Journal of Biosciences and Medicines, 2025, 13(2), 531-547
https://www.scirp.org/journal/jbm
ISSN Online: 2327-509X
ISSN Print: 2327-5081

Impacts of Severe Acute Malnutrition on the Kidney among Under-Five Children Admitted to Tertiary Hospitals in Central Tanzania

Majaliwa Jackson[1*], Shakilu Jumanne[2], Secilia Ng'weshemi Kapalata[3], Dina Mahamba[2]

[1]Department of Paediatrics & Child Health, Mirembe Hospital, Dodoma, Tanzania
[2]Department of Paediatrics & Child Health, University of Dodoma, Dodoma, Tanzania
[3]Department of Community Medicine, University of Dodoma, Dodoma, Tanzania
Email: *majaliwa.paeds@gmail.com, dinamahamba@gmail.com, shakiluj@gmail.com, mwatty92@yahoo.com

How to cite this paper: Jackson, M., Jumanne, S., Kapalata, S.N. and Mahamba, D. (2025) Impacts of Severe Acute Malnutrition on the Kidney among Under-Five Children Admitted to Tertiary Hospitals in Central Tanzania. *Journal of Biosciences and Medicines*, **13**, 531-547.
https://doi.org/10.4236/jbm.2025.132040

Received: January 19, 2025
Accepted: February 25, 2025
Published: February 28, 2025

Abstract

Background: Severe acute malnutrition (SAM) is one of the major public health problems associated with increased mortality in under-five children. In low-income countries, renal dysfunction (RD) contributes to about 34% mortality in under-five children with severe acute malnutrition. This study aimed to determine the impacts of severe acute malnutrition on the kidney among the admitted under-five children. **Methods:** In this prospective longitudinal observational study, a total of 190 children aged 6 to 59 months were enrolled from Iringa and Dodoma tertiary hospitals. Socio-demographic, clinical and laboratory data were collected using a structured questionnaire. Estimated Glomerular Filtration Rate (eGFR) and urine albumin creatinine ratio (uACR) were used to determine RD. Data analysis was done using SPSS version 26 and statistical significance was assumed for factors with p-value < 0.05. **Results:** Out of 190 children with severe acute malnutrition, 36 (19%) had renal dysfunction. Factors associated with RD in malnourished children were the history of local herbs used within one week (AOR = 5.85, 95% CI [1.41, 24.319], p = 0.0152), Acute watery diarrhea with severe dehydration (AOR = 2.15, 95% CI [1.033, 4.711], p = 0.0166), and positive urine leukocytes (AOR = 19.91, 95% CI [4.09, 96.989], p = 0.0002). At three months of follow up, out of 36 children with RD, 20 (55.56%) attained full recovery, while 4 (11.11%) developed chronic kidney disease (CKD). Children with RD had prolonged hospital stays for more than 14 days with a mean 12.25 ± 5.00 days compared to those with no RD with a

mean 6.29 ± 1.68 days ($p < 0.0001$). Children with RD had a higher mortality 12 (33.33%) compared to those without RD 2 (1.30%) ($p < 0.0001$). **Conclusion:** Renal dysfunction is common among children with severe acute malnutrition. It is associated with prolonged hospital stays and increased mortality. Further studies which can determine the burden of RD in children with severe acute malnutrition as compared to those with no severe acute malnutrition are needed.

Keywords

Impacts, Severe Acute Malnutrition, Kidney, Under Five, Tanzania

1. Introduction

Severe acute malnutrition is a global health concern affecting about 17 million under-five children worldwide and it is more common in low- and middle-income countries compared to developed countries due to inadequate food intake, illness, poor health services, lack of safe water and sanitation and inadequate child and maternal care due to poverty [1]. Severe acute malnutrition affects almost all organs in the body, including the kidney and the heart. Reduction in cardiac muscle mass in malnourished children results in decreased cardiac output, which impacts the kidney by reducing renal function and glomerular filtration rates [2]. High frequency of diarrhea, vomiting and dehydration in children with severe acute malnutrition causes significant hypovolemia, which impairs tubular function and glomerular filtrations, causing renal dysfunctions. The predictors of renal dysfunction in malnourished children studied to date include vomiting, diarrhea with severe dehydration, infections and local herbs use [3].

One third of hospitalized children with malnutrition suffer from kidney impairment worldwide [4]. Children with severe acute malnutrition are nine times at risk of dying compared to well-nourished children with a case fatality rate ranging from 6% to 29% [5] [6]. In low-income countries, renal dysfunction contributes to about 34% of mortality in under-five children with severe acute malnutrition [7].

In Sub-Saharan Africa, studies on the effects of severe acute malnutrition on the kidney are limited [8]. In Tanzania, few studies have been conducted concerning renal dysfunction in other pediatric populations apart from severe acute malnutrition such as sickle cell diseases, HIV and Diabetes [9]-[11]. One study in children with severe acute malnutrition has been published in Tanzania showing a prevalence of renal dysfunction to be 14.5% [12]. A study by Chami *et al.*, 2019 failed to evaluate whether renal dysfunction was transient or could lead to chronic kidney disease as the baseline creatinine was not known and the three month follow up to meet chronic kidney disease criteria was not done. Therefore, the current study, which is a follow up study, was essential so as to ascertain whether

renal dysfunction at baseline may develop into chronic kidney disease at three months. This study aims to determine the impacts of severe acute malnutrition on the kidney, which will generate local data that are useful in early diagnosis and timely intervention to decrease mortality.

2. Material and Methods

Study design and setting

This was a prospective longitudinal observational study conducted at Iringa and Dodoma tertiary hospitals for 6 months from December 2021 to May 2022. Both hospitals are designated teaching hospitals for medical students in central Tanzania. They provide inpatient diagnostic and therapeutic management for malnutrition and run scheduled malnutrition clinics every week with more than 150 children attending clinic monthly. On average more than 30 children with severe acute malnutrition are admitted to Paediatric wards per month.

Study participants, inclusion and exclusion criteria

The study included all children aged 6 months to 59 months admitted in Paediatric wards with pitting edema of both feet or mid-upper arm circumference of <11.5 cm or weight for length of <−3 SD or severe visible wasting which is defined as presence of muscle wasting in the gluteal region, loss of subcutaneous fat or prominence of body structures, particularly over the thorax. Children with pre-existing renal disease and those with known congenital heart disease were excluded from the study.

Sample size and sampling procedures

Using the Krejcie and Morgan formula, a minimum sample size of 145 was calculated, and a total of 190 participants were recruited over the course of six months, from December 2021 to May 2022. Iringa and Dodoma were purposely chosen as study centers due to high prevalence of malnutrition above the national prevalence. The participants from each health facility, were selected using convenience sampling techniques after meeting the inclusion criteria, in which the study participants were recruited based on their availability so as to maximize the sample size.

Data collection and Study procedures

After written consent was obtained from caregivers or parents, a structured pre-tested questionnaire adapted from WHO STEPS instruments [13] and modified to suit the intended objectives was used to collect information on socio-demographic, medical history, clinical examination findings and laboratory results. History of diarrhea, vomiting, use of local herbs within one week and history of SCD were recorded. Each participant was examined thoroughly and measurements of length, weight and MUAC were also taken. The hydration status was done using the World Health Organization dehydration assessment scale that categorizes dehydration into "no signs of dehydration", "some dehydration", and "severe dehydration" based on presenting clinical signs including general appearance, appetite and eyes, skin turgor [14].

Height/length was measured by stadiometer with length board (PRESTIGE-SM, India). Weight was measured using Salter Hanging Scale (CMS89, UK) which was adjusted to zero before each measurement. MUAC was measured using a MUAC tape measure (AnthroFlex, BO8F5N-China) at the left arm. WHO Z-charts for nutritional assessment were used for interpretation of results. The temperature was measured using Rox Max TG 380 digital thermometer (India), the tip was swabbed using cotton wool soaked in 70% alcohol before each measurement.

About 10 mls of urine were collected for analysis of urine nitrates, leukocytes, creatinine and albumin using urine multistrip test (MISSION 8, Acon Labs, USA). The test strip was immersed in a urine sample for 5 seconds, and then placed on a surface of a collection bottle in order to drain excess urine. Reading was done after approximately 1 minute whereas the color of the test pad was matched with the color scale on the vial containing the test strip. All participants were tested for HIV using Rapid HIV antibody test as recommended by WHO and current Tanzania guideline. About one drop of blood from the EDTA tube was used to test for HIV using a rapid test (S.D. Bio Line HIV-1/2 3.0 Kit), four drops of the diluents assay were added vertically into the sample. The results were read after 10 - 20 minutes after adding the diluents. Malaria was tested using rapid antigen test using the Bio Line Ag P.f/Pan, 5 μL of whole blood collected in a special capillary was transferred into the sample pad and two drops of assay diluents were added into the square assay diluents. The results were read within 20 minutes. Malaria rapid diagnostic test standard operating procedure provided by the Ministry of the health of the Republic of Tanzania was observed.

