

**Paediatric and neonatal admissions to an intensive care unit at a regional hospital in the Western Cape**

Submitted by

**Dr Irma Kruger**

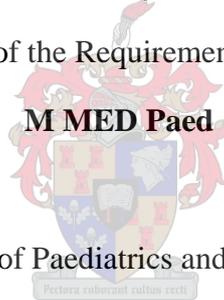
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A Dissertation Submitted to the Faculty of Medicine and Health Sciences

In part Fulfilment of the Requirements for the Degree of

**M MED Paed**



Department of Paediatrics and Child Health

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.....Cr tki'2016

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April 2014

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**SIGNATURE PAGE**

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hospital in the Western Cape**

A Dissertation Presented by

Dr Irma Kruger

As the Supervisor, I hereby certify that I have read this dissertation prepared under my  
direction and recommend that it be accepted as fulfilling the dissertation requirement.

Signed: \_\_\_\_\_



Professor M Kruger

Date: \_\_\_\_\_

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I, the undersigned, hereby declare that the work contained in this assignment is my original work and that I have not previously submitted it, in its entirety or in part, at any university for a degree.

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Dr Irma Kruger

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## ABSTRACT

### **Objective:**

The aim of the study was to determine the outcome of critically ill neonates and children admitted to a general intensive care unit in a large regional hospital (Worcester) in the Western Cape. A secondary aim of the study was to determine the risk factors for death in these neonates and children.

### **Methodology:**

This was a retrospective descriptive survey of all paediatric admissions (under 13 years of age; July 2008 till June 2009) to an intensive care unit at a large regional hospital in Worcester, South Africa. Data collected included: demography, admission time, length of stay, diagnoses, interventions and outcome. Outcome was defined as successful discharge, death or transfer to a central hospital.

### **Results:**

There were 194 admissions including children and neonates. The files of 185 children and neonates were analysed, while 8 children were excluded due to incomplete data set and one patient was a surgical admission. The male: female ratio was 1.3: 1 and the majority of patients (83%) admitted, were younger than 12 months of age at admission with a mean age of 8.5 months (median age 3.7 months; range 0 to 151 months). The majority (70%) of admissions were successfully discharged, nearly a quarter (24%) transferred to central hospitals in Cape Town and only 6% died (all younger than 5 years of age). Causes of death included acute lower respiratory tract infections (33%), acute gastroenteritis (25%), birth asphyxia complicated by pulmonary hypertension (16%) and prematurity (16%). Patients requiring airway assistance, were more likely to experience an adverse event ( $p=0.0001$ ) and invasive ventilation was associated with an increased risk for a poor outcome ( $p=0.00$ ).

### **Conclusion:**

The majority of children requiring access to a paediatric ICU are younger than one year of age. The common causes of death are acute lower respiratory tract infections, acute gastroenteritis, prematurity and neonatal asphyxia. A regional hospital in South Africa should offer intensive care to children as the majority of their admissions can be successfully cared for without transfer to tertiary hospitals. To our knowledge, this is the first study reporting admissions and outcome of neonates and children cared for in a mixed intensive care unit in a large regional hospital in South Africa. This study suggests that large regional hospitals in South Africa should have mixed intensive care units to improve child survival.

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## Chapter 1

### Review of the Literature

Globally, more than 10 million children die annually and the majority of these deaths originate in Sub-Saharan Africa (41%) and southern Asian countries (34%).<sup>1</sup> The causes of death differ substantially from one country to another, but common causes in children less than five years old include diarrhoea, pneumonia, measles, malaria, HIV/AIDS and malnutrition.<sup>2</sup> Asphyxia, preterm delivery, sepsis and tetanus account for the majority of neonatal deaths.<sup>2</sup> In 1990 the World Summit for Children called for a worldwide reduction in child mortality to below 70 deaths per 1000 live births by the year 2000 and in 2000 the United Nations adopted eight Millennium Development Goals as a focus for international development. Millennium Developmental Goal 4 (MDG4) aims to reduce the global under-five mortality rate by two-thirds from the base year (1990) by 2015.<sup>1, 3, 4</sup> To date there has been progress in 62 countries, but in 27 countries the under-five mortality rate is stagnant or worsening.<sup>5</sup> A country's epidemiological profile and health system largely dictate the implementation and development of public health interventions.<sup>1</sup> Sub-Saharan Africa accounts for 11% of the world's population, but 24% of the global disease burden.<sup>6</sup> Health expenditure in these countries is limited and accounts for less than 1% of global resources, which leads to an overburdened under resourced health system in developing countries.<sup>6</sup> Economic developments positively affect infant and child mortality in lower income countries and the introduction of national health insurance has increased access to intensive care for critically ill children in the United Kingdom.<sup>7</sup>

Paediatric intensive care is more than 50 years old with the first unit established in the United States in 1965.<sup>8</sup> Paediatric intensive care is defined as a "... separate physical facility or unit specifically designated for the treatment of paediatric patients who... require intensified, comprehensive observation and care".<sup>9</sup> The facility needs trained staff and specialised equipment, which is expensive.<sup>9, 10</sup> Despite this, paediatric intensive care should be available to all children, irrespective of where they live.<sup>10, 11</sup> Child survival is improved if children are cared for in specialist paediatric intensive care units (PICUs) in either tertiary or regional hospitals as demonstrated in the United States in 1991.<sup>12</sup> A similar study in Britain reported a substantial reduction in mortality if every child, requiring endotracheal intubation for more than 24 hours, were admitted to a large specialist paediatric intensive care unit (PICU).<sup>10, 13</sup> After the introduction of a centralised PICU the child mortality decreased by 0.34 deaths per 1000 (1.04 to 0.70 deaths per 1000) in a 12 month period.<sup>11</sup> Australian health authorities issued a statement that critically ill children must not be cared for in adult units and most critically ill children are cared for in PICUs at tertiary paediatric hospitals.<sup>14</sup> Australia has an urbanized population with 67% of the population living in the capital cities, which facilitates the centralisation of paediatric intensive care.<sup>14</sup>

Skilled teams to transport critically ill children to specialised care centres are essential for the success of these centralised paediatric intensive care units.<sup>15</sup> These transport services should function as an extension of the intensive care unit (ICU), with team members dedicated to the transport service in order to reduce adverse events during transport.<sup>16, 17, 18</sup> Research therefore

indicates that PICUs should be centralised and retrieval services should be available to ensure safe access to specialised services.<sup>10, 19</sup> If the population lives in rural regions, it can complicate transfer to centralised PICUs as reported in Australia where the retrieval time may be very long.<sup>14</sup> The mortality rates in these areas are therefore higher than in the metropolitan areas. New Zealand faces a unique situation where the population is spread over two islands. This poses a significant problem to inter-hospital transfer of critically ill children. Some children are therefore cared for in regional centres' adult ICUs.<sup>14</sup>

