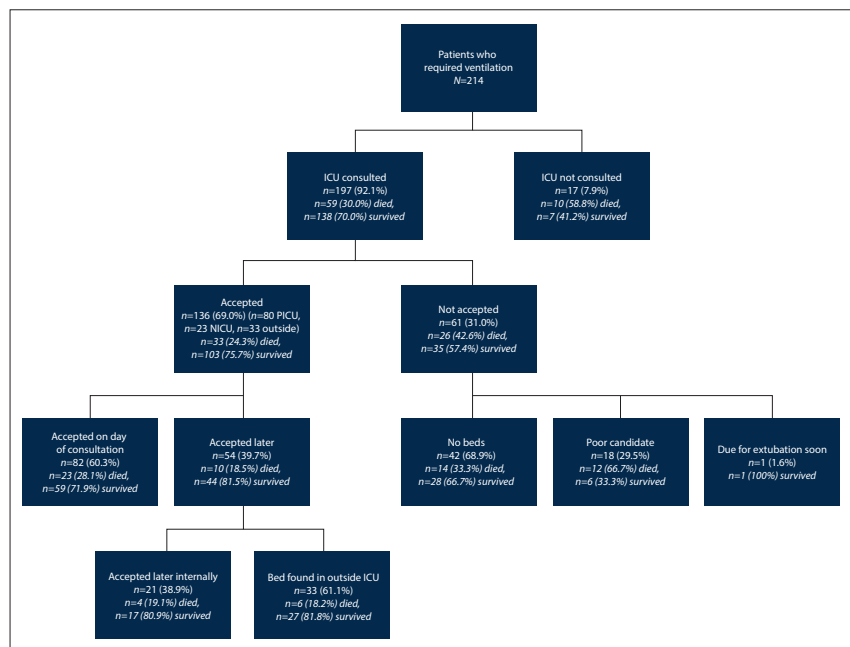

Fig. 1. ICU acceptance and mortality outcomes of patients ventilated in an HCA. (ICU = intensive care unit; HCA = high-care area.)

Mortality and mortality scores

Of the 214 patients, 69 (32.2%) died. The age group 1 - 5 years had the highest mortality rate (48.0%), and neonates the next highest (38.5%). The main diagnosis in patients who died was lower respiratory tract infection (36.8%), followed by sepsis (20.6%).

Sufficient data to calculate PIM3 scores were available for 32 of the 69 patients overall who died and for 111 of the 145 overall who survived. This comparison is illustrated in Table 5. Factors contributing to an increased risk of mortality included need for vasoactive support and high-risk diagnoses, both of which contribute to a worse PIM3 score. An overall SMR was calculated at 2.2 for those cases in which enough data were available to calculate a PIM3 score.

Comparison between PIM3 scores of the 148 patients deemed suitable ICU candidates v. the 31 patients deemed unsuitable was not done, as there were insufficient data to calculate PIM3 scores in enough patients to make the comparison accurate.

An analysis of PIM3 scores and probability of mortality scores in the 33 patients who died in the ICU compared with the 36 patients who died in the HCA was done (Table 6). The SMR for patients who died in the ICU was 1.3, while that for patients who died in the HCA was 3.3.

Table 4. Characteristics of patients deemed suitable candidates for intensive care compared with patients who were deemed unsuitable candidates

