Demographics and predictors of mortality in children undergoing resuscitation at Khayelitsha Hospital, Western Cape, South Africa

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Background. The clinical outcomes of paediatric patients requiring resuscitation depend on physicians with specialised knowledge, equipment and resources owing to their unique anatomy, physiology and pathology. Khayelitsha Hospital (KH) is a government hospital located near Cape Town, South Africa, that sees ~44 000 casualty unit patients per year and regularly functions at more than 130% of the bed occupancy. Many of these patients are children requiring resuscitation.
Objectives. We sought to describe characteristics of children under the age of 12 who required resuscitation upon presentation to KH, determine predictors of mortality, and compare paediatric volume to specialist physician presence in the unit.
Methods. A retrospective chart review was performed on patients younger than 12 years who were treated in the resuscitation area of KH during the six-month period from 1 November 2014 to 30 April 2015.
Results. A total 317 patients were enrolled in the study with a median age of 14 months. The top 5 diagnoses were: pneumonia (n=58/317); neonatal sepsis (n=40/317); seizures (n=37/317); polytrauma (n=32/317); and acute gastroenteritis complicated by septic shock (n=28/317). Overall mortality was 7% (n=21/317) and mortality in children less than 1 month of age was 12% (n=5/42). Premature birth was associated with a mortality odds ratio of 8.44 (p=0.002). More than two-thirds (73%; n=231/317) of paediatric resuscitations occurred when specialist physicians were not physically present in the unit.
Conclusion. The study findings indicate that children under one month of age with a history of prematurity are at high risk and may benefit most from paediatric-specific expertise and rapid transfer to a higher level of care.

The clinical outcomes of paediatric patients requiring resuscitation depend on physicians with specialised knowledge, equipment and resources owing to their unique anatomy, physiology, and pathology. These patients have the greatest quality-life years at risk compared with the general patient population. Inadequate management of paediatric patients could have a severe, long-lasting and possibly disabling effect on the future of this vulnerable group. In many clinical settings across SA, this specialised knowledge, equipment and resources can be severely limited, which may adversely affect the outcomes of paediatric patients.

In the present study, we sought to describe the demographics and clinical course of a cohort of paediatric patients who required resuscitation in an emergency centre located in a resource-limited setting. Additionally, we analysed the data for predictors of mortality that could be identified early in care, allowing patients to be transferred to tertiary centres more quickly after entering the health system.

Khayelitsha Hospital (KH) is located in Khayelitsha, a township ~32 km from the central business district of Cape Town, SA. In the past two decades, the population of Khayelitsha has increased by 700 000 to more than 1.5 million residents, making it the largest township in the Western Cape Province of SA.[1,2] The area is marked largely by informal settlements, high unemployment and widespread poverty.

The community infrastructure of Khayelitsha was not designed to accommodate the influx of new residents it continues to receive. As a result, many live in unsanitary, unsafe and unstable conditions with more than half of the households lacking access to running water, and 89% of the population being recognised as moderately or severely food-insecure.[3] In addition to rampant poverty, Khayelitsha has a high prevalence of chronic diseases. Although the prevalence of HIV remains unknown in children living in Khayelitsha, it is estimated that there are 260 000 new paediatric infections in low- and middle-income countries every year, including SA.[4] Meanwhile, the incidence of tuberculosis in Khayelitsha is 1 389 per 100 000, compared with a national incidence of 834 per 100 000.[5]

A subset of this demographic that is particularly vulnerable is the paediatric population.[6] Among SA children younger than 5 years, 27% are stunted, 12% are underweight, and 5% are wasted.[7] Malnourished and undernourished children are more susceptible to death and serious infection,[8] which is demonstrated by the fact that 60% of children with tuberculosis worldwide were also found to be underweight.[5] In another study, paediatric mortality rates from lower respiratory tract infections (LRTIs) in HIV-positive children were seven times greater than in HIV-negative children with LRTIs.[9] This is even more troubling considering that one-third of SA children were failing antiretroviral therapy.[10] Such high levels of undernutrition, HIV, tuberculosis and treatment failure all complicate the landscape of paediatric care in Khayelitsha.