Resource limited countries have a vastly different population and disease profile compared to the developed countries.<sup>6</sup> During 2000 – 2002 estimates show up to 204 million undernourished people living in Sub-Saharan Africa.<sup>6</sup> Deaths due to infectious diseases are higher in Africa than in any other area in the world, while resources are low and health care personnel are limited.<sup>6</sup> Little is known about the needs for critical care in low- and middle income countries, but published results indicate an inadequate quality of care and high mortality rates.<sup>20</sup> Intensive care, as provided in developed countries, is not possible in developing countries due to lack of infrastructure, human resources, services and expert support.<sup>5, 6</sup> This results in many patients requiring ICU care (according to standards set in well-resourced countries), being admitted to general wards in resource limited settings.<sup>6, 20</sup> Critically ill children, admitted to general wards with low nurse-to-patient ratios, receive uncoordinated care and are at increased risk for nosocomial infections and death.<sup>20, 21</sup> Provision of intensive care on the children's ward places not only the critically ill child at risk, but also compromises the care of the remainder of the children in the ward by the reallocation of resources to the critically ill child.<sup>17, 8</sup> Lack of ICU services led to increased morbidity and mortality rates in South America.<sup>22, 23</sup> The establishment of inter-facility transport teams is virtually impossible and the lack of transport of critically ill children to paediatric intensive care services also contributes to the high mortality reported in South America.<sup>8</sup>

South Africa is classified as a middle income country and has an adequate health care system.<sup>23, 24</sup> There are currently only reports regarding PICUs in the public sector and little is known about the PICUs in the private sector. The overall mortality rate over a 25 year period (1971 – 1995) at King Edward VIII Tertiary Hospital, Durban, South Africa was 35.44% (range 5.4–29.9 %), with a bed occupancy rate of 120% in 2003, while Red Cross War Memorial Children's Hospital in Cape Town reported their mortality as 10% in 2008.<sup>25, 26</sup> A study conducted at Chris-Hani Baragwanath Hospital (CHBH), Johannesburg, South Africa compared European and American paediatric intensive care populations to their own population and found that their patients were younger and were more severely ill (higher admission PRISM score). The most common diagnoses leading to admission in the PICU were respiratory infections and sepsis with very few surgical admissions. Their average length of stay was also longer in their PICU than those of the developed world, with great variability in the time taken to transfer a critically ill patient (range 0.3 – 6 hours) to the PICU.<sup>6, 27</sup> Transfer of critically ill children poses a challenge in South Africa and a study from Cape Town, has reported a high incidence of transfer related adverse events in children transferred from non-academic metropolitan hospitals to tertiary care centres.<sup>28</sup> Poor

infrastructure and lack of trained ambulance personnel are contributing factors for adverse events during the transport of critically ill child.<sup>21</sup>

Sub-Saharan Africa is the area most affected by the Human Immunodeficiency virus (HIV) pandemic, but is home to only 3% of the global health workforce.<sup>6, 29</sup> This HIV epidemic has increased the demand for paediatric intensive care services.<sup>30</sup> The number of PICU admissions known to be HIV infected increased by 19% from 1993 to 2000 at King Edward VIII Hospital in Durban, South Africa.<sup>30</sup> Resource rich countries have shown a dramatic decrease in the number of HIV infected children needing the intensive care unit (ICU) due to the availability of highly active antiretroviral therapy (HAART) and successful prevention of mother to child transmission of HIV (PMTCT) programmes.<sup>30</sup> The seroprevalence of HIV among antenatal clinic attendees in South Africa was 29.4% in 2009 despite the introduction of HAART to the South African public sector in 2004.<sup>25, 31</sup> The country has made great strides in providing ART to all those who qualify for treatment, but even though more than 95% of pregnant women were tested for HIV in 2010 and over 95% HIV positive pregnant women received ART in 2011, only 68% of HIV-exposed infants received ART as part of prevention of mother to child transmission (PMTCT) strategies.<sup>15, 32</sup> Fortunately the PMTCT programme showed a reduction in transmission of HIV from mother to child from 12% in 2008 to 2.7% in 2011.<sup>28</sup>

There is no clear guidance regarding infrastructure of an ICU in a low income setting. Using a number as little as 2% will mean that a 300 bed regional hospital should have 6 ICU beds.<sup>20</sup> The national audit of 2005 showed that 19.6% of all hospital beds (private and public sector) are dedicated to paediatric and neonatal patients.<sup>67</sup> According to the Western Cape Department of Health there are 18 paediatric ICU beds available within the 2 tertiary hospitals in Cape Town (Red Cross War Memorial Children's Hospital and Tygerberg Children's Hospital), with a patient turnover of approximately 2000 per year (2008).<sup>15</sup> King Edward VIII Hospital in Durban has 8 beds with an annual turnover of 400 admissions (2005).<sup>30</sup> At these regional level hospitals ICU care is often provided by non-specialist medical officers and nursing staff.<sup>20</sup> Literature suggests that these units should care for adults as well as children in order to concentrate expertise and resources.<sup>5</sup> Little data is currently available regarding non-tertiary mixed adult and paediatric intensive care unit outcomes.

This study was done to determine the outcome of neonates and children admitted to such a mixed adult and paediatric ICU at a large regional hospital in the Western Cape, South Africa.

## **Chapter 2**

### **Methodology**

#### **2.1 Aim**

##### ***2.1.1 The primary objective***

To determine mortality of critically ill neonates and children admitted to an intensive care unit in a large regional hospital in the Western Cape.

##### ***2.1.2 The secondary aim***

To determine the risk factors for death in neonates and children admitted to the study unit.

#### **2.2 Setting**

The study was conducted at a large regional facility in the Western Cape outside the Cape Town Metropolitan area. The facility is located in Worcester in the Breede River Valley District. The hospital has a high care unit accredited by the Western Cape Provincial Department of Health. The unit consist of 5 beds. One bed is dedicated to paediatric care and may be utilised for invasive ventilation. Two of the other beds are used on a first come first served basis and may be utilised for non-invasive ventilation or for patients requiring high care. There are two full time paediatricians in the paediatric department. Two paediatricians working in private practice provide after-hour coverage on a sessional basis. Additional staff include a paediatric registrar (rotating for a year from Tygerberg Hospital), a medical officer, a community service medical officer (post internship compulsory rotation) and an intern, each of whom take turns to be on call after hours and during weekends. Currently this unit has no written criteria for referral of children to tertiary facilities. This decision relies on the discretion of the consultant.