	Suitable candidate (*N*=148)	Unsuitable candidate (*N*=31)	*p*-value
Continuous variables, median (range)			
Age (months)	2.7 (1.0 - 6.6)	6.3 (0.9 - 38.8)	0.55
Weight for age (*z*-score)	−1.6 (−3.4 - −0.5)	−2.2 (−3.6 - −0.8)	0.39
Height for age (*z*-score)	−1.5 (−3.6 - −0.3)	−1.7 (−2.6 - −1.3)	0.45
	(*N*=105*)	(*N*=15*)	
Weight for height (*z*-score)	−0.5 (−2.5 - 1.0)	−2.0 (−3.0 - −0.7)	0.08
	(*N*=103*)	(*N*=15*)	
Categorical variables, *n* (%)			
HIV status			0.47
Positive	14 (9.5)	2 (6.5)	
Negative	134 (90.5)	29 (93.5)	
Diagnosis			
Respiratory	100 (67.5)	4 (12.9)	0.78
Cardiac	6 (4.1)	5 (16.1)	0.50
Renal	6 (4.1)	1 (3.2)	0.64
Neurological	8 (5.4)	7 (22.6)	0.60
Endocrine	1 (0.7)	0	0.99
Infectious	17 (11.4)	9 (29.0)	0.44
Neonatal	4 (2.7)	2 (6.5)	0.85
Other	6 (4.1)	3 (9.7)	0.68
Weighted diagnosis according to PIM3 score			
Very high risk	3 (2.0)	10 (32.3)	0.34
High risk	24 (16.2)	11 (35.4)	0.57
Low risk	121 (81.8)	10 (32.3)	0.52
Mechanical ventilation			
Respiratory	128 (86.5)	11 (35.4)	0.87
Cardiac	12 (8.1)	16 (51.7)	0.93
Neurological	6 (4.1)	4 (12.9)	0.83
Pre/post-surgery/intervention	2 (1.43)	0	0.99
Need for vasoactive support			
Yes	38 (25.7)	20 (64.5)	0.93
No	110 (74.3)	11 (35.5)	0.40

PIM3 = Paediatric Index of Mortality 3.
*Numbers in brackets represent the number of patients for whom data were available for that specific variable.

Table 5. PIM3 scores and probability of mortality scores in patients who died v. those who survived

	Died (*N*=32*)	Survived (*N*=111*)	*p*-value
PIM3 score, median (IQR)	−3.9 (−5.5 - −1.1)	−5.1 (−5.8 - −4.2	0.01
Probability of mortality (%), median (IQR)	2.0 (0.4 - 24.7)	0.6 (0.3 - 1.4)	0.09

PIM3 = Paediatric Index of Mortality 3; IQR = interquartile range.
*Numbers in brackets represent the number of patients for whom data were available to calculate a PIM3 score.

Table 6. PIM3 scores and probability of mortality scores in patients who died in the ICU compared with patients who died in the HCA

	Died in ICU (*N*=21*)	Died in HCA (*N*=36*)	*p*-value
PIM3 score, median (IQR)	−5.1 (−5.6 - −2.4)	−2.0 (−4.7 - −0.8)	0.12
Probability of mortality (%), median (IQR)	0.6 (0.4 - 8.2)	14.5 (1.1 - 31.0)	0.20

PIM3 = Paediatric Index of Mortality 3; ICU = intensive care unit; HCA = high-care area; IQR = interquartile range.
*Numbers in brackets represent the number of patients for whom data were available to calculate a PIM3 score.

When comparing patients who were deemed to be good candidates and were ventilated in the HCA with those who were ventilated in an ICU, whether internal or external, the unadjusted odds ratio (OR) of mortality was 1.8 (95% confidence interval (CI) 1.4 - 6.0), indicating that mortality was increased in patients who were ventilated in the HCA v. patients who were ventilated in an ICU.

Discussion

In SA, a low-income environment, a high burden of disease paired with limited critical care bed availability and limited resources can prevent paediatric patients from having access to critical care if they need it.[3] The limited PICU bed availability often results in paediatric patients who require mechanical ventilation being managed outside

a PICU, even though this practice has been shown to increase morbidity and mortality.[2] No studies have assessed whether the practice of ventilating in an HCA outside a PICU rather than in a ward carries the same morbidity and mortality as management in a PICU. This study represented an attempt to describe the characteristics and outcomes of paediatric patients receiving mechanical ventilation in a paediatric HCA outside a PICU and to compare their mortality rates with those for patients who were ventilated in a PICU.