About 2 milliliters of blood put on the EDTA tube was used for analysis of WBC, Neutrophils, lymphocyte absolute counts and platelet levels using CELL-DYN Ruby system hematological analyzer (ABBOTT LABS, USA). Serum creatinine was measured using XL-180 Fully Automated Chemistry analyzer machine made from Germany, employing the buffered kinetic Jaffe's reaction, which was IDMS-traceable. Serum creatinine results were used to calculate glomerular filtration rate using the original Schwartz formula: (Height in cm × 0.55) ÷ Serum creatinine [15].

The primary outcome was presence of renal dysfunction. Serum creatinine was used to calculate eGFR using Schwartz formula. eGFR < 60 ml/min/1.73 m^2 and or uACR of ≥30 mg/g was defined as renal dysfunction and the eGFR > 60 ml/min/1.73m^2 and or uACR of <30 mg/g was defined as normal renal function.

The secondary outcome was recovery, death and development of chronic kidney disease at three months of follow up. Recovery was determined by eGFR > 60 ml/min/1.73 m^2 and or uACR of <30 mg/g at three months. Death at any time of three months follow up from admission was recorded through hospital records in the wards and phone contacting the participants' caregivers after discharge. Chronic kidney disease development was determined by eGFR < 60 ml/min/1.73m^2 and or uACR of ≥30 mg/g at three months.

Follow up procedures

The treatment outcome of children with renal dysfunction among children with severe acute malnutrition included recovery, death, hospital stay and development of chronic kidney disease. All children were followed up from admission to three months. Treatments given to children with severe acute malnutrition as per protocol were similar at Iringa and Dodoma regional referral hospitals and were followed up. Hospital stay was recorded as soon as the patient is discharged through patient files and discharge forms. Death was recorded from time of admission during treatment and also followed up after discharge through caregivers' contacts. At three months, the serum creatinine and urine microalbumin were measured again to determine the eGFR and uACR respectively. Children with eGFR > 60 ml/min/1.73 m^2 and or uACR of <30 mg/g were declared as attained recovery and those with eGFR < 60 ml/min/1.73 m^2 and or uACR of ≥30 mg/g were defined as having CKD. Anthropometrics measurements were also repeated to see the resolution of malnutrition.

Study validity and reliability

Data collection was preceded by training research assistants for two days. The questionnaire was pretested using a small sample size at Chamwino health center in Dodoma, which was not part of the study area. The pilot study participants were similar to those in the study area. All questions were well responded with exception of one question was found to be unclear to participant and it was corrected. Daily proofreading of the collected data was done by the researcher. Moreover, to ensure the consistency and completeness of the collected data, close supervision by researcher was performed throughout the period of data collection.

Data analysis

The analysis was done using SPSS version 26. Continuous data were presented using mean and median with interquartile range. Categorical data were presented using proportion. Estimated glomerular filtration rate was calculated using original Schwartz formula by taking height in centimeter times 0.55 divide by serum creatinine in mg/dl. Univariate analysis using binary logistic regression was performed to determine the factors associated with renal dysfunction in children with severe acute malnutrition. Variables with a p-value < 0.2 was subjected to a multivariate model to identify the independent associations. Any variables after multivariate analysis with a p-value < 0.05 was considered statistically significant. Results from logistic regression analysis were reported as an odd ratio (OR) and adjusted odds ratio (AOR) with a 95% confidence interval.

Ethical consideration

The ethical clearance to conduct the study was sought from the University of Dodoma Directorate of Research and Publication (MA.84/261/02). The permission to conduct the research and data collection was obtained from Vice Chancellor's office at the University of Dodoma and regional administrative secretaries at Iringa and Dodoma regions. The informed written consent was obtained from the parents or guardians before recruitment of study participants. All questionnaires

did not contain the names of study participants rather than the Identification numbers. Parents or guardians were assured that participation of their children to this study was voluntary and they were free to withdraw from the study at any time. All study participants received treatments according to hospital protocols regardless of their participation in this study. Children who were found to have CKD, HIV and Malaria were linked to medical care and treated as per Tanzania treatment guideline.