#### **2.3 Design**

The study was a retrospective descriptive study capturing data for a 12 month period from 01/07/2008 until 30/06/2009.

A list of patients in compliance with the study criteria was compiled from the admissions book of the unit (each admission to the unit has their patient sticker placed in the admission book). Data collected was entered into an MS Excel Worksheet.

## **2.4 Inclusion criteria**

- All children younger than 13 years of age admitted to the high care unit with a medical condition.
- Neonatal admissions - defined as an age of less than 28 days at time of admission.

## **2.5 Exclusion criteria**

- Children who were older than 13 years of age at the time of admission.
- Children admitted to the unit by surgical disciplines.
- Admissions before 01/07/2008, but present in the unit on or after 01/07/2008.
- Children directly transferred to tertiary services via casualty, the paediatric and neonatal wards or peripheral referral hospitals.

## **2.6 Ethical considerations**

The protocol was submitted for and approved by the Medical Superintendent of Worcester Hospital. Waiver of individual consent was requested from and granted by the Health Research Ethics Committee, Stellenbosch University.

Patients were assigned a unique study number. Data was collected against this number. The number is kept separate from the data collected, for access of the researcher only. In order to ensure the anonymity of the hospital, no reference will be made to Worcester hospital in case of further publication.

## **2.7 Data analysis**

Data was analysed in Statistica version 11.

Continuous variables (age, duration of stay, gestation, weight for age and weight for age z-scores) were analysed descriptively using means and standard deviations, medians and interquartile ranges as well as 95% confidence intervals for the mean. Data were represented graphically using histograms. All nominal variables were analysed descriptively using frequency distributions where absolute and relative frequencies were presented. Data were presented graphically using bar charts.

To compare continuous variables by Group (“Successful discharge”, “Transfer” or “Died”) a Kruskal-Wallis ANOVA was used since data were not normally distributed. In the case of overall significance post-hoc testing was applied, correcting for multiple comparisons using the Bonferroni approach. Comparisons of nominal variables and Group were performed using Chi-squared tests for association. A significance level of 5% was applied to all analyses.

## 2.8 Study definitions

For the purpose of the study patient *outcomes* are defined as:

- *Successful discharge*: Discharged to an ordinary inpatient ward, step down facility or discharged home
- *Transfer*: Transfer to a tertiary hospital
- *Death*: A death that occurred within the ICU

An *intervention* is defined as follows:

- *Airway assistance* is defined as non-invasive or invasive ventilation. *Non-invasive ventilation* refers to nasal continuous positive airway pressure (nCPAP) while *invasive ventilation* refers to endotracheal intubation and ventilation. For the purposes of this study nasal cannula oxygen was not considered an intervention, as nasal cannula oxygen can easily be provided outside the ICU setting.
- *Transfusions* are defined as infusion of blood, blood products or albumin.
- *Inotropic support* refers to intravenous infusion of dopamine, dobutamine, adrenaline or a combination of these drugs.

*Place of admission* refers to where the patient was admitted before transfer to the ICU and was divided into the following areas:

- Referral facility - defined as another level 1 or 2 hospital.
- Casualty – defined as the casualty department of the study hospital.
- Wards – refers to the neonatal and paediatric wards.
- Theatre - refers to patients admitted to the ICU directly from the theatre, but who did not have surgery, i.e. Post caesarean section/after intubation in theatre.

A *weight-for-age z-score* was determined for each patient's admission weight. The weight-for-age z-scores (WAZ) were used to classify the nutritional status of each admission. The following programs were used:

- Children 0 -5 years born at term: WHO Anthro program
- Children older than 5 years: Centre for Health Statistics
- Premature infants: Fenton Growth charts

The following definitions apply to the WAZ:

- Normal: WAZ between -1SD and +1SD
- Under weight for age: WAZ between -1SD and -2SD
- Moderate malnutrition: WAZ between -2SD and -3SD
- Severe malnutrition: WAZ less than -3SD

The following definitions apply to premature infants:

- Extremely low birth weight (ELBW): birth weight <1kg

- Very low birth weight (VLBW): birth weight between 1kg and 1.5kg
- Low birth weight (LBW): birth weight between 1.5kg and 2.5kg
- Normal birth weight: birth weight >2.5kg

In term infants small for gestational age was defined as:

- Birth weight < 2 SD from the mean

A *premature infant* refers to an infant younger than 37 completed weeks gestational age at the time of admission to the unit.

After-hours is defined as after 17:00, but before 08:00 on weekdays and from Friday 17:00 until Monday 08:00.

## Chapter 3

### Results

#### 3.1 Study population

More than a third (36%) of the patient population, admitted to the ICU, were neonates and children (194/535 patients). Eight children were excluded from data analysis due to incomplete data or folder unavailability and one patient was a surgical admission. The files of 185 children and neonates were analysed. There was an overall male predominance with male: female ratio of 1.3: 1. The age distribution indicated that 83% of patients admitted, were younger than 12 months old at time of admission (table 1) with a median age of 3.7 months (mean age 8.5 months; range 0 to 151 months). Neonatal admissions constituted 4% (n=41) of the total admissions, but 22% of the paediatric population.

Patients entered the unit through either the casualty department (54%), from an inpatient ward (34 %), or from a referral hospital (12%). The majority (62%) of patients were admitted after-hours. The majority of neonates (51%) were admitted from the inpatient wards, while the majority of children older than 1 month (62.5%) were admitted from the casualty department.

**Table 1: Age distribution of children admitted to ICU (surgical admissions excluded)**

Age group	n	% of Total admissions	Referred from			
			Casualty	Wards	Theatre/Labour ward	Referral facility
< 28 days	41	22%	9	21	1	10
29 days to ≤6 months	76	41%	48	20	1	7
>6 months to <12 months	37	20%	21	14	0	2
≥12 months to <5 years	27	15%	18	5	1	3
≥5 years	4	2%	3	1	0	0

The mean WAZ was -1.8 SD (median -1.54SD, range: -6.51SD to 1.88SD), with 25% of children severely malnourished, and 16% moderately malnourished. The majority (80%) of children with severe malnutrition were younger than 1 year of age.