The high burden of disease in SA was evident in this study, with 4.5% of all patients admitted to the paediatric service requiring intensive care. This figure is in keeping with other reported SA public hospital statistics of ~7% of patients requiring intensive care services.[9] The majority (69.0%) of the patients referred to an ICU were ultimately accepted to an ICU, either internal or external. While limited literature regarding admission rates to ICUs in SA public hospitals is available, this figure is in keeping with reported admission rates of 65% and 72%, although these figures are derived from audits of adult admissions.[10,11] The most frequent reason for patients being denied ICU admission on the day of consultation was limited availability of ICU beds, as has been reported in other audits nationwide.[2,10,12] Limited available current evidence reports that SA has critical care resource shortages in terms of both numbers of beds and trained staff, resulting in limitations in the number of ICU beds available.[3,13,14] Contributing to this problem is the discrepancy between the availability of resources in the public and private healthcare systems, with only 30% of doctors working in the public sector, which serves >80% of the country's population.[13] An audit of critical care resources carried out in 2004/05 showed that 84% of private hospitals but only 23% of public hospitals have ICUs or HCAs.[3] ICU beds should comprise 5 - 12% of hospital beds.[3] Private hospitals reach this target at 8.9%, but public hospitals fall far short at 1.7%.[3] In addition, the audit reported insufficient numbers of ICU-trained nurses, with the ratio of full-time nurses per functional bed reported at 1.1:1, with only 25.6% of these nurses being ICU trained. These figures are far below international guidelines, which recommend a ratio in excess of 5:1, with a minimum of 50% of nurses being ICU trained.[3]

This imbalance between demand and availability of resources in the public sector has resulted in the need for triaging of patients to prioritise ICU admission for patients who need intensive care the most.[14] International guidelines for ICU admissions in developed countries with more resources have fewer exclusionary criteria and are difficult to apply in our resource-limited setting.[15] A consensus statement to provide a framework to inform ICU admission, rationing and triage decision in an SA context was published recently.[14] Furthermore, each ICU should develop its own specific admission criteria.[14] In the present study, when determining the suitability of a patient for ICU admission, many patient characteristics were assessed with no significant difference in any characteristics, including HIV status, being found. Median anthropometric parameters were all within normal values, although there were some patients who fell outside the lower range of the normal -2 z-score for weight for age and height for age. While these patients were not individually assessed, perhaps this finding requires intensivists to scrutinise their selection of suitable candidates, which may be affecting outcomes. While there was little difference in weight alone between suitable and unsuitable candidates for intensive care, patients who were deemed unsuitable candidates had lower weight-for-height scores (i.e. were wasted); however, this difference was not found to be statistically significant. Studies have shown that although both HIV and malnutrition may result in increased length of mechanical ventilation and ICU stay, with

resultant heavier burdens on PICUs, with the additional advent of highly active antiretroviral therapy, patients with HIV and malnutrition have improved short- and long-term outcomes and should not be denied access to intensive care.[2,16-19] However, it may be argued that our resource-limited setting perhaps requires us to be more discriminatory towards these patients in order to allow the limited resources to be used for patients with greater potential for benefit and longer functional outcome. In terms of patient diagnoses, patients with respiratory illnesses were more likely to be considered suitable ICU candidates and those with neurological illnesses were more likely to be considered poor candidates, although these findings were not statistically significant. This may tie in with the finding that patients with low-risk diagnoses, which include respiratory illnesses, were considered more suitable candidates and were more likely to be accepted to an ICU. Patients with very high-risk diagnoses and high-risk diagnoses, which include neurological disorders, were more likely to be deemed to be unsuitable candidates. Once again, these findings were not statistically significant. These results show that very high-risk patients in whom prognosis is uncertain are not getting the benefit of ICU care and may be deemed 'too ill' for ICU admission. This is consistent with literature suggesting that patients who are perceived to be too ill to benefit from critical care are more often refused admission to ICU when bed availability is limited.[20]