3. Results

Participant's enrollment

From December 2021 to May 2022, a total of 207 children with severe acute malnutrition were admitted in Paediatric wards, 53 children from Iringa and 154 children from Dodoma. Six patients from Iringa and eleven patients from Dodoma had pre-existing renal disease and hence were excluded from the study. Therefore, a total of 190 children with severe acute malnutrition were included into the study (Figure 1).

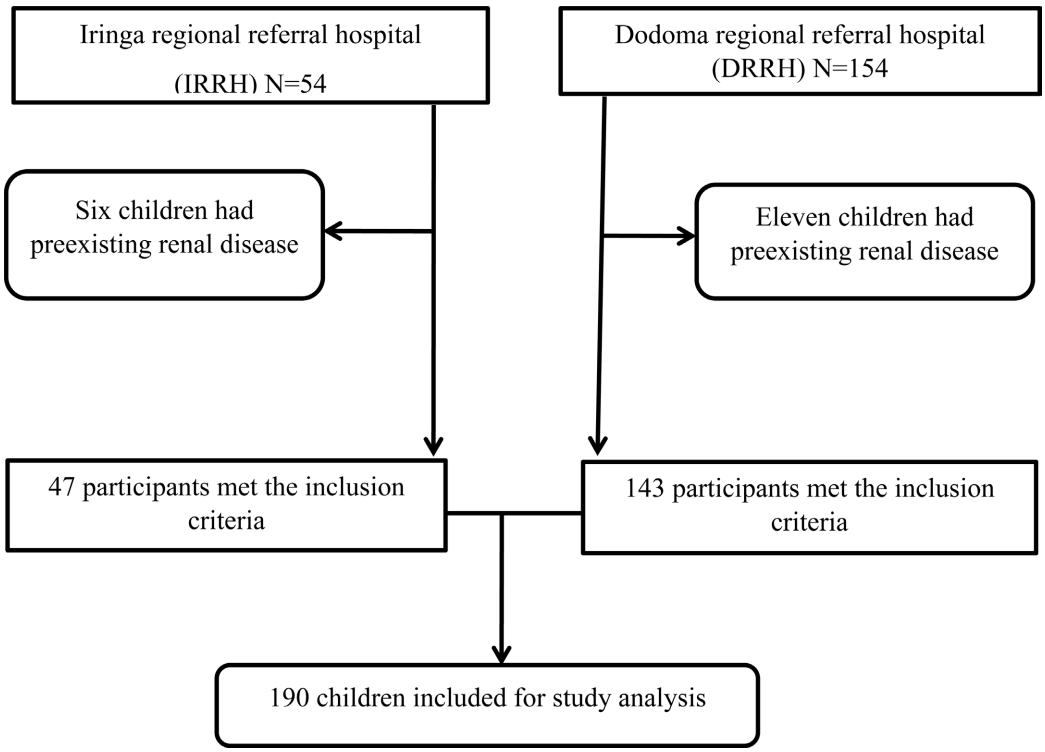

Figure 1. Participant's enrollment.

Baseline characteristics of children with severe acute malnutrition

The mean age of children with severe acute malnutrition was 18.47 ± 10.96 months ranging from 6 to 59 months old with male gender predominance 117 (61.58%). Majority of children with severe acute malnutrition 134 (70.53%) were from rural areas. Out of 190 participants, 31 (16.32%) had history of local herbs use within 1 week prior to admission. Almost half of the study participants, 98

(51.58%) and 96 (50.53%) were having AWD with severe dehydration and vomiting respectively (Table 1).

Table 1. Baseline characteristics of children with severe acute malnutrition (N = 190).