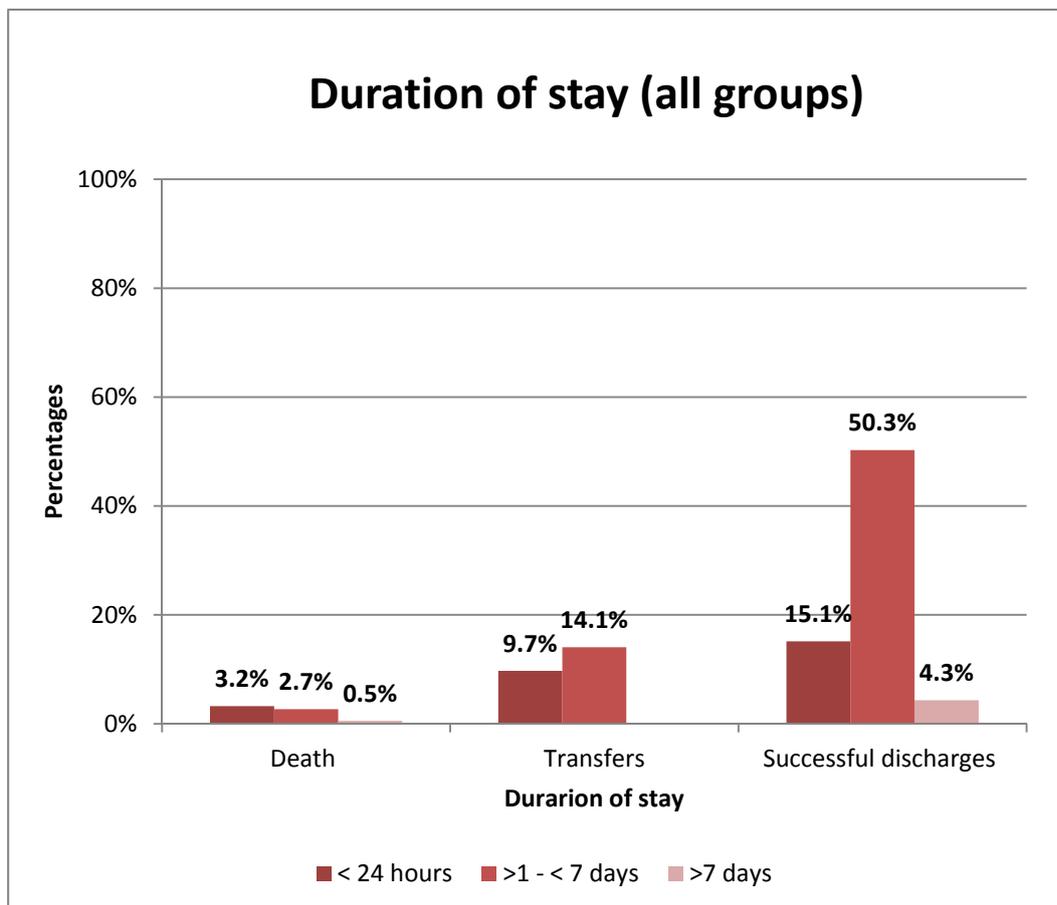
The majority (70%) of patients were successfully discharged and 30% experienced an adverse event (table 2). Nearly a quarter (24%) was transferred to the tertiary hospital for intensive care and 6% died. All the deaths were infants less than 1 year old (100%). More than half the deaths (58%) occurred in the age group between 1 and 6 months (mean age: 2.6 months; median: 2.5 months; range: new-born to 9.3 months).

**Table 2: Outcome of ICU stay**

Age Group	Step down/discharge	Referral to Tertiary Hospital	Death
<28 days	27	10	4
29 days – 6 months	55	14	7
>6 months – 1 year	28	8	1
>1 year – 5 years	16	11	0
>5 years	3	1	0
Total	129	44	12
% of total admissions	70%	24%	6%

The overall mean age at transfer was 11.96 months (median: 4.0 months; range new-born to 12.5 years). The highest transfer rate to a tertiary facility was in the group aged between 1 and 5 years of age (40%).

**Figure 1: Duration of ICU Stay**



The overall mean duration of admission was 2.5 days (median 1.83 day; range 1 hour to 13.4 days). Most patients (67%) were admitted for between 1 and seven days. The majority of deaths (50%) and transfers (34%) occurred within 24 hours of admission, and there were no deaths after 7 days of admission (figure 1). Duration of stay was significantly associated with

the risk for transfer to a tertiary facility ( $p=0.00$ ), but was not associated with an increased risk of death, although the trend was towards significance ( $p=0.06$ ).

### 3.2 Neonatal admissions

#### 3.2.1 Premature infants

Eleven of the 41 neonates admitted during the study period were newly born (admitted at <24 hours of age). Nearly half (46%) of all neonatal admissions were premature babies ( $n=20$ ) with a mean gestational age of 31 weeks (range: 29 – 36 weeks) and a mean age of 7 days (median: 3 days; range: 0 to 27 days). The male to female ratio was 2.3: 1. The mean duration of stay was 3.1 days (range: 4 hours to 13.4 days) and 65% were admitted after-hours. Fourteen (70%) premature infants were successfully discharged, 20% were transferred to the tertiary hospital and 2 babies (10%) died. Only 1 infant had a normal weight for gestation, while 40% were of low birth weight (LBW), 45% were of very low birth weight (VLBW) and 10% had an extremely low birth weight (ELBW).

**Table 3: Reasons for admission of premature infants**

Diagnosis	n
Sepsis	9
Hyaline membrane disease	6
Necrotising Enterocolitis	1
Congenital syphilis	1
Apnoea	1
Hypoglycaemia	1
Upper gastrointestinal tract bleed (non-specific)	1

Sepsis was the main reason (9 patients) for admission of premature infants to the ICU (table 3), followed by 6 babies admitted due to hyaline membrane disease (HMD). Two patients were diagnosed with Grade 1 HMD (spontaneous resolution with minimal intervention) and 6 patients with Grade 4 (invasive ventilation and surfactant administration) HMD. Half of the premature infants admitted due to HMD were successfully discharged, while 37% were transferred to tertiary care. One premature infant died after developing a left sided pneumothorax due to grade 4 HMD. Three infants were admitted with non-specific diagnoses, which included apnoea, hypoglycaemia and upper gastrointestinal tract bleeding and no cause was found. All three were successfully discharged. One premature infant was admitted due to suspected congenital syphilis and received treatment, with a successful discharge.

#### 3.2.2 Full term newborns

The mean age for full term neonates ( $n=21$ ) admitted to ICU was 8 days (median: 7 days; range: new-born – 25 days). There was a female predominance (male: female ratio - 0.2: 1).

The mean duration of stay for term infants was 2.9 days (median: 1.7 days; range: 1.5 hours to 12.3 days) and more than half of the admissions (61%) were admitted to the unit after hours. The majority (13) were successfully discharged, while 6 babies were transferred to tertiary facilities and 2 died. Seven of these infants (33%) were small for gestational age and the weight of 14 infants (67%) were normal for gestational age.

Table 4 shows the reasons for admission of term infants.

**Table 4: Reasons for admission for term infants**

Diagnosis	n
Acute gastroenteritis	8
Sepsis	4
Birth Asphyxia	4
Meconium aspiration complicated by pulmonary hypertension	2
Congenital diaphragmatic hernia	1
Infant of a diabetic mother	1
Haemorrhagic disease of the new-born	1

Acute gastroenteritis (8 patients) was the most common cause of admission in these full term babies, followed by sepsis (4 patients) and birth asphyxia (4 patients). Death was caused by birth asphyxia, complicated with pulmonary hypertension, in two full term infants. The other 50% were successfully discharged. Two infants, admitted with meconium aspiration, complicated by pulmonary hypertension, required transfer to the tertiary hospital for further management, as well as one baby with a diaphragmatic hernia. One baby was the infant of a diabetic mother, with hypoglycaemia and was successfully managed and discharged, while another baby was admitted with haemorrhagic disease of the newborn, and was also successfully discharged.

### 3.3 Admissions >29 days

The vast majority (77%) of all admissions were children between the ages of one month and 1 year and 8 out of the 12 deaths were in this age group (Table 5). The male to female ratio was 1.4: 1 and the mean age 10.8 months (median 5.6 months; range 1 month to 12.5 years). The majority (62%) of infants between 1 month and 1 year of age were admitted after-hours. Most (73%) of these infants were successfully discharged, while only 20% were transferred to a tertiary facility. The younger infants (1 – 6 months) had a lower mean WAZ (mean: -2.13SD, median: -1.92SD, range: -5.56SD to 1.88SD) than the WAZ score (mean: -1.94SD, median: -1.87SD, range: -6.51SD to 1.07SD) for older infants (6 – 12 months).

Children older than one year of age accounted for only 17% of the total admissions to the unit. The children between 1 and 5 years old, tended to be younger (mean age 23 months, median 15.6 months). The male to female ratio was 1:1 for the age group older than 1 year of

age. The majority of the admissions (62%) in this group occurred after hours. There were no deaths for children between 1 and 5 years of age, but nearly a third (29 %) of these children required transfer to tertiary care. Children between 1 and 5 years of age (mean WAZ -1.76 SD, median -1.4 SD, range -5.86 to 1.43 SD) and children older than 5 years (WAZ -1.79 SD, median -1.25 SD, range -2 to 0.5 SD), tended to be underweight for their age. There were only 4 children older than 5 years admitted to the unit (mean age: 99 months, median age: 92.5 months, range: 63.1 to 151 months). All of them were admitted after-hours. No deaths occurred in children older than 5 years of age, 25% were transferred and 75% were successfully discharged,

**Table 5: Data for ages > 1month**

Data	29 days - < 6 months	6 months - < 1 year	1- 5 years	>5years
N	76	37	27	4
mean age (months)	3.1	8.52	22.64	99.86
Male: female ratio	1.71: 1	1.05 :1	1.25 : 1	1:3
Mean duration of stay (days)	2.46	2.35	1.75	2.47
Mean weight-for-age z-score (SD)	- 2.13	-1.94	-1.76	-1.79
Admissions after hours	48	22	15	4
Death	7	1	0	0
Transfer out	14	8	8	1
Successful discharge	55	28	16	3

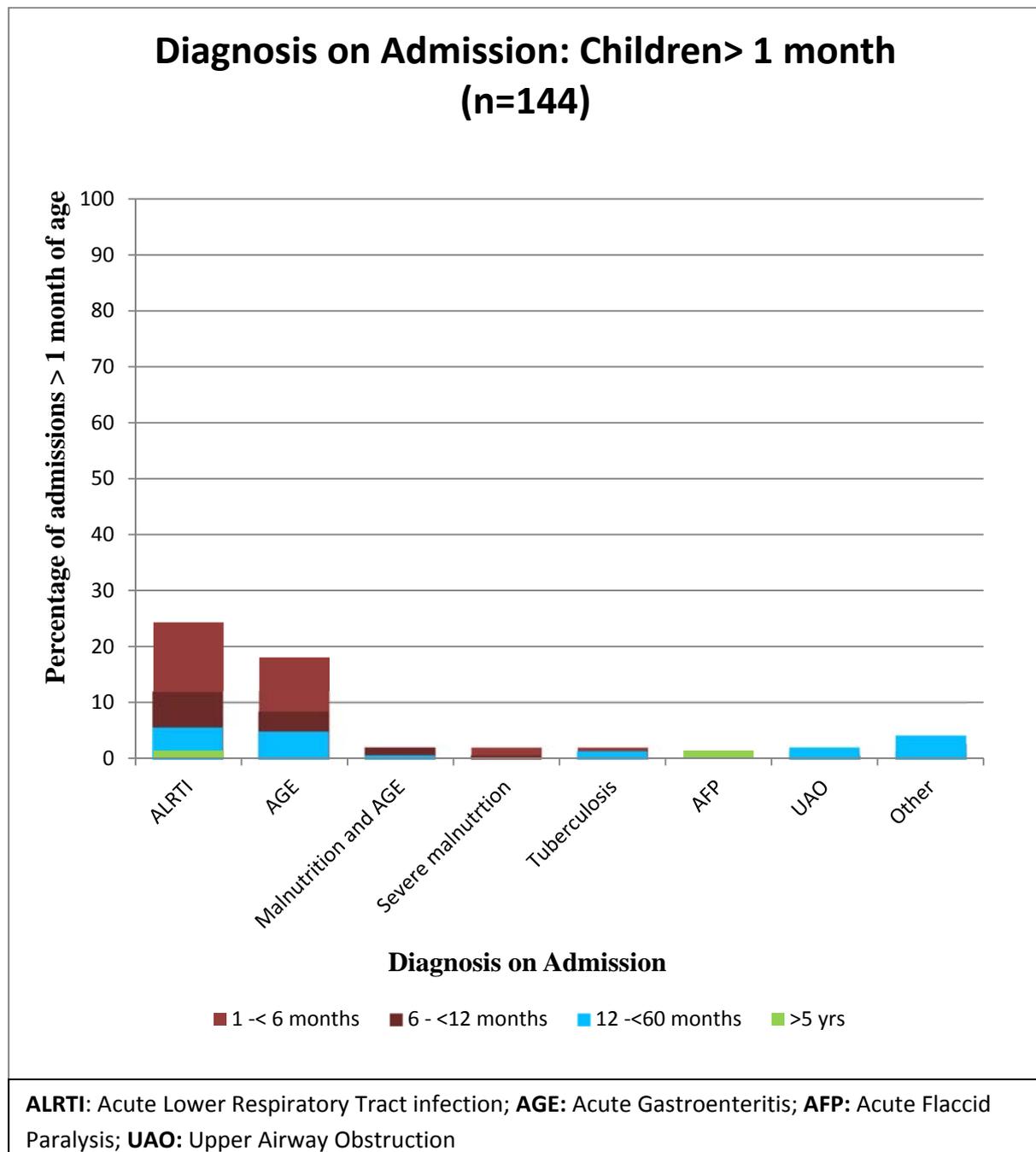
Figure 2 shows the admission diagnosis for this age group. The most common diagnoses were acute lower respiratory tract infections (ALRTI) (n=61) and acute gastroenteritis (n=52). The outcome of patient's admitted for acute respiratory tract infections included 4 deaths and 14 transfers to a tertiary facility. Airway assistance was required by 84% of patients admitted with ALRTI, but only 23% needed invasive ventilation, while 77% received nCPAP.

