Patterns of mortality in children presenting to a tertiary paediatric emergency unit in Sub-Saharan Africa: a cross sectional study

TRACEY JOSEPHS

UCT Student Number: JSPTRA001

Submitted in fulfilment of the requirements for the degree

MMED (Paediatrics) in the Faculty of Health Sciences, University of Cape Town, 2019

SUPERVISORS: **Dr. Heloise Buys**

Dr. Adelaide Masu

Prof Rudzani Muloiwa

1

2 **DECLARATION**

I, Tracey Lee Josephs, declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

I empower the university to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

Signature: Signed by candidate

Date: 02/12/2019

UCT HREC: 747/2018

3 **PLAGIARISM DECLARATION**

This thesis/ dissertation has been submitted to the Turnitin module and I confirm that my supervisor has seen my report and any concerns revealed by such have been resolved with my supervisor.

Name: Tracey Lee Josephs

Student Number: JSPTRA001

Signature: Signed by candidate

Date: 02/12/2019

Abstract

Background

Pneumonia, diarrhoea and perinatal factors are the foremost killers of South African children as in other low- and middle-income countries. Poverty, poor access to care and pre-hospital care are reported major pre-hospital factors and lack of triage, poor skills, delays, poor adherence to treatment protocols and inadequate emergency care determining mortality have been reported to increase in-hospital mortality.

Objectives

To describe the clinical presentation and management of children admitted via the medical emergency unit (MEU) of the Red Cross War Memorial Children's Hospital (RCWMCH) who subsequently died.

Methods

We did a retrospective study undertaking a cross-sectional review of children who died following admission via RCWMCH MEU in 2008. Demographic information, clinical data, time factors and mortality data were reviewed and summarised by descriptive and inferential statistics. The unit utilised the WHO Emergency Triage Assessment and Treatment (ETAT) triage tool, categorising children into Red (emergency), orange (priority) and Green (non-urgent). Patient management was assessed by means of ETAT and the Integrated Management of Childhood Illness (IMCI) tools, which is used to identify severity of illness and strategize treatment plans accordingly.

Results

A total of 135 children met the inclusion criteria. The crude mortality rate was of 6.25 per 1000 admissions. Of the 135 children who died, 119 (88%) were under five years of age, 33(24%) were HIV-infected, of whom 29 (88%) were under 5 years old. In 67 (50%), a chronic medical condition could be identified while 67 (50 %) were moderately or severely malnourished. There were 29 (22%) deaths within 24 hours of arrival at the MEU. Fifty-five (41%) presented after hours. Community health centres referred 65 (48%) patients, general practitioners referred 20 (15%) and 38 (28%) were self-referred. Ambulance services provided pre-hospital transport to 69 (51%). The two top presenting illnesses in 88 (65%) of the children were acute respiratory illness and acute gastroenteritis. Prior to referral, oxygen was not provided in 57 (59%) children, 35 (71%) with suspected sepsis did not receive antibiotics and glucose was not checked in 39 (80%) with depressed level of consciousness. The median time to ward transfer was 3.23 (IQR: 2.12-4.92) hours. Twelve deaths (9%) occurred in the MEU, 57 (42%) in PICU, 56 (42%) in medical wards and 10 (7%) in specialist wards. The five most common causes of death were acute respiratory infections in 45 (33%), acute gastroenteritis in 27 (20%), septicaemia 22 (16%), meningitis in 13 (10%) and cardiac conditions in 12 (9%) children.

Conclusion

The top causes of mortality in this hospital cohort in 2008 were pneumonia, acute gastroenteritis, and septicaemia. Using the IMCI and ETAT standard of care, suboptimal management was identified in pre-hospital management, as well as MEU management.

Appropriate training and protocol implementation to improve morbidity and mortality should be undertaken.

Keywords

Emergency care, mortality, children, South Africa

(461 words)

Table of Contents

51

ACKNOWLEDGMENTS

The completion of this undertaking could not have been possible without the dedication and assistance of Dr. Heloise Buys, who has provided endless support, kindness and understanding.

Thank you to Dr. Adelaide Masu and Professor Rudzani Muloiwa for sharing their expertise and availing their time throughout this process.

To my family and friends, thank you for your support and understanding and never giving up on me.

Above all, to the Creator of all, sincere praise for His grace and mercy.

ABBREVIATIONS

MDGs	**:**	**Millennium Development Goals**
UN	**:**	**United Nations**
U5MR	**:**	**Under 5 Mortality Rate**
HR	**:**	**Hazard ratio**
WHO	**:**	**World Health Organization**
SDGs	**:**	**Sustainable Development Goals**
RCWMCH	**:**	**Red Cross War Memorial Children's Hospital**
ETAT	**:**	**Emergency Triage Assessment and Treatment**
ED	**:**	**Emergency Department**
MEU	**:**	**Medical Emergency Unit**
LMICs	**:**	**Low- and middle-income countries**
PMTCT	**:**	**Prevention of mother to child transmission**
ChildPIP	**:**	**Child Healthcare Problem Identification Programme**
GP	**:**	**General Practitioner**
CHC	**:**	**Community Health Centre**

IQR	**:**	**Interquartile range**
CI	**:**	**Confidence Interval**
CFT	**:**	**Capillary Filling Time**
IPPV	**:**	**Intermittent Positive Pressure Ventilation**
CPAP	**:**	**Continuous Positive Airway Pressure**
HREC	**:**	**Human Research Ethics Committee**
IO	**:**	**Intraosseous**
IV	**:**	**Intravenous**

List of Tables

61

66

List of Figures

Chapter One

The Research Problem/Introduction

Millennium Development Goal (MDG) 4 entailed reducing under-five mortality by two thirds and this varied based on the country context; in the case of South Africa, this would have required reducing under-five mortality from 60 per 1000 live births in 1996 to 20 per 1000 live births by 2015. [1] This goal was not met. Sustainable Development Goals (SDGs) were then adopted in 2015 at a United Nations congress to address challenges faced globally with regards to poverty, inequality, prosperity, justice and various other challenges. One of the SDGs is to reduce child mortality to less than 25 per 1000 live births by the year 2030. [2]

Prior to the SDGs, the MDGs were devised by the United Nations (UN) in the year 2000. The MDG 4 stated that by the year 2015, global mortality should be reduced by two thirds. [3] There has been a steady decline in the global under-five mortality rate (U5MR) from 93 per 1000 live births in 1990 to 41 per 1000 live births in 2016, equating to a 56% reduction in mortality. [4] However, whilst global mortality has decreased, the World Health Organisation (WHO) reported that Africa still had the highest under-5-mortality rate, 76.5 per 1000 live births, indicating disparities in child survival based on where children live.

Globally, the main killers of children under 5-years-of-age in 2016 were preterm birth complications (18%), pneumonia (16%), intrapartum-related events (12%), diarrhoea (8%), neonatal sepsis (7%) and malaria (5%). [4]

Whilst there are published data for causes of childhood mortality such as malaria, acute respiratory infections and HIV, as well as modifiable factors such as immunisation coverage, availability of medical services, levels of parental education and residing in a rural area, in countries such as Malawi and Nigeria [5, 6], there is little known with regards to the factors that play a role in patients who present to a health facility in South Africa, and any reported mortality within 24 hours of presentation. Factors such as household poverty, access to care and emergency medical transport may influence outcome.[6] Children who are critically ill should be correctly identified by a triage tool at presentation, appropriately resuscitated and receive effective on-going management in an appropriate ward. [7, 8] Although hospitals with intensive care facilities may be expected to achieve improved outcomes, poor initial patient management may still negatively impact on final outcome. The need for triage to prioritise and categorise acutely ill children arriving at any hospital is highlighted by the fact that many deaths occur within the first 24 hours of presentation to hospitals in low- and middle-income countries (LMICs). [9-11]Finally, appropriately skilled staff, as well as evidence-based protocols and implementation of quality assurance monitoring are factors that may also play a positive role in any emergency unit managing acutely ill children.[11]

The management and outcome of children seen at the Medical Emergency Unit (MEU) of the Red Cross War Memorial Children's Hospital (RCWMCH) who die within 24 hours is discussed at the unit's monthly morbidity and mortality meetings. However, a critical review of all the children dying following admission through the unit has not been formally evaluated and reported; this review serves to address an aspect of this deficit.

The importance of obtaining this information may help identify modifiable factors that could be reviewed with the view to create prevention strategies and thereby hopefully, reduce childhood mortality.

Chapter two

Literature review

Aim of the literature review

This review serves to summarise causes of mortality in children under several headings: global, sub-Saharan Africa (SSA) and South Africa. These headings were chosen because there are differences in child mortality rates depending on where children live. The review will also evaluate the impact of factors that may be associated with mortality in the early phases of management and will also discuss whether any of these causative factors can be prevented and further, identify prevention strategies to improve childhood mortality, as set out in the SDGs.

The mortality of hospitalised children is well described across several settings as greatest within the first 24 hours of presentation, making triage and recognition of serious illness an important intervention point in the child's pathway to care. Malnutrition's contribution to mortality is significant and is often hidden behind the more commonly presented causes of death in most countries, it is thought to be a cross-cutting contributor to mortality in 30-50% of childhood deaths. [12]

HIV remains a huge burden in sub-Saharan Africa and its role in mortality cannot be ignored. In 2015, 36.9% of in-hospital deaths in South Africa were associated with HIV. [12]

Methodology

A structured literature review was done by accessing the Medline library via PubMed and Google Scholar in November 2018 for publications in English involving children aged 0-18 years, using the following search terms:

- "global" OR "Sub-Saharan Africa" OR "South Africa" AND "child OR childhood" AND "mortality"
- "triage" AND "child" OR "childhood" AND "mortality"
- "child" OR "childhood" AND "HIV" AND "mortality"
- "child" OR "childhood" AND "mortality" AND "malnutrition"

Studies with the following characteristics in their titles were then excluded as they were deemed not relevant to this project:

- Trauma
- Neonatal-specific studies
- Disease-specific studies
- Studies prior to 1998 (>10 years prior to current database)

I then reviewed a total of 283 abstracts which seemed relevant and included the following:

- 88 studies regarding global child mortality
- 75 studies regarding childhood mortality in SSA
- 34 studies regarding childhood mortality in South Africa

- 32 studies regarding triage and child mortality
- 30 studies regarding HIV and child mortality
- 24 studies regarding malnutrition and child mortality

However, after a more detailed study of the full text articles and excluding duplicate articles, in fact only 48 were suitable for inclusion in this literature review because the focus was on the following selected factors:

a) Childhood mortality: global
b) Childhood mortality: sub-Saharan Africa
c) Childhood mortality: South Africa and access to care
d) Triage and Emergency management
e) HIV and Malnutrition

Results

Global childhood mortality

Global childhood mortality studies have shown a reduction in the under-five mortality rate (U5MR) from 91 per 1000 live births in 1990 to 43 per 1000 live births in 2015. The United Nations Inter-Agency Group for child mortality also reported that 16 000 children under the age of 5 years die daily. [4] While this seems very negative, progress has been made, with 65 out of 195 countries having met the MDG 4 target, thereby saving 48 million lives. Neonatal mortality rates have been reduced from 36 per 1000 live births in 1990 to 19 per 1000 live births in 2015. In low- and middle-income countries (LMICs), pneumonia, diarrhoea and perinatal-related

causes remain at the forefront as causes of mortality in children, accounting for 13%, 8% and 7% respectively of the under-5-mortality. In high-income countries, the commonest cause of death is congenital abnormalities. [13, 14]

Childhood mortality in sub-Saharan Africa

More than 50 % (3.3 million) of global child deaths in 2018 occurred in Sub-Saharan Africa (SSA). The overall estimate for SSA as a region is an U5MR of 83/1000 live births. However, mortality rates in SSA vary considerably between countries, with Botswana having an U5MR of 15.6/1000 and Central African Republic having an U5MR of 135/1000 live births. Notably six of the seven countries with an U5MR of more than 100 per 1000 live births are situated in West and Central Africa. They include Somalia, Chad, Central African Republic, Mali, Sierra Leone and Nigeria. [15]

A study regarding access to care showed that only 16 out of 48 Sub-Saharan countries met the international benchmark of more than 80% of the population having access to care within a two-hour travelling distance to a healthcare facility. [16] In Burkina Faso, mortality risk was more than 50% higher if distance to a healthcare facility was more than four hours away. [17] In South Ethiopia, an in-depth look at mortality factors revealed pre-hospital and primary healthcare factors such as poor perinatal care, lack of immunisations, poor vitamin A coverage and not breastfeeding as significantly increasing under-5-mortality. [18] There is evidence showing a strong association between household size and multiple gestations and mortality. [19] There is great disparity between countries across the world and even in SSA. Economic

input into improving access to healthcare appears to have played a significant role in reaching the MDG 4 target. [20]

The top three causes of child mortality in SSA are pneumonia, diarrhoea and perinatal-related factors. In malaria-endemic areas such as Mozambique, Benin, Burkina Faso, Burundi and Central African Republic, however, malaria is prominent and diarrhoea less common. These four causes have been unchanged for over 25 years as the top causes of death in SSA, as evidenced by studies from 1990-2015. [14, 21-23] Factors associated with mortality have been found to be lack of resources, inadequate senior level of care, access to healthcare and the effects of poverty such as access to sanitation, as well as lack of maternal education and poor health-seeking behaviour.[24-27] In a tertiary hospital in Malawi, modifiable risk factors identified for mortality were appropriate assessment and monitoring and timely provision of testing and treatment. [9] Staff in resource-constrained areas such as Kenya and Rwanda have been trained and the staff and triage system evaluated, pre- and post-implementation. [28, 29] In addition to triage, treatment needs to be implemented timeously, as illustrated in studies reporting that increased morbidity is directly proportional to increased time to treatment initiation. [30, 31]

In Nigeria, two out of ten children were dying before reaching the age of 5 years in 1990. [32, 33] The under-five mortality rate (U5MR) decreased from 213 per 1000 live births in 1990 to 128 deaths per 1000 in 2013. Infectious diseases accounted for more than 90% of these deaths. Risk factors related to mortality were access to care and poor recognition of illness, as well as cultural and resource-related factors.[24] One study showed a 45.9% lower risk of child

mortality in patients with mothers with tertiary education, a 28.3% increase in childhood mortality if living in a rural area and a risk of mortality 49% lower in richer areas, when compared to the poorest areas.[32] Another study from Nigeria showed increased risks for infant and child mortality if a child lived in a low-income household (HR=1.40), multiple gestation (HR=1.94), maternal age <20years (HR=3.04) and lack of maternal education (HR=1.38). [33]

Childhood mortality and access to care in South Africa

In 2005, South Africa was one of only four countries that had shown an increase in U5MR since 1990, the others being Eswatini (formally Swaziland), Lesotho and Zimbabwe. [34] This was largely due to the impact of HIV and HIV-related illnesses. With the introduction of 'Prevention of Mother to Child Transmission' (PMTCT) and access to antiretroviral therapy (ART), the U5MR was at 34.7 per 1000 live births in 2015, whereas it peaked at 75 per 1000 live births in 2006. [35] One third of under-five mortality occurs in the newborn period, whilst the most common causes of mortality outside of the neonatal period are similar to those of global trends in low and middle-income countries, with pneumonia, diarrhoea and perinatal-related events cited as the most common causes of death.[36] Pneumonia, diarrhoea and septicaemia accounted for 78% of in-hospital causes of death. Looking at associated risk factors for mortality, 36.9% of in-hospital mortality was associated with HIV disease and 30.9% was associated with severe acute malnutrition (SAM). Further social determinants of health as risk factors include access to water and sanitation. Twenty-six percent of South African children do not have access to clean

running water and 32% do not have adequate sanitation resources.[37, 38] The situation is even more dire in places such as Eastern Cape and Limpopo provinces, where 60% of children have no running water and 49% have no sanitation resources respectively. [12]

In South Africa, strategies have been implemented in order to reduce mortality. Improved services have been provided with regards to primary healthcare with the introduction of the "Integrated Management of Childhood Illnesses" (IMCI) programme, an improved expanded programme on immunization and vitamin A coverage for children under five years of age; all of which played a role in a significant reduction in mortality secondary to diarrhoeal illness. [39] Using these approaches, the diarrhoeal incidence in Limpopo improved from 54 per 1000 to 5 per 1000. The IMCI tool looks at ways to assess and identify illness severity and then classify severity with consequential treatment plans. It was devised by the WHO and UNICEF because most children in the developing world die from illnesses that are preventable. It therefore focuses on treatment entities that are geared at treating pneumonia, diarrhoea, measles, malaria and serious bacterial infection. There is also a national process known as Child Healthcare Problem Identification Programme (ChildPIP) whereby participating hospitals audit all paediatric deaths and modifiable factors identified with a view to preventing future deaths by implementing quality assurance interventions such as community based care, social service interventions, firming up referral pathways and access to care, staff training and allocation, effective triage, protocols, equipment and resource provision at all levels of care. [12]

Triage, emergency care and child mortality

Studies in LMICs reported child mortality within 24 hours of admission to a hospital to be between 34-55%. Early mortality factors have been cited as delayed recognition of illness severity with delayed presentation to emergency centres and delays in emergency centres. Specific clinical signs placing patients at high risk of death within first 24 hours of presentation were fever and subcostal recessions. [40] WHO introduced IMCI and the Emergency Triage and Assessment and Treatment(ETAT) courses to address poor recognition, lack of triage, poor emergency care and poor staff training.[11] In Guatemala, ETAT was shown to lead to a decline in admission rates, as well as a decrease in mortality. [7]Molyneux et al., developed, introduced and highlighted the importance of triage and emergency care in a study performed in Malawi, where appropriate training of staff in ETAT and triage, improving patient flow and good communication with inpatient staff were cited as significant factors that played a role in reducing mortality. With the introduction of triage and improved flow, they reported a massive reduction in number of deaths within 24 hours of admission from 36% to 12.6%. [8] The value of implementing a facility-based appropriate triage system was evaluated in a study performed at RCWMCH, at two different points in time, with the outcome showing an appropriate threefold increase in admissions for each advance in triage colour, as well as a strong association between triage colour and severity of illness, indicating appropriate prioritisation of care. In addition, more than 90% of patients were appropriately triaged with the use of the Emergency Triage Assessment and Treatment (ETAT). [11]

Role of HIV in child mortality

In South Africa, between 2006 and 2011, child mortality was associated with HIV in 43% of cases. With subsequent efficient rollout of PMTCT and ART, a decline was noted down to 36.9% by 2015. The risk of dying secondary to an HIV-related illness was also noted to be higher if the maternal viral load was high and in patients from a lower wealth index.[41] Subsequent to the introduction of PMTCT and ART, there was a significant reduction in South Africa's overall mortality. [42, 43]

The role of malnutrition in child mortality

Sub-Saharan Africa has high rates of malnutrition, with East and West Africa being the worst affected.[44] Malnourished children are at high risk of mortality, secondary to metabolic instability and immune compromise, which in turn results in susceptibility to infection, placing them at greater risk and converting simple gastroenteritis and pneumonia to lethal events.[45] According to the United Nations Children's Fund and WHO, children with severe wasting have a nine-fold risk of death compared to normally nourished children. [45]A study in Eswatini (Swaziland) showed that weight-for-height and associated oedema increased the risk of mortality.[46] A West African mortality study looking at factors contributing to death within 24 hours of presentation, revealed malnutrition as one of these contributory factors.[10] Another study in Malawi reported that an analysis of the reduction in their U5MR from 247 per 1000 in 1990 to 71 per 1000 in 2013, was partly attributable to a reduction in malnutrition.[47]

Discussion

There has been a decline in global child mortality. The decline, however, has not been adequate to meet the MDG4 of 2000. The SDG 3 target for 2030, which was subsequently set in light of the MDG 4 target not being met, is attainable, but will require some developing countries to implement strategies such as improved access to care, as well as political and economic input. This will be in keeping with the WHO Universal Health Coverage Strategy of achieving universal health coverage, financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all. Pneumonia and diarrhoea as persistent significant causes of mortality prompts improved access to care, maternal education and appropriate resources within appropriate travelling distance. In terms of perinatal-related events, lack of antenatal care has been identified as a very important risk factor for neonatal mortality.

In SSA, malaria is endemic and in many SSA countries, it is the most common cause of childhood mortality. HIV exposure or disease as well as malnutrition are very often comorbid factors that contribute to high mortality in this region. There have been numerous studies evaluating risk factors for mortality. Much emphasis has been placed on improvement of primary healthcare and access to care facilities. These two factors appear to play a role with regards to morbidity and mortality across SSA, with economic input required in order to create appropriate health services, as well as appropriate and attainable transport or access to care, whether it be mobile health care services or improved infrastructure and transportation. The poorer countries have an additional burden of poor maternal education, increased parity and poor immunization coverage. There is a need to improve access to education and in addition,

strategies need to be put in place that empower parents to recognize ill health and act appropriately. Immunisation campaigns have been implemented, but it is uncertain why the access to immunisations has been blunted in certain areas such as Rwanda. Prenatal care is a great concern as well as antenatal care, as these are entities that not only impact mortality, but also the general health and well-being of the newborn and the mother. In addition, there appears to be a strong association between household size and multiple gestations and mortality. Again, it appears that economic input, as well as access to care are shortfalls which will continue to impact mortality, should there not be a change.

However, it is with great dismay that 6 of the SSA countries still have 1 out of 10 children dying before they reach the age of 5 years. What is poorly understood is how these countries differ from those who have met the MDG 4 target. Factors such as war, unrest and a poor resource provision may play significant roles. However, evidence does not reveal absolute risk factors and the magnitude thereof in the Central African countries. Malawi, Kenya and Nigeria are relatively well studied populations in terms of childhood mortality and have shown major advances in improved mortality.

In South Africa, the U5MR has steadily declined since 2006, but not rapidly enough to reach the MDG 4 target. In 2015, U5MR was at 34.7 per 1000 live births with the most common causes of death, according to the Child Problem Identification programme (Child PIP), being infectious causes. Pneumonia, diarrhoea and septicaemia remain at the forefront as the most common in-hospital causes of death. Factors such as HIV disease and severe acute malnutrition (SAM) continue to impact and increase risk of mortality, as well as social determinants. Access to clean

running water and adequate sanitation resources are major risk factors that require economic input and government intervention.

With regards to factors leading to mortality and a more in depth look at triage and the first 24 hours of admission, studies revealed that appropriate triage aids in recognition and appropriate timing in management, thereby affecting morbidity and mortality. Triage systems should be geared at what is applicable to a setting and should aid in risk identification and stratification.

Conclusion

This literature review highlights that pneumonia, diarrhoea and perinatal factors are the foremost killers of SA children, these factors are similar to those found in other low-and middle-income countries. There is an urgent need to evaluate strategies to prevent these diseases from causing mortality. There is enough evidence to advise policy on mandatory triage, resuscitation and appropriate on-going care.

This review is followed by a study that looked at the cause of deaths of children admitted via the medical emergency unit of a children's hospital over one year and aims to evaluate the presenting illness and triage characteristics, and impact of treatment and other factors on their mortality.

Chapter three

Aims and Objectives

3.1 Aims

To describe the clinical presentation and acute management of children admitted via the medical emergency unit (MEU) at the Red Cross War Memorial Children's Hospital (RCWMCH) who subsequently died.

3.2 Objectives

- To describe the crude mortality rate (per 1000 admissions) for children admitted to the hospital via the MEU
- To describe the demographic characteristics, clinical presentation, and management of the children that die following admission via MEU
- To describe the causes of death of children admitted via the MEU of the RCWMCH

Chapter four

Methodology

Setting

The study was done at Red Cross War Memorial Children's Hospital (RCWMCH) - a tertiary academic hospital in the Western Cape Province, South Africa. RCWMCH provides secondary and tertiary level care to approximately 1.4 million children aged 0-14 years from all over the Western Cape, as well as quaternary care to patients from across the country.

Approximately 35 000 children present to the emergency unit at RCWMCH per annum. With regards to the Sustainable Development Goals, it was necessary to ascertain all factors that could effectively assist in achieving these goals. Therefore, this study undertook to describe demographics, potential risk and modifiable factors of patients who presented to the RCWMCH medical emergency unit in one year, 2008, and died at or during the admission.

Study design

A descriptive retrospective cross-sectional study with an analytical component

Study Population

All children who presented to RCWMCH in 2008, who subsequently died in hospital.

Inclusion criteria:

Children admitted via the medical emergency service at RCWMCH and subsequently died in hospital within the study period 2008.

Exclusion criteria

Children admitted directly to any wards of RCWMCH from any other source than the medical emergency unit.

Definitions

For the purposes of this document the following definitions were used:

- Emergency Treatment Assessment and Treatment (ETAT) is a WHO tool that trains and equips frontline staff at health facilities with the skills to recognise and identify critically ill children and then to systematically manage them according to Advanced Paediatric Life Support principles of airway, breathing, circulation, coma and dehydrating diarrhoea with assessment and management. The first step in identifying critically ill children is by triage into one of three categories: Red category- children with emergency signs requiring immediate treatment; Orange category- those with priority or urgent signs and requiring urgent care and Green category- those children with non-urgent conditions who can await care in a queue. [11]
- HIV infection: "a positive HIV DNA PCR result confirmed by either a HIV RNA PCR or repeat HIV DNA PCR test, in any child < 18 months old, or 2 positive serological test results (HIV ELISA or HIV Rapitest) or a positive HIV DNA PCR result confirmed by either a HIV RNA PCR or repeat HIV DNA PCR test, in a child > 18 months old were considered HIV-infected" [48]
- Unknown HIV status: any infant or child where there was no record of HIV testing at the National Health Laboratory Services (NHLS) laboratory database and whose mother's HIV status was unknown.

- HIV-exposed status: Any infant or child whose mother's HIV status was known to be positive during pregnancy and whose own status was negative by HIV testing at the NHLS laboratory. Using World Health Organisation (WHO) growth reference standards, moderate underweight was classified as weight-for-age z score (WAZ) between -2 and -3 standard deviations (SD) below the median while severe underweight was a WAZ < -3 SD. [45]
- Impaired Circulation: capillary filling time more than 3 seconds or weak pulse or cold extremities [11]
- Severe dehydration: two or more signs of lethargy, sunken eyes and very slow skin pinch [11]
- Shock: all of -capillary filling time more than 2 seconds and weak and/or fast pulse and cold hands[11]
- Hypoxaemia: pulse oximetry saturation less than 90% [11]
- Hypoglycaemia: point-of care glucose measurement less than 3mmol/L [11]

Data collection:

This was a data analysis performed on a database compiled in 2008 at the MEU at the RCWMCH. The data was collected by performing a retrospective folder review of all deaths that occurred in patients who presented to RCWMCH MEU where a meticulous register is kept of all children passing through- arrival and disposition. The case notes were retrieved from the medical records department and data abstracted. There were no missing folders and the resuscitation sheet is standardised for all children, however, there may have been some

variation in the detail recorded within the folders. Incomplete data were recorded as such in the results." The variables collected included:

1. *Demographic data:*
    a. Age, sex, weight, weight-for-age z-score, HIV status
2. *Clinical data:*
    a. Clinical presentation, triage information, clinical diagnosis, pre-hospital and in hospital treatment.
3. *Time factors:*
    a. Time of admission, time to initiation of treatment, time to ward transfer.
4. *Mortality data:*
    a. Cause(s) of death, time to death, and place of death

Data Analysis:

The analysis was done using STATA Statistical software, release 13, (College Station, Texas, USA) and constituted descriptive and analytical components.

Numerical data

Numerical data was tested for normality. Data was summarised using mean(s) with standard deviation(s) or median(s) with interquartile range(s) as appropriate. Hypothesis testing was done with a t-test on data with normal distribution, and Wilcoxon Ranksum used to test non-parametric distribution. A level of two-sided $p<0.05$ was chosen for statistical significance.

Categorical data

Categorical data were presented as proportions together with the 95% confidence interval. The chi-squared test was performed between categorical data to look for association. A significance level of $p<0.05$ was chosen.

Ethical considerations:

The study was submitted for ethical review to the Human Research Ethics Committee **(HREC Ref: 747/2018)** of the Faculty of Health Sciences at the University of Cape Town and had the approval of the RCWMCH Administration. In view of the retrospective nature of the study, the Ethics committee was approached to provide a waiver of individual consent. The study was done in accordance with the Declaration of Helsinki, 2013.

Chapter five

Results

Mortality and demographics

A total of 135 patients died following treatment in the medical emergency unit (MEU) at the Red Cross War Memorial Children's Hospital (RCWMCH) from January to December 2008. Over this period 21 600 children were admitted to RCWMCH, giving a crude mortality rate of 6.25 per 1000 admissions for the year. The median age of the children who died was 8 months with an interquartile range (IQR) of 3 to 17 months; 81 (60%) were infants of whom 40 (30%) were under 3 months, 38 (28%) were aged 12-59 months, and 16 (12%) were more than 5 years-old. There were 67(50%) male children. **(Table 1)**

The median weight-for-age z-score was -2 (IQR -3.2 to -1). There were 67(50%) with moderate or severe underweight-for-age children, 28 of whom were moderately underweight-for-age (UWFA) and 39 who were severely underweight-for-age.

Of 108 children with known HIV status, 33 (31%) were HIV-infected, 66 (61%) unexposed uninfected, and 9 (9%) were HIV-exposed uninfected. The HIV status was unknown in 27 (20%).

Table 1: Demographic Characteristics of the study children (n=135)

		Number	Percentage
Age in months			
	<1 month	20	15
	1 to 3 months	20	15
	3 to 11 months	41	30
	12 to 59 months	38	28
	>60 months	16	12
Sex			
	Male	67	50
	Female	68	50
Weight-for-age[#]			
	Normal WFA	66	50
	Moderate UWFA	26	20
	Severe UWFA	41	30
HIV status			
	Unexposed uninfected	66	49
	Infected	33	24
	Exposed uninfected	9	7
	Unknown	27	20
Referral status			
Unreferred		38	28
Referred		97	72
	Community Health Centre	65	48
	General Practitioner	20	15
	Other hospital	12	9
Telephonic notification			
	No	105	78
	Yes	30	22
Mode of Transport			
	Ambulance	69	51
	Own Transport	62	46
	Unknown	4	3

WFA: weight-for-age; UWFA: underweight-for-age; [#]moderate underweight = WFA z-score between -2 and -3 and severe underweight WAZ < -3 SD

495

Referral pattern

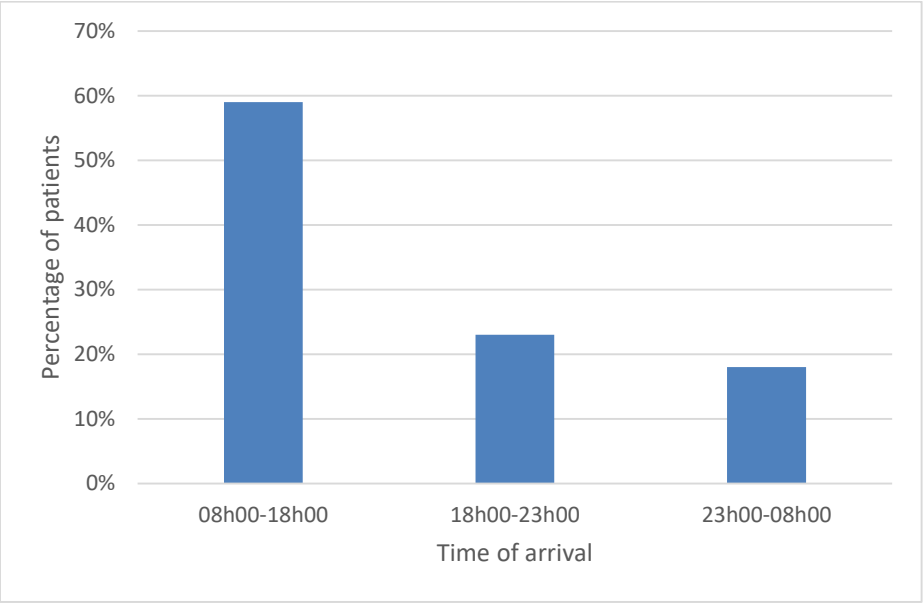
The children lived in six main health sub-districts within the Western Cape Metropolitan area: most of the patients that died came from Khayelitsha (n=44; 33%) and the Klipfontein sub-district (n=40; 30%). There were 29 (22%) children from Mitchells Plain, 8 (6%) from the Southern, 7 (5%) from the Tygerberg and 6 (4%) from the Western health districts. There were 69 (51%) children brought by the emergency ambulance services and 62 (46%) arrived by private transport. The mode of arrival was unknown for the remaining four children.

Telephonic notification of referrals to the MEU was made in 30 (22%) cases. General practitioners (GP) referred 20 (15%), the community health centres (CHC) referred 65 (49%), and 12 (9%) came from other local hospitals, whilst 38 (28%) of children were self-referred.

Time of arrival at RCWMCH emergency and triage

Eighty (60%) patients arrived during normal working hours between 08h:00 and 18h:00, while 55 (40%) arrived between 6pm and 8am, **Figure 1**. At triage, 98 (73%) were categorised as red (emergency) and 31 (23%) as orange (priority). One patient was triaged as green (non-urgent) category. Five patients did not have a triage category assigned.

Figure 1: Time of arrival of 135 study children in the medical emergency unit



Clinical presentation at MEU and triage information

Presenting diagnosis

The top three presenting diagnoses were pneumonia, acute gastroenteritis and septicaemia.

(**Table 2)**; 113 (84%) children had more than one clinical diagnosis at presentation**.**

528 ***Table 2: The presenting condition of the 135 study patients***

PRESENTING ILLNESS	N	(%)
Pneumonia	62	46
Acute gastroenteritis	35	26
Septicaemia	33	24
Cardiac	23	17
Acute neurological	20	15
Severe acute malnutrition	16	12
Other	16	12
Bacterial meningitis	8	6
Tuberculous meningitis	7	5
Pulmonary tuberculosis	6	4
Acute surgical abdomen	6	4

529

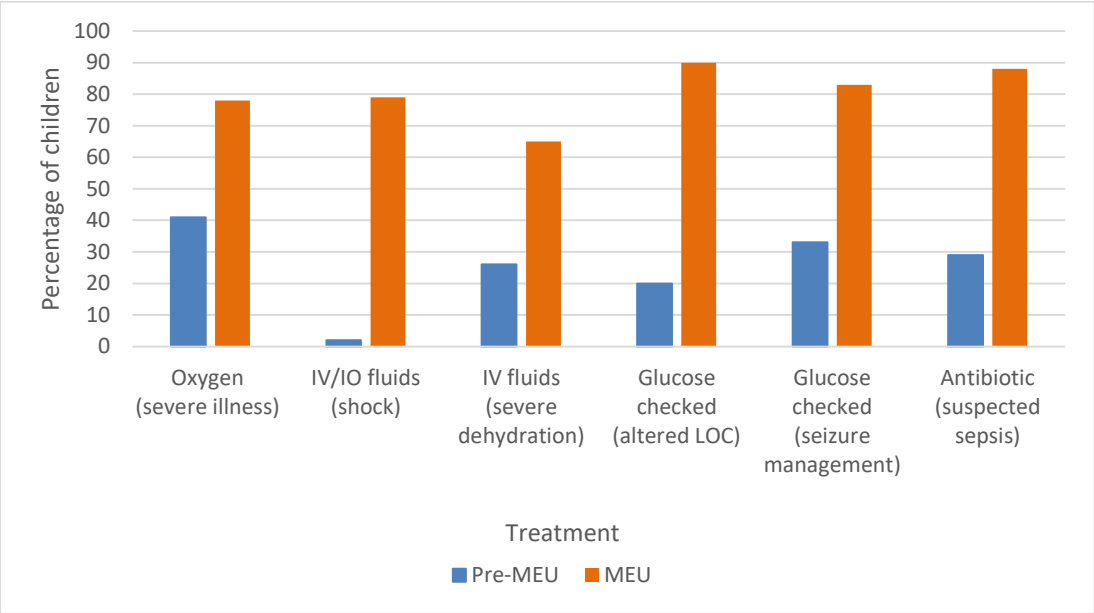
530 Hypoxaemia as indicated by pulse oximetry <90% was a feature at presentation for 81 (60%)
531 children. There were 61 (45%) children identified with impaired circulation and 43 (32%) with
532 shock having a capillary filling time (CFT) of more than 2 seconds plus a weak pulse and cold
533 extremities. Diarrhoea with dehydration was present in 48 (36%) children with signs of severe
534 dehydration in 23 (48%) of those children.

535 Sixty-seven (50%) children had a chronic underlying medical condition and there were five
536 children who had more than one underlying medical condition. **(Table 3)**

Table 3: Underlying medical conditions of study population, n=135

Underlying Diagnosis	n (%)
None	68(50)
HIV	33(24)
Cardiac	13(10)
Cerebral Palsy	5(4)
Down Syndrome	5(4)
Chronic Lung Disease	2(2)
Tuberculous Meningitis	2(2)
Inborn errors of metabolism	1(1)
Neoplasm	1(1)
Chronic Renal Disease	1(1)
Unspecified syndrome	1(1)
Asthma	1(1)
Neurofibromatosis	1(1)
Sickle cell anaemia	1(1)

Figure 2: Treatment at referral centres and MEU



Legend: MEU – medical emergency unit; IV – intravenous; IO – intraosseous; LOC – level of consciousness

Treatment at referral centres and MEU

The management of the severe illness was evaluated according to the treatments in parentheses **Fig 2**:

A. Hypoxia (oxygen given)
B. Shock (intravenous/intraosseous fluid bolus)
C. Diarrhoea with severe dehydration (intravenous fluids)
D. Seizures (glucose check)
E. Altered level of consciousness (glucose check)
F. Suspected sepsis (antibiotics given)

A. Management of severe illness with oxygen

Pre-hospital oxygen was given in 40 (41%) of the 97 children who were referred. One hundred and five (78%) received oxygen in the MEU. Eighty-one (60%) of the children had documented hypoxia.

B. Shock management

There were 43 (32%) children who had shock documented. Of these, eight (2%) received a fluid bolus at the referral centre, whilst 34 (79%) received a fluid bolus in the MEU. One child's records did not document whether a fluid bolus was given.

C. Diarrhoea with severe dehydration management

There were 23 (17%) children with diarrhoea with severe dehydration; an intravenous (IV) line for IV rehydration fluids was inserted at the referral centre in 6 (26%) of these children, whilst IV fluids were commenced in 15 (65%) of the children who presented with severe dehydration in the MEU.

D. Management of altered level of consciousness

Of the 49 (36%) children who had an altered level of consciousness, a glucose check was done in 10 (20%) children at the referral centre. At the MEU 44 (90%) children had a glucose check.

E. Management of seizures

Fifteen children were referred with seizures from the referral centre. Of these children, a glucose check was not done in 10 (67%).

Eighteen children were diagnosed with seizures at the MEU. Fifteen (83%) had a glucose checked.

F. Management of suspected sepsis

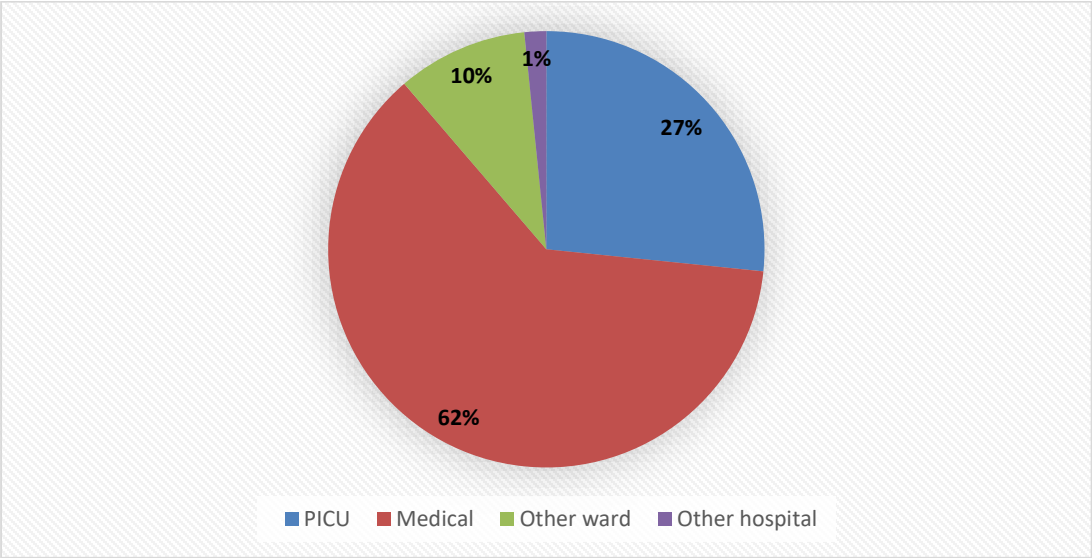
There were 49/135 (36%) children who presented to the MEU with suspected sepsis, with either hypothermia or pyrexia, of whom 14 /49 (29%) received antibiotics at the referral centres, with antibiotics documented as given in 43/49 (88%) children in the MEU.

