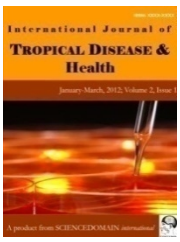

International Journal of TROPICAL DISEASE & Health
4(4): 444-456, 2014

SCIENCEDOMAIN *international*
www.sciencedomain.org

Characteristics of and Risk Factors for Early Pediatric Mortality at Zomba Central Hospital, Malawi

M. Landes[1,2*], L. M. Puchalski Ritchie[2,3], S. Berman[2], F. Chiwaya Banda[4] and M. Joshua[4]

[1]Department of Family and Community Medicine, University of Toronto, Toronto, ON, Canada.
[2]University Health Network, Toronto, ON, Canada.
[3]Department of Medicine, University of Toronto, Toronto, ON, Canada.
[4]Ministry of Health Malawi, Zomba, Malawi.

Authors' contributions

Authors ML, LMPR and FCB were responsible for the study design. Author FCB supervised the data collection. Author ML analyzed the data. Authors ML, LMPR and SB were responsible for drafting the manuscript. All authors participated in critical revision of the manuscript, read and approved the final manuscript.

Original Research Article

Received 30th September 2013
Accepted 19th December 2013
Published 18th February 2014

ABSTRACT

Background: Pediatric mortality rates are high throughout sub-Saharan Africa with most deaths occurring within 48 hours of admission to hospital. Early identification and treatment of at risk children is essential to improve outcomes, however, few studies have identified disease specific risk factors for early mortality.
Study Aims: To identify risk factors for early pediatric mortality and to explore areas for improvement in diagnostic and treatment practices.
Study Design: Case-control study of patients admitted to the pediatrics ward of Zomba Central Hospital, Malawi.
Methodology: Cases included all pediatric deaths over a four-month period in 2010 occurring within 48 hours of admission with a diagnosis among the four most common causes of death (malaria, pneumonia, diarrhea/dehydration, meningitis or measles given

**Corresponding author: Email: mlandes.md@gmail.com;*

a large outbreak during the study period). Controls included children admitted during the same period, with a discharge diagnosis among the same 5 diagnoses, who survived to at least 72 hours.
Analysis: Associations between mortality and clinical characteristics were assessed using STATA 11.0.
Results: Overall, 142 cases and 162 controls were included. 62.7% of deaths occurred within 12 hours with malaria the most common diagnosis in both groups. Clinical characteristics on presentation associated with death included: symptoms/signs of respiratory distress (OR1.9, 95% CI 1.0-3.4, p=0.04), low Blantyre Coma Score (OR 3.4, 95% CI 2.1-5.6, p<0.01), age under 5 (OR 3.2, 95% CI 1.1-9.3, p=0.03) and pallor among malaria cases (OR2.2, 95% CI 1.8-6.6), p<0.01). Areas identified for quality improvement included delay in initial investigations and initiation of treatment both prior to transfer to and after admission to the district hospital.
Conclusion: Improvements in the identification of children at risk for early mortality are critical to reducing mortality through early intervention.

Keywords: Early mortality; pediatric; in-hospital; risk factors; clinical characteristics.

1. INTRODUCTION

The fourth United Nations Millennium Development Goal, to reduce under-5 mortality by two thirds by 2015, remains a significant global challenge. Improving medical care at health facilities in low-resource settings is an important component of this effort. In sub-Saharan Africa, most in-hospital pediatric mortality occurs within 48 hours of admission suggesting that children are presenting in critically ill states [1,2]. Additionally, preventable and treatable diseases, such as malaria, pneumonia and diarrhea, comprise the most common causes of under-5 mortality [1,3-5].

Several training programs and clinical guidelines for the treatment of the critically ill child in low-resource settings have been developed, including the Emergency Triage Assessment and Treatment (ETAT) and the WHO Integrated Management of Childhood Illness (IMCI) [6,7]. Appropriate adoption of these guidelines has been shown to improve care for critically ill children and reduce in-hospital mortality [6,8].

In Malawi, under-5 mortality is estimated at 112 deaths per 1,000 live births [9]. In the region, several studies identify disease specific prognostic factors for mortality for severe malaria and sepsis [10,11]as well as clinical indicators for immediate (<4 hours), early (<48 hours), and late mortality (>48 hours) [2,8]. However, information about the prevalence, characteristics of, and risk factors for pediatric in-hospital mortality occurring within 48 hours on presentation to care remains limited.