To combat the growing population and increasing disease burden, KH was constructed in 2012. It is one of the two district hospitals built by the province in the last 40 years, demonstrating the shortage of resources faced by this province.[10] Today, KH is recognised as

one of the most overburdened hospitals in the Western Cape, with an average bed occupancy rate of 131% of its capacity.[11] This 47-bed emergency centre sees a regular influx of more than 120 patients daily, many of whom are treated for life-threatening conditions.[11] Children comprise 40% of the population of Khayelitsha and represent a substantial proportion of those receiving emergency care at KH.[12]

The diverse paediatric burden of disease seen at KH Emergency Centre, to our knowledge, has not been adequately characterised. The barriers to care in a resource-poor community, as well as an emergency centre that is overrun and under-staffed, compound complications in dealing with the spectrum of paediatric disease. KH has two paid emergency medicine consultants on staff, with the majority of care provided by registrars, medical officers or community service medical officers.

Methods

A retrospective cohort study was performed on all patients who were treated in the resuscitation area of the KH emergency centre between 1 November 2014 and 30 April 2015, and who were ≤12 years old at the time of hospital admission. Study subjects were identified by a review of the resuscitation area logs and raw data prepared by the physicians who originally cared for the patients. Admission to the KH resuscitation area depends on the triage colour assigned to the patient, which is determined by the severity of their presenting illness, stability of their vital signs, and other clinical signs and symptoms. The most severe triage category assigned to patients is *Red*, which automatically necessitates their admission into the resuscitation area. Additionally, the physician may refer any patient assigned Orange, Yellow, or Green to the resuscitation area based on their clinical judgement. Exclusion criteria for participation in the study included patients with medical records recognised as being totally incomplete. Patients with partially missing data were included in the database but were excluded from analyses involving the specific aspect of missing data.

Six medical students performed the data collection. Beforehand, they were trained in identifying and collecting the relevant data points from clinical records and in entering it into data collection sheets. The students were blinded to the study purpose until after data collection had been completed. The following data were collected:

- general demographics (age, sex)
- mode of transport to hospital (Emergency Medical Services, self (family), other
- referral method (clinic, self (family), other)
- triage category assigned at admission: red, orange, yellow, green
- laboratory work performed in the resuscitation area, often including, but not limited to, complete blood count and basic metabolic panel
- existing known co-morbidities: prematurity defined as birth at <37 weeks' gestation; congenital cardiac anomalies; HIV status as documented in medical records; HIV exposure; TB status as documented in medical records; failure to thrive; and acute malnutrition defined as weight-for-height Z-score (WHZ) <−2 standard deviations of the WHO growth chart mean
- diagnosis determined during hospital admission
- final disposition: transfer to higher level of care to Tygerberg Hospital (TBH), KH Department of Paediatrics, Red Cross War Memorial Children's Hospital (RCWMCH), KH ICU, or discharged to home
- mortality secondary to medical diagnosis at time of presentation to KH.

The above data were entered into a Microsoft Excel spreadsheet by the data collectors while they were physically present at KH. All identifying information was removed and unique study numbers were assigned. The de-identified data were then sent to the USA where they were imported into a REDCap database for analysis.

The study protocol was approved by the Health Research Ethics Committee of Stellenbosch University (ref. no. N14/08/102) and by the Colorado Multiple Institutional Review Board (ref. no. 15-2238).

Results

A total of 325 patients met the inclusion criteria during the 6-month period of study (Table 1). Eight of these had no medical records available, leaving 317 for analysis; 57.4% (*n*=182/317) were male. The median age was 14 months; 13.2% (*n*=42/317) of the patients were less than 2 months old. The distribution of ages was: 13.6% (*n*=43/317) <1 month; 34.7% (*n*=110/317) >1 - <12 months; 35.0% (*n*=111/317) >12 months - <5 years; and 16.7% (*n*=53/317) >5 - <12 years of age.