Outcomes

Ward transfer

Of the 125 patients who were transferred from the MEU to wards, 33 (26%) were admitted to the Paediatric Intensive Care Unit (PICU) from the MEU, 77 (62%) to the medical wards, 12 (10%) went to a specialized medical or surgical ward and 2 (2%) were transferred to secondary level hospitals. **Figure 3**

Figure 3: Destination ward after stabilisation in the MEU



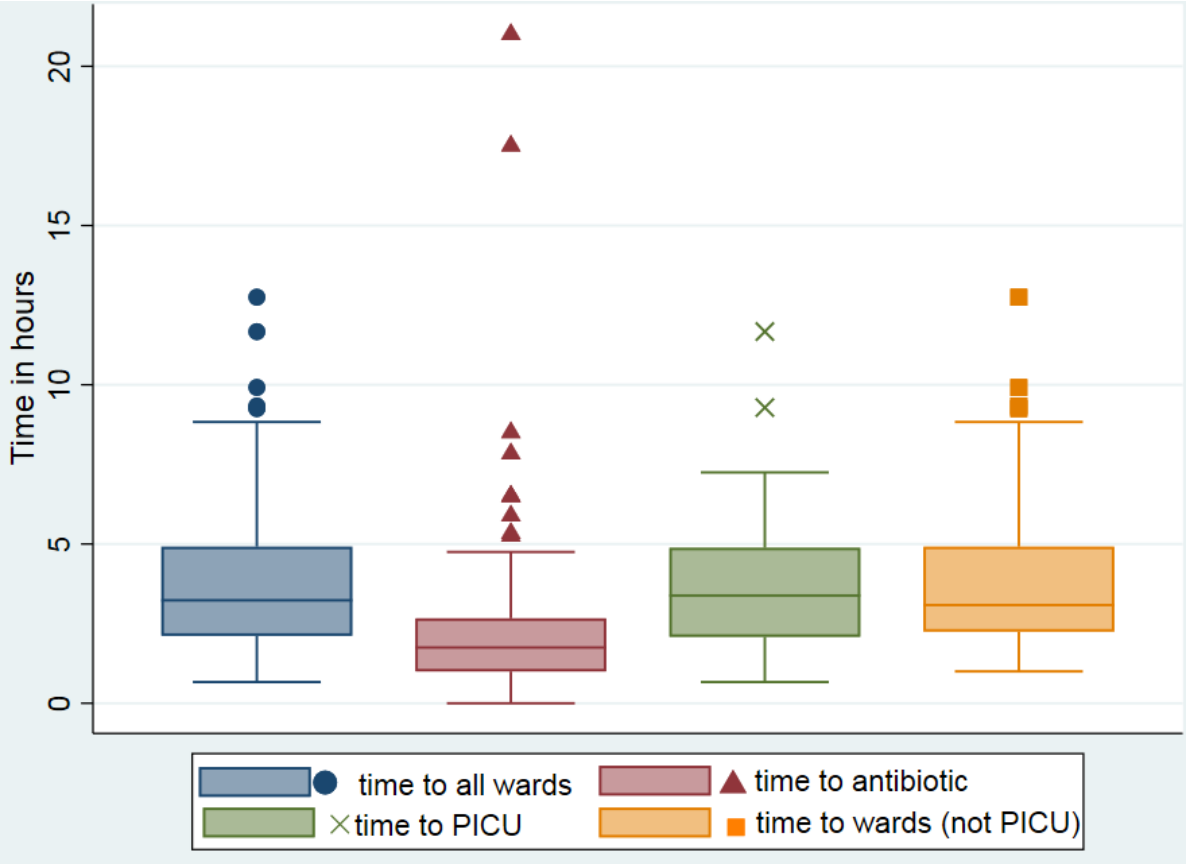
Legend: MEU: medical emergency unit; PICU: paediatric intensive care unit

Time Factors

Once stabilisation had occurred, six of the 125 (5%) patients who were transferred from the MEU to other wards, were transferred within an hour. The other 119 (95%) were transferred at later than one hour to an inpatient ward. There was no significant difference in the median time to ward transfer was 3.23 (IQR 2.1-4.9) hours compared to the median time to PICU directly from the MEU, was 3 (IQR 2.0-4.0) hours. Of the 33 children transferred to ICU 8 (24%) were transferred within an hour.

Of the 102 (76%) who did not receive antibiotic prior to MEU, 21 did not have records of having received antibiotic before death. Of the remaining 81 (79%), time taken to the first dose of antibiotic being administered to patients was a median of 1.75 hours (IQR 1-2.6).

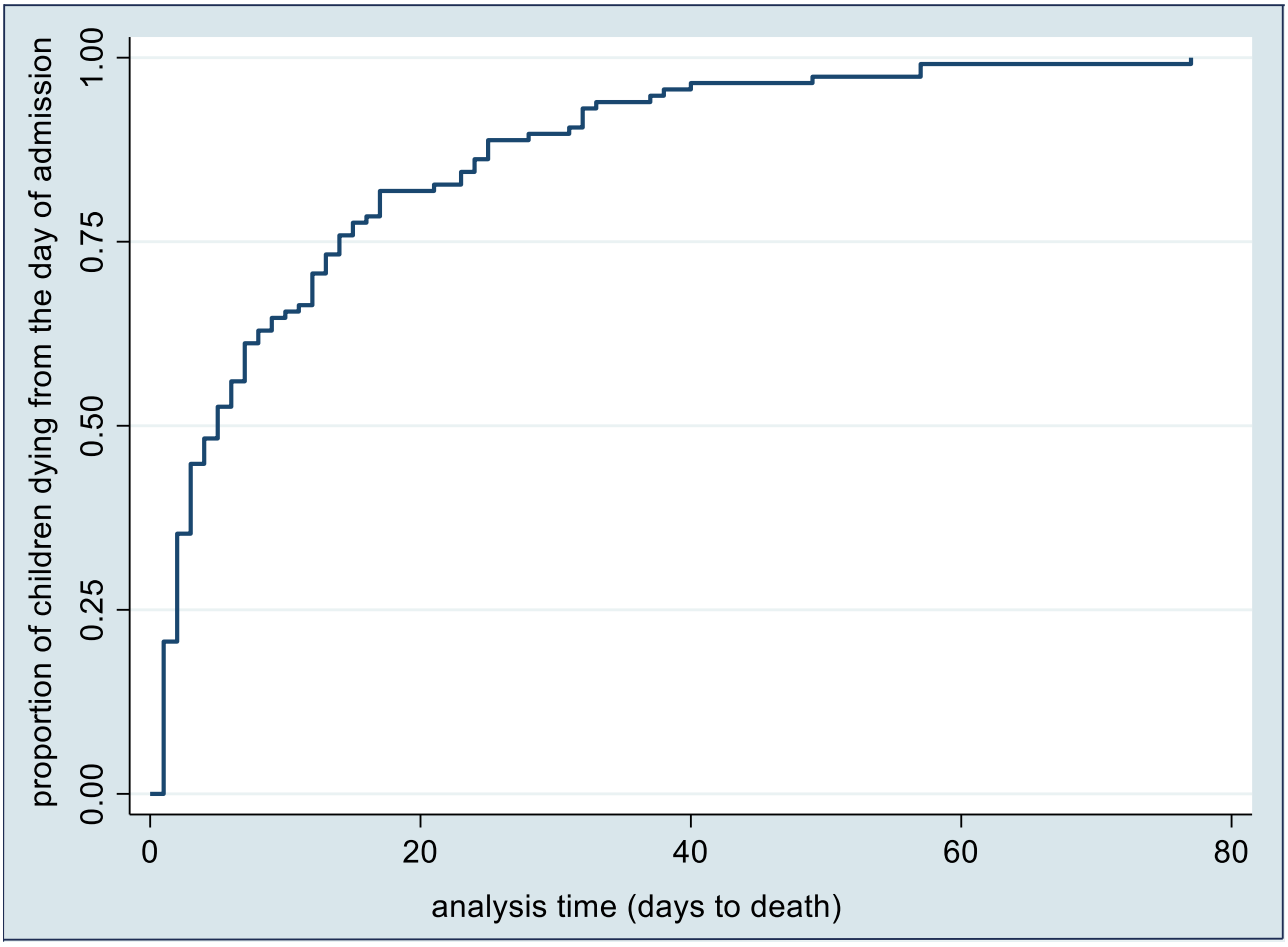
Figure 4: Box and whisker plot of time variables



Legend: PICU – Paediatric Intensive Care Unit; (for completeness and accuracy, outliers are indicated for each plot by circles, triangles, crosses and squares)

A survival curve showing time to death is shown in **Figure 5**. There were 29 (22%) children who died within 24 hours of presentation. Forty-five percent of children died within 72 hours of admission; 80% died within 17 days of admission and 20% died between day 18 and day 80.

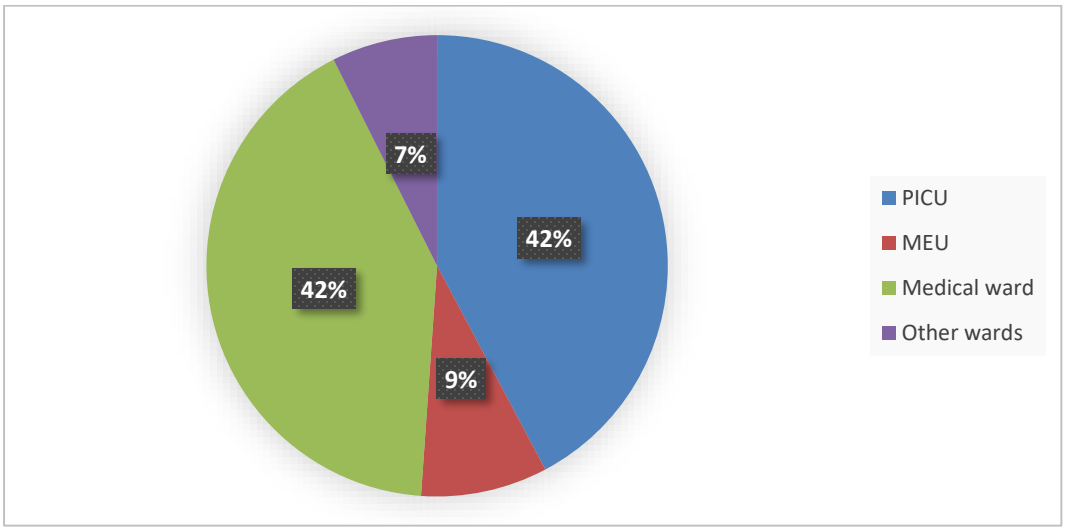
Figure 5: Graph showing the cumulative mortality over time of the study children from the time of admission to the medical emergency unit (MEU)



Place of death

Of the 135 deaths, there were 12 (9%) that occurred in the MEU, 56 (42%) occurred in the PICU, 56 (42%) in the medical wards and the last 10 (7%) in the speciality wards. (**Figure 6**)

Figure 6: Place of death of study patients



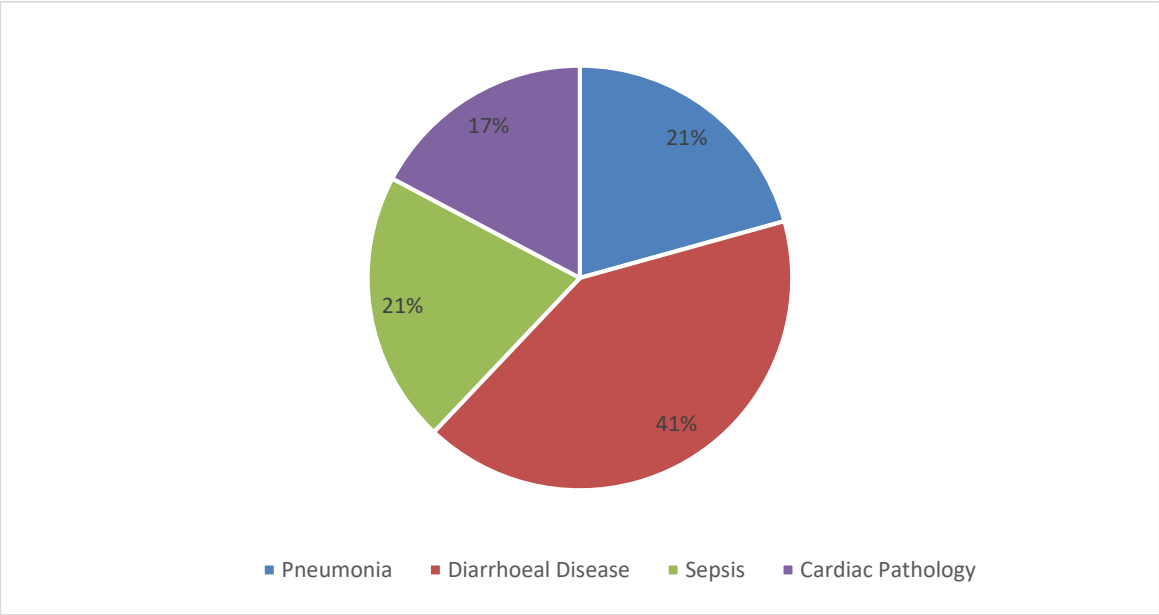
Legend: PICU: paediatric intensive care unit; MEU: medical emergency unit

Deaths within the first 24 hours

There were 29 (22%) children who died within 24 hours of presentation. Twelve (41%) of these 29 children died in the MEU, 11 (38%) died in PICU and 6 (21%) died in the medical wards. Three of the 29 (10%) were HIV-infected, none of whom went to the PICU.