Variable	Frequency	Percent
Study site		
Dodoma	143	75.26
Iringa	47	24.74
Children age group [18.47 ± 10.96] months		
<24	143	75.26
>24	47	24.74
Sex of the child		
Male	117	61.58
Female	73	38.42
Place of residence		
Urban	56	29.47
Rural	134	70.53
Local herbs use within 1 week		
Yes	31	16.32
No	159	83.68
History of SCD		
Yes	4	2.11
No	186	97.89
Fever [36.65 ± 0.77]˚C		
>37.5	34	17.90
<37.5	156	82.10
AWD with severe dehydration		
Yes	98	51.58
No	92	48.42
Vomiting		
Yes	96	50.53
No	94	49.47
Edema		
Yes	113	59.47
No	77	40.53
HIV status		
Yes	7	3.68

Continued

No	183	96.32
MRDT positivity		
Yes	2	1.05
No	188	98.95
Urine nitrites positivity (>+1)		
Yes	22	11.58
No	168	88.42
Urine leukocytes >15 WBCs/μL		
Yes	42	22.11
No	148	77.89
White blood counts (10^3/μL)		
4 - 15	136	71.58
>15	54	28.42
Absolute neutrophils count (10^3/μL)		
1.5 - 8.5	143	75.26
>8.5	47	24.74
Absolute lymphocytic counts (10^3/μL)		
1.5 - 8.5	32	16.84
>8.5	158	83.16
Platelet levels (10^3/μL)		
150 - 450	124	65.26
>450	66	34.74

Local herbs use among children with severe acute malnutrition

Alovera (*Aloe vera*) 9 (29.03%) followed by Mwarobaini (*Azadirachta indica*) 5 (16.13%) and Ndulele (*Solanum incanum*) 5 (16.13%) were among the common herbal medication used by some of the children with severe acute malnutrition (Figure 2).

Prevalence of Renal dysfunction among children with severe acute malnutrition

The overall prevalence of renal dysfunction in children with severe acute malnutrition was 36 (19%) whereby the prevalence of RD at Iringa was 10 (21.28%) and at Dodoma it was 26 (18.8%).

Factors associated with renal dysfunction among children with severe acute malnutrition

All presenting baseline characteristics of the children with severe acute malnutrition were evaluated as possible factors predictive of renal dysfunction. On Univariate binary logistic regression, the factors associated with renal dysfunction

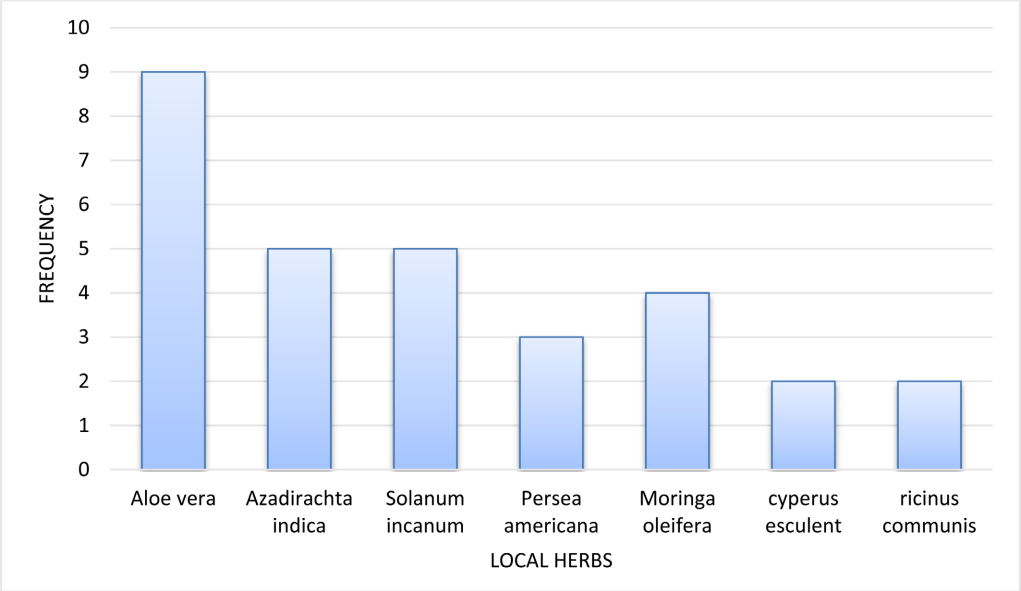

Figure 2. Local herbs use among children with severe acute malnutrition.

included local herbs use within one week, AWD with severe dehydration, positive urine nitrites, positive urine leukocytes 15 > wbcs/μL, white blood count > 15 × 10^3, absolute neutrophils count > 8.5 × 10^3, Platelet levels > 450 × 10^3 were associated with Renal dysfunction. Following multivariate logistic regression, children who used local herbs had six times risk of getting RD as compared to non-users. Children with AWD with severe dehydration were observed to have two times increased risk of getting RD compared to those who did not have AWD. Having positive urine leukocytes was associated with twenty times increased risk for RD compared to those with negative urine leukocytes (Table 2).

