Annals of Medicine and Surgery 75 (2022) 103362

Contents lists available at ScienceDirect

Annals of Medicine and Surgery

journal homepage: www.elsevier.com/locate/amsu

Case Series

Acute Kidney Injury: Incidence, aetiology, management and outcome measures of a Samoan case series

Nathan Maligi Chadwick [a,b], Mai Ling Perman [b], Folototo Leavai [a], Annette Kaspar [c,*]

[a] Medical Unit, Tupua Tamasese Meaole Hospital, Ministry of Health, Apia, Samoa
[b] Internal Medicine Unit, School of Medical Sciences, Fiji National University, Suva, Fiji
[c] Research Consultant, Tupua Tamasese Meaole Hospital, Ministry of Health, Apia, Samoa

ARTICLE INFO

Keywords:
Acute kidney injury
Pacific islands
Incidence
Aetiology
Prevention
Complications
Case series

ABSTRACT

Background: Acute Kidney Injury (AKI) is a major and under-recognised cause of morbidity and mortality worldwide. Low and middle-income countries bear the greatest burden of AKI (85%). There is currently no published literature on AKI from the Pacific Islands. The aim of the present study was to report the incidence, aetiology, management and outcomes measures of AKI from the tertiary referral hospital of Samoa.

Materials and methods: Single-centre prospective observational study. Participants were recruited by the lead investigator from the hospital patient information system. The inclusion criteria for participation was (1) adults (>18 years) admitted to general wards of Tupua Tamasese Meaole (TTM) Hospital with a diagnosis of AKI between December 1, 2019 and May 31, 2020, and (2) serum creatinine level of >200 μmol/L, and (3) compliance with the current Kidney Disease Improving Global Outcomes (KDIGO) criteria for AKI diagnosis. The data collection form was adapted from the International Society for Nephrology - Global Snapshot Project, and recorded demographic and baseline characteristics, precipitating causes of AKI, treatment/management, and outcomes measures.

Results: There was a total of 114 AKI admissions over the study period corresponding to a hospital-based AKI incidence of 26.8 per 1000 admissions per 6 months. 75% of AKI cases were community acquired. The leading causes of AKI were dehydration (79%) and sepsis (64%). More than 40% of cases presented with two or more Non-Communicable Disease co-morbidities. The in-patient mortality rate was 20.2%. In the 3 months following discharge from hospital, 25% of AKI cases had completely resolved, 25% of patients had died, and 18.7% of AKI cases had progressed to chronic kidney disease. The leading causes of mortality were cardiovascular events (35%) and sepsis (35%).

Conclusions: The hospital-based incidence and unfavourable outcomes of AKI are high in Samoa. Greater awareness of this under-recognised condition is warranted among the public, government officers, and health professionals.

1. Introduction

Acute Kidney Injury (AKI) is described as a rapid increase in serum creatinine, decrease in urine output, or both [1]. AKI is not a disease in itself, but rather a silent and under-recognised syndrome that exists on a spectrum, usually secondary to other major aetiologies such as heart failure and sepsis/shock [1]. AKI is associated with various pathophysiological processes that include retention of waste products, impaired electrolyte homeostasis, and generalised inflammatory response affecting distant organs [2]. It represents 10–15% of hospitalisations worldwide, and AKI prevalence in the intensive care unit may exceed 50% [1]. Early recognition of AKI enables timely management and improvement/recovery of kidney function, and therefore reduces the risk of long-term morbidity and mortality from both kidney disease and the primary/precipitating health concern (i.e., myocardial infarct) [1,2].

The current international consensus regarding the definition of AKI is when, over a period of seven days or less, a patient presents with a ≥ 1.5

Abbreviations: AKI, Acute Kidney Injury; ISN, International Society of Nephrology; KDIGO, Kidney Disease Improving Global Outcomes; LLMICs, Low- and Lower-Middle Income Countries; NCDs, Non-Communicable Diseases; TTM, Tupua Tamasese Meaole.

* Corresponding author.
E-mail address: annette.kaspar@gmail.com (A. Kaspar).

https://doi.org/10.1016/j.amsu.2022.103362
Received 23 December 2021; Received in revised form 3 February 2022; Accepted 10 February 2022
Available online 11 February 2022

times increase in baseline serum creatinine (or increase of ≥ 0.3 mg/dL within any 48h period), and/or a urine volume =< 0.5 ml/kg for more than 6 h. The definition of AKI is further classified into three stages of increasing severity (Table 1). These criteria were published by the Kidney Disease Improving Global Outcomes (KDIGO) group to serve as an international gold standard, as well as to facilitate unity and comparison between AKI research findings worldwide.

According to global epidemiology studies [2–4], the greatest burden of AKI (85%) is found in low-income and lower-middle income nations (LLMICs). The high incidence of AKI in these countries is largely attributed to environmental factors, specifically to contaminated water and endemic disease (i.e., malaria on the African continent) [2]. There is also evidence that AKI affects younger individuals in low-resourced settings, with volume-responsive renal failure, obstetric complications, infections and toxins as the main causes of kidney injury [5]. While the overwhelming proportion of AKI research (82.7%) is generated by high-income nations, the few studies from low-resourced settings indicate that a significant proportion of AKI is preventable. To this end, the International Society of Nephrology launched the "0by25 Initiative", which aims to eliminate preventable AKI as a cause of mortality worldwide [6,7]. The review of the literature found that there are currently no publications on AKI in the Pacific Islands.

Samoa is a Polynesian nation of the Pacific Island region (Fig. 1). Tupua Tamasese Meaole (TTM) Hospital is the only tertiary referral centre in the country, and it is located in the capital city Apia. A caseload review of the Emergency and Internal Medicine Departments suggested that AKI may be a significant yet under-recognised presentation to the TTM hospital. Given the published reports on kidney failure and haemodialysis in Samoa [8,9], the aims of the present study were to evaluate the incidence, aetiology, management and outcome measures of adult patients attending the TTM Hospital with an AKI diagnosis. The results of the study should not only improve early identification and management of AKI in our setting, it may also lead to reducing the burden of chronic kidney disease on our country.

2. Methods

2.1. Ethical approval

Ethical approval for the present study was obtained from the Fiji National University College Health Research Ethics Committee (CHREC) and the Government of Samoa Ministry of Health – Health Research Committee (MoH-HRC). Gatekeeper approval was also obtained from the Deputy Director General of the TTM Hospital.

2.2. Registration

In accordance with the Declaration of Helsinki that "Every research study involving human subjects must be registered in a publicly accessible database", the present study was registered with ClinicalTrials.gov (Protocol ID: 117.19; ClinicalTrials.gov ID: NCT05167292).

Table 1
KDIGO definition of AKI.

	Serum Creatinine criteria	Urine output criteria
Stage 1	1.5–1.9 times baseline OR ≥0.3 mg/dl (≥26.5 μmol/l) increase	<0.5 ml/kg/h for 6–12 h
Stage 2	2.0–2.9 times baseline	<0.5 ml/kg/h for 12 h
Stage 3	3.0 times baseline OR Increase in serum creatinine to ≥4.0 mg/dl (≥353.6 μmol/l) OR Initiation of renal replacement therapy	<0.3 ml/kg/h for 24 h OR Anuria for 12 h

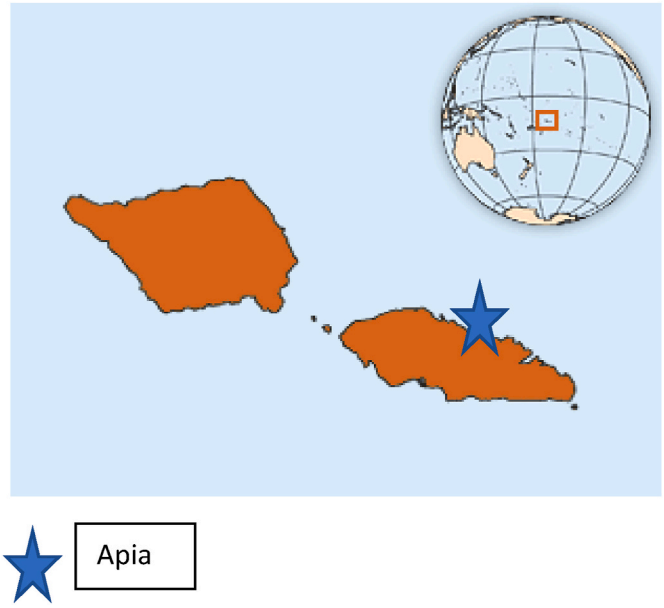

Fig. 1. Map of Samoa.

2.3. Study design and data collection

The present study is reported in line with the PROCESS 2020 criteria [10]. This was a single-centre prospective observational study. Participants were recruited from the hospital patient information system by the lead investigator, a senior physician specialising in internal medicine. The inclusion criteria for participation were (1) adults (>18 years) admitted to general wards of Tupua Tamasese Meaole (TTM) Hospital with a diagnosis of AKI between December 1, 2019 and May 31, 2020, and (2) serum creatinine level of >200 μmol/L, and (3) compliance with the current Kidney Disease Improving Global Outcomes (KDIGO) criteria for AKI diagnosis. Patients with underlying chronic kidney disease who experienced an episode of AKI during the study period were also included in the present study. Exclusion criteria were (1) patients on chronic haemodialysis, (2) patients with underlying chronic kidney disease with no evidence of AKI, and (3) patients for whom it was not possible to ascertain a diagnosis (i.e., patients with one elevated serum creatinine result and no subsequent follow-up haematology).

The hospital Laboratory Database was accessed to identify all patients admitted to TTM Hospital during the study period with a serum creatinine level greater than 200 μmol/L. This is higher than the reference intervals for normal creatinine levels reported in the literature (60–110 μmol/L for adults males, 45–90 μmol/L for adult females) [11]. This criteria was chosen to align with the criteria used by the Fijian teaching hospital that is affiliated with the Fiji National University: the 200mcmol/L criteria reflects their AKI triage management guidelines based on the low-resourced context. The present study therefore adopted the same criteria to evaluate the similarly low-resourced context of Samoa. A total of 1185 patients were identified, and a request for their complete medical records was made to the Medical Record Department. Each record was reviewed for its suitability, and a total of 1071 records did not meet inclusion criteria. The sample size for the present study was therefore 114 patients.

The data collection form is an adaptation of the form used by the International Society for Nephrology for the Global Snapshot Project [12]. For each participant, the following information was collected:

2.3.1. Demographic and baseline characteristics

- Demographic Information: age (years), gender (male/female), ethnicity (Samoan/Other).

- Admission Information: Admitting Department (Medica/Surgical/Obstetrics&Gynecology), risk factors for AKI (age>75 years/Diabetes Mellitus/Chronic Liver Disease/Chronic Heart Failure/Chronic Kidney Disease/anemia (Hb < 9 g/dL)/none/unknown), AKI acquisition (community/hospital), baseline serum creatinine within previous 12 months (micromole/L).
- Presenting symptoms for suspicion of AKI: Dehydration (diarrhea/vomiting/increased thirst/decreased intake), urinary symptoms (oliguria/polyuria/dysuria/heamaturia/incontinence/urolith passed), swelling (anasarca/face & neck/upper limbs/lower limbs/other), hypotension (MAP<65/shock and use of vasopressors/hemmorrhage), pregnancy and delivery-related symptoms (PV bleeding/coma/seizures/other), Fever, Traumatic injury (site), allergic reaction (specify), poisoning (specify).
- AKI KDIGO criteria-based diagnosis: increase in serum creatinine by 0.3 mg/dL or more within 48 h OR, increase in serum creatinine to 1.5 times baseline or more within the last 7 days OR, urine output less than 0.5 ml/kg/h for 6 h.

2.3.2. Aetiology

- Factors contributing to development of AKI: dehydration (diarrhea/vomiting/polyuria/decreased intake), liver (hepatorenal syndrome/cirrhosis/acute liver failure), cardiac (acute myocardial infarct/VHD/heart failure/pulmonary embolism/infective endocarditis/cardiorenal syndrome), hypotension and shock (cardiogenic shock/hemorrhage/sepsis/drug induced/anaphylaxis/post partum/hypotension of unclear cause), acute kidney diseases (acute glomerulonephritis/interstitial nephritis/pyelonephritis/rhabdomyolysis/intravascular hemolysis), urinary obstruction (sone/tumor/prostate condition), infections (leptospirosis/dengue/TB, other bacterial/other viral), pregnancy related (miscarriage with septic shock/puerperal sepsis), systemic diseases (multiple myeloma/SLE/DIC/preeclampsia/PPH/hyperemesis gravidarum), nephrotoxic agents (ACEI/ARB, NSAIDS, aminoglycosides/chemotherapy/contrast), poisoning (yes/no).
- Blood parameter on the day AKI was confirmed: Urea (umol/L), creatinine (umol/L), urine output in past 24 h (mls).
- Known infection site (yes/no), and if yes specify infection site.
- Other organ failures: pulmonary, cardiovascular, hepatic, hematological, neurological, none.