Causes of death in this group of children were acute gastroenteritis 12 (41%), acute respiratory infection 6 (21%), septicaemia 6 (21%) and cardiac pathology in 5 (17%) as a primary cause of death in the form of cardiomyopathy, myocarditis or congenital cardiac disease. (**Figure 7**)

643 *Figure 7: Causes of death of patients who died within 24 hours (n=29)*



644

645

646 **Cause of death**

647 The top five primary causes of death were acute respiratory infections (ARI) 45 (33%), acute
648 gastroenteritis (AGE) 27 (20%), septicaemia 22 (16%), meningitis 12 (9%) and mixed cardiac
649 disease 12 (9%). There were 82 (61%) patients with secondary diagnoses and 21 (16%) with a
650 third diagnosis or underlying condition. A further 3 (2%) had a fourth diagnosis or underlying
651 condition. (**Table 4)**

652

653

654 ***Table 4: The primary cause of death in the study children (n=135)***

Primary cause of death	N	%
Acute respiratory infection	45	33
Hypovolaemic shock secondary to AGE	27	20
Septicaemia	22	16
Bacterial meningitis	8	6
Tuberculous meningitis	5	4
Surgical (Acute abdomen)	5	4
Cardiomyopathy	4	3
Complex congenital cardiac	4	3
Myocarditis	4	3
Liver failure	3	2
Status epilepticus	1	1
Suffocation	1	1
Diphtheria	1	1
Malignancy	1	1
Inborn error of metabolism	1	1
Severe anaemia with congestive cardiac failure	1	1
End stage renal failure (Nephrotic Syndrome)	1	1
Cerebral haemorrhage	1	1

655 Legend: AGE- acute gastroenteritis; percentages rounded to whole numbers

656

657

The role of HIV infection

Of the 33 HIV-infected children, 19 (58%) were under 1 year. There were 18 (55%) female children. It is unknown whether patients were on antiretroviral therapy and their viral loads and CD4 counts were not recorded. Of those who were HIV-infected, 3 (9%) were admitted to ICU. Eighteen (27%) of the 66 patients who were HIV-uninfected went to ICU.

The most common causes of death in the HIV-infected group of children were ARI 18 (55%), AGE 8 (24%) and septicaemia 4 (12%).

The role of malnutrition:

In the study population, there were 67 (50%) children who were moderately or severely underweight-for-age, ten (15%) of these children died within 24 hours. Seventeen (25%) were HIV-infected. The top three causes of death in this group was 25 (37%) with acute respiratory infections, 14 (21%) with acute gastroenteritis with hypovolaemic shock and 13 (19%) with septicaemia.

Chapter six

Discussion

In our study, we described the demographics of 135 children who presented to the MEU at Red Cross War Memorial Children's Hospital in the year 2008, who subsequently demised. The leading causes of death were acute respiratory infections, diarrhoeal disease and septicaemia, in keeping with mortality studies from other developing countries including Angola, Nigeria, and Malawi, as well as in South Africa. [36, 49, 50]

Most of the children attending the MEU (73%) were critically ill and appropriately identified at triage as "Red" category cases. There was only one patient who subsequently demised and was triaged "Green", this is likely an error in triage assessment. Sixty percent of patients who died were under 1 year of age. This correlates with global statistics where childhood mortality studies have shown that up to two thirds of childhood deaths occur in infancy.[49, 51] The burden of critically ill children remains high in SSA, mortality in the first twenty-four hours was 22% (29/135) in the present study; in one study Malawi reported a rate of 44%.[5] Nigeria, a rate of 57%.[6] What is evident is that 11 years after this study, acute respiratory infections, diarrhoeal disease and sepsis remain the top causes of mortality in sub-Saharan Africa and provides a strong focus for preventive strategies. [12]

One of the factors being addressed is malnutrition, which is thought to contribute to half of the global under-5-years mortality and is thought to be related to decreased immunity and causal increased severity of illness.[45] Similarly, in this study, 50% of patients were moderately to severely underweight-for-age.

HIV disease as well as HIV exposure continues to play a role in mortality, but this has improved substantially since the rollout of the prevention -of-mother-to-child-transmission (PMTCT) programme, with a reduction in HIV-related under 5 mortality having declined from 116.8 deaths per 100 000 population in the period 2001 to 2004 to 14.8 deaths per 100 000 population in the period 2010 to 2014.[52] In our study 24% of children were HIV-infected. Disparity still exists but has shown improvement in certain sub-districts such as Khayelitsha, where HIV-related deaths declined from 230.5/100 000 to 21.1/100 000 in the same aforementioned periods.[52]

Patients were referred from various centres. Community health centres provided treatment to most of the referred patients. Despite treatment provided, a significant number of patients did not receive IMCI-defined adequate treatment modalities, as can be noted with regards to oxygen provision for hypoxia, glucose checks, fluid management and antibiotic provision. This has been shown to be of concern in various sub-Saharan countries.[53] The patients who were referred by GPs had received no treatment prior to presentation. This raised the concern with regards to adequate and appropriate care provision in primary health. The Advanced Paediatric Life Support course emphasises stabilisation of airway, breathing, circulation and dextrose prior to transfer. This study marks a need to provide more support to primary health care, with subsequent development of district paediatric care and outreach.

A significant number of patients who presented, resided in Khayelitsha, a township in the Metro East of the Western Cape, where many children reside in informal dwellings, have limited access to tap water within their dwellings and generally poor sanitation services. There

were also a large number of patients who presented from the Klipfontein sub-district, a middle- to low-income area situated within a 5km radius from Red Cross Children's Hospital. These two areas accounted for more than 60% of the study population who presented. It was therefore pertinent to address the two areas as to how socioeconomics impacts on health and the challenges experienced. Red Cross War Memorial Children's Hospital is situated more than 20km away from Khayelitsha, thereby impacting further on access to care. Khayelitsha is the second largest township in South Africa. In 2008, 15% of the MEU attendees were from Khayelitsha of whom 33% died. Access to emergency care is restricted due to lack of transportation, inability of emergency services to access certain areas within the township and continued informal dwellings being erected without appropriate infrastructure. These poverty challenges may continue to maintain differential mortality statistics. Access to healthcare has been partially addressed by the opening of a district hospital in Khayelitsha in 2012. This has aided in the decline in under-five mortality of 976.6 deaths per 100 000 population in the period 2001 to 2004 to 570.2 deaths per 100 0000 population in the period 2010 to 2013, a decline of 41.6%.[52] Despite the significant improvement in mortality, Khayelitsha still remains the sub-district with the highest U5MR.

With 73% of the study population being triaged as 'Red' category, time of presentation is another important consideration as a risk factor for mortality, as the staff complement is diminished in both number and expertise after 5pm in the evening.[54] This places critically ill children at risk for possible management errors.

Delayed antibiotic administration in children with severe sepsis has been shown to be a risk factor for increased mortality.[54, 55] In 2008, within the MEU, there was a significant time delay in time to antibiotics, with less than 25% of patients receiving antibiotics within the recommended “golden hour”. The reason for this is unclear. Access to the ICU or wards was also significantly delayed, with less than 25% of patients being transferred from the MEU within 2 hours of arrival and a further 25% only exiting the MEU more than 5 hours after arrival. This has resulted in a need for upskilling of ward staff, provision of more high care beds and very recently, the upgrading and resultant increased capacity of the ICU. It would be valuable to review time delays to transfer now that capacity has been increased, along with looking at factors causing any delays.

Over 80% of the study patients had more than one recognised diagnosis as a possible cause of death indicating the complexity of pathology which may be related to the study site being a tertiary referral centre.

Programmatic improvements in many South African child health issues since 2008 may well have affected the disease spectrum and severity in the communities covered by Red Cross War Memorial Children’s Hospital e.g., improved prevention -of-mother-to-child-transmission (PMTCT) of HIV disease, encouraged breast-feeding including in the context of HIV, access to antiretroviral therapy to mothers and children, strengthening of primary health care and pre-hospital emergency medical services, the introduction of mandatory triage and life support training for all staff seeing children. The first 1000 days initiative, which prioritises the care of an infant from conception to the age of 2 years under the 3 domains, grow, play and love, aims

to improve the nutrition, health, development and social well-being of all children and thereby, optimise health, growth, brain development and social skills, so as to improve their future and the future of society. This initiative has been recognised by the Western Cape department of health (WCDOH) as an initiative that will be implemented throughout facilities and practices that involve the care of mother and child antenatally as well as postnatally.

Limitations

This study was a retrospective study conducted at a single centre in 2008 and had inherent limitations of incompleteness of information and missing data contained in handwritten patient records and referral letters. It is also possible that the urgency involved with stabilising and transferring a critically ill child in a busy unit, both pre-hospital and at the MEU, may be associated with incomplete documentation of all treatments and interventions given. The protocols available in 2008 were no longer available to scrutinize either at the pre-hospital or emergency room level. Since then, new protocols including the Child PIP death review process and staff training programmes have been implemented to improve management outcomes. Nevertheless, notwithstanding all limitations, this audit is an important clinical governance tool that necessitated completion.

It is important for emergency units to conduct audits of this nature to give insight into causes of mortality of children in order to identify and prioritize interventions to optimize patient care and quality of healthcare services in the paediatric emergency department. The review indicates that top causes of mortality remain virtually unchanged. Lastly, the study did not

investigate the skills and training of the staff providing care in the triage room and MEU, and pre-hospital setting. This may need further interrogation as poor skills may be a contributing factor particularly as much of the work of the unit occurred at time periods when there was less senior supervision.

Strengths

This study captured and reported all the deaths that passed through the MEU for the period 2008. We identified all the causes of death, described the demographic characteristics of all the study children, their clinical presentation and treatment plans as well as speculated contributory and possible modifiable factors. Thereby we were able to compare with international literature and strengthen treatment protocols and management guidelines, as well as devise strategies to improve and address modifiable factors.

Chapter Seven

Conclusion

Significant gaps were identified in the pre-referral care of children with potentially life-threatening diseases. In particular, general practitioners did not provide emergency treatment. Dehydration and shock management represented a significant cause of death, the management of which was sub-optimal in some cases in 2008. In 2008, even the medical emergency unit management appeared sub-optimal at times. However, poor documentation may have been a contributing factor.

Recommendations

We recommend that the MEU reviews the results of this study and considers conducting a modern prospective clinical study to critically review the current performance of this tertiary unit in providing quality emergency care to children to see if the problems raised have changed after modifications to protocols, training, duty rosters, staffing levels, patient flow and minimised delays, consultant presence after-hours, provision of dedicated trained coding staff and encouraging an ethos of research with the ultimate view to sustaining and maintaining best practice. Sharing this information at a wider forum may be of interest to provincial governance groups who may wish to critically review the pathways to care, management and outcomes for critically ill children from home to the definitive hospital bed and home again. Regular auditing as a quality improvement strategy would help identify remaining barriers inhibiting the achievements of the SDGs.

References

1. Sachs JD. From millennium development goals to sustainable development goals. The Lancet. 2012;379(9832):2206-11.

2. Le Blanc D. Towards integration at last? The sustainable development goals as a network of targets. Sust Dev. 2015;23(3):176-87. doi: DOI: 10.1002/sd.1582.

3. United Nations. The millennium development goals report. New York: United Nations. 2015.

4. UNICEF, WHO, The World Bank, United Nations (2012) Levels and Trends in Child Mortality: Report 2012 website. 2012.

5. Moise IK, Kalipeni E, Jusrut P, Iwelunmor JI. Assessing the reduction in infant mortality rates in Malawi over the 1990–2010 decades. Global Public Health. 2017;12(6):757-79.

6. Yaya S, Ekholuenetale M, Tudeme G, Vaibhav S, Bishwajit G, Kadio B. Prevalence and determinants of childhood mortality in Nigeria. BMC Public Health. 2017;17(1):485.

7. Crouse HL, Torres F, Vaides H, Walsh MT, Ishigami EM, Cruz AT, et al. Impact of an Emergency Triage Assessment and Treatment (ETAT)-based triage process in the paediatric emergency department of a Guatemalan public hospital. Paediatrics and International Child Health. 2016;36(3):219-24.

8. Molyneux E, Ahmad S, Robertson A. Improved triage and emergency care for children reduces inpatient mortality in a resource-constrained setting. Bulletin of the World Health Organization. 2006;84:314-9.

9. Fitzgerald E, Mlotha-Mitole R, Ciccone EJ, Tilly AE, Montijo JM, Lang H-J, et al. A pediatric death audit in a large referral hospital in Malawi. BMC Pediatrics. 2018;18(1). doi: 10.1186/s12887-018-1051-9.