Of the children presenting at the KH resuscitation bay, 63.7% (*n*=202/317) were assigned an initial triage category of red, 18.0% (*n*=57/317) were orange, 8.5% (*n*=27/317) were yellow, and 9.8% (*n*=31/317) were green. TBH functions as both the secondary and tertiary referral hospital for patients at KH and patients who were not accommodated at TBH were referred to RCWMCH (Table 2).

The mortality statistics for the 317 patients were obtained from a provincial database and are shown in Table 3. Mortality shown here but not reflected in Table 2 results from patients who were alive when transferred or discharged from KH but ultimately died at the receiving hospital as a result of their presenting illness.

Diagnoses of the 21 deceased patients were as follows: neonatal sepsis (*n*=5/21); pneumonia (*n*=5/21); acute gastroenteritis (*n*=4/21); polytrauma (*n*=2/21); acute respiratory distress syndrome (*n*=2/21); septic shock (*n*=2/21); and unspecified (*n*=1/21).

Predictors of mortality were calculated using the patient parameters collected in their medical record (Table 4). Comorbidities were determined from diagnoses of the treating physicians documented in the medical record. For continuous variables, an inter-quartile range was calculated; however, none reached statistical significance (Table 5).

The presence of a consultant emergency physician in the emergency centre was compared with paediatric resuscitation volume (Fig. 1). The standard of practice at KH is to have consultant emergency physicians present from 08h00 - 16h00 on weekdays and 08h00 - 11h00 on weekends. Beyond these hours, they are available telephonically and will come in if necessary. Based on these parameters, it was determined that 73% (*n*=231/317) of patients presented after hours, when a consultant emergency physician was not physically present at KH.

Discussion

Over a 6-month period, there were 317 paediatric resuscitations in the Emergency Centre at Khayelitsha Hospital, equating to roughly 1.7 paediatric resuscitations per day. Here we discuss the distribution of age, common diagnoses, dispositions, and predictors of mortality in these critically ill children.

Among all paediatric resuscitation patients, 48.3% (*n*=153/317) were under one year of age, with a mortality of 85 per 1 000 live births (*n*=13/153). The remaining 51.7% (*n*=164/317) of paediatric resuscitations were between the ages of 1 and 12 years with a mortality rate of 49 per 1 000 live births (*n*=8/164). The younger age group represents a phase of life where paediatric anatomy and pathophysiology differs the most from adult anatomy and pathophysiology. Resuscitation of patients in this age group requires specialised training and equipment, whereas older patients more closely resemble adult anatomy and physiology.

Sepsis was the most common diagnosis among paediatric patients who were less than 1 month old, while pneumonia was the most

Table 1. Diagnoses by age group

Diagnosis	Age group			
	<2 months	2 months - 2 years	2 - 12 years	Total
Pneumonia	0	54	4	58
Neonatal sepsis	39	1	0	40
Seizures	1	7	29	37
Polytrauma	0	1	31	32
AGE in shock	0	21	7	28
AGE unspecified volume status	0	20	3	23
AGE 10% weight loss	1	13	1	15
Respiratory distress	0	4	8	12
Fracture/dislocation	0	0	11	11
Asthma exacerbation	0	2	8	10
Burn	0	7	2	9
AGE 5% weight loss	0	6	1	7
Drug toxicity	0	1	6	7
Croup	0	5	1	6
Other	0	0	6	6
Shock	0	1	2	3
Animal bite	0	0	2	2
Head injury	0	1	1	2
Hypoglycaemia	0	1	1	2
Meningitis	0	1	1	2
Diabetic ketoacidosis	0	0	1	1
Laceration	0	1	0	1
Bowel obstruction	1	0	0	1
Pneumothorax	0	1	0	1
Varicella	0	1	0	1

AGE = acute gastroenteritis.