Where ICU resources are not available to a patient requiring critical care, hospitals and doctors should provide alternative solutions to provide the best possible care by appropriately trained staff in other settings.[14] Because of scarce critical care resources, many SA hospitals provide life-supporting therapies such as mechanical ventilation in HCAs or general wards.[14] While this may be appropriate for patients requiring lower levels of care, it worsens outcomes in those who require high levels of intensive care.[14] In this study, the in-HCA mortality rate was higher than the in-ICU mortality rate (46.2% v. 24.3%). However, this result is biased in that it compares patients admitted to an ICU who were deemed suitable candidates with all patients left in the HCA, who included both suitable and unsuitable ICU candidates. When comparing the in-ICU mortality rate with the in-HCA mortality rate of those who were deemed good ICU candidates but were denied admission owing to lack of availability of beds, the in-HCA mortality rate was closer to that for the ICU (33.3% v. 24.3%). The overall mortality rate of 24.3% in an ICU, whether internal or external, is much higher than rates in developed countries. Studies report rates of between 2% and 7.5% for developed countries,[21-24] while figures from developing countries are much more variable, with reported mortality rates between 8.8% and 36.1%.[2,25-28] In the present study, the SMR, using predicted mortality based on the PIM3 score, for all patients who died in an HCA was 3.3, while the SMR for those patients who died in an ICU was 1.3, indicating that more deaths occurred than predicted by the PIM3 score. Few studies report on PIM3 scores and SMRs, but in those that can be found, SMRs in ICUs vary greatly. A study in the UK[5] reported SMRs between 0.6 and 0.9, while a study in Turkey[29] reported SMRs between 3.7 and 4.0. The higher than expected mortality in the present study may be attributed to a high burden of severe illness being managed in an under-resourced environment (both physical and human), resulting in differences in quality of care. However, available scores have demonstrated relatively poor performance in estimating mortality.[20] While many scores, such as the PIM3, show reasonable discrimination, calibration is relatively poor, limiting their ability to predict outcome.[20]

The unadjusted OR of mortality between suitable ICU candidates who were ventilated in the HCA owing to unavailability of beds v.

patients who were ventilated in an ICU was 1.80 (95% CI 1.39 - 6.03), evidence that managing these patients outside an ICU increases their risk of mortality. This is in keeping with findings of a systematic review that patients who are referred to an ICU and refused had excess mortality even when adjusted for severity of illness, with a combined OR of death of up to 3 times that for patients who were accepted into an ICU.[20] However, if an ICU is not available for these patients, offering life-supporting therapies in a ward or HCA may at least offer a benefit, even though not optimal.[14] The recently published Critical Care Society of Southern Africa Consensus Statement on ICU Triage and Rationing[14] recommended that 'Lower levels of care can be justified in certain circumstances' and that 'Where lower levels of care are offered as a substitute for ICU care, efforts to improve access for patients to ICU care should not be relaxed.'

To the best of our knowledge, this is the first SA study to describe the experience of ventilating paediatric patients outside an ICU in an HCA. It has relevance in light of the recently published Critical Care Society of Southern Africa Consensus Statement on ICU Triage and Rationing.[14]

Study limitations

Limitations of this study include limited numbers for analysis for ICU suitability where assessments on patient suitability were not carried out. Numbers for PIM3 score analysis were also limited where insufficient data were recorded to determine a PIM3 score, as is a limitation of retrospective study designs. Sample bias occurred where comparisons were made between outcomes of ICU patients against HCA patients, who included those who may not have been suitable ICU candidates.

Conclusions

Limited available current evidence shows that SA, an LMIC, has critical care resource shortages in terms of both bed numbers and trained staff, despite having a high burden of disease. This lack results in life-supporting therapies such as mechanical ventilation being provided in HCAs or general wards. The present study has shown that mortality is increased when paediatric patients are ventilated in an HCA rather than an ICU.

However, if intensive care is not available for these patients, offering life-supporting therapies in an HCA may offer some benefit and may be justified. While there is a need to increase access to ICU services, increasing ICU capacity may not be feasible immediately, and emphasis therefore needs to be placed on the optimal use of resources available. Measures should include clear ICU triage guidelines and admission criteria; effective, practical and equitable use of scarce resources; effective transport systems, both to the hospital and to the ICU; effective use of intensivists and other well-trained health professionals; and use of intermediate facilities such as the HCA for patients with lower critical care needs, with more intensive training of nursing and medical staff in charge of their care.[2,14,20,26,30-34]

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