2.3.3. Management

- Non-dialytic treatment at the time of AKI diagnosis: fluid therapy, diuretics, vasosupressors, antibiotics, urinary diversion (percutaneous nephrostomy, cystectomy, urethral catheterization), fluid restriction, other.
- Patient received dialysis (yes/no).
- Indication for starting dialysis: fluid overload, symptomatic uremia, electrolyte or acid-based disturbance, intoxication/poisoning, other.
- Number of days from diagnosis of AKI to initiation of haemodialysis (days).
- Blood parameters on the day haemodialysis was started: Urea (umol/L), creatinine (umol/L), urine output in past 24 h (mls).

2.3.4. Outcome

- Patient status: Alive/deceased.
- Cause of death: kidney failure, infection/sepsis, cardiovascular, shock, dehydration, hemorrhage, pregnancy-related, liver failure, pulmonary condition, neurological, trauma, poisoning, systemic illness, malignancy, unknown.

2.4. Data analysis

The data was analysed using the Microsoft Excel and STATA statistical software packages. Descriptive analysis and pivot tables were performed initially, followed by comparison of binary variables (unpaired *t*-test significant at $p < 0.05$) and the unadjusted Kaplan Meier curve.

3. Results

3.1. Demographics and baseline characteristics

The sample population (N = 114) ranged from 18 to 92 years of age (mean = 55.8 years), with 66 (57.9%) male and 48 (42.1%) female participants (Table 2). Community acquired AKI was identified in 75% of cases (85/114). 80% of cases (91/114) were admitted to the Department of Internal Medicine, 19% 22/114) to the Department of Surgery, and 0.9% (1/114) to the Department of Obstetrics and Gynecology. On admission, 52.6% of cases presented with Stage 1 AKI, followed by Stage 3 AKI (27.2%) and Stage 2 AKI (20.2%). The study cohort was characterised by Non-Communicable Diseases (NCDs), 54 cases (47%) presenting with hypertension, 49 cases (43%) with chronic kidney disease, 47 cases (41%) with Type 2 Diabetes Mellitus, 36 cases (32%) with heart failure, 1 case (1%) with chronic liver disease, and 49 cases (43%) reporting 2 or more of these NCD co-morbidities.

3.2. Incidence

There was a total of 114 AKI admissions over the 6-month study period. An average of 19 admissions per month computes to a hospital-based incidence of 26.8 per 1000 admissions per 6 months. The population based incidence was 1880.9 per million population per year. The Samoan population is currently estimated to be 200, 581 and so this translates to approximately 378 AKI cases per year.

3.3. Aetiology

The most common precipitating causes of AKI were dehydration (79%) and sepsis (64%) (Fig. 2). Cardiovascular events accounted for 36% of cases. The remaining causes were shock (16%), nephrotoxic agents (10%), urinary obstruction (3.6%), acute liver failure (1.8%), and pregnancy related (0.9%).

3.4. Management

The leading treatment modalities were Intravenous Antibiotics (79%) and Intravenous Fluids (63%).

There were 27 cases (24%) who met indications for haemodialysis, and 5 cases agreed to proceed with intermittent acute haemodialysis using the Fresenius 4008b machine. The average time from AKI diagnosis to initiation of dialysis was 2.4 days. The indications for haemodialysis were electrolyte imbalance, acid base disturbance, and/or refractory fluid overload. Overall, the 5 cases underwent an average of 3.8 sessions of haemodialysis. Two patients experienced recovery of kidney function, where the reversal occurred within an average of 16 days. One patient progressed to End-Stage Kidney Disease requiring permanent maintenance haemodialysis. The last two patients passed away while receiving haemodialysis treatments, and the cause of death was sepsis.

3.5. Outcome

During the 6-month study period, 20.2% (23/114) cases died during admission. The leading causes of death as classified on the death certificates were Cardiovascular Events (35%) and Sepsis (35%) (Fig. 3). The remaining causes of death were pulmonary disease (22%),

Table 2
Age and gender distribution for study participants.

Age (years)	18–29	30–39	40–49	50–59	60–69	70–79	80–89	90+	Total
Male	6	2	6	19	21	8	2	1	65
Female	6	5	10	6	12	4	4	2	49
Total	12	7	16	25	33	12	6	3	114

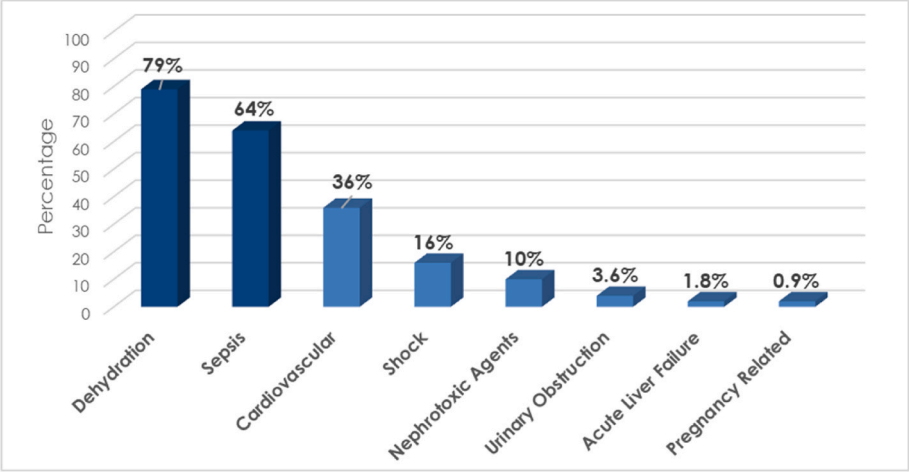

Fig. 2. Precipitating causes of AKI

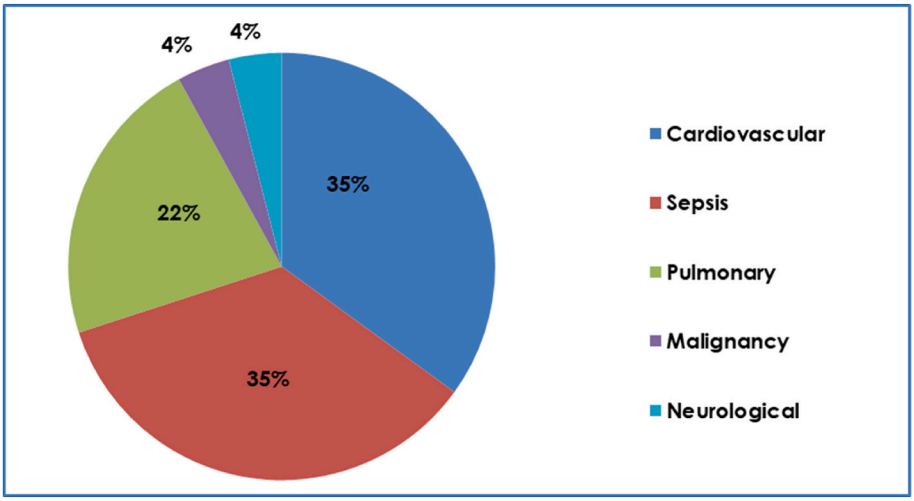

Fig. 3. Causes of death.

malignancy (4%), and neurological events (4%).

Patients were followed-up 3 months post-discharge. A total of 91 cases (79.8%) were alive when discharged from hospital. The AKI resolved in 23 cases (25%). The AKI did not resolve in 40 cases (40%), of which 26 were known CKD cases, and 14 were de-novo cases. A total of 23 patients (25%) died within three months (10 died in hospital, 13 died at home).

A total of 5 cases (6%) were lost to follow-up.

4. Discussion

The present study described the experience of AKI among patients attending the national referral tertiary hospital in Samoa. This is the first published research study on AKI from a Pacific Island country. A hospital-based AKI incidence of 26.8 per 1000 admissions per 6 months was calculated for Samoa. Among a total of 114 AKI hospital admissions, 75% of cases were community-acquired, and more than 40% presented with NCD co-morbidities. The main precipitating factors for AKI were dehydration (79%) and sepsis (64%). The in-patient mortality rate was 20.2% (n = 23), where 78.3% (n = 18) of cases were community-acquired AKI, and 21.7% (n = 5) were hospital-acquired AKI. The leading causes of mortality were cardiovascular events (35%) and sepsis (35%). In the 3 months following discharge from hospital, 25% of AKI cases had completely resolved, 25% of patients had died, and 18.7% of AKI cases had progressed to chronic kidney disease.

In the present study, the majority of AKI hospital presentations were among people in the 50–69 age group with multiple NCD co-morbidities. This finding aligns with the well-recognised NCD public health crisis in the Pacific Islands, and may also explain why our baseline demographics are more comparable to AKI presentations for high-income countries than low-lower-middle-income countries (LLMICs) [12]. The AKI Global Snapshot study found that AKI in LLMICs tends to occur among young

adults with no NCD co-morbidities. The NCD crisis public health crisis may also partly account for the fact that the AKI hospital admission rate in Samoa (2.7%) is similar to that of a high-income country Australia (1.6%). Where the Samoan experience is typical of the LLMIC setting is in the overwhelmingly high proportion of community-acquired AKI presentations, a finding most probably associated with multiple reasons for delayed hospital care (i.e., transport/logistics, preference for traditional medicine).

In our study cohort, 24% (n = 27) of patients met the indications for haemodialysis, and of these, only 18.5% (n = 5) proceeded with haemodialysis. Given that three of these patients died while undergoing haemodialysis, it may be that our population will only consider haemodialysis when the patient is truly critical. Unfortunately, the chance of survival in such cases is small. It was outside the scope of this study to explore the health beliefs, attitudes, and behaviours of patients and their families with regards to haemodialysis, and this should be considered in future studies. It may be that the reluctance to proceed with haemodialysis in Samoa is linked to the perception that it is the haemodialysis, rather than the advanced stages of life-threatening disease(s), that is the cause of death.

The AKI!Now Initiative is a global strategy aimed at creating greater awareness, recognition, and management of AKI [13]. Partnering with health promotion activities and delivering key public health messages should make a positive contribution to reducing the burden of AKI in Samoa. World Kidney Day (March 10th) is an annual event that offers a national platform to highlight acute/chronic kidney disease. These initiatives should be favourable to health policymakers, given the evidence that investment in AKI prevention strategies will reduce the financial and resource burden of acute/chronic kidney disease into the future [14].

Further research to build on the present study is desirable, and opportunities exist under the International Society of Nephrology Dehydration for Kidney Health Research Initiative. Future studies should be multi-centre in design, and should use the international standard reference intervals to define abnormally high creatinine levels (>110 μmol/L for adults males, >90 μmol/L for adult females). Given that dehydration was the leading precipitating factor in our Samoan cohort, a collaboration between our research team and this ISN initiative should be welcomed. The results from Samoa may be translational to other Pacific Island countries, and a Pan-Pacific Island study may be considered.

4.1. Limitations of the present study

The generalizability of the study findings may be compromised by the study design (single-centre), cohort sample size, and study duration. The present study focused on the adult population, and we acknowledge that it is important for future studies to investigate kidney disease among children and adolescents.

A greater number of cases may have been included in the sample size, however: (1)The serum creatinine criteria (>200 μmol/L) may have excluded AKI cases of lesser severity from inclusion in the study, (2) The inconsistent coding of AKI diagnosis into the hospital Patient Information System may have excluded cases from inclusion in the study, and (3) the creatinine reagent was out of stock for three weeks of the study period, prohibiting case identification. The present study underestimated rather than overestimated the incidence of AKI in Samoa.

5. Conclusion

This is the first published research study on AKI in the Pacific Islands, and shows that the hospital-based incidence and unfavourable outcomes of AKI are high in Samoa. The present study design underestimates the true hospital and national burden of AKI. Greater awareness of this under-recognised condition is warranted among the public, government officers, and health professionals. There is currently international goodwill and momentum to address the burden of acute and chronic kidney disease worldwide, and Samoa has an opportunity to lead efforts in the Pacific Islands.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Ethical approval

Ethical approval for the present study was obtained from the Fiji National University College Health Research Ethics Committee (CHREC) and the Government of Samoa Ministry of Health – Health Research Committee (MoH-HRC). Gatekeeper approval was also obtained from the Deputy Director General of the TTM Hospital.

Please state any sources of funding for your research

None.

Author's contribution

The work was undertaken by NMC as part of his Masters studies, and MLP and FL were his supervisors. Colleague AK assisted with the revision of the Masters thesis into the present format for journal publication.

Please state any conflicts of interest

No conflicts of interest to declare.

Registration of research studies

1. Name of the registry: Clinical Trials.gov
2. Unique Identifying number or registration ID: NCT05167292
3. Hyperlink to your specific registration (must be publicly accessible and will be checked):

Https://clinicaltrials.gov/ct2/results?cond = &term = NCT05167292&cntry = &state = &city = &dist =

Guarantor

Nathan Maligi Chadwick. The work was his research undertaken as part of a Masters degree.

Consent

N/A. Study design was review of de-identified clinical records.

Annals of medicine and surgery

The following information is required for submission. Please note that failure to respond to these questions/statements will mean your submission will be returned. If you have nothing to declare in any of these categories then this should be stated.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amsu.2022.103362.

References

[1] C. Ronco, R. Bellomo, J.A. Kellum, Acute kidney injury, Lancet 394 (2019) 1949–1964.

[2] E.A.J. Hoste, J.A. Kellum, N.M. Selby, A. Zarbock, P.M. Palevsky, S.M. Bagshaw, et al., Global epidemiology and outcomes of acute kidney injury, Nat. Rev. Nephrol. 14 (2018) 607–625.
[3] P. Susantitaphong, D.N. Cruz, J. Cerdá, M. Abulfaraj, F. Alqahtani, I. Koulouridis, et al., World incidence of AKI: a meta-analysis, Clin. J. Am. Soc. Nephrol. 8 (2013) 1482–1493.
[4] J. Cerdá, N. Lameire, P. Eggers, N. Pannu, S. Uchino, H. Wang, et al., Epidemiology of acute kidney injury, Clin. J. Am. Soc. Nephrol. 3 (2008) 881–886.
[5] J. Cerdá, A. Bagga, V. Kher, R.M. Chakravarthi, The contrasting characteristics of acute kidney injury in developed and developing countries, Nat. Clin. Pract. Nephrol. 4 (2008) 138–153.
[6] R.L. Mehta, J. Cerdá, E.A. Burdmann, M. Tonelli, G. García-García, V. Jha, et al., International Society of Nephrology's 0by25 initiative for acute kidney injury (zero preventable deaths by 2025): a human rights case for nephrology, Lancet 385 (2015) 2616–2643.
[7] R. Horton, P. Berman, Eliminating acute kidney injury by 2025: an achievable goal, Lancet 385 (2015) 2551–2552.
[8] N. Aitaoto, K.L. Raphael, Haemodialysis in Samoa: a model for other Pacific nations, The Lancet Reg. Health - West. Pac. 6 (2021) 100071.
[9] M. Tafuna'i, B. Matalavea, D. Voss, R.M. Turner, R. Richards, Sopoaga Fa, et al., Kidney failure in Samoa, The Lancet Reg. Health - West. Pac. 5 (2020), 100058.
[10] R. Agha, C. Sohrabi, G. Mathew, T. Franchi, A. Kerwan, N. O'Neil, The PROCESS 2020 guideline: updating consensus preferred reporting of case series in Surgery (PROCESS) guidelines, Int. J. Surg. 84 (2020) 231–235.
[11] G. Koerbin, J.R. Tate, Harmonising adult reference intervals in Australia and New Zealand - the continuing story, Clin. Biochem. Rev. 37 (3) (2016) 121–129.
[12] J. Feehally, The ISN 0by25 global Snapshot study, Ann. Nutr. Metabol. 68 (Suppl. 2) (2016) 29–31.
[13] K.D. Liu, S.L. Goldstein, A. Vijayan, C.R. Parikh, K. Kashani, M.D. Okusa, et al., AKI!Now Initiative: recommendations for awareness, recognition, and management of AKI, Clin. J. Am. Soc. Nephrol. 15 (12) (2020) 1838–1847.
[14] D. Collister, N. Pannu, F. Ye, M. James, B. Hemmelgarn, B. Chui, et al., Health care costs associated with AKI, Clin. J. Am. Soc. Nephrol. 12 (2017) 1733–1743.