10. Adeboye M, Ojuawo A, Ernest S, Fadeyi A, Salisu O. Mortality pattern within twenty-four hours of emergency paediatric admission in a resource-poor nation health facility. West African Journal of Medicine. 2010;29(4).

11. World Health Organisation. Emergency triage assessment and treatment (ETAT). 2005.

12. McKerrow N SH BL, et al., Committee on Morbidity and Mortality in Children Under 5 Years. . 3rd Triennial Report of the Committee on Morbidity and Mortality in Children Under 5 Years (CoMMiC). 2017.

13. Jamison DT, Gelband H, Horton S, Jha P, Laxminarayan R, Mock CN, et al. Global health 2035: a world converging within a generation. Oxford University Press for the World Bank Washington, DC; 2017.

14. Mathers C, Stevens G, Hogan D, Mahanani WR, Ho J. Global and regional causes of death: patterns and trends, 2000–15. Disease Control Priorities: Improving Health and Reducing Poverty 3rd edition: The International Bank for Reconstruction and Development/The World Bank; 2017.

15. UNICEF, WHO, World Bank Group, United Nations. Levels & Trends in Child Mortality. Report 2018. Estimates developed by the UN Inter-agency Group for Child Mortality Estimation. 2018.

16. Ouma PO, Maina J, Thuranira PN, Macharia PM, Alegana VA, English M, et al. Access to emergency hospital care provided by the public sector in sub-Saharan Africa in 2015: a geocoded inventory and spatial analysis. The Lancet Global Health. 2018;6(3):e342-e50.

17. Schoeps A, Gabrysch S, Niamba L, Sié A, Becher H. The effect of distance to health-care facilities on childhood mortality in rural Burkina Faso. American Journal of Epidemiology. 2011;173(5):492-8.

18. Shifa GT, Ahmed AA, Yalew AW. Maternal and child characteristics and health practices affecting under-five mortality: A matched case control study in Gamo Gofa Zone, Southern Ethiopia. PloS one. 2018;13(8).

19. Adekanmbi VT, Kandala N-B, Stranges S, Uthman OA. Contextual socioeconomic factors associated with childhood mortality in Nigeria: a multilevel analysis. J Epidemiol Community Health. 2015;69(11):1102-8.

20. Maruthappu M, Watson RA, Watkins J, Zeltner T, Raine R, Atun R. Effects of economic downturns on child mortality: a global economic analysis, 1981–2010. BMJ Global Health. 2017;2(2):e000157.

21. You D HL, Ejdemyr S, Idele P, Hogan D, Mathers C, Gerland P, New JR, Alkema L, for the, Estimation UNI-aGfCM. Global, regional, and national levels and trends in under-5 mortality between 1990 and 2015, with scenario-based projections to 2030: a systematic analysis by the UN Inter-agency Group for Child Mortality Estimation. 2015:8.

22. McAllister DA, Liu L, Shi T, Chu Y, Reed C, Burrows J, et al. Global, regional, and national estimates of pneumonia morbidity and mortality in children younger than 5 years between 2000 and 2015: a systematic analysis. The Lancet Global Health. 2019;7(1):e47-e57.

876 23. Golding N, Burstein R, Longbottom J, Browne AJ, Fullman N, Osgood-Zimmerman A, et
877 al. Mapping under-5 and neonatal mortality in Africa, 2000–15: a baseline analysis for the
878 Sustainable Development Goals. The Lancet. 2017;390(10108):2171-82.
879 24. Adedini SA, Odimegwu C, Bamiwuye O, Fadeyibi O, Wet ND. Barriers to accessing health
880 care in Nigeria: implications for child survival. Global Health Action. 2014;7(1):23499.
881 25. Forshaw J, Gerver SM, Gill M, Cooper E, Manikam L, Ward H. The global effect of
882 maternal education on complete childhood vaccination: a systematic review and meta-analysis.
883 BMC Infectious Diseases. 2017;17(1):801.
884 26. Chadoka-Mutanda N, Odimegwu CO. Maternal health-seeking behaviour and under-five
885 mortality in Zimbabwe. Journal of Biosocial Science. 2017;49(3):408-21.
886 27. Karra M, Fink G, Canning D. Facility distance and child mortality: a multi-country study of
887 health facility access, service utilization, and child health outcomes. International Journal of
888 Epidemiology. 2017;46(3):817-26.
889 28. Irimu GW, Gathara D, Zurovac D, Kihara H, Maina C, Mwangi J, et al. Performance of
890 health workers in the management of seriously sick children at a Kenyan tertiary hospital:
891 before and after a training intervention. PloS one. 2012;7(7).
892 29. Hategeka C, Mwai L, Tuyisenge L. Implementing the Emergency Triage, Assessment and
893 Treatment plus admission care (ETAT+) clinical practice guidelines to improve quality of hospital
894 care in Rwandan district hospitals: healthcare workers' perspectives on relevance and
895 challenges. BMC Health Services Research. 2017;17(1):256.
896 30. Balamuth F, Weiss SL, Fitzgerald JC, Hayes K, Centkowski S, Chilutti M, et al. Protocolized
897 treatment is associated with decreased organ dysfunction in pediatric severe sepsis. Pediatric

critical care medicine: a journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies. 2016;17(9):817.

31. Oliveira CF, de Sá FRN, Oliveira DS, Gottschald AF, Moura JD, Shibata AR, et al. Time-and fluid-sensitive resuscitation for hemodynamic support of children in septic shock: barriers to the implementation of the American College of Critical Care Medicine/Pediatric Advanced Life Support Guidelines in a pediatric intensive care unit in a developing world. Pediatric Emergency Care. 2008;24(12):810-5.

32. Adekanmbi VT, Kandala N-B, Stranges S, Uthman OA. Factors that predict differences in childhood mortality in Nigerian communities: a prognostic model. The Journal of Pediatrics. 2016;168:144-50. e1.

33. Angela C, Uju O. Determinants of under-five Mortality in Nigeria: An application of Cox proportional hazard and Cox frailty models. IOSR J Math Ver I [Internet]. 2015;11(4):2278-5728.

34. Kerber KJ, Lawn JE, Johnson LF, Mahy M, Dorrington RE, Phillips H, et al. South African child deaths 1990–2011: have HIV services reversed the trend enough to meet Millennium Development Goal 4? AIDS (London, England). 2013;27(16):2637.

35. Nannan N, Dorrington R, Laubsher R, Zinyakatira N. Under-five mortality statistics in South Africa: Shedding some light on the trend and causes 1997-2007. Cape Town: South African Medical Research Council. ; 2012.

36. Bamford L, McKerrow N, Barron P, Aung Y. Child mortality in South Africa: Fewer deaths, but better data are needed. S Afr Med J. 2018;108(3):25-32.

37. He Z, Bishwajit G, Zou D, Yaya S, Cheng Z, Zhou Y. Burden of common childhood diseases in relation to improved water, sanitation, and hygiene (WASH) among Nigerian children. International Journal of Environmental Research and Public Health. 2018;15(6):1241.

38. Yaya S, Hudani A, Udenigwe O, Shah V, Ekholuenetale M, Bishwajit G. Improving water, sanitation and hygiene practices, and housing quality to prevent diarrhea among under-five children in Nigeria. Tropical Medicine and Infectious Disease. 2018;3(2):41.

39. World Health Organisation, South Africa. Department of Health. Integrated Management of Childhood Illness (IMCI) guidelines. 2011.

40. Wammanda R, Ali F. Conditions associated with the risk of death within 24 hours of admission in children in Zaria, Nigeria. 2004.

41. Nkonki LL, Chopra M, Doherty TM, Jackson D, Robberstad B. Explaining household socio-economic related child health inequalities using multiple methods in three diverse settings in South Africa. International Journal for Equity in Health. 2011;10(1):13.

42. Venkatesh KK, de Bruyn G, Marinda E, Otwombe K, van Niekerk R, Urban M, et al. Morbidity and mortality among infants born to HIV-infected women in South Africa: implications for child health in resource-limited settings. Journal of Tropical Pediatrics. 2011;57(2):109-19.

43. Tlou B, Sartorius B, Tanser F. Investigating risk factors for under-five mortality in an HIV hyper-endemic area of rural South Africa, from 2000-2014. PloS one. 2018;13(11).

44. Akombi BJ, Agho KE, Merom D, Renzaho AM, Hall JJ. Child malnutrition in sub-Saharan Africa: A meta-analysis of demographic and health surveys (2006-2016). PloS one. 2017;12(5).

45. World Health Organization. WHO child growth standards and the identification of severe acute malnutrition in infants and children: joint statement by the World Health Organization and the United Nations Children's Fund. 2009.

46. Acevedo P, Esteban MTG, Lopez-Ejeda N, Gómez A, Marrodán MD. Influence of malnutrition upon all-cause mortality among children in Swaziland. Endocrinologia, diabetes y nutricion. 2017;64(4):204-10.

47. Kanyuka M, Ndawala J, Mleme T, Chisesa L, Makwemba M, Amouzou A, et al. Malawi and Millennium Development Goal 4: a Countdown to 2015 country case study. The Lancet Global Health. 2016;4(3):e201-e14.

48. Schneider E, Whitmore S, Glynn MK, Dominguez K, Mitsch A, McKenna MT. Revised surveillance case definitions for HIV infection among adults, adolescents, and children aged< 18 months and for HIV infection and AIDS among children aged 18 months to< 13 years—United States, 2008. Morbidity and Mortality Weekly Report: Recommendations and Reports. 2008;57(10):1-12.

49. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000–15: an updated systematic analysis with implications for the Sustainable Development Goals. The Lancet. 2016;388(10063):3027-35.

50. Harris C, Mills R, Seager E, Blackstock S, Hiwa T, Pumphrey J, et al. Paediatric deaths in a tertiary government hospital setting, Malawi. Paediatrics and International Child Health. 2019;39(4):240-8.

51. Jin Y, Mankadi PM, Rigotti JI, Cha S. Cause-Specific child mortality performance and contributions to all-cause child mortality, and number of child lives saved during the millennium development goals era: a country-level analysis. Global Health Action. 2018;11(1):1546095.

52. Groenewald P, Neethling I, Evans J, Azevedo V, Naledi T, Matzopoulos R, et al. Mortality trends in the City of Cape Town between 2001 and 2013: Reducing inequities in health. South African Medical Journal. 2017;107(12):1091-8. doi: 10.7196/SAMJ.2017.v107i12.12458. PubMed PMID: 29262963.

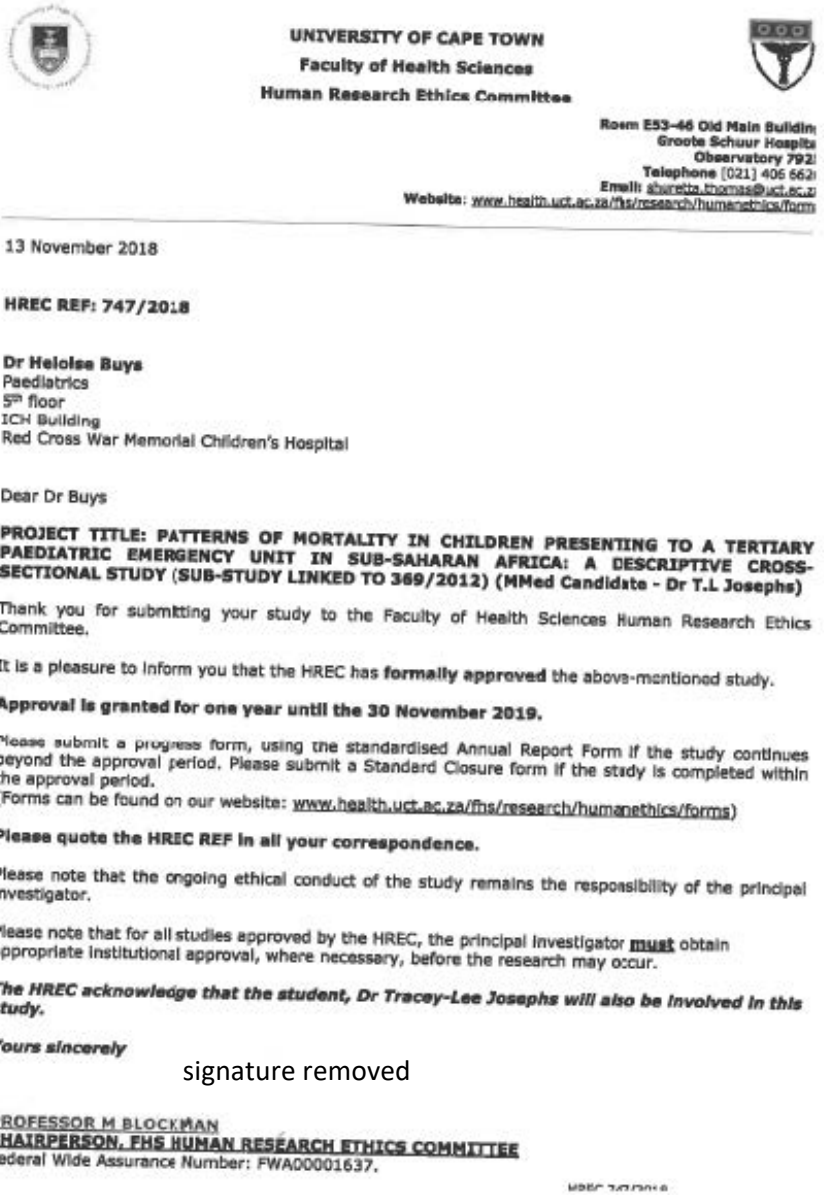
53. Krüger C, Heinzel-Gutenbrunner M, Ali M. Adherence to the integrated management of childhood illness guidelines in Namibia, Kenya, Tanzania and Uganda: evidence from the national service provision assessment surveys. BMC Health Services Research. 2017;17(1):822.