The majority (62%) of patients admitted with acute gastroenteritis (AGE) were shocked and nearly all (85%) required inotropic support. Acute gastroenteritis was complicated by severe malnutrition in 12% of cases, but these children were successfully discharged despite their poor nutritional states. Three patients admitted with acute gastroenteritis died and eight patients were transferred to a tertiary facility. Acute gastroenteritis was complicated by malnutrition in 7 patients. Another 4 patients were admitted to the unit with severe malnutrition without any co-morbidity.

Four patients were admitted to the unit with a diagnosis of Tuberculosis, but only one of these patients was admitted to the unit with a diagnosis of TB without any co-morbidity. The other patients (n=3) were admitted with comorbid diseases such as HIV, dilated cardiomyopathy, lower airways obstruction and TB meningitis. Three of these patients were transferred and two were successfully discharged.

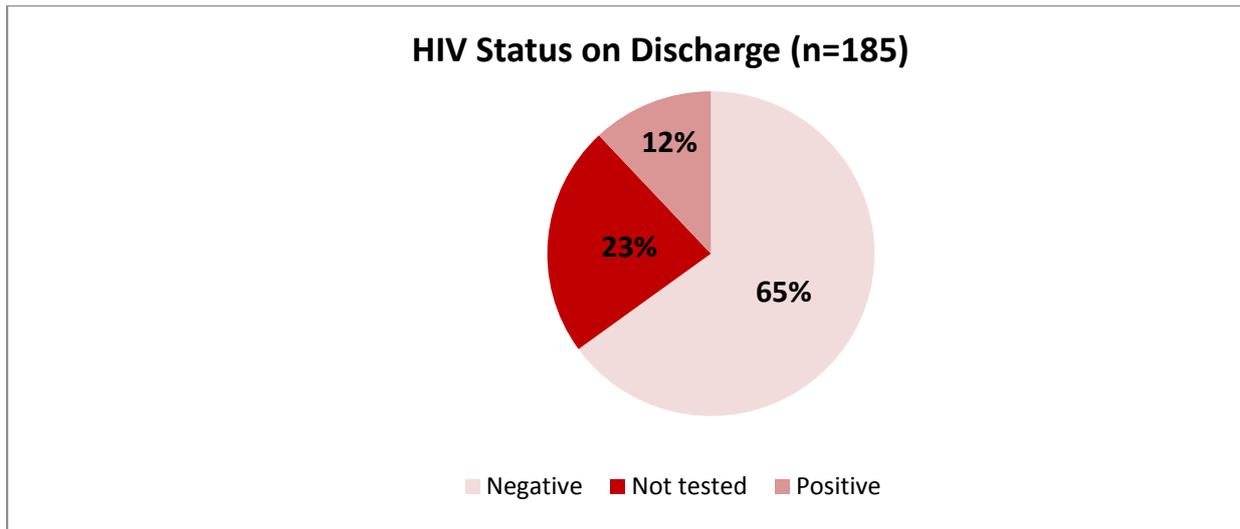
Five patients were admitted due to upper airways obstruction (UAO and the majority (n=3) required invasive ventilation and were transferred to tertiary care. Two patients were successfully discharged. Both of these children did not require invasive ventilation, but high care nursing and close observation. Two cases of acute flaccid paralysis (AFP) were admitted to the ICU. One patient was managed and discharged successfully, but the second case required invasive ventilation and was transferred to a tertiary facility. Two patients were admitted to the unit due to acute liver failure. In both these cases the liver failure was due to the ingestion of unknown herbal medication. Both these children were transferred to tertiary care.

**Figure 2: Diagnoses on admission: Children older than 29 days**



The majority of patients older than 1 month of age (112/129) were tested for HIV and more than half (59%) were screened with an HIV rapid test. A HIV rapid test was performed on 14 patients, which were known to be HIV exposed on admission, as well as less than 18 months. This test did not contribute to the exclusion of HIV infection. DNA PCR was performed for 11 patients and 5 patients were found to be HIV-infected (Figure 3). These newly diagnosed HIV-infected children did not receive anti-retroviral treatment during their stay in the ICU. At discharge 12% of admissions were known to be HIV positive.

**Figure 3: HIV Status on discharge (all groups)**



### 3.4 Readmissions

Ten patients were readmitted during the study. The male: female ratio was 1.5: 1. Four patients were readmitted to the unit after being discharged home while 6 were readmitted from the paediatric ward in the hospital. The mean age of the readmitted patients was 4.44 months (median: 4.07 months; range: 0.9 – 8.13 months). Most readmissions (70%) happened after hours. Reasons for readmission included ALRTI (50%), acute gastroenteritis (20%), sepsis (10%) and severe malnutrition (10%). The mean WAZ was -2.49 SD (median: -2.22 SD; range: -5.34 SD to -0.87SD). The mean duration of stay after readmission was 2.73 days (median: 1.63 days; range: 5.7 hours – 9.89 days). Five patients received airway support after readmission (4 patients received invasive ventilation and one received nCPAP). Most patients (60%) were successfully discharged after readmission, but 40% of readmissions were transferred to tertiary care. No deaths occurred after readmission. Readmission was not associated with a poor outcome ( $p=0.75$ ).

### 3.5 Deaths and transfers compared to good outcomes

Table 6 provides a comparison between patients who died, or were transferred with patients successfully discharged after their stay in the ICU. There was a male predominance amongst

the patients (2:1) who died, as well as amongst those (1.4:1) who were successfully discharged. Equal numbers of males and females (1:1) were transferred to a tertiary facility. Sex was not significantly associated with a poor outcome ( $p=0.49$ ).