Table 2. Factors associated with RD among children with severe SAM (N = 190).

Variable	No RD n (%)	RD n (%)	Univariate OR [95% CI]	p-value	Multivariate AOR [95% CI]	p-value
Children age group (months)						
< 24	114 (79.72)	29 (20.28)	Ref			
>24	40 (85.11)	7 (14.89)	0.69 [0.280, 1.693]	0.4158		
Sex of the child						
Male	93 (79.49)	24 (20.51)	Ref			
Female	61 (83.56)	12 (16.44)	0.76 [0.355, 1.637]	0.4866		
Local herbs use within one week						
No	143 (89.94)	16 (10.06)	Ref		Ref	
Yes	11 (35.48)	20 (64.52)	16.25 [6.61, 39.93]	< .0001	5.85 [1.41, 24.319]	**0.0152**
Fever						
No	125 (80.13)	31 (19.87)	Ref			

Continued

Yes	29 (85.29)	5 (14.71)	0.695 [0.249, 1.943]			
AWD with severe dehydration						
No	79 (85.87)	13 (14.13)	Ref		Ref	
Yes	75 (76.53)	23 (23.47)	1.864 [0.880, 3.945]	0.1037	2.15 [1.033, 4.711]	**0.0166**
Vomiting						
No	86 (91.49)	8 (8.51)	Ref		Ref	
Yes	68 (70.83)	28 (29.17)	4.43 [1.896, 10.330]	0.0006	2.60 [0.402, 16.864]	0.3156
Edema						
No	89 (78.76)	24 (21.24)	Ref			
Yes	65 (84.42)	12 (15.58)	0.685 [0.319, 1.469]	0.3306		
Positive urine nitrates (>+1)						
No	141 (83.93)	27 (16.07)	Ref		Ref	
Yes	13 (59.09)	9 (40.91)	3.615 [1.406, 9.296]	0.0076	1.89 [0.39, 11.494]	0.4825
Urine leukocytes (>15 WBCs/μL)						
No	137 (92.57)	11 (7.43)	Ref		Ref	
Yes	17 (40.48)	25 (59.52)	18.32 [7.67, 43.72]	< .0001	19.91 [4.09, 96.989]	**0.0002**
White blood cells (10^3/μL)						
>15	40 (74.07)	14 (25.93)	1.81 [0.848, 3.881]	0.1251	1.57 [0.126, 2.608]	0.1098
4 - 15	114 (83.82)	22 (16.18)	Ref		Ref	
Absolute neutrophils count (10^3/μL)						
>8.5	35 (74.47)	12 (25.53)	1.70 [0.772, 3.741]	0.1873	3.74 [0.743, 18.861]	0.1098
1.5 - 8.5	119 (83.22)	24 (16.78)	Ref		Ref	
Absolute lymphocytic counts (10^3/μL)						
>8.5	25 (78.13)	7 (21.88)	1.25 [0.491, 3.156]	0.6435		
1.5 - 8.5	129 (81.65)	29 (18.35)	Ref			
Platelet levels (10^3/μL)						
>450	46 (69.70)	20 (30.30)	2.94 [1.397, 6.166]	0.0045	2.83 [0.865, 9.239]	0.0854
150 - 450	108 (87.10)	16 (12.90)	Ref		Ref	

Treatment outcomes of renal dysfunction among children with severe acute malnutrition

Children with RD had prolonged hospital stay, 15 (41.67%) with a mean 12.25 ± 5.00 days compared to those without RD with a mean of a 6.29 ± 1.68 days. At three month follow up, the mortality in children with RD was 12 (33.33%). Out of 36 study participants with Renal dysfunction, 20 (55.56%) attained full recovery within 3 months of follow up, while 4 (11.11%) developed chronic kidney disease (Table 3).

Table 3. Treatment outcomes of renal dysfunction among children with severe acute malnutrition.

Treatment outcomes	No RD (N = 154) n (%)	RD (N = 36) n (%)	p-value
Hospital stays	**6.29 ± 1.68**	**12.25 ± 5.00**	<0.0001*
<14	153 (99.35)	21 (58.33)	
14+	1 (0.65)	15 (41.67)	
Mortality			
Alive	152 (98.70)	24 (66.67)	<0.0001*
Death	2 (1.30)	12 (33.33)	
Recovery			
Yes		20 (55.56)	
No		16 (44.44)	
Development of CKD			
Yes		4 (11.11)	
No		32 (88.89)	

*Fisher exact test.