In order to improve identification of children at risk of early mortality in our setting, we conducted a case-control study to investigate the characteristics of and risk factors for early mortality (<48 hours) on the pediatrics ward at Zomba Central District Hospital (ZCH), Malawi. Additionally, we evaluated specific quality indicators in diagnostic and treatment practices for cases of early mortality in comparison to standard international practices in order to explore areas for quality improvement in care.

2. METHODOLOGY

2.1 Setting and Study Design

Zomba Central Hospital (ZCH) is a large hospital in the southeast zone of Malawi with 100,000 pediatric patients admitted each year from the surrounding urban and rural areas. Patients are admitted to the pediatrics ward (either as walk-ins or referrals from local health centers) through the outpatient pediatric clinic during business hours or directly to the ward after hours. All staff are trained in emergency triage and treatment via the WHO ETAT guidelines and patients are further treated as per the Malawi Ministry of Health guidelines for acutely ill children.

A case-control study was conducted over a 4-month period in 2010 to compare clinical, diagnostic and treatment characteristics of cases of 'early mortality' (death <48 hours after admission) to children surviving similar conditions.

2.2 Participants

Cases included all patients who died within the 4 month study period in 2010 at less than 48 hours after admission and had a diagnosis among the four most common causes of mortality (as per ZCH hospital discharge records reviewed from 2010): malaria, pneumonia, diarrhea/dehydration and meningitis. Additionally, given a large outbreak of measles during the time of study, we chose to include all measles deaths during the study period in the case definition.

Controls included a random sample of children admitted to the general pediatrics ward during the same time period with survival to at least 72 hours and a discharge diagnosis consistent with the same 5 diagnoses (as above). Potential cases/controls were excluded if time of death/discharge or death/discharge diagnosis was not recorded.

2.3 Data Extraction and Statistical Analysis

Each chart was reviewed by one of four medical officers trained as research assistants using a standardized data collection sheet. Variables of interest included: death or discharge diagnosis, time of death, age, route to ward, time of arrival to ward, distance from referral center, clinical characteristics at presentation, TB and HIV status, diagnostic tests and treatments ordered, test results, time of order and when order completed.

Data were entered into an excel spreadsheet and analyzed using STATA 11.0 (STATA Corp., College Station, TX). The distribution of variables across cases and controls were described using descriptive statistics and univariable analysis of categorical variables was done using Mantel-Haenszal Odds Ratiosto identify associations between mortality and variables of interest.

3. RESULTS

All 199 deaths on the general pediatric ward over the 4-month period were reviewed. Fifty-seven cases were excluded (Fig. 1) for the following reasons: 4 time of death not recorded, 35 deaths occurred after 48 hours, 15 no cause of death recorded, and 3 with death attributed to a cause outside of the 5 included diagnoses. Overall 142 deaths met all

inclusion criteria. 216 controls were reviewed of which 51 were excluded because of no final discharge diagnosis and 4 excluded because of a discharge diagnosis outside of the diagnosis of interest, leaving 161 controls. There was no difference in the categorization of diagnosis at discharge or death between cases and controls.

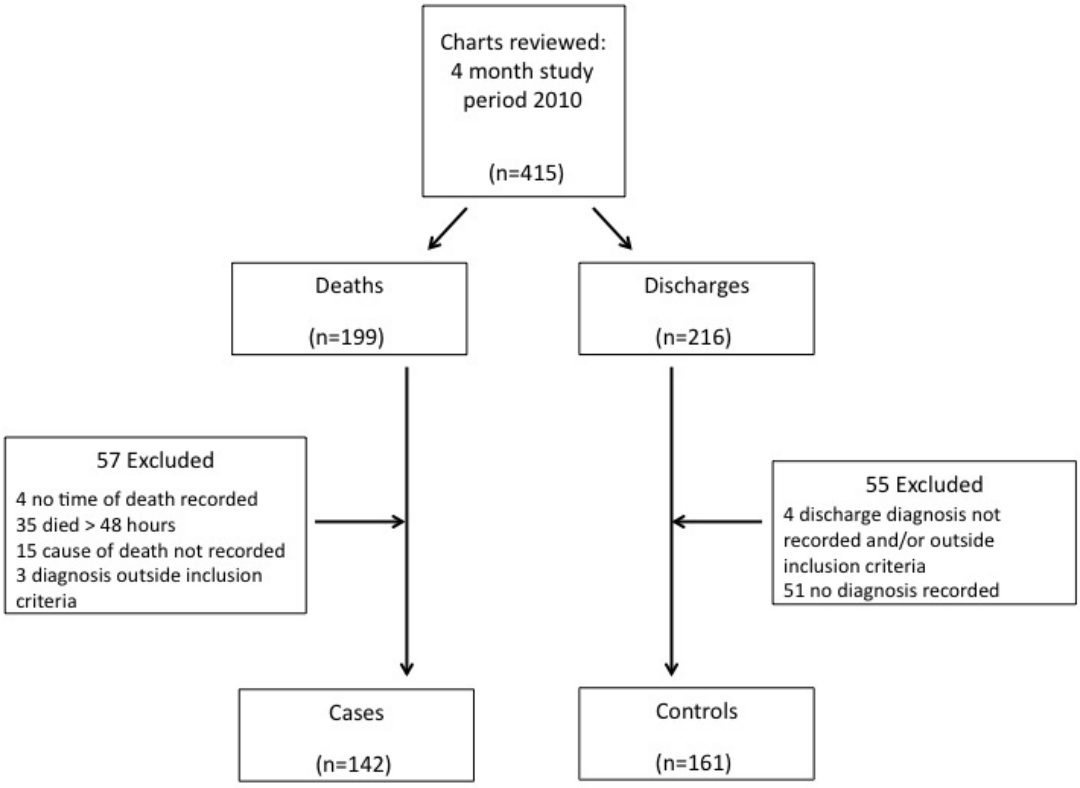

Fig. 1. Flow chart of case and control selection

3.1 Timing and Cause of Death

Of the 142 deaths included as cases the majority occurred within 12 hours (62.3%) and cumulatively within the first 24 hours after arrival for admission (88.4%) (Table 1).

Malaria *(P. falciparum)* was the most common diagnosis among both cases and controls (no significant difference; 69.7% and 77.6% respectively). Among all deaths occurring less than 48 hours from admission, there was an association between cause of death and age (*P*=.02). Children under 5 were more likely to die from malaria than older children (OR 3.2, 95%CI 1.1-9.3, *P*=.03) and children over 5 were more likely to die from pneumonia than malaria (OR 15.4 95%CI 1.4-155.3, *P*=.02).

Table 1. Comparison of admission diagnosis and route to admission

	Controls N=161(%)	Cases N=142 (%)	P-value
Time of death (in hours)			
0-12		89 (62.3)	
13-24		37 (26.1)	
25-36		10 (7.0)	
37-48		6 (4.2)	
Death or discharge diagnosis			.469
Malaria	125 (77.6)	99 (69.7)	
Pneumonia	16 (9.9)	19 (13.4)	
Diarrhea/Dehydration/Sepsis	12 (7.5)	17 (12.0)	
Meningitis	2 (1.2)	3 (2.1)	
Measles	6 (3.7)	4 (2.8)	
Age			.151
0-1year (Infant)	44 (27.3)	52 (36.6)	
1-5 years (Under 5)	95 (59.0)	75 (52.8)	
Over 5 years	21 (13.0)	12 (8.5)	
Unknown	1 (0.6)	3 (2.1)	
Referred from within hospital			.424
Under 5 Clinic	129 (80.1)	103 (72.5)	
Direct to ward	24 (14.9)	27 (19.0)	
Tisungane ART Clinic	1 (0.6)	1 (0.7)	
Unknown	7 (4.4)	11 (7.8)	
Time of day admitted to ward			.862
Working hours (8-5pm)	83 (51.6)	73 (51.4)	
Evening hours (5-12pm)	36 (22.4)	32 (22.5)	
Overnight (12-8am)	11 (6.8)	13 (9.2)	
Unknown	31 (19.3)	24 (16.9)	
Referred from Health Center			.028
No	80 (49.7)	49 (34.5)	
Yes	76 (47.2)	87 (61.3)	
Unknown	5 (3.1)	6 (4.2)	
Distance of health center(km)			.239
0-10	8 (10.5)	8 (9.2)	
11-20	6 (7.9)	12 (13.8)	
21-30	20 (26.3)	11 (12.6)	
31-40	14 (18.4)	23 (26.4)	
>41	2 (4.0)	5 (5.8)	
Not documented	25 (32.9)	28 (32.2)	

3.2 Route to Admission to the Ward

The majority of children (76.6%) were referred for admission to the pediatrics ward from the ZCH outpatient pediatrics clinic (ie. the Under-5 Clinic). Mortality was not associated with location of referral for admission (Under-5 Clinic vs. Antiretroviral Clinic vs. directly to ward), nor with time of admission to the ward.

Of the 232 children referred from the Under-5 clinic, cases were over three times more likely than controls to be flagged for immediate attention on the ward by the admitting clinician (17.5% vs. 6.2%; OR 3.2, 95%CI 1.3-7.7, *P*=.009).

Cases were more likely to have been seen at a health center prior to admission than controls, (87/142 vs. 76/161 controls; OR 1.8, 95%CI 1.2-3.0, *P*=.01). Mortality was not associated with health centre distance to the hospital (*P*=.18). Of those patients referred from health centres, 11 had documented investigations done prior to arrival, (10/11 with a hemoglobin (HgB) and 5/11 with Malaria Parasite Screen (MPS)). Of patients referred from a health centre, 55.8% received some treatment, most commonly paracetamol (36.8% cases vs. 28.7% controls; *P*=.27), quinine (35.5% and 33.3%; *P*=.77) and antibiotics (21.1% vs. 19.5%; *P*=.81).

3.3 Clinical Characteristics and Status at Admission

Overall, vital signs were poorly recorded on presentation (Table 2), thus we were unable to evaluate their association with mortality. For example, of the 54 patients presenting with the symptom of respiratory distress, only 3(5.6%) had a documented oxygen saturation and only 1 (1.8%) had a documented respiratory rate.

Cases were twice as likely to present with symptoms of respiratory distress (noisy or difficult breathing by parent report) than controls (OR 1.9, 95%CI 1.0-3.4, *P*=.04). There was a trend towards an association of symptoms of respiratory distress and mortality among the subset of patients with pneumonia (OR 2.1, 95%CI 0.9-4.9, *P*=.09) and among those patients with malaria (OR 2.1, 0.9-4.8, *P*=.078). Furthermore, among the subset of malaria patients, mortality was associated with a four-fold increase in documented abnormal chest findings (ie. elevated respiratory rate, adventitious sounds, in-drawing or nasal flaring) on physical exam (OR 4.1, 95%CI 1.2-13.6, *P*=.02), however this association was not seen among other diagnoses.

Mortality was associated with a low Blantyre Coma Scale (BCS) with cases over three times more likely than controls to present with an abnormal BCS (=BCS <5) (OR 3.4, 95%CI 2.1-5.6, P=.000). A low BCS (<5) was associated with a 17.5 increased risk of death among cases of diarrhea/dehydration (95%CI 2.7-114.8, *P*=.003) and a tripling of the risk of death among malaria patients (OR 3.3, 95%CI 1.9-5.8; *P*=.000). Among malaria patients, mortality was associated with meeting the WHO criteria for a diagnosis of cerebral malaria (ie. severe *P. falciparum* with BCS<3); 37.4% of cases met criteria vs. 18.4% of controls (p=0.001). BCS score was not related significantly to death in pneumonia, measles or meningitis cases.

Pallor was significantly associated with death (OR 2.2, 95%CI 1.3-3.6, *P*=.003), however on subgroup analysis this association remained significant only for patients with malaria (OR 3.5, 95%CI 1.8-6.6, *P*=.000).

HIV-infection status was poorly documented on admission with over 65% of controls and 74% of cases without documentation. Among those with known status, mortality was associated with documented HIV-infection on presentation (OR 5.1, 95%CI 1.5-17.1, *P*=.009) or documented HIV-exposure with unknown status (OR4.1, 95%CI 1.1-15.5, *P*=.03). TB exposure had slightly better documentation than HIV-infection status with 41% of controls and 35% of cases without documentation (*P*=.056).