**Table 6: Deaths vs. Transfers vs. Successful discharges**

	<b>Death n=12</b>	<b>Transfers n=44</b>	<b>Successful Discharges n=119</b>	<b>p-value</b>
Male: Female ratio	2 : 1	1 : 1	1.4 : 1	$p=0.49$
Age	Mean: 2.6 months Median: 2.4 months Range: 0 – 9.2 months	Mean: 11.9 months Median: 4.06 months Range: 0 -12 years	Mean: 7.8 months Median: 3.9 months Range: 0 – 9.5 months	Died vs. Transfer: $p=0.15$ Died vs. Discharge: $p=0.17$
Admissions after hours	83%	45%	64%	$p=0.07$
Duration of stay	Mean: 1.6 days Median: 1.01 days Range: 1 hour – 5 days	Mean: 1.5 days Median: 1.2 days Range: 2 hours – 5.1 days	Mean: 2.9 days Median: 2.0 days Range: 1 hour to 13.4 days	
WAZ-score	Mean: -1.6SD Median: -1.3SD Range: -4.8 to 0.89SD	Mean: -1.4SD Median: -1.49SD Range: -5.2 to 1.88SD	Mean: -1.91SD Median: - 1.63SD Range: -6.5 to 1.57SD	$p=0.56$
Interventions				*Ventilation: $p=0.00$ *Invasive Ventilation: $p=0.00$ Inotropes: $p=0.16$ Transfusion: $p=0.87$
• None	8%	7%	18%	
• One	17%	48%	52%	
• Two	50%	32%	22%	
• Three	25%	13%	8%	
Acute Lower Respiratory Tract infection	33%	32%	35%	Diagnosis: $p=0.17$
Acute Gastroenteritis	25%	23%	37%	

**\* Statistically significant**

The patients, who died were younger (mean age 2.6 months, median: 2.4 months, range: newborn to 9.2 months) than the patients who were transferred (mean age 11.9 months, median: 4.06 months, range: newborn to 12 years) or successfully discharged (mean age 7.8 months, median: 3.9 months, range: newborn to 9.5 months), but this was not statistically significant (respectively  $p=0.15$  and  $p=0.17$ ). Admission after hours was also not significantly associated with a poor outcome, but there was a trend towards significance ( $p=0.07$ ). The WAZ for patients who died, were in a lower range than the two other groups, but was not statistically significant (death compared to successful discharge:  $p=0.56$ ).

The patients, who died, were more critically ill and the majority (75%) required 2 or more interventions compared to 45% of patients transferred and 30% of patients successfully discharged. Patients requiring airway assistance, were more likely to experience an adverse event ( $p=0.0001$ ) and the need for invasive ventilation was strongly associated with an adverse event ( $p=0.00$ ). Only 28% of admissions received a transfusion of one or more blood products, but the use of blood products was not significantly associated with a poor outcome ( $p=0.87$ ). The use of inotropes was also not significantly associated with a poor outcome ( $p=0.16$ ). Although acute gastroenteritis and ALRTI were the cause of admission in more than 50% of patients, there was no statistically significant association between diagnosis and

outcome ( $p=0.17$ ). Prematurity per se, was also not significantly associated with poor outcome ( $p=0.98$ ). Patients, who were diagnosed with HIV infection or patients known to be HIV positive at the end of their stay in the ICU, had a statistically significant poorer outcome than those who were not infected with HIV ( $p=0.01$ ). An outside referral centre was not significantly associated with a poor outcome ( $p=0.38$ ).

Five patients were admitted with a diagnosis of sepsis, but none of these had bacteriological confirmation. Less than half (41%) of all admissions had blood cultures performed during their ICU stay. Only 22 of these had a positive culture result. Of the cultures that were positive 16 had a positive culture for *Staphylococcus epidermidis*; all were reported as contaminants. Three cultures were positive for methicillin resistant *Staphylococcus aureus*, one for *Haemophilus influenzae* and one for *Serratia marcescens*. One culture was positive for two organisms: *Klebsiella pneumoniae* and *Group B streptococcus*. Both these organisms were drug sensitive. Only 4 of the patients, who died, had a blood culture performed before death. Two cultures were negative, while one had the *Haemophilus influenzae* positive culture and one had the methicillin resistant *Staphylococcus aureus* culture.

## Chapter 4

### Discussion

Mortality in paediatric intensive care units vary from continent to continent and large discrepancies exist even within the same country. Mortality rates in developing countries classically remain high. The mean mortality in PICUs in Latin America is reported as 13.3% compared to 3.8% in North America, 5.7% in the United Kingdom and 4.5% in Singapore. The mortality rate (6.5%) in this study was similar to mortality in developed countries such as the United Kingdom (6%).<sup>8, 16, 33</sup> This study, however, does not include the deaths that occurred outside of the ICU.

Males are predominantly admitted for intensive care, which correlates with findings in this study (male to female ratio: 1.3: 1). Sex, however, was not significantly associated with outcome ( $p=0.49$ ).<sup>34, 35</sup> A North American study suggest that race has an influence on overall mortality of children, which was not determined in this study.<sup>36</sup> International literature indicates that age is significantly associated with outcome of, especially cardiac arrests within the PICU, but results are conflicting.<sup>26, 33</sup> Admissions in this study were young (mean age 8.5 months) and even though all deaths ( $n=12$ ) in our study occurred in newborns and infants younger than 1 year of age, age was not significantly associated with outcome ( $p=0.17$ ).

An association between admission time and outcome is reported, but the data is ambiguous.<sup>36</sup> <sup>37</sup> Our study confirmed that most patients were admitted after-hours, but there was no significant association with a poorer outcome ( $p=0.07$ ). A study from Australia and New Zealand showed the casualty department as the main entry point (60%) into intensive care, which was similar to our study (54%).<sup>14, 34</sup> A large Australian paediatric intensive care unit had a readmission rate of 5%, which is similar to a review of adult ICUs where the readmission rate was 7.78%, a finding confirmed in our study (5.4%).<sup>39</sup> Literature suggests that readmissions to intensive care have higher mortality rates than those not readmitted, but this was not demonstrated in this study where readmission to the ICU was not significantly associated with a poorer outcome ( $p=0.75$ ).<sup>39</sup>

A multicentre ICU study from the United States reported a mean duration of stay of 2 days and factors directly related to length of stay include the PRISM score, previous admission or admission from an inpatient ward.<sup>40</sup> The relationship between length of stay and severity of illness has been proven, but not well explained. Patients who died, stayed on average twice as long as patients who survived, which was not confirmed in this study (mean length of stay 2.5 days), where the majority of deaths occurred within 24 hours (50%), 25% within 48 hours and the rest (25%) after 48 hours.<sup>40</sup> Seven of these patients (58%) required airway support (6 invasive and 1 nCPAP) as well as inotropic support and were considered severely ill. The length of stay was significantly associated with the risk of transfer ( $p=0.00$ ). The unit does not use the PRISM score to classify severity of illness; it is therefore difficult to comment on the relationship between severity of disease, mortality and length of stay. PICU mortality rates are also influenced by the presence of an intensivist or residents.<sup>40</sup> The unit in this study

does not have an intensivist on duty. After-hours the intensive care is the responsibility of the doctor on call, which is often an intern or community service doctor.