4. Discussion

In this study the overall prevalence of renal dysfunction among children with severe acute malnutrition was 19%. Similar findings were found in a study done in Northern Tanzania, which found the prevalence of renal dysfunction to be 16.2% [12]. Similarity in findings may be attributed due to the fact that both studies used eGFR < 60 and uACR ≥ 30 mg/g for renal dysfunction determination. In addition, in both studies, the local herbal medication (p = 0.001) and dehydration (p = 0.001) were independent factors associated with renal dysfunction.

The obtained prevalence in this study was high compared to studies done in Malawi by Bjornstad *et al.*, 2020, which found a prevalence of 10%. The study in Malawi enrolled more than 50% participants with normal nutritutional status contrary to the index study in which all study participants had severe acute malnutrition, which may explain a low prevalence obtained in Malawi as compaired to the index study. In addition, eGFR alone was used to determine renal dysfunction as which is different to the index study which used both eGFR and uACR. A sudden reduction in renal function is not shown by serum creatinine until after 24 to 48 hours but urinary albumin as a biomarker of RD, accurately predicts renal dysfunction in the early stages compared to creatinine [16], this delay in picking the renal dysfunction could have contributed to low prevalence obtained compared to the index study which used both eGFR and uACR. Similarly, another study done in Uganda by Imani *et al.*, 2013 found a prevalence of 13.5% which is lower as compared to the index study. Use of serum creatinine in defining RD and inclusion of underweight (20.7%) and normal nutritional status (79.3%) could

explain the differences in prevalence observed.

The prevalence of this study was found to be low compared to the study done in Uganda which found that the prevalence of renal dysfunction among children with severe acute malnutrition was 44.8% [17]. In that study, the study participants were observed to have HIV infection (12.2%) compaired to the index study in which only 3.68% of participants were HIV infected. In addition, the study included children with commobidies (12.6%) which were congenital heart disease and cerebral palsy which is asociated with impared glomerular filtration rates [18]. Similary, the prevalence in this study was observed to be low as compared to a study done in Pakistan which revealed a high prevalence of 59% [19]. The study in Pakistan included children with renal abnormalities such as hydronephrosis 27%, hypoplastic kidney 27% and renal calculi 9%, which may impair glomerular filtration rates and hence increasing the prevalence of renal dysfunction. Also, a wider inclusion criterion for children born prematurely and low birth weight (12%) aged 2 to 60 months may inflate the prevalence because the nephron is still developing and therefore decreased renal function [20].

This study found that, history of local herbs uses within one week among children with severe acute malnutrition was significantly associated with renal dysfunction compared to children who did not use. The caretakers who gave local herbs to their children explained that they used local herbs to treat malnutrition and its complications due to traditional myths in the community that the local herbs treat malnutrition, however, they could not be able to narrate the amount or dosages of local herbs given. This finding is similar to the study done in Northern Tanzania which found that that children with SAM who used local herbs were more likely to get renal dysfunction as compared to non-users [12]. In this study, children with acute watery diarrhea with severe dehydration were observed to be more likely to get renal dysfunction as compared to those with no diarrhea. Similarly, the study done in India revealed that diarrhea with dehydration was significantly associated with renal dysfunction [19]. We found that positive urine leukocytes were significantly associated with renal dysfunction among children with severe acute malnutrition as compared to children with negative urine leukocytes. This finding was similar to a study done in Nigeria [16].

Children with renal dysfunction were observed to have prolonged hospital stay for more than 14 days as compared to children with no renal dysfunction. Similar findings were found by a study done in London by Messova *et al.*, 2019 and in California by Sutherland *et al.*, 2013. We also found that children with RD were more likely to die as compared to those with no RD with a mortality of 33.3%. Similar findings were observed in studies done in Uganda and Malawi [17] [21].

At three month follow up we found that almost half of children with renal dysfunction at baseline attained full recovery with few 4 (11.11) developing chronic kidney disease. Similar finding was observed by a study done in Ethiopia [22]. In the index study, there was a good progress of children with severe acute malnutrition at three months in which 2.27% had severe acute malnutrition, 7.39% had

moderate malnutrition and 90.34% had normal nutritional status, which might have impacted on the recovery of children with RD.