Table 2. Clinical presentation and history at admission

	Controls N=161(%)	Cases N=142(%)	P-value
Vital signs recorded			
Heart Rate	3 (1.9)	2 (1.4)	.756
Oxygen Saturation	3 (1.9)	4 (2.8)	.581
Temperature	48 (29.8)	21 (13.4)	.001
Respiratory Rate	3 (1.9)	0	.102
Blood Pressure	0	0	-
Presenting symptoms			
Fever/Chills	146 (90.7)	118 (83.1)	.077
Cough	54 (33.5)	48 (33.8)	.316
Respiratory Distress	22 (13.7)	32 (22.5)	.037
Convulsions	36 (22.4)	27 (19.0)	.258
Diarrhea	28 (17.4)	28 (19.7)	.270
Vomiting	55 (34.2)	56 (39.4)	.185
Presenting Signs			
Abnormal chest auscultation	16 (9.9)	22 (15.5)	.300
Rash	6 (3.7)	3 (2.1)	.231
Pallor	57 (35.4)	72 (50.7)	.021
Blantyre Coma Scale			.000
0	0 (0)	2 (1.4)	
1	2(1.2)	1 (0.7)	
2	1 (0.6)	8 (5.6)	
3	23 (14.3)	37 (26.1)	
4	22 (13.7)	28 (19.7)	
5	97 (60.3)	40 (28.2)	
Not documented	16 (9.9)	26 (18.3)	
HIV Status at Admission			.000
Negative	32 (19.9)	3 (2.1)	
Positive	7 (4.4)	7 (4.9)	
Exposed, unknown status	6 (3.7)	7 (4.9)	
Exposed, recent negative test	1 (0.6)	0 (0)	
Documented as 'unknown'	10 (6.2)	19 (13.4)	
Not documented	105 (65.2)	106 (74.7)	
TB exposure			.662
No	92 (57.1)	88 (62.0)	
Yes	3 (1.9)	3 (2.1)	
Not documented/unknown	66 (40.99)	57 (35.9)	

3.4 Investigations and Treatment

3.4.1 Investigations

Although testing for hemoglobin (HgB) and malaria parasites (MPS) was ordered for the majority of patients in the study, a large proportion of the results were not documented in the chart (Table 3; HgB=45.5%, MPS=71.3%). For both HgB and MPS, cases were less likely to have documented results than controls (P=.01 and P=.000 respectively). These differences may be related to timing of death with 5 cases recorded to have died before their HgB result and 65% of the missing HgB data occurring in cases that died before 12 hours. Given the

data, we were unable to reliably analyze results of testing or timing of receiving the HgB or MPS test results in relation to mortality (neither as a risk factor nor as a quality indicator for timing of investigations/interventions).

Similarly, HIV testing and counseling (HTC) orders were much less likely to be completed among cases than controls (10% vs. 56%, *P*=.002); 68.9% of cases with missing HTC data died before 12 hours likely impeding the organization and completion of HTC.

Table 3. Investigations and Treatment at Admission

	Controls N=161 (%)	Cases N=142(%)	P-value
Investigations			
HgB			.001
>11.1	4 (3.7)	3 (2.7)	
<6 g/dl (severe anemia)	28 (25.5)	19 (17.6)	
6-10.9 dl (anemia)	28 (25.5)	9 (8.3)	
Not documented	50 (45.5)	77 (71.3)	
MPS			.000
Negative	27 (18.8)	9 (7.0)	
Positive	35 (21.7)	12 (8.4)	
Patient died before test	0 (0)	9 (7.0)	
Not documented	81 (56.6)	111 (68.5)	
HIV			.002
Non-Reactive	25 (50)	2 (10.0)	
Reactive	3 (6.0)	0 (0)	
Not documented/done	22 (44)	18 (90.0)	
Treatment ordered at admission			
Oxygen			
Quinine	3 (1.9)	41 (28.0)	.000
Lumafanterine Artemether	127 (85.2)	115 (81.0)	.333
Single antibiotic	12 (7.5)	0 (0)	.001
2 or more antibiotics	77 (47.8)	66 (46.5)	.748
Anticonvulsant	18 (11.2)	20 (14.1)	.468
IV Fluids	10 (6.2)	14 (9.9)	.241
Transfusion	8 (5.0)	17 (12.0)	.014
	36 (22.6)	32 (23.2)	.067
Time to administration			
Antimalarial			.653
Not given/not documented	27 (20.3)	30 (26.6)	
<4 hours	47 (35.3)	34 (30.1)	
4-24 hours	55 (41.4)	45 (39.8)	
24-48 hours	4 (3.0)	4 (3.5)	
Antibiotic			.233
Not given	12 (13.5)	20 (23.3)	
<4 hours	28 (31.5)	25 (29.1)	
4-24 hours	48 (53.9)	38 (44.2)	
24 -48	1 (1.1)	3 (3.5)	
Transfusion			.002
<24hrs	11 (31.4)	8 (25.0)	
24-48 hr	9 (25.7)	1 (3.1)	
>48 hours	4 (11.4)	0 (0)	
Documented as not given	3 (8.6)	13 (40.6)	
Not documented	8 (22.9)	10 (31.3)	