54. Royal C, McKerrow N. A retrospective review of the transfer of critically ill children to tertiary care in KwaZulu-Natal Province, South Africa. South African Journal of Child Health. 2015;9(4):112-8.

55. Hodkinson P, Argent A, Wallis L, Reid S, Perera R, Harrison S, et al. Pathways to care for critically ill or injured children: a cohort study from first presentation to healthcare services through to admission to intensive care or death. PloS one. 2016;11(1).

Appendices

Appendix 1: Ethics approval letter



UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E53-46 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 662
Email: aburetta.thomas@uct.ac.z
Website: www.health.uct.ac.za/fhs/research/humanethics/form

13 November 2018

HREC REF: 747/2018

Dr Heloise Buys
Paediatrics
5th floor
ICH Building
Red Cross War Memorial Children's Hospital

Dear Dr Buys

PROJECT TITLE: PATTERNS OF MORTALITY IN CHILDREN PRESENTING TO A TERTIARY PAEDIATRIC EMERGENCY UNIT IN SUB-SAHARAN AFRICA: A DESCRIPTIVE CROSS-SECTIONAL STUDY (SUB-STUDY LINKED TO 369/2012) (MMed Candidate - Dr T.L Josephs)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30 November 2019.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

The HREC acknowledge that the student, Dr Tracey-Lee Josephs will also be involved in this study.

Yours sincerely

signature removed

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.

977

Appendix 2: Protocol

Research Proposal

Patterns of mortality in children presenting to a tertiary paediatric emergency unit in Sub-Saharan Africa: a cross sectional study

Researchers:

MMED Student: Dr Tracey Josephs

UCT Student Number: JSPTRA001

Student number: JSPTRA001

Dr Heloise Buys [1,2]

Dr Adelaide Masu [2]

A/P Rudzani Muloiwa [2]

1 Emergency and Ambulatory Paediatrics, Red Cross War Memorial Children's Hospital

2 Department of Paediatrics and Child Health, UCT

Background

The Sustainable Development goals (SDGs) were adopted in 2015 at a United Nations congress and address challenges faced globally with regards to poverty, inequality, prosperity, justice and various

other challenges. (1, 57) One of the SDGs is an aim to reduce child mortality to less than 25 per 1000 live births by the year 2030. Globally, the main killers of children under age 5 in 2016 were preterm birth complications (18%), pneumonia (16%), intrapartum-related events (12%), diarrhoea (8%), neonatal sepsis (7%) and malaria (5%). (4)

Prior to the SDGs, the Millennium Development goals (MDGs) were devised by the United Nations (UN) in the year 2000. The MDG 4 stated that by the year 2015, the aim would be to reduce global mortality by two thirds. (3) Globally, the under-five mortality rate (U5MR) has decreased from 93 per 1000 live births in 1990 to 41 per 1000 live births in 2016, a 56% reduction in mortality. (4) However, while global mortality has decreased, the World Health Organisation (WHO) reported that Africa still had the highest incidence of under 5 mortality, 76.5 per 1000 live.

In order for Sub-Saharan Africa to achieve the SDG goal on child mortality progress needs to accelerate to combat the top causes of mortality in the region. The top causes of mortality are pneumonia, diarrhoea, malnutrition and malaria. Factors contributing to these causes of mortality are rural living, poor access to resources, poverty, maternal age and parental education level. (58-60)

In South Africa, The Child Problem Identification Programme (Child PIP) is a system implemented to look at trends in mortality, as well as identification of modifiable factors. Child PIP data is collected at all government hospitals across the country and a report is collated with regards to childhood mortality. (61, 62) The under-five mortality rate in South Africa declined from 59 in 2000 to 34.7 in 2015 but has

subsequently remained stagnant. (30, 63). The top causes of mortality in South African children are prematurity-related, pneumonia, gastro-enteritis and injuries. (64, 65)

Many children suffering from one of the top causes of mortality present to health facilities critically ill. Recognizing critically ill children is the first step in their management. (66) These children should be correctly identified by a triage tool at presentation, and appropriately resuscitated. The need for triage to prioritise and categorise acutely ill children arriving at any hospital is highlighted by the fact that many deaths occur within the first 24 hours of presentation to hospitals in developing countries. (31, 59) Appropriate triage is critical to ensuring the delivery of timely emergency care. (67, 68)

The Emergency Triage, Assessment and Treatment tool (ETAT) was developed in 2005 in Malawi and has been endorsed by the WHO as a paediatric triage tool across many countries, including Rwanda, Kenya and Malawi.(59, 69, 70) In South Africa, it was rolled out in Kwazulu Natal and in the Eastern Cape in 2016(71). RCWMCH is a hospital in the Western Cape which provides secondary and tertiary level care to 1.5 million children <14years from all over the Western Cape, as well as quarternary care to patients from across the country. According to the computerised hospital information system (HIS) application, Clinicom®, the medical emergency unit sees approximately 30 000 children who present per annum. In 2007 Red Cross War Memorial Children's Hospital (RCWMCH) introduced ETAT, as an adapted triage tool, with a view to understanding the processes involved in the initial management of these children with respect to triage, resuscitation, management after admission and cause of death.(34) In 2013, a collaborative process merged the clinical discriminators of ETAT with the physiological measurements and a Triage Early Warning Score of another existing triage tool SATS to enhance the safety and sensitivity of the final revised tool called the Paediatric South African Triage Scale (PSATS)(72).

There is little data in Sub Saharan Africa highlighting the effective use of a triage tool (in this case ETAT) and the impact it has on child mortality especially in the first 24 hours. This study aims to address the gap as part of a quality improvement initiative.

Aim:

To evaluate the impact of factors associated with in hospital death of children admitted via the Medical Emergency Unit (MEU) at the Red Cross War Memorial Children's Hospital (RCWMCH).

Objectives:

- To describe the in-hospital mortality rate (per 1000 admissions via MEU) of children admitted to the hospital via the medical emergency unit (MEU)
- To describe the demographic characteristics, clinical presentation, and treatment plans of the demised children to the MEU
- To describe the cause(s) of death
- To describe factors leading to death within 24 hours of admission
- To assess if timing of treatment impacts on mortality of children in the MEU

Methods:

Study design

Cross sectional study with an analytical component

Sample size:

The sample population will be the 136 children who died in 2008.

Inclusion Criteria:

Children that died following treatment in the medical emergency service at RCWMCH within the study period 2008.

Exclusion Criteria

- Children that died who were admitted to the Red Cross War Memorial Children's Hospital via other areas e.g. Trauma Unit; directly into ICU from outside RCWMCH or surgical wards
- Children transferred from other hospital wards other than casualty/emergency rooms.
- All children who were 'Dead on Arrival' (DOA)

Data collection:

This is a secondary data analysis on a database compiled in 2008 at the MEU at the RCWMCH. The variables collected include:

Demographic data:

Age, gender, weight, nutritional status, HIV status

Clinical data:

Clinical presentation, ETAT information, vital signs, clinical diagnosis, pre-hospital and in-hospital treatment.

Time factors:

Time of admission, time to initiation of treatment, time to ward transfer.

Mortality data:

Cause(s) of death, time to death, time of death and place of death

Data Analysis:

The analysis will be done using Stata13v11 and will constitute descriptive and analytical components.

Numerical data

Summary descriptive statistics will be done on numerical data reporting either median and interquartile ranges of means with ranges as appropriate. Means/Median with interquartile ranges/ranges (IQR) of numerical data with either a paired t-test or a Wilcoxon ranksum test with 95% Confidence Intervals (CI) and p-values reported. A significance level of $p<0.05$ will be chosen.

Categorical data

Categorical data will be presented as proportions and chi-squared test performed between categorical data to look for association. The 95% CI and the p-values will be reported. A significance level of $p<0.05$ will be chosen.

Ethical considerations:

Risk-Benefit Ratio

The benefits of this study outweigh the risks.

This study is a minimum risk study as the personal data of patients will not be included in the study and there will be no direct contact with the participants.

The results will benefit the future management of patients presenting to the RCWMCH Medical Emergency Unit (MEU) by identifying the variables leading to mortality.

Independent Review

The research will be submitted for ethical review to the Human Research Ethics Committee (HREC) at the University of Cape Town.

Informed Consent

In view of the retrospective nature of the study, the Ethics committee will be approached to provide a waiver of individual consent. All information pertaining the patient's credentials are stored in a password protected computer and any other relevant data will be protected by the principal investigator to guarantee anonymity. The data sheets feature alphanumeric characters assigned to each patient to safeguard anonymity. Should the study be published in any form, all identifying information of the patients will be removed.

Confidentiality:

Data will be stored in a locked office on a password protected computer, with only the principal investigator having access to the data. Study numbers (but not names / folder numbers) will be entered on an electronic database for anonymous analysis and reporting.

Timetable

October 2018 Protocol completion and ethics submission

December 2018 - March2019 Data analysis

March-August 2019 Discussion and write up

October 2019 Publication submission

REFERENCES

1. Sachs JD. From Millennium Development Goals to Sustainable Development Goals. The Lancet. 2012;379:2206-11.

2. Le Blanc Dl. Towards integration at last? The Sustainable development goals as network of targets.pdf. DESA Working Paper March 2015.

3. United Nations. The Millennium Development Goals Report 2015. New York; 2015.

4. United Nations Children's Fund, World Health Organization, World Bank, Division UNP. Levels and trends in child mortality 2017 2017.

5. Fitzgerald E, Mlotha-Mitole R, Ciccone EJ, Tilly AE, Montijo JM, Lang H-J, et al. A pediatric death audit in a large referral hospital in Malawi. BMC Pediatrics. 2018;18(1):75-.

6. Adeboye MA, Ojuawo A, Ernest SK, Fadeyi A, Salisu OT. Mortality pattern within twenty-four hours of emergency paediatric admission in a resource-poor nation health facility. West African Journal of Medicine. 2010;29(4):249-52.

7. WHO. Paediatric emergency triage, assessment and treatment: Care of critically ill children 2016.

8. Liu L, Oza S, Hogan D, Chu Y, Perin J, Zhu J, et al. Global, regional, and national causes of under-5 mortality in 2000-15: an updated systematic analysis with implications for the Sustainable Development Goals. Lancet (London, England). 2016;388(10063):3027-35.

9. Collaborators GBDM. Global, regional, and national under-5 mortality, adult mortality, age-specific mortality, and life expectancy, 1970-2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet (London, England). 2017;390(10100):1084-150.

10. Mathers C, Stevens G, Hogan D, Mahanani WR, Ho J. Global and Regional Causes of Death: Patterns and Trends, 2000-15. In: Jamison DT, Gelband H, Horton S, Jha P, Laxminarayan R, et al., editors. Disease Control Priorities: Improving Health and Reducing Poverty. Washington (DC): The International Bank for Reconstruction and Development / The World Bank; 2017.

11. UNICEF, WHO, The World Bank, United Nations. Child Mortality Report 2012. 2012.

12. Ouma PO, Maina J, Thuranira PN, Macharia PM, Alegana VA, English M, et al. Access to emergency hospital care provided by the public sector in sub-Saharan Africa in 2015: a geocoded inventory and spatial analysis. The Lancet Global health. 2018;6(3):e342-e50.

13. Schoeps A, Gabrysch S, Niamba L, Sie A, Becher H. The effect of distance to health-care facilities on childhood mortality in rural Burkina Faso. Am J Epidemiol. 2011;173(5):492-8.

14. Shifa GT, Ahmed AA, Yalew AW. Maternal and child characteristics and health practices affecting under-five mortality: A matched case control study in Gamo Gofa Zone, Southern Ethiopia. PLoS One. 2018;13(8):e0202124.

15. Adekanmbi VT, Kandala NB, Stranges S, Uthman OA. Contextual socioeconomic factors associated with childhood mortality in Nigeria: a multilevel analysis. Journal of Epidemiology and Community Health. 2015;69(11):1102-8.

16. Maruthappu M, Watson RA, Watkins J, Zeltner T, Raine R, Atun R. Effects of economic downturns on child mortality: a global economic analysis, 1981-2010. BMJ Global Health. 2017;2(2):e000157-eG

17. McAllister DA, Liu L, Shi T, Chu Y, Reed C, Burrows J, et al. Global, regional, and national estimates of pneumonia morbidity and mortality in children younger than 5 years between 2000 and 2015: a systematic analysis. The Lancet Global Health. 2018;7(1):e47-e57.

18. Golding N, Burstein R, Longbottom J, Browne AJ, Fullman N, Osgood-Zimmerman A, et al. Mapping under-5 and neonatal mortality in Africa, 2000-15: a baseline analysis for the Sustainable Development Goals. Lancet (London, England). 2017;390(10108):2171-82.

19. Adedini SA, Odimegwu C, Bamiwuye O, Fadeyibi O, De Wet N. Barriers to accessing health care in Nigeria: implications for child survival. Global Health Action. 2014;7:23499.

20. Forshaw J, Gerver SM, Gill M, Cooper E, Manikam L, Ward H. The global effect of maternal education on complete childhood vaccination: a systematic review and meta-analysis. BMC Infectious Diseases. 2017;17(1):801-.

21. Chadoka-Mutanda N, Odimegwu CO. Maternal health-seeking behaviour and under five mortality in Zimbabwe. Journal of Biosocial Science. 2017;49(3):408-21.