Acute lower respiratory tract infections (ALRTI), acute gastroenteritis (AGE), birth asphyxia and prematurity are reported as the main causes of death in children under five years of age.<sup>2, 8, 41</sup> ALRTI leads to significant hospital admissions in children younger than 5 years of age.<sup>42</sup> Globally ALRTI remain the main cause in at least 20% of deaths in children under 5 years of age.<sup>42, 43, 44, 45</sup> This agrees with the findings of the CHBH study.<sup>27</sup> Our study confirmed ALRTI as the lead cause of admission and death. Acute gastroenteritis is the second leading cause of mortality in children worldwide, but microbiological investigations are not well utilised, despite the fact that severity of disease is related to aetiology and not age.<sup>46</sup> The inability to identify a causative organism prevents the use of directed microbiological treatment and consequently complicates the management of gastroenteritis.<sup>47</sup> Although AGE was the second leading cause of admission in our study, we also did not have data on the cause of gastroenteritis to analyse.<sup>47</sup>

The literature reports the incidence of birth asphyxia as between 1 – 8/1000 live births and a single hospital series from Nigeria reported figures as high as 26/1000 live births.<sup>48</sup> It is estimated that 20% of infants with birth asphyxia will die within the neonatal period.<sup>49</sup> The majority of patients with birth asphyxia in our study was managed outside of the ICU. Only four term infants were admitted with birth asphyxia in this study and two died. The death rate (per 1000) due to birth asphyxia cannot be accurately estimated. This is due to the fact that most cases of birth asphyxia were managed outside of the intensive care and therefore the exact data is not available. Despite all these findings the diagnosis at time of admission was not significantly associated with outcome.

Severe malnutrition is reported in 18 – 65% of all paediatric admissions and 15 – 65% of admissions to paediatric ICU.<sup>50, 51, 52</sup> Malnutrition (mild, moderate and severe) has been linked to poor outcome. Studies report mortality rates as high as 30%, but differing methodologies used to classify malnutrition, makes it difficult to compare the incidence and mortality rates in different studies.<sup>50, 53, 52</sup> This study did not prove a significant association between nutritional status and a poor outcome.

Mechanical ventilation was significantly associated with a poorer outcome in PICUs in Singapore; Greece and Brazil, which is similar to our findings ( $p=0.00$ ).<sup>33, 54, 55</sup> Noninvasive ventilation has become a common intervention to provide airway support for ALRTI.<sup>56</sup> Literature reports up to 10% of children admitted to paediatric intensive care receiving noninvasive airway support.<sup>56</sup> The addition of noninvasive airway support (including nCPAP) to treatment during ICU is associated with better outcomes and does not contribute significantly to adverse events.<sup>57</sup> In our study noninvasive airway support was used in a high percentage of patients (33.5%), and was associated with a poorer outcome ( $p=0.001$ ). The addition of inotropic support to the treatment of patients in our study was not significantly associated with a poorer outcome, which differs from a Brazilian study where the addition of inotropes to treatment was a risk factor for death during intensive care unit stay.<sup>55</sup> Transfusion of blood products are commonly used (up to 50% of admissions) in critically ill children

admitted to PICUs, which was not demonstrated in our study, where only 28% of patients received blood product transfusions.<sup>58</sup> Children receiving transfusion of blood products are at an increased risk of adverse events such as mortality compared to adults, but this study found no significant association between blood transfusions and a poorer outcome ( $p=0.87$ ).<sup>50, 60</sup>

The PICU Society conducted a sepsis audit in the United Kingdom and found that up to 20% of paediatric intensive care admissions were due to sepsis, with 54% of patients having a positive bacteriological confirmation of infection, while only 2.7% of our admissions had sepsis and none of these cases had a positive bacteriological culture.<sup>34</sup> South Africa is home to the largest HIV programme in the world.<sup>61</sup> Despite this less than half of children in need of antiretroviral therapy (ART) are started on treatment.<sup>61</sup> Antiretroviral therapy was introduced to the public sector in South Africa in 2004 and combination ART has become standard of care for HIV infected individuals.<sup>31, 62</sup> During the early part of the ART programme in South Africa children receiving treatment was cared for at large urban hospitals and large numbers of undiagnosed children presented to public health care.<sup>61, 64</sup> Mortality rates in infants are higher than in older children and without intervention about 50% of children die before 2 years of age.<sup>64, 65</sup> A HIV infected child admitted to PICU who receives mechanical ventilation is at high risk of dying (40 – 84%).<sup>66</sup> However, a study from Red Cross War Memorial Children's Hospital reported 75% of HIV-infected children successfully treated in PICU.<sup>63</sup> This study demonstrated that underlying HIV infection was significantly associated with an adverse event ( $p=0.01$ ). Despite the availability of ART, studies report low ART initiation rates in acutely ill HIV infected infants and children admitted to PICU, which was true for this study as well.<sup>63</sup>

The Society of Critical Care Medicine and the American Association of Critical Care Nurses endorses a multidisciplinary approach to critical care. Little research exist that evaluates the direct relationship between the multidisciplinary approach and outcome of critically ill patients.<sup>68</sup> The presence of a multidisciplinary team may improve the efficiency and quality of care provided and, therefore, the outcome of critically ill patients.<sup>69</sup> Even though our unit cares for patients across all age groups and disciplines there is limited access to specialised health care professionals. This study did not evaluate the outcome of children in relation to the approach to care – did those cared for by younger doctors have a better outcome than those cared for by more senior staff. Did those receiving multidisciplinary care (physiotherapy, speech therapy) have a better outcome than those who didn't. Literature suggests that this is the case, but this was not directly examined in our study.<sup>68,69</sup>

This study was a retrospective folder review. Limitations include a short study period and a small sample size. A prospective study with routine collections of more comprehensive data, including causes of morbidity and mortality, linked to ICD10 codes and interventions done will provide more information that can be used for future interventions and quality control.

## **Conclusion**

Children younger than one year of age still provide the biggest challenge to paediatric health care. Acute lower respiratory tract infections, acute gastroenteritis, prematurity and neonatal

asphyxia are the greatest contributors to mortality. A level two hospital's intensive care unit can successfully care for and discharge the majority of their neonatal and childhood admissions. To our knowledge, this is the only study reporting on a non-tertiary intensive care unit but it indicates the importance of such a facility at regional hospitals to improve the survival of neonates and children. This study suggests that large regional hospitals should have equipped intensive care units which increase the neonatal and childhood survival, especially where transport and resources remain a challenge.

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