Table 3 Continued……

Time to first nursing reassessment			
Not done/Not documented	103 (66.5)	82 (58.2)	.046
<6 hours	18 (11.6)	33 (23.4)	
<24 hours	24 (15.5)	21 (14.9)	
24-48 hours	10 (6.5)	5 (3.6)	
Vitals recorded at RN reassessment			
Not done/Not documented	123 (76.4)	114 (80.3)	.711
At least one recorded	28 (17.4)	21 (14.8)	
>1	10 (6.2)	7 (4.9)	
Time to first MD assessment			
Not done/Not documented	15 (9.3)	75 (52.8)	.000
<6 hours	3 (1.9)	13 (9.2)	
<24 hours	37 (22.9)	28 (19.7)	
24-48 hours	88 (54.7)	26 (18.3)	
>48 hours	18 (11.2)	0 (0)	

3.4.2 Treatment

Mortality cases were 21.5 times more likely to have received oxygen supplementation at admission than controls (95%CI 6.5-70.9, *P*=.000). Overall, the majority of oxygen was ordered for those patients with a final diagnosis of malaria (73.9%) or pneumonia (11.6%).

Among the 224 patients with malaria, 210 (93.75%) were documented to have been ordered an anti-malarial, most commonly quinine (90.2%). Of note, cases were less likely to be ordered oral antimalarials (ie. Lumafanterine artemether) than controls (0% vs. 7.5%; *P*=.000) either reflecting local guidelines to use IV anti-malarials for complicated malaria or the patient's ability to tolerate oral medications. Of the 12 who were ordered oral LA, only 1 had a BCS<5.

There was no association between mortality and the ordering of antibiotics or anticonvulsants (*P*=.75 and *P*=.24). The most common antibiotics ordered were ceftriaxone (21.7%) and penicillin (19.8%), leaving many cases without broad-spectrum antibiotic coverage. The most common anticonvulsant used was diazepam (3.4% of patients received) and then phenobarbital (1.9%), reflecting the algorithm in ETAT for convulsions.

There was poor documentation of fluids ordered and administered among both cases and controls (91.9% and 80.3% respectively), as a result the impact of fluid management on outcome could not be assessed.

3.5 Timing of Medication Administration

We collected data on the timing of administration of antimalarials, antibiotics and transfusions as quality indicators of emergency care. There was no association between mortality and the timing of antimalarials; overall 33.2% of patients received antimalarials within 4 hours of admission and an additional 39.9% within 24 hours. Similarly, although only 28.3% received antibiotics within 4 hours, no association was found between mortality and timing of antibiotics (*P*=.14).

Data was available for the timing of transfusion administration for 67/68 documented transfusions ordered at admission. 13 cases (40.6%) were found to have been ordered but not have received a transfusion compared to only 3 (8.6%) of controls (*P*=.002). Eleven of these cases died within 12 hours of presentation for admission with 7 documented to have died before receiving blood (1 due to a documented lack of blood in bank and 6 with no documented reason). Mortality was associated with a 6-fold increased risk of not receiving a transfusion (OR 5.95, 95%CI 28.1, *P*=.02).

3.6 Monitoring the Ward

We collected data regarding the monitoring of critically ill patients by both nursing and medical officers. While there was no association seen between the total number of nursing reassessments, mortality was associated with an earlier nursing assessment documented in the chart as cases were twice as likely than controls to have an RN reassessment within 6 hours after admission (OR 2.3 95%CI 1.2-4.4, *P*=.011). Overall, only 21.8% of all patients had nursing vitals re-documented at this assessment.