5. Strengths and Limitation of the Study

This study was able to evaluate the burden and risk factors associated with renal dysfunction in children with severe acute malnutrition. It was a follow up study and therefore it was able to evaluate both acute and chronic kidney disease. However, several limitations are admitted. This was a longitudinal follow up study; it was not compared with the control group so as to increase reliability of severe acute malnutrition as a risk factor for renal dysfunction. Moreover, the preparation methods and dosages for local herbs given to malnourished children were not known, which is one of the potential factors for nephrotoxicity.

6. Conclusion and Recommendation

The prevalence of renal dysfunction among admitted children with severe acute malnutrition in the two tertiary hospitals was 36 (19%). Factors associated with renal dysfunction were AWD with severe dehydration, positive urine leukocytes and local herbs use within one week. RD in children with severe acute malnutrition is associated with prolonged hospital stay and higher mortality. Counseling parents or caregivers on the adverse effects of Local herb use is needed. Further studies are needed, which can determine the burden of renal dysfunction in children with severe acute malnutrition compared with the control group with no severe acute malnutrition.

Acknowledgements

Authors would like to thank all the children and their caretakers for participating in this study. Special thanks to all staff at Paediatric Departments and Laboratories in Iringa and Dodoma hospitals.

Authors' Contributions

MJ conceptualized the study, participated in data collection and analysis, and prepared the manuscript. DM, SJ, and SNK contributed to the study's conceptualization, provided technical guidance during development and data analysis, and reviewed the manuscript draft. All authors read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix: Questionnaire (English Version)

Thank you for your willingness to participate in this study to assess the determine the impacts of severe acute malnutrition on the kidney among the admitted under-five children. I will read each question for you and wait for your response. Take time to remember or think about your response. If you need any clarification, do not hesitate to ask; I will clarify for you. All answers you provide will be kept confidential, and your participation is voluntary; you can withdraw from the study at any time.

S/N	CODE	QUESTIONS	CODING CATEGORY
A. Demographic characteristics			
1.	DATE	Date of interview	|___|___| |___|___| |___|___|___|___| Day Month Year
2.	IDNO	Enrollment ID number	|___|___|___|
3.	FIN	Hospital file number	|___|___|___|___|___|___|___|___|
4.	INT	Patient initials	|___|___|___|
5.	AGE	Age of the child	|___|___|months
6.	SEX	Sex of the child	i. Male ii. Female
7.	RESD	Place of residence	i. Urban ii. Rural
8.	PHONE	Phone number of parent/caregivers	|___|___|___|___|___|___|___|___|___|___|
B. Child Medical history			
9.	HERBS	Local herbs use within 1 week	i. Yes ii. No If Yes, Mention _____
10.	SCD	History of SCD	i. Yes ii. No
C. Presenting clinical signs and symptoms			
11.	TEMP	Body temperature ˚C	
12.	DIARR	Diarrhea	.i. Yes ii. No
13.	VOMIT	Vomiting	.i. Yes ii. No
14.	DEHYD	Dehydration	.i. Yes ii. No
15.	EDEM	Oedema	.i. Yes ii. No
D. Laboratory tests and results			
16.	HIV	HIV positivity	.i. Yes ii. No
17.	MAL	MRDT positivity	.i. Yes ii. No
18.	WBC	White blood counts	-----$\times 10^3/\mu L$
19.	ANC	Absolute neutrophil counts	-----$\times 10^3/\mu L$
20.	ALC	Absolute Lymphocyte counts	-----$\times 10^3/\mu L$
21.	PLT	Platelet counts	-----$\times 10^3/\mu L$
22.	NIT	Urine nitrites positivity	.i. Yes ii. No
23.	LEUK	Urine Leukocytes > 15	.i. Yes ii. No
24.	SCr	Serum Creatinine (mg/dl)	

Continued

25.	LENG	Length/Height (cm)		
26.	ALBU	Urine Albumin (mg/L)		
27.	UCr	Urine Creatinine (g/L)		
E. Treatment outcome for children with Renal dysfunction				
28.	STAY	Hospital stays (Days)		
29.	DEATH	Death within 3-month follow-up	i. Yes	ii. No
30.	ALBU*f*	Urine Albumin (mg/L)		
31.	Ucr*f*	Urine Creatinine (g/L)		