Table 2. Disposition by age group

	Age			
	<2 months	2 months - 2 years	2 - 12 years	Total
Transferred to TBH	22	67	45	134
Admitted to KH Paeds	10	40	18	68
Discharged	1	22	38	61
Transferred to RCWMCH	2	4	17	23
Admitted to KH ICU	7	11	4	22
Not specified	0	1	4	5
Deceased in KH ED	0	4	0	4

TBH = Tygerberg Hospital; KH = Khayelitsha Hospital, Paeds = Department of Paediatrics; RCWMCH = Red Cross War Memorial Children's Hospital; ICU = intensive care unit; ED = Emergency Department.

Table 3. Mortality by age group

	Age group			
	<2 months	2 months - 2 years	2 - 12 years	Total
Living (*n*)	37	139	120	296
Deceased (*n*)	5	10	6	21
Mortality rate (%)	12	7	5	7

common diagnosis for all age groups more than one year old. Of note, if all categories of acute gastroenteritis are merged together, it becomes the most common diagnosis in the 1-year to 12-year age group. This finding is similar to a study performed at a secondary hospital in the central business district of Cape Town where gastroenteritis was the leading diagnosis for children presenting for care.[11] Gastroenteritis represents a substantial burden of disease and typically comes in seasonal waves with marked increases during the warm months. The present study was conducted over a period of 6 months, mostly during the warm months. The calculated incidence

Table 4. Odds ratio of death for comorbid diagnoses

	OR	CI	*p*-value
Premature birth	8.44	2.47 - 28.81	0.002
Cardiac abnormalities	2.67	0.14 - 51.94	1
Chest pain	4.96	0.23 - 104.9	1
Failure to thrive	0.94	0.05 - 17.10	1
HIV	0.44	0.05 - 3.80	0.401
Mode of transport	0.93	0.38 - 2.29	1
Protein energy malnutrition	9.29	0.92 - 94.20	0.14

OR = odds ratio; CI = confidence interval.

Table 5. Selected laboratory values in paediatric patients managed within the resuscitation area of Khayelitsha Hospital

	Survivors, median (IQR)	Non-survivors, median (IQR)
Haemoglobin (g/dL)	11.1 (10.1 - 12.1)	11.5 (9.0 - 14.0)
Potassium (mEq/L)	4.1 (3.5 - 4.7)	5.1 (4.3 - 5.6)
Sodium (mEq/L)	137 (134 - 139)	133 (129 - 139)

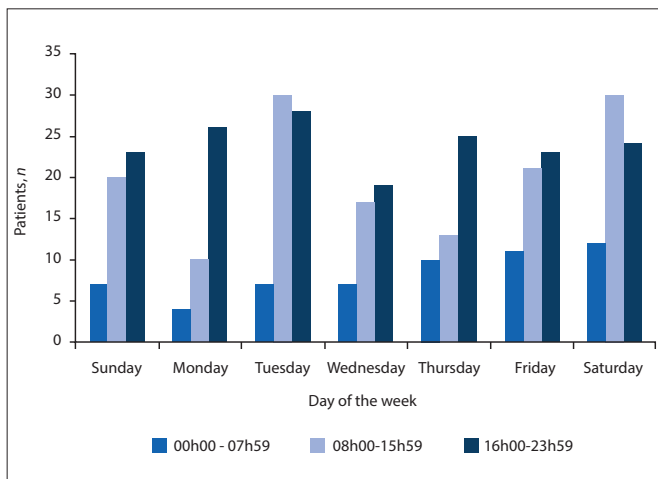IQR = interquartile range.

Fig. 1. Paediatric resuscitation volume by 8-hour block time of presentation.

of acute gastroenteritis-related paediatric resuscitations during this study period may be higher than it is during other months of the year.