Additionally, cases were almost six times more likely than controls to be seen by an MD within 6 hours after admission for reassessment (OR 5.7, 95%CI 1.5-22.0, *P*=.01) rather than the standard next day rounds.

When limiting the analysis to the subset of cases that died before 12 hours, death remained significantly associated with both an earlier MD assessment (ie. <6 hours after admission; OR 11.1, 95%CI 2.5-48.8, *P*=.001) and with no assessment recorded (OR 15.8, 95%CI 6.4-38.7, *P*=.000).

4. DISCUSSION

Overall our findings show that the majority of deaths on the ZCH pediatrics ward occurred within 48 hours of admission, with a high proportion of those occurring less than 24 hours. High rates of early mortality are consistently shown throughout the region and have been attributed both to children presenting for admission in critically ill states and a lack of adequate systems for critical care [2,6,12,13]. Several studies in Malawi have shown diminished rates of early mortality with the institution of emergency triage and emergency treatment guidelines (as per ETAT) [6,12].

Additionally, we identified several clinical characteristics on presentation that were associated with death in this study. For patients with malaria, younger age, symptoms and signs of respiratory distress, pallor and a low BCS were associated with early mortality. These characteristics likely represent signs of disease severity including cerebral malaria and severe anemia. Marsh et al. [11] have similarly identified impaired consciousness and respiratory distress as predictive of mortality among children with a primary diagnosis of malaria. Additionally, Berkeley et al. [2] found impaired consciousness and respiratory distress to be among general prognostic factors for early mortality among all diagnoses presenting to a district hospital in Kenya. Together, this suggests these risk factors can be used to enhance identification of at-risk patients on presentation to the pediatric wards both at ZCH and similar settings.

HIV infection or exposure was associated with a greater risk of death in this study, however, given the large amount of missing data, this result should be interpreted with caution. Ahmad

et al. [13] show in an urban hospital in Malawi that survival to 24 hours during resuscitation was not different between HIV-infected children and HIV-uninfected children, thus supporting aggressive resuscitation regardless of HIV-status for all critically ill children [13].

We additionally identified several areas for quality improvement in care for critically ill children at our facility. A large percentage of children, principally cases, were referred from health centres likely reflecting appropriate transfer of critically ill children. However few health centres were able to perform initial investigations and/or initiate treatment. Outreach and advocacy within the system for improved early investigation, treatment and transfer of critically ill children along with strengthened linkage of health centres to the district hospital may improve care.

Internationally, time to first dose of antibiotic is used as a standard measure of quality of emergency services and studies have shown that early antibiotic administration leads to improved outcomes in acutely ill patients [14]. At ZCH, 29% of patients were given antibiotics within 4 hours and an additional 42.4% on the same day, which leaves room for improvement in this component of quality care. Additionally, there was a large reliance on single spectrum antibiotics, which suggests room for improvement in antibiotic coverage particularly early in the course of care of critically ill cases.

We also identify that mortality was associated with delay to getting or not getting a transfusion. Although we did not have secondary information on system issues such as blood bank stock availability, other studies in the region have identified such shortages as contributing to worse patient outcomes [15]. Ongoing work with the laboratory and the national blood services to advocate for improved protocols and systems may improve care.

In this study, we found the children who died before 12 and 24 hours were more likely to have multiple nursing and medical officer reassessments, likely indicating appropriate reassessment of critically ill children. However, we also identify poor documentation of key clinical information important for decision making, such as vital signs (initial and during admission). Although we do not have secondary information on available equipment and staff to patient ratios, this finding may support the use of critical care or vital sign flow sheets to standardize and improve documentation. Innovative ideas around improving the critical care environment for acutely ill children such as these should be prioritized.

5. LIMITATIONS

Our ability to rigorously identify prognostic factors for early mortality was affected by the limitations of poor documentation within this retrospective chart review. In some cases missing data is related to early death and it is difficult to interpret with poor documentation whether the investigations, orders or reassessments were carried out for these critically ill children. As a result we were not able to evaluate potential risk factors for death on admission, such as vital sign measures, investigations, timing of investigations and administration of treatments. In addition, due to lack of documentation of investigations, such as chest x-ray findings, we were unable to verify the documented diagnosis or cause of death in the majority of cases. As a result it is likely at least a portion of cases are misdiagnosed or missing contributing diagnosis that could have improved both the reliability and depth of our analysis. This is unlikely to have significantly impacted the relationship of death to clinical findings such as low BCS or respiratory distress, but may have an important impact on findings associated with diagnosis requiring these results to be interpreted with a degree of caution.