22. Karra M, Fink G, Canning D. Facility distance and child mortality: a multi-country study of health facility access, service utilization, and child health outcomes. International Journal of Epidemiology. 2017;46(3):817-26.

23. Irimu GW, Gathara D, Zurovac D, Kihara H, Maina C, Mwangi J, et al. Performance of health workers in the management of seriously sick children at a Kenyan tertiary hospital: before and after a training intervention. PLoS One. 2012;7(7):e39964.

24. Hategeka C, Mwai L, Tuyisenge L. Implementing the Emergency Triage, Assessment and Treatment plus admission care (ETAT+) clinical practice guidelines to improve quality of hospital care in Rwandan district hospitals: healthcare workers' perspectives on relevance and challenges. BMC Health Services Research. 2017;17(1):256.

25. Balamuth F, Weiss SL, Fitzgerald JC, Hayes K, Centkowski S, Chilutti M, et al. Protocolized treatment is associated with decreased organ dysfunction in pediatric severe sepsis. Pediatric critical care medicine : a Journal of the Society of Critical Care Medicine and the World Federation of Pediatric Intensive and Critical Care Societies. 2016;17(9):817-22.

26. Oliveira CF, Nogueira de Sa FR, Oliveira DS, Gottschald AF, Moura JD, Shibata AR, et al. Time- and fluid-sensitive resuscitation for hemodynamic support of children in septic shock: barriers to the implementation of the American College of Critical Care Medicine/Pediatric Advanced Life Support Guidelines in a pediatric intensive care unit in a developing world. Pediatric Emergency Care. 2008;24(12):810-5.

27. Yaya S, Ekholuenetale M, Tudeme G, Vaibhav S, Bishwajit G, Kadio B. Prevalence and determinants of childhood mortality in Nigeria. BMC Public Health. 2017;17(1):485.

28. Adekanmbi VT, Kandala NB, Stranges S, Uthman OA. Factors that predict differences in childhood mortality in Nigerian communities: A prognostic model. J Pediatr. 2016;168:144-50.e1.

29. Okonkwo ACU. Determinants of under-5 mortality in Nigeria: and application of cox proportional hazard and cox frailty models.pdf. IOSR Journal of Mathematics. 2015;11(4):42-6.

30. Kerber KJ, Lawn JE, Johnson LF, Mahy M, Dorrington RE, Phillips H, et al. South African child deaths 1990–2011: have HIV services reversed the trend enough to meet Millennium Development Goal 4? AIDS. 2013;27(16):2637-48.

31. Nannan NDR, ; Laubscher R.; Zinyakatira N.; Prinsloo M.; Darikwa T.; Matzopoulos R.; Bradshaw D. Under-5 Mortlaity Statistics in South Africa: Shedding some light on the trends and causes: 1997-2007. Burden of disease research unit; 2012.

32. Bamford L, McKerrow N, Barron P, Aung Y. Child mortality in South Africa: Fewer deaths, but better data are needed. S Afr Med J. 2018;108(3):25-32.

33. He Z, Bishwajit G, Zou D, Yaya S, Cheng Z, Zhou Y. Burden of common childhood diseases in relation to improved water, sanitation and hygiene (WASH) among Nigerian Children. International Journal of Environmental Research and Public Health. 2018;15(6):1241.

34. Yaya S, Hudani A, Udenigwe O, Shah V, Ekholuenetale M, Bishwajit G. Improving water, sanitation and hygiene practices, and housing quality to prevent diarrhoea among under-five children in Nigeria. Tropical Medicine and Infectious Diseases. 2018;3(2).

35. McKerrow N SH, Bamford L, et al. 3rd Triennial Report of the Committee on Morbidity and Mortality in Children Under 5 Years (CoMMiC). Pretoria: CoMMiC, 2017 : 1-316. Pretoria, South Africa: Committee on Morbidity and Mortality in Children Under 5 Years. ; 2017.

36. R.D. Wannamanda, Ahmadu Bello University Teaching Hospital, Zaria, Nigeria; F.U.Ali. Risk of death within 24 hrs of admission Dev countries. Annals of African Medicine. 2004;3(No. 3):134-7.

37. Crouse HL, Torres F, Vaides H, Walsh MT, Ishigami EM, Cruz AT, et al. Impact of an Emergency Triage Assessment and Treatment (ETAT)-based triage process in the paediatric emergency department of a Guatemalan public hospital. Paediatr Int Child Health. 2016;36(3):219-24.

38. Molyneux E, Ahmad S, Robertson A. Improved triage and emergency care for children reduces inpatient mortality in a resource-constrained setting. Bulletin of the World Health Organization. 2006;84(4):314-9.

39. Buys H, Muloiwa R, Westwood C, Richardson D, Cheema B, Westwood A. An adapted triage tool (ETAT) at Red Cross War Memorial Children's Hospital Medical Emergency Unit, Cape Town: an evaluation. S Afr Med J. 2012;103(3):161-5.

40. Nkonki LL, Chopra M, Doherty TM, Jackson D, Robberstad. Explaining household socio-economic related child health inequalities using multiple methods in three diverse settings in South Africa. 2011;10(1):13. http://www.equityhealthj.com/content/10/1/13

41. Venkatesh KK, de Bruyn G, Marinda E, Otwombe K, van Niekerk R, Urban M, et al. Morbidity and mortality among infants born to HIV-infected women in South Africa: implications for child health in resource-limited settings. J Trop Pediatr. 2011;57(2):109-19.

42. Tlou B, Sartorius B, Tanser F. Investigating risk factors for under-five mortality in an HIV hyper-endemic area of rural South Africa, from 2000-2014. PloS One. 2018;13(11):e0207294-e.

43. Akombi BJ, Agho KE, Merom D, Renzaho AM, Hall JJ. Child malnutrition in sub-Saharan Africa: A meta-analysis of demographic and health surveys (2006-2016). PLoS One. 2017;12(5):e0177338.

44. UNICEF WHO. WHO growth standards and odds of death with malnutrition. 2009.

45. Acevedo P, Garcia Esteban MT, Lopez-Ejeda N, Gomez A, Marrodan MD. Influence of malnutrition upon all-cause mortality among children in Swaziland. Endocrinologia, diabetes y nutricion. 2017;64(4):204-10.

46. Kanyuka M, Ndawala J, Mleme T, Chisesa L, Makwemba M, Amouzou A, et al. Malawi and Millennium Development Goal 4: a countdown to 2015 country case study. Lancet Glob Health. 2016;4(3):e201-14.

47. Schneider E WS, M. Kathleen Glynn M, Dominguez K, Mitsch A. and T. McKenna M.T. Revised Surveillance Case Definitions for HIV Infection Among Adults, Adolescents, and Children Aged <18 Months and for HIV Infection and AIDS Among Children Aged 18 Months to <13 Years — United States, 2008. Centers for Disease Control & Prevention (CDC); 2008 December 5, 2008. Contract No.: 10.

48. Harris C, Mills R, Seager E, Blackstock S, Hiwa T, Pumphrey J, et al. Paediatric deaths in a tertiary government hospital setting, Malawi. Paediatrics and International Child Health. 2018:1-9.

49. Jin Y, Mankadi PM, Rigotti JI, Cha S. Cause-specific child mortality performance and contributions to all-cause child mortality, and number of child lives saved during the Millennium Development Goals era: a country-level analysis. Global Health Action. 2018;11(1):1546095-.

51. Groenewald P, Neethling I, Evans J, Azevedo V, Naledi T, Matzopoulos R, et al. Mortality trends in the City of Cape Town between 2001 and 2013: Reducing inequities in health. South African Medical Journal. 2017;107(12):1091-8. doi: 10.7196/SAMJ.2017.v107i12.12458. PubMed PMID: 29262963.

Appendix 3: Data collection sheet

Study title: Patterns of mortality in children presenting to a tertiary paediatric emergency unit in Sub-Saharan Africa: a cross sectional study

Biographical information

Study number				
Folder number				
Date of birth				
Gender	MALE		FEMALE	
Date of arrival				
Time of arrival (triage)				
Date of death				
Time of death				
Triage form Y/N	Yes		No	
Triage Colour: Red/Orange/Green/Nil	Red	Orange	Green	Nil
Chief presenting problem if not RED (taken from triage form where available)				
	Tiny tot (<2 months)			
	Temperature			
	Trauma/surgical			

	Severe palmar pallor (Hb<5)	
	Poisoning (overdose)	
	Pain (severe)	
	Respiratory distress	
	Restless/irritable	
	Referral (urgent)	
	Malnutrition (visible severe wasting)	
	Oedema	
	Burns	
	Some dehydration (1 of 3 signs)	
	Unable to drink/feed OR vomits everything	
	Tender swelling behind ear	
	Mouth ulcers (severe)	
	Measles(complicated)	
	Nil (No triage form)	
	Other-specify	
	Nil specified	
Chief presenting problem RED (taken from triage form where available)	RED CATEGORY SYMPTOMS	

	Airway and Breathing	
	Circulation	
	Coma	
	Convulsions	
	Dehydration and Diarrhoea	
	Other	
	Taken to emergency room (no paper triage or triage form not filled)	
Presenting illness diagnosis(ICD 10)		
Underlying diagnosis(specify)		
Other co-morbid illnesses(specify)	1.	
	2.	
	3.	
	4.	

Clinical parameters on arrival:		
Time into ER:	Time out of ER/died:	
Transfer to :	Ward:	
Temperature in ^{o}C(axillary)		

Weight (Kg):			
Airway and Breathing:			
- Spontaneous respiration	Y	N	
- Arrived intubated	Y	N	
- Has tracheostomy	Y	N	
- RR (tachypnoea for age)			
- Sats < 92% in RA (hypoxia)			
- Stridor	Y	N	
- Wheeze	Y	N	
- Arrival saturation (%)			
- Departure saturation			
- needs more than NPO_2 to keep sats>92%	Y	N	
Circulation:			
- Cardiac arrest	Y	N	
- Admission tachycardia for age	Y	N	
- Admission bradycardia for age	Y	N	
- HR on arrival			
- HR on departure			
- CFT >2s	Y	N	
- Weak/feeble pulses	Y	N	
- Cold/mottled hands and/or feet	Y	N	

Level of Consciousness (AVPU):			
- Alert (A)			
- Lethargic(V)			
- Altered LOC			
- Coma (P, U)			
- Pupils fixed and dilated			
- Pupils pinpoint			
Convulsions:			
- Currently	Y	N	
- Immediately postictal	Y	N	
Confusion:	Y	N	
Dehydration and diarrhoea	Y	N	
- Lethargy			
- Sunken fontanelle			
- Slow skin pinch			
Laboratory results:			
pH (<7.25)			
Base deficit (>5 mmol/l)			
Lactate (>3mmol/l)			

Blood glucose <3mmol/l					
Positive blood culture(72h)	Y	N			
Organism grown					
Meningitis on CSF	Y	N			
HIV status (anytime during admission)	Exposed		Pos	Neg	Unknown
Treatment given at referral facility:(taken from referral letter)					
Oxygen	Y	N			
Intubated	Y	N			
Plasma expander bolus	Y	N	Volume:		
CPR	Y	N			
Antibiotic	Y	N	*Name:*		
Blood glucose checked	Y	N			
Anticonvulsant	Y	N			
Other (specify)					
Child referred	Y	N			
Telephonic warning	Y			N	
Referred from where				N/A	
Transport used					

1274

Therapy/resuscitation events in ER **(taken from case notes)**			
Airway and Breathing			
Arrived intubated but ETT dislodged	Y		N
Intubated in emergency room	Y	N	N/A
Given oxygen	Y		N
Sats monitored	Y		N
Saturation on	Admission:		Discharge:
Given nebulised adrenaline	Y	N	N/A
Given nebulised bronchodilator	Y	N	N/A
NCPAP	Y	N	N/A
IPPV	Y	N	N/A
CXR done	Y	N	N/A
Circulation			
External cardiac compressions	Y	N	N/A
HR monitored	Y		N
HR on	Admission		Discharge
BP monitored	Y		N
BP on	Admission		Discharge
IV line in situ on arrival	Y		N
IV line inserted ER	Y		N

IO line on arrival	Y		N	
IO line inserted in ER	Y		N	
Fluid bolus given(20ml/kg)	0	<20ml/kg	20-30ml/kg	31-40ml/kg
Fluid bolus>60ml/kg	Y		N	
Inotropes started	Y	N	N/A	
Disability				
Antibiotics given before arrival	Y		N	
Antibiotic given in MEU	Y		N	
Time antibiotics given(MEU)	Y		N	
Blood glucose done	Y		N	
Blood glucose <3 mmol/l	Y		N	
Other drugs: (Y/N)	Activated charcoal			
	Adrenaline			
	Anticonvulsants			
	Bronchodilators			
	IV steroids			
	Mannitol			
	Calcium			

	Oral KCL	
	Sodabic	
	Other-specify	

1275

1276

Cause of Death if known-ICD-10 (list compiled from CHIP Causes of death list v2.0 Appendix 2-Code Lists 2007)		
	Acute diarrhoea, hypovolaemic shock	
	Acute respiratory infection	
	Aspiration of gastric contents or foreign body	
	Asthma	
	Cardiomyopathy	
	Cirrhosis, portal hypertension, liver failure	
	Complex congenital heart problem	
	Drowning	
	Meningitis	
	Myocarditis	

	Paraffin inhalation	
	Poisoning	
	Septicaemia	
	Status epilepticus	
	Severe malnutrition	
	HIV related disease	
	Surgical (acute abdomen)	
	Tuberculosis	
	Other-specify	

1277