Overall, the rate of transfer for paediatric resuscitation patients to a higher level of care was 80.2% (*n*=247/308), with children of less than one month of age having the highest rate of transfer of 97.6% (*n*=41/42). There was a clear trend in decreasing rates of transfer with increasing age, suggesting that physicians were more comfortable treating older patients and more likely to transfer younger patients. This finding may reflect an apparent gap in training, familiarity or exposure in treating younger patients. We did not seek to assess if these referrals were appropriate or if patients who should have been referred were not.

In our study population, the under one-year mortality rate was 85 per 1 000 live births (*n*=13/153), while the 2013 Western Cape mortality rate was 21 per 1 000 live births and the SA national rate was 65 per 1 000 live births.[13] Similarly, in our study population, the under-5 mortality rate was 71 per 1 000 live births (*n*=19/268), while the 2013 Western Cape mortality rate was 15 per 1 000 live births and the national rate was 50 per 1 000 live births.[13] This comparison demonstrates that the mortality rate of the population in our study was substantially higher than the provincial and national figures for the same groups. Our study population included only children in the resuscitation area, while the comparison population included all

in-facility deaths, biasing our data toward a higher mortality rate. The extent of this bias is unknown.

The cause of death for the 21 patients at KH align with the national statistics for under-5 deaths, but there are too few deaths in this study population to discern if one particular group is over- or under-represented.[14]

Numerous potential predictors of mortality were investigated, with only one reaching statistical significance. Children under one month of age with a history of prematurity had an odds ratio of death of 8.44 and a resultant mortality rate of 12%. In low-income settings, half of children born before 32 weeks' gestation die, often due to a lack of feasible and cost-effective interventions, making premature children a particularly high-risk/high-reward group.[15] Immediate recognition of this group's high risk of mortality and high likelihood of transfer to a higher level of care by providers is critical. Protocols for early transfer of these patients to a higher level of care exist at KH but are not well known or applied. Clarifying and applying these protocols may decrease the mortality in this group and warrants further investigation.

More than two-thirds (73%; *n*=231/317) of patients in this study presented after hours. This finding is similar to another study of Emergency Department volume and case mix conducted in Cape Town where the majority of paediatric presentations occurred between 16h00 and 00h01.[16] With decreased coverage by more experienced providers during these hours, the specialty knowledge of paediatric anatomy and physiology may be diminished.

The International Federation for Emergency Medicine Paediatrics Standards of Care Document[17] states that it is essential that all providers receive training and understand the differences in paediatric presentations compared with adult presentations. With less experienced providers scheduled to work during peak periods of paediatric resuscitation volume, it is less likely that these providers have the experience and 'comfort' resuscitating children compared with more senior providers. Alignment of the presence of more experienced providers with the time periods of high paediatric resuscitation volumes should be considered, but is understandably multifactorial.

Study limitations
As with any retrospective chart review, this study had limitations. Specific potential biases identified in this study include selection bias and misclassification bias. By including only patients identified as requiring resuscitation, we would have missed patients who were

indeed resuscitated but were not labelled as such in the medical record. A standardised data abstraction tool was utilised to minimise the effect of misclassification bias. A type II error was possible as we investigated a variety of variables for correlation with mortality. particularly A sample size appropriate to detect a difference in one variable may not be an adequate sample size to detect a difference in another variable.

Conclusion

This review of paediatric resuscitation characteristics at KH provides important information about the common diagnoses, patient dispositions, mortality rates, predictors of mortality, and temporal patterns of resuscitation volume. The mortality rate for all children undergoing resuscitation at KH was 7% (n=21/317), with 12% (n=5/37) of children under the age of 1 month dying. Premature birth as a comorbidity was associated with an odds ratio of 8.44 for death. These two findings indicate that children under 1 month of age, with a history of prematurity, are at high risk and may benefit most from paediatrics-specific expertise and rapid transfer to a higher level of care.

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