6. CONCLUSIONS

With significant rates of early pediatric mortality on presentation to health care facilities in settings such Malawi, improvements must be made in the early identification of children at risk of mortality. Additionally, we identify several areas for quality improvement of care which include assessment and strengthening of referring health centre capacity and availability and timely implementation of emergency interventions (ie. antibiotics and transfusions).

CONSENT

Not applicable.

ETHICAL APPROVAL

The study was approved by both the Malawi National Health Sciences Research Committee and the University Health Network Research Ethics Board.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Monique Van Lettow, Dignitas International Zomba, for the logistical support provided to this project.

FUNDING AND COMPETING INTERESTS

This study was funded by a Departmental Research Grant, University Health Network Department of Emergency Medicine. The authors have declared that no competing interests exist.

REFERENCES

1. Campbell JD, Sow SO, Levine MM, Kotloff KL. The Causes of Hospital Admission and Death among Children in Bamako, Mali. J Trop Ped. 2004;50:158-63.
2. Berkley JA, Ross A, Mwangi I, Osier FHA, Mohammed M, Shebbe M, et al. Prognostic indicators of early and late deaths in children admitted to district hospital in Kenya: cohort study. BMJ. 2003;326:361-7.
3. Lawless J, Lawless M, Garden M. Admissions and mortality in a children's ward in an urban tropical hospital. Lancet. 1966;26:2(7474):1175-6.
4. Adazu K, Lindblade KA, Rosen DH, Odhiambo F, Ofware P, Kwach J, et al. Health and demographic surveillance in rural western Kenya: A platform for evaluating interventions to reduce morbidity and mortality from infectious diseases. Am J Trop Med Hyg. 2005;76:1151-8.
5. ePinto EA, Alves JG. The causes of death of hospitalized children in Angola. East Afr Med J. 1995;72(3):165-9
6. Molyneux EM, 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.
7. World Health Organization. 2005. Handbook: Integrated Management of Childhood Illness. Geneva: WHO. Accessed: 2 May 2013.
Available: http://whqlibdoc.who.int/publications/2005/9241546441.pdf

8. English M, Berkley J, Mwangi I, Mohammed S, Ahmed M, Osier F, et al. Hypothetical performance of syndrome-based management of acute paediatric admission of children aged more than 60 days in a Kenyan district hospital. Bulletin of the World Health Organization. 2003;81:166-173.
9. National Statistical Office (NSO) and ICF Macro. 2011. Malawi Demographic and Health Survey 2010. Zomba, Malawi, and Calverton, Maryland, USA: NSO and ICF Macro. Accessed 2 May 2013.
Available: http://www.measuredhs.com/pubs/pdf/FR247/FR247.pdf
10. Norton EB, Archibald LK, Nwanyanwu OC, Kazembe PN, Dobbie H, Reller LB, et al. Clinical predictors of bloodstream infections and mortality in hospitalized Malawian children. Pediatr Infect Dis J. 2004;23:145-51.
11. Marsh K, Forster D, Waruiru C, Mwangi I, Winstanley M, Marsh V, et al. Indicators of life-threatening malaria in African children. NEJM. 1995;332(2): 1399-404.
12. Robison JA, Ahmad ZP, Nosek CA, Durand C, Namathanga A, Milazi R, et al. Decreased pediatric hospital mortality after an intervention to improve emergency care in Lilongwe, Malawi. Pediatrics. 2012;130(3):e676-82.
13. Ahmad S, Ellis JC, Kamwendo H, Molyneux EM. Impact of HIV infection and exposure on survival in critically ill children who attend a paediatric emergency department in a resource-constrained setting. Emerg Med J. 2010;27(10):746-9.
14. Dellinger RP, Levy MM, Rhodes A, Annane D, Gerlach H, Opal SM, et al. Surviving Sepsis Campaign Guidelines Committee including the Pediatric Subgroup. Crit Care Med. 2013;41(2):580-637.
15. Idro R, Aloyo J. Manifestations, quality of emergency care and outcome of severe malaria in Mulago Hospital, Uganda. Afr Health Sci. 2004;4(1):50-7.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=418&id=19&aid=3746