



**A Nurse Led Intervention Improves Detection And Management of AKI in Malawi**

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Table 1 – Clinical, demographic and outcome of patients admitted to QECH HDU

		Pre intervention (Phase 1)	Immediately post intervention (Phase 2)	3 months post intervention (Phase 3)	p value
<b>Days of data collection per phase</b>		17	16	16	-
<b>Number of patients per phase</b>		33	45	26	-
<b>Mean age years (SD)</b>		44.4 (17.4)	42.5 (18.3)	49.8 (18.3)	0.20
<b>Male (n, %)</b>		15 (45.5)	20 (44.4)	13 (50.0)	0.64
<b>Median days on HDU (IQR)</b>		3 (3-6)	3 (2-5)	3 (2-6)	0.31
<b>HIV Status</b>	Positive <sup>@</sup>	14 (42.4%)	18 (40.0%)	6 (23.1%)	0.26
	Negative	6 (18.2%)	9 (20.0%)	3 (11.5%)	
	Unknown	13 (39.4%)	18 (40.0%)	17 (65.4%)	
<b>Co-morbidity</b>	Hypertension	5 (15.2%)	9 (20.0%)	4 (15.4%)	0.12
	Diabetes mellitus	7 (21.2%)	6 (13.3%)	1 (3.8%)	0.07
	Heart failure	2 (6.1%)	3 (6.7%)	5 (19.2%)	0.11
	Pulmonary tuberculosis <sup>#</sup>	5 (15.2%)	5 (11.1%)	3 (11.5%)	0.57
<b>Reason for admission to HDU as documented in medