**Spectrum, Treatments and Outcomes of Shock in Acutely-ill Children Seen at the Emergency Room of a Tertiary Hospital in Southern Nigeria**

**Abstract**

**Introduction**: Shock is a state of inadequate tissue perfusion. The emergency care of shock in children is dynamic but fluid therapy remains its cornerstone, with variable effectiveness. We evaluated the spectrum, therapies and outcomes of shock in our Children Emergency Room.

**Methods**: This was an analytic, cross-sectional study. Data were collected using a structured questionnaire comprising demography, clinical features, shock diagnoses, emergency care and outcomes. Co-existing morbidities in the participants were mainly infection-related. Both descriptive and inferential analyses were done; prognostic factors in children with shock were identified, using odds ratio (OR) and 95% confidence intervals (CI).

**Results**: Five hundred and fifty-four acutely-ill children participated in the study. Their mean duration of illness was 13.5 days (± 4.7). The incidence of shock was 83 (15.0%). For the types of shock recorded (n = 42), hypovolemic shock was the commonest, 24 (57.1%). Septic shock occurred in 14 (33.3%) children, while cardiogenic shock was seen in 4 (9.6%) children. Among the affected children, 17 (40.5%) were fluid responsive, 5 (11.9%) were fluid refractory, and 20 (47.6%) were fluid refractory and dopamine dependent. The case fatality rate of shock was 57.8%. Children who presented with shock were more likely to die compared to others (OR = 11.811, 95% CI = 6.976–19.998, p < 0.001). Dopamine infusion was significantly associated with lower mortality risk, with an odds ratio of 0.039 (95% CI 0.008-0.196, p < 0.001).

**Conclusion**: Circulatory failure especially hypovolemic shock is common in acutely-ill children with dire consequences. Fluid therapy and catecholamine infusion can improve survival in the emergency setting.

**Key words**: shock; types; treatment; outcome; prognostic factors

**Introduction**

Shock is a life-threatening morbidity among acutely ill patients, especially children, due to their high rate of fluid loss and basal metabolism1. Shock, or circulatory failure, refers to a state of inadequate tissue perfusion with resultant hypoxia and impaired substrate delivery at the cellular level. This has cardiovascular and other systemic effects. Shock accounts for about 2% of pediatric admissions in developed countries2, with Chowday & Chandra3 in India reporting shock in 8% of children seen in their emergency rooms. Also, several African researchers have reported shock incidences at children emergency departments, ranging from 1.5% in Kenya4,2.2% in Ethiopia5, to 4.2% in Senegal6. Incidence rates were notably higher in Pediatric Intensive Care Units (PICUs), with Basnet *et al.*7 in Nepal recording as high as 44.3% and Ahmad *et al.*8 in Malawi reporting 42.4%. In Nigeria, studies have noted incidence rates ranging from 2.6% to 14.3% in acute care settings9-11. The variability likely reflects differences in healthcare access and study populations. Shock can be classified based on its underlying aetiology as hypovolemic, distributive, cardiogenic or obstructive shock12. However, both hypovolemic shock due to fluid loss and distributive septic shock often co-exist in children. Shock is further classified into compensated and decompensated forms based on the body's ability to maintain adequate perfusion13. Decompensation, marked by a failure to maintain normal blood pressure, is frequently encountered in children due to late presentation to health facilities5,14.

The emergency care of shock in children is influenced by its severity and type but fluid therapy remains the cornerstone of management. The American Heart Association and American Academy of Paediatrics’ Emergency Cardiovascular Care guidelines recommend initial rapid fluid boluses to reverse shock alongside treatment of any underlying cause15,16. Likewise, the Surviving Sepsis Campaign guidelines also emphasize early restoration of blood pressure, with fluid therapy and vasopressors17. There are pertinent cautions that have been highlighted in African children with septic shock based on the FEAST trial that showed increased mortality with fluid boluses18. Nonetheless, adequate fluid boluses should be given to children in shock, especially in facilities that are capable of vasoactive therapies and mechanical ventilation, and patients who fail to respond to a total of 60ml/kg of crystalloids should be managed as fluid-refractory shock, with prompt initiation of vasopressors such as norepinephrine or dopamine14,19. Also, corticosteroid therapy is recommended in children with dopamine-dependent shock20. Kidanu *et al.*5 found that 45.5% of children with shock required inotropes in their series. If available, colloids such as dextran and Haemaccel infusions can also effectively reverse shock21. Blood transfusion is only indicated in children with low haemoglobin concentration and persistent hypoxemia22. Invasive procedures such as pericardial and pleural fluid drainages or corrective surgery for a congenital lesion may be indicated23.

The outcome of shock in children depends on its duration, severity and coexisting morbidities as well as prompt initiation of therapies. Chowday & Chandra3 in India reported that 75% of children who presented with shock in their emergency department survived to hospital discharge. In a recent systematic review and meta-analysis on pediatric shock in Asia, the Middle East and Sub-Saharan Africa24, the pooled mortality rate was 18.6%. On sub-analysis, patients with septic shock and diarrhea had the highest mortalities of 30.3% and 34.3% respectively. Shock is associated with a high case fatality rate in children including neonates, and a poor prognostic factor in critically ill children independent of co-existing morbidities25.

Considering the foregoing and the high incidence of acute illnesses in Nigerian children, we evaluate the spectrum of shock seen in our emergency department as well as their specific therapies and outcomes. We hypothesized that sociodemographic and clinical characteristics of the children may influence the short-term outcome of shock in the participants.

**Methodology:**

This study took place in the Children Emergency Rooms (*CHERs*) of the University of Benin Teaching Hospital (*UBTH*), in southern Nigeria. The CHER comprises a Triage, an emergency ward and a critical care bay with relevant equipment including non-invasive multi-parameter monitors, automated external defibrillated (AED), High Flow Nasal Cannula system (*Airvo2; Fisher & Paykel*) and mechanical ventilators (*Siaretron 2000 and Falco 202 EVO*).

**Study design**: This study adopted an analytic, cross-sectional design.

**Participants:** Thesechildren participated in a large project evaluating shock in children at the referral centre. They all presented to the emergency room with acute illnesses and were admitted during the six-month study period*.* Details of their socio-demographics and comorbidities have been previously described.9,11 Their socio-economic classification was based on their parental educational levels and occupations. Severe malaria and infection-related disorders such as meningitis, encephalitis and pneumonias were the common underlying morbidities in the participants.

**Inclusion criteria**: Children who are under 18 years of age with a critical or severe illness during the study period. A critical illness was defined as the presence of a life-threatening disorder which requires prompt intervention to avert death.

**Exclusion Criteria**: Ill children without evidence of severe illnesses were excluded. In addition, newborns were excluded because they were admitted directly into the neonatal unit.

**Sample size:** The minimum sample size was determined using the Fisher’s formula:

N = Z12-α(P)(1-P)/d2; where, Z1-α = normal standard deviation for confidence level of 95% = 1.96. P = Proportion of critically-ill children with circulatory failure (*we assumed 50%*); d = margin of error to be tolerated (*fixed at 5%*). This was adjusted for a 10% non-response rate. Altogether, 554 children were recruited during the study period.

**Sampling Method**: This was a total population study of all eligible children admitted into CHER during the study period; they were consecutively selected and recruited into the study following parental consent.

**Data Collection:** Data were collected using a researcher-administered questionnaire comprising sections on baseline/clinical characteristics, clinical features, shock diagnoses, emergency care and outcomes. Description of emergency care included fluid boluses, correction of dehydration, catecholamine infusion and other relevant in-patient care. Outcome was classified into discharged, died, transferred into paediatric wards or left against medical advice (LAMA). Shock was defined based on WHO criteria as previously described:9 cold extremities, prolonged capillary refill >3 seconds, and fast and weak pulse) or the presence of hypotension (systolic BP < 70mmHg in infants or <70 +2n, where n= age in years for under-ten children) Also, participants’ clinical documentations were reviewed to ascertain their diagnoses, emergency care and outcomes. Children who developed shock while already on admission are also identified as well as their response to therapy.

**Statistical Analysis:** Descriptive and inferential analyses of the data were done using the IBM Statistical Package for Social Sciences (SPSS) version 26.0 for windows. Categorical variables were expressed as percentages. The overall and type-specific incidence of shock was derived from the proportion of affected children. Bivariate analysis (*Pearson chi-square*) was done to detect any significant association between the descriptive variables and shock. Variables that were significant on binary analysis were then subjected to multivariate logistic regression to identify independent predictors of mortality in the participants, using adjusted odds ratio (aOR) and 95% confidence intervals (CI). P < 0.05 was considered significant.

**Results**

**Baseline features of the participants (N=554)**

Five hundred and fifty-four acutely-ill children participated in the study; their gender distribution was nearly even, with males slightly predominating at 53.6% (297 participants) compared to females at 46.4% (257 participants). The mean age was 5.84 years (± 5.1 years), The mean duration of illness was 13.5 days (± 4.7). Their mean body temperature was 37.47°C (± 2.1). The mean pulse rate was 125.78 beats per minute (± 27.2), and the mean heart rate was 116.76 beats per minute (± 41.3). Blood pressure measurements showed a mean systolic pressure of 103.9 mmHg (± 22.5), a diastolic pressure of 62.5 mmHg (± 18.3), and a pulse pressure of 43.14 mmHg (± 16.2). The mean oxygen saturation (SPO₂) was 88.89% (± 13.5).

**Spectrum of Shock and Shock Indices**

At presentation, 83 patients (15.0%) were in shock, while 471 (85.0%) were not. Upon admission, 17 patients (3.1%) were in shock, while 537 (96.9%) had a stable cardiovascular system after initial resuscitation. The shock index varied by age group, with a mean of 1.39 (± 0.3) for 118 patients (21.3%) under one year, 1.33 (± 0.3) for 294 patients (53.1%) aged one to five years, and 1.04 (± 0.5) for 142 patients (25.6%) five years and older. For the type of shock recorded (n = 42), hypovolemic shock was the most common, affecting 24 (57.1%) cases. Septic shock occurred in 14 (33.3%) cases, while cardiogenic shock was seen in 4 (9.6%) cases. About a half of patients with shock (n=41) were unclassified into any specific type. Further details are shown on Table 1.

Table 1: **Spectrum of Shock and Heart-related Disorders in the Participants** (N = 554)

|  |  |  |
| --- | --- | --- |
| **Shock and related disorders** | **Frequency (n )** | **Percentage (%)** |
| Shock (at presentation) | 83 | 15.0 |
| **Type of Shock (n=42)** |  |  |
| Hypovolemic | 24 | 57.1 |
| Septic | 14 | 33.3 |
| Cardiogenic | 4 | 9.6 |
| **Heart-related Disorders** |  |  |
| Myocarditis | 1 | 0.2 |
| Supraventricular tachycardia | 1 | 0.2 |

**Anti-shock Therapies and Emergency Care**

A total of 90 (16.2%) individuals received an anti-shock bolus (including 7 dehydrated children who were pre-emptively given anti-shock therapy). The mean duration of the anti-shock bolus administration was 30.54 ± 12.2 minutes. Among the participants, 42 (7.6%) received a repeat anti-shock. Of the 42 individuals who received a repeat anti-shock, 30 (71.2%) were given one repeat dose, 8 (19.0%) received two doses, 2 (0.04%) received three doses, and 2 (0.04%) were given four doses. The total fluid boluses administered on repeat were 20 ml/kg for 34 (81.0%) participants, 40 ml/kg for 5 (11.9%), and 60 ml/kg for 3 (7.1%). Correction of dehydration was done in 57 (10.3%) participants. Other treatments included maintenance intravenous fluid for 285 (51.4%), infusion of dopamine for 15 (2.7%), and blood transfusion for 63 (12.3%) mainly due to severe malarial anaemia as well as persistent shock in 4 (0.7%). The mean volume of blood transfusion was 20.8 ± 8.9 ml/kg. Also, other specific medications such as Artesunate 162 (29.2%) and ceftriaxone 81 (14.6%) were administered to participants (Table 2).

Table 2: **Anti-shock Therapies and Emergency Care of Participants** (N = 554)

|  |  |  |
| --- | --- | --- |
| **Emergency care** | **Frequency, n** | **Percentage (%)** |
| **Anti-shock fluid bolus** |  |  |
| Yes | 90 | 16.2 |
| No | 464 | 83.8 |
| Duration of anti-shock bolus in minutes (Mean ±S.D) | 30.5 **±** 12.2 |  |
|  |  |  |
| **Repeat anti-shock fluid boluses given** |  |  |
| Yes | 42 | 7.6 |
| No | 512 | 92.4 |
| Number of repeat anti-shock given (n=42) |  |  |
| 1 | 30 | 71.2 |
| 2 | 8 | 19.0 |
| 3 | 2 | 0.04 |
| 4 | 2 | 0.04 |
| Total fluid boluses given on repeat (ml/kg) (n=42) |  |  |
| 20 | 34 | 81.0 |
| 40 | 5 | 11.9 |
| 60 | 3 | 7.1 |
|  |  |  |
| **Correction of dehydration** |  |  |
| Yes | 57 | 10.3 |
| No | 497 | 89.7 |
| Maintenance intravenous fluid | 285 | 51.4 |
|  |  |  |
| **Other anti-shock therapies\*** |  |  |
| Infusion dopamine | 15 | 2.7 |
| Blood transfusion | 63 | 12.3 |
| Hydrocortisone | 4 | 0.8 |
| Blood transfusion volume in ml/kg (Mean ± S.D) | 20.8± 8.9 |  |
|  |  |  |
| **Medications** |  |  |
| Artesunate | 162 | 29.2 |
| Cefuroxime | 156 | 28.2 |
| Ceftriaxone | 81 | 14.6 |
| Gentamycin | 67 | 12.1 |
| Zinc | 52 | 9.4 |
| Probiotics | 50 | 9.0 |
| Others\*\* | 25 | 4.5 |

\* Multiple responses, \*\* Vitamin C, Omeprazole, Ranitidine, Phenytoin, Dexamethasone

**Clinical Course and Outcomes**

The clinical course of participants in the emergency room and their outcomes are shown on Table 3. Concerning response to anti-shock therapies, among the 42 individuals assessed, 17 (40.5%) were fluid-responsive, 5 (11.9%) were fluid-refractory, and 20 (47.6%) were fluid-refractory and dopamine-dependent. The post anti-shock vitals were assessed, revealing a mean systolic blood pressure of 103.52 ± 21.1 mmHg and a mean diastolic blood pressure of 64.4 ± 18.0 mmHg. The average pulse rate was 115.5 ± 27.2 beats per minute, and the average respiratory rate was 38.8 ± 15.4 cycles per minute. The mean percutaneous oxygen saturation (SpO2) was 94.4% ± 3.5. During the first 24 hours on admission, 368 (66.4%) patients showed improvement, 143 (25.8%) had static conditions, and 44 (7.8%) worsened. Electrocardiogram (ECG) reports were available for 12 patients, with 7 (58.3%) showing abnormal results and 5 (41.7%) normal results. The mean electrolyte values were as follows: sodium 130 ± 7.9 mmol/L, potassium 4.16 ± 1.0 mmol/L, bicarbonate 18.57 ± 4.0 mmol/L, and chloride 99.12 ± 15.2 mmol/L. Full blood count results were normal in 353 (63.7%) patients, while 201 (36.3%) had abnormal results.

The overall outcome of treatment showed that 314 (56.7%) patients were discharged, 85 (15.3%) were transferred to paediatric wards, 58 (10.5%) were ‘left against medical advice’, and 97 (17.5%) died. Only 2 (0.4%) patients were referred to another facility; Table 3. Among the 83 participants who presented with shock, 35 (42.2%) survived and 48 (57.8%) died. This constituted a case fatality rate of 57.8% for shock in the study. In contrast, of the 471 respondents without shock at presentation, 422 (89.6%) were alive, while 49 (10.4%) had died. Children who presented with shock were significantly more likely to die compared to those without shock (OR = 11.81, 95% CI = 6.98–20.00, p < 0.001).

|  |  |  |
| --- | --- | --- |
| **Clinical Course/Outcome** | **Frequency, n** | **Percentage (%)** |
| **Response to shock (n=42)** |  |  |
| Fluid responsive | 17 | 40.5 |
| Fluid refractory | 5 | 11.9 |
| Fluid refractory, dopamine dependent\* | 20 | 47.6 |
| **Post anti-shock vitals** (Mean ± S.D) |  |  |
| Systolic blood pressure in mmHg | 103.52 **±** 21.1 |  |
| Diastolic blood pressure in mmHg | 64.35 **±** 18.0 |  |
| Pulse rate (beats per minute) | 115.52 **±** 27.2 |  |
| Respiratory rate (cycles per minute) | 38.79 ± 15.4 |  |
| **First 24 hours on admission** |  |  |
| Improving | 368 | 66.4 |
| Static | 143 | 25.8 |
| Worsening | 44 | 7.8 |
| **Outcome** |  |  |
| Discharged | 314 | 56.7 |
| Died | 97 | 17.5 |
| Transferred to Paediatric wards | 85 | 15.3 |
| Left against medical advice\* | 58 | 10.5 |
| **Referred to another facility** |  |  |
| Yes | 2 | 0.4 |
| No | 552 | 99.6 |

Table 3: **Clinical Course and Outcomes of Participants** (N= 554)

\**Common in late presentation;* \*\**Often due to financial constraint; care continued on out-patient basis.*

**Factors Associated with Shock and Outcomes**

Table 4 shows factors associated with the occurrence of shock while already on admission. Gender showed a significant association with shock (χ2 = 6.381, p = 0.013), but age and socioeconomic status did not have a significant effect (p = 0.309). Seizures (χ2 = 6.706, p = 0.010), dehydration (χ2 = 56.072, p < 0.001), and pallor (χ2 = 43.900, p < 0.001) were found to be significantly associated with shock. Severe sepsis was significantly associated with the incidence of shock (χ2 = 45.084, p < 0.001). Table 5 shows factors that are associated with outcomes among the participants. The duration of illness (χ2 = 8.984, p = 0.011), and use of dopamine infusion on admission was significantly associated with outcomes (χ2 = 25.813, p < 0.001).

Table 4: **Clinical-demographic variables Associated with Shock while on Admission among the Participants (N=554)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Clinical-demographic variables** | **Shock while on admission** | | **χ2** | **p-value** |
| **Yes (n = 17)**  **n (%)** | **No (n=537)**  **n (%)** |
| **Age group (years)** |  |  |  |  |
| <1 | 7 (3.9) | 174 (96.1) | 0.586 | 0.782 |
| 1-5 | 6 (2.8) | 212 (97.2) |  |  |
| >5 | 4 (2.6) | 151 (97.4) |  |  |
| **Gender** |  |  |  |  |
| Male | 4 (1.3) | 293 (98.7) | 6.381 | 0.013\* |
| Female | 13 (5.1) | 244 (94.9) |  |  |
| **Illness Duration (days)** |  |  |  |  |
| 1 | 2 (1.8) | 112 (98.2) | 0.836 | 0.658 |
| 2-7 | 11 (3.4) | 314 (96.6) |  |  |
| >7 | 4 (3.5) | 111 (96.5) |  |  |
| **Pallor** |  |  |  |  |
| Yes | 5 (29.4) | 12 (70.6) | 43.900 | <0.001\* |
| No | 11 (2.1) | 525 (97.9) |  |  |
| **Gastroenteritis** |  |  |  |  |
| Yes | 6 (6.6) | 85 (93.6) | 15.271 | <0.001\* |
| No | 11 (2.4) | 452 (97.6) |  |  |
| **Severe sepsis** |  |  |  |  |
| Yes | 10 (16.4) | 51 (85.6) | 45.084 | <0.001\* |
| No | 7 (1.3) | 530 (98.7) |  |  |
| **Severe malaria** |  |  |  |  |
| Yes | 10 (4.7) | 204 (95.3) | 1.417 | 0.304 |
| No | 7 (2.1) | 333 (97.9) |  |  |

\* Statistically significant

Table 5: **Clinical-demographic variables Associated with Outcomes of Participants** (N =554)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Clinical-demographic variables** | **Outcome** | | **χ2** | **p-value** |
| **Discharged/Transferred**  **(n = 399)**  **n (%)** | **Died/LAMA**  **(n=155)**  **n (%)** |  |  |
| **Source of patient** |  |  |  |  |
| Private referral | 35 (63.6) | 20 (36.4) | 7.760 | 0.020\* |
| Public referral | 32 (59.3) | 22 (40.7) |  |  |
| Home | 332 (74.6) | 113 (25.4) |  |  |
| **Age (years)** |  |  |  |  |
| <1 | 121 (66.9) | 60 (33.1) | 3.687 | 0.158 |
| 1-5 | 161 (73.9) | 57 (26.1) |  |  |
| >5 | 117 (75.5) | 38 (24.5) |  |  |
| **Gender** |  |  |  |  |
| Male | 213 (71.7) | 84 (28.3) | 0.029 | 0.924 |
| Female | 186 (72.4) | 71 (27.6) |  |  |
| **Duration of illness (days)** |  |  |  |  |
| 1 | 90 (78.9) | 24 (21.1) | 8.984 | 0.011\* |
| 2-7 | 238 (73.2) | 87 (26.8) |  |  |
| >7 | 71 (61.7) | 44 (38.3) |  |  |
| **Dopamine infusion** |  |  |  |  |
| Yes | 2 (12.5) | 14 (87.5) | 25.813 | <0.001\* |
| No | 360 (73.6) | 129 (26.4) |  |  |
| **Pallor** |  |  |  |  |
| Yes | 10 (58.8) | 7 (41.2) | 1.551 | 0.213 |
| No | 389 (72.6) | 147 (27.4) |  |  |
| **Gastroenteritis** |  |  |  |  |
| Yes | 69 (71.4) | 22 (29.6) | 0.911 | 0.897 |
| No | 330 (71.2) | 133 (29.8) |  |  |
| **Severe sepsis** |  |  |  |  |
| Yes | 23 (37.7) | 38 (62.3) | 13.024 | <0.001\* |
| No | 376 (76.2) | 117 (23.8) |  |  |
| **Severe malaria** |  |  |  |  |
| Yes | 156 (76.4) | 58 (23.6) | 2.211 | 0.094 |
| No | 243 (71.5) | 97 (28.5) |  |  |

\* Statistically significant

.

**Multivariate analysis for predictors of mortality**

Duration of illness was a significant independent predictor of mortality. For patients with an illness duration of one day, the odds ratio was 0.282 (95% CI 0.119-0.668, p = 0.004), showing significantly lower mortality odds compared to those with illness lasting more than seven days, the reference category. Patients with illness lasting 2-7 days had an odds ratio of 0.506 (95% CI 0.286-0.895, p = 0.019), indicating a significant reduction in mortality odds.

Dopamine infusion was strongly associated with lower mortality odds, with an odds ratio of 0.039 (95% CI 0.008-0.196, p < 0.001), indicating a substantial reduction in the likelihood of death among those who received it. Severe sepsis was a significant predictor of mortality, with an odds ratio of 0.223 (95% CI 0.122-0.408, p < 0.001), indicating that patients with severe sepsis had significantly lower odds of surviving compared to those without severe sepsis. The model's R2 value was between 16.4% and 27.0%, indicating moderate explanatory power (Table 6).

Table 6: **Multiple Logistic Regression Analysis for Predictors of Mortality among the Participants**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Predictors** | **β (Regression co-efficient)** | **Odds**  **Ratio** | **95% CI for OR** | | **p-value** |
| **Lower** | **Upper** |
| **Age group (years)** |  |  |  |  |  |
| <1 | 0.246 | 1.279 | 0.667 | 2.454 | 0.459 |
| 1-5 | -0.229 | 0.795 | 0.419 | 1.511 | 0.484 |
| >5\* |  | 1 |  |  |  |
| **Gender** |  |  |  |  |  |
| Male | 0.066 | 1.068 | 0.647 | 1.765 | 0.796 |
| Female\* |  | 1 |  |  |  |
| **Duration of illness (days)** |  |  |  |  |  |
| 1 | -1.267 | 0.282 | 0.119 | 0.668 | 0.004\*\* |
| 2-7 | 0.681 | 0.506 | 0.286 | 0.895 | 0.019\*\* |
| >7\* |  | 1 |  |  |  |
| **Dopamine infusion** |  |  |  |  |  |
| Yes | -3.243 | 0.039 | 0.008 | 0.196 | <0.001\*\* |
| No |  | 1 |  |  |  |

*\* Reference Category, \*\* Statistically significant, R2 = 16.4% - 27.0%*

.

**Discussion**

This study shows that the spectrum of shock predominantly includes hypovolemic and septic shock in children seen at the emergency department, comparable to prior reports by Sadoh *et al9* in Edo, Ndukwu & Onah26 in Anambra and Eki-Udoko *et al*27 in Edo, Nigeria. Also, several foreign researchers have reported a high incidence of septic shock in severely-ill children. Haliu *et al28* in Ethiopia found that over one-quarter of acutely-ill children admitted to their unit were managed for septic shock before discharge. Likewise, Kumwenda *et al29* in Malawi observed that shock was a leading morbidity in children admitted into their emergency department who later required critical care. About a half of our participants who presented with shock in the emergency department were not sub-classified into a specific form of shock, perhaps due to mixed features or overlap of clinical signs in the participants. Kidanu *et a*l5 in Ethiopia reported that about a half of children seen in their series had features of mixed shock. Also, Biban and colleagues12 in Italy reported that mixed shocked often occurred in children who presented in their emergency department, with typical cold clammy extremities associated with hypovolemic shock being a prominent feature among cases of septic shock, highlighting the dynamic overlap in the clinical features of shock in children. As a result, some participants were not classified into a specific shock category at the emergency department.

Factors associated with the development of shock while on admission include female gender, dehydration, pallor and seizure, consistent with prior reports9,10. Eke *et al*30 in Enugu reported that children with gastroenteritis and dehydration were at an increased risk of cardiovascular shock in the emergency room. Also, Sadoh *et al*9 in Edo, Nigeria found that pallor, seizure and coma were leading features in acutely ill-children with circulatory failure in their centre. The worsening homeostatic derangement associated with dehydration and ongoing fluid loss can readily predispose a child to shock while on admission if optimal rehydration is not promptly achieved15. Also, neurologic features like convulsion and coma in an acutely-ill child may be due to underlying disorders such as severe malaria or meningitis that can predispose a child to shock31. Nonetheless, children with malaria who were undergoing treatment did not progress to develop shock while on admission in this study.

Fluid therapy was the primary treatment given to our participants who presented in shock with two out every 10 children receiving at least one anti-shock bolus, consistent with previous research findings17,20. Some of our participants were also transfused with blood due to refractory shock; this is in keeping with the Pediatric Advance Life support (PALS) recommendation on the use of colloid in patients with persistent shock and hypoxemia20. The mean duration of anti-shock in the index study was 30 minutes, reflecting the preponderance of hypovolemic shock among the participants. Owobu *et al*10 in Irrua, Nigeria and Ikuta *et al.32* in Kenya reported the use of rapid fluid boluses in children with shock in line with some extant guidelines17. Nonetheless, the FEAST trial has cautioned against the use of rapid fluid boluses in African children with septic shock18. Vasopressors, corticosteroids and vagal maneuvers were also used in selected participants in our study, consistent with standard protocols for the management of fluid-refractory shock and tachyarrhythmia.20,33

Nonetheless, the short-term outcome of shock following therapy was fair with nearly a half of them being fluid-responsive similar to other reports.34 Also, a similar proportion required dopamine after multiple fluid boluses. About two-thirds of our participants were improving after the first day on admission for the acute illnesses while about one in ten children experienced a clinical deterioration. Acutely–ill children with shock were eleven times more likely to die in this study when compared to those without shock, consequent to the multi-systemic complications and end-organ damage that are prevalent in circulatory failure. Mbevi *et al.4* in Kenya andKidanu *et al*5 in Ethiopia reported that nearly one-third to half of children with shock died in their emergency room. In contrast, Eki-Udoko *et al*27 in Edo and Oldendorff *et al*35 in Sweden found that mortality rate from circulatory failure was less than ten percent in their series. The high case-specific fatality rate of paediatric shock in resource-limited settings is partly related to late presentation and co-existing morbidities.5,9,25 Factors associated with a decrease in survival of participants in this study included an increased duration of admission, presence of seizure or severe sepsis similar to previous reports from emergency departments.5,36

The strength of this study includes its large sample size ensuring the study is adequately powered to detect shock in emergency room and enabling in-depth inferential analysis; also, this allows for potential generalization of findings to other acute care settings. Nevertheless, this study did not ascertain the long-term outcome and multi-systemic effects of shock in the survivors. Future research can seek to document post-shock sequelae and quality of life during a long-term follow-up of affected children.

**Conclusion**: hypovolemic and septic shocks are common in childhood critical illnesses with dire consequences. Fluid boluses remain the mainstay of therapy. There is a need for enhanced monitoring and relevant therapeutic interventions to forestall shock during in-patient care of acutely-ill children. Optimal and timely management of underlying disorders are also pertinent to the survival of children with shock.

**Ethical Approval:**

Ethical approval for the shock project was obtained from the Research and Ethics Committee (REC) of the College of Medical Sciences, University of Benin (CMS/REC/2018/020).

**Consent:**

As per international standards, parental written consent has been collected and preserved by the author(s).

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

**Authors’ contributions:** Author WES conceived the study; both authors designed the study; author MTA carried out data collection and wrote the initial daft of the manuscript. Both authors were involved in data management, review and approval of the final manuscript.

**Source of financial support**: The Lead Author received financial support from National Research Fund (NRF) Tertiary Education Trust Fund (*NRF2023/SETI/III/00572/VOL.1*); this partly aids the manuscript development and publication.

**Acknowledgement**: The Lead Author thanks the CPAP High-Flow Research Group NRF TETFUND. Both authors thank Ojeh-Oziegbe Oseyomon (clinical data analyst) and Oluwaseun Adeola who participated in data collection during this study.

**References**

1. Zieg J, Ghose S, Raina R. Electrolyte disorders related emergencies in children. BMC nephrology. 2024;25(1):282.
2. Kliegman RM, St. Geme JW. Nelson Textbook of Pediatrics. 21st ed. Philadelphia: Elsevier; 2020.
3. Chowday SS, Chandra T. A study on the prevalence of shock among the paediatric age group in and around West Godavari district, Andhra Pradesh. Pediatr Rev Int J Pediatr Res. 2021;8(5):231-235. doi:10.17511/ijpr.2021.i05.031
4. Mbevi G, Ayieko P, Irimu G, Akech S, English M; on behalf of the Clinical Information Network authors. Prevalence, aetiology, treatment, and outcomes of shock in children admitted to Kenyan hospitals. BMC Med. 2016;14:184. doi:10.1186/s12916-016-0722-x
5. Kidanu MG, Tazebe E, Tesfa AB, Hadush MY, Kahsay MM, Tedla MG. Pediatric Shock: The Magnitude, Its Determinants and Short-Term Outcome on Patients. A Cross-Sectional Hospital-Based Study. Pediatric Health Med Ther. 2024;15:213-221. doi:10.2147/PHMT.S458438
6. Mbodj M, Fall AL, Thiongane A, Diagne I, Sow A, Ndiaye ST, *et al.* Epidemiological, diagnostic, and therapeutic aspects of cardiogenic shock in children at the Albert Royer Children’s Hospital in Dakar. Open J Pediatr. 2021;11(4):648-658. doi:10.4236/ojped.2021.114062
7. Basnet S, Shrestha S, Ghimire A, Timila D, Gurung J, Karki U, *et al.* Development of a PICU in Nepal: the experience of the first year. Pediatr Crit Care Med. 2014;15(7):e314-e320. doi:10.1097/PCC.0000000000000163
8. 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):746-749. doi:10.1136/emj.2009.083741
9. Sadoh WE, Abiodun MT. Clinical predictors of circulatory failure and coexisting morbidities in children seen in an emergency room in Southern Nigeria. Niger J Clin Pract. 2022;25:1295-1300.
10. Owobu A, Kesieme C, Idialu J, Owobu C, Ike C, Okogbenin S. Easy protocol assessment in children emergency room, Irrua Specialist Teaching Hospital Nigeria. Int J Trop Dis Health. 2021;42:1-11. doi:10.9734/IJTDH/2021/v42i1030486
11. Abiodun MT, Sadoh WE. Socio-demographic characteristics and pre-hospital care of children with circulatory failure in a children’s emergency room in southern Nigeria. Pan Afr Med J. 2021;40(65). doi:10.11604/pamj.2021.40.65.30003
12. Standl T, Annecke T, Cascorbi I, Heller AR, Sabashnikov A, Teske W. The nomenclature, definition and distinction of types of shock. Dtsch Arztebl Int. 2018;115(45):757-768. doi:10.3238/arztebl.2018.0757
13. Bonanno FG. Clinical pathology of the shock syndromes. J Emerg Trauma Shock. 2011;4(2):233-243. doi:10.4103/0974-2700.82211
14. Festekjian A, Glavinic J. Pediatric septic shock: recognition and management in the emergency department. Pediatr Emerg Med Pract. 2022; 19(11):1-24. PMID: 36279398
15. Merchant RM, Topjian AA, Panchal AR, Cheng A, Aziz K, Berg KM, *et al.* Part 1: executive summary: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2020;142(16\_Suppl\_2):S337-S357.
16. Cornell T, Arutyunyan T, Custer JR, McInerny TK, Adam HM, Campbell DE. Shock (Chapter 373). In: McInerny TK, Adam HM, Campbell DE, et al, eds. American Academy of Pediatrics Textbook of Pediatric Care. 2016.
17. Evans L, Rhodes A, Alhazzani W, Antonelli M, Coopersmith CM, French C, *et al.* Surviving sepsis campaign: international guidelines for management of sepsis and septic shock 2021. Intensive Care Med. 2021;47(11):1181-1247. doi:10.1007/s00134-021-06506-y
18. Levin M, Cunnington AJ, Wilson C, Nadel S, Lang HJ, Ninis N. Effects of saline or albumin fluid bolus in resuscitation: evidence from re-analysis of the FEAST trial. Lancet Respir Med. 2019;7(7):581-593. doi:10.1016/S2213-2600(19)30114-6
19. Hon KL, Leung KKY, Oberender F, Leung AK. Paediatrics: how to manage septic shock. Drugs Context. 2021;10:2021-1-5. doi:10.7573/dic.2021-1-5
20. Respond to Shock. Pediatric Advanced Life Support (PALS) Certification Course. Updated December 2024. Accessed December 24, 2024. <https://www.savealife.com/pals-certification-course>
21. Naisbitt C, Mos KF, Kishen R. Crystalloids, colloids, blood products and blood substitutes. Anaesthesia & Intensive Care Medicine. 2019;20(6):353-60.
22. Demaret P, Emeriaud G, Hassan NE, Kneyber MCJ, Valentine S, Bateman S; et al. Recommendations on red blood cell transfusions in critically ill children with acute respiratory failure from the Pediatric Critical Care Transfusion and Anemia Expertise Initiative. \*Pediatr Crit Care Med.\* 2018;19(9):S114-S120. doi:10.1097/PCC.0000000000001619
23. Weiss SL, Nicolson SC, Naim MY. Clinical update in pediatric sepsis: focus on children with pre-existing heart disease. Journal of Cardiothoracic and Vascular Anesthesia. 2020;34(5):1324-32.
24. Assies R, Snik I, Kumwenda M, Chimalizeni Y, Langton J, van Woensel JBM, et al. Etiology, pathophysiology, and mortality of shock in children in low- and middle-income countries: A systematic review. \*J Trop Pediatr.\* 2022;68(4):fmac053. doi:10.1093/tropej/fmac053
25. Saini SS, Shrivastav AK, Kumar J, Sundaram V, Mukhopadhyay K, Dutta S, et al. Predictors of mortality in neonatal shock: A retrospective cohort study. Shock. 2022;57(2):199-204. doi:10.1097/SHK.0000000000001887.
26. Ndukwu CI, Onah SK. Pattern and outcome of postneonatal pediatric emergencies in Nnamdi Azikiwe University Teaching Hospital, Nnewi, South East Nigeria. Niger J Clin Pract. 2015;18(3):348-353. doi:10.4103/1119-3077.153246
27. Eki-Udoko FE, Ani C, Ekienabor GO, Atimati AO. Paediatric emergency admissions, mortalities, and unmet intensive care needs at a tertiary hospital in southern Nigeria. Niger J Paediatr. 2024;51(2):93-102. doi:10.4314/njp.v51i2.03.
28. Hailu AM, Bayisa T, Worku Y, et al. Prevalence and outcome of sepsis and septic shock in intensive care units in Addis Ababa, Ethiopia: A prospective observational study. Afr J Emerg Med. 2021;11(1):188-195. doi:10.1016/j.afjem.2020.10.001.
29. Kumwenda M, Assies R, Chathima G, et al. Prevalence, mortality, and aetiology of paediatric shock in a tertiary hospital in Malawi: A cohort study. PLOS Glob Public Health. 2024;4(1):e0002282. Published 2024 Jan 8. doi:10.1371/journal.pgph.0002282
30. Eke CB, Ndu IK, Edelu BO, Uleanya ND, Ekwochi U, Chinawa JM, et al. Clinical profile and electrolyte abnormalities in hospitalized underfive children with acute gastroenteritis in a tertiary health facility. Niger J Med 2020;29:295-302.
31. Botez GI, Doughty L. Life threatening tropical infections. Pediatric Critical Care Medicine: Volume 3: Gastroenterological, Endocrine, Renal, Hematologic, Oncologic and Immune Systems. 2014:577-605.
32. Ikuta G, Ayieko P, Irimu G, Akech S, English M. Prevalence, aetiology, treatment and outcomes of shock in children admitted to Kenyan hospitals. BMC Med. 2016;14:214. doi:10.1186/s12916-016-0728-x.
33. Carrara M, Ferrario M, Bollen Pinto B, Herpain A. The autonomic nervous system in septic shock and its role as a future therapeutic target: a narrative review. Ann Intensive Care. 2021;11(1):80. doi:10.1186/s13613-021-00869-7
34. Charaya S, Angurana SK. Predicting fluid responsiveness in children with shock: POCUS can guide. Indian J Pediatr. 2023;90(9):1065-1066. doi:10.1007/s12098-023-04772-w.
35. Oldendorff F, Nordberg V, Giske CG, Navér L. A decade of neonatal sepsis in Stockholm, Sweden: Gram-positive pathogens were four times as common as Gram-negatives. Eur J Clin Microbiol Infect Dis. 2024;43(5):959-968. doi:10.1007/s10096-024-04809-8
36. Rusmawatiningtyas D, Nurnaningsih N. Mortality rates in pediatric septic shock. Paediatr Indones. 2017;56(5):304-310. doi:10.14238/pi56.5.2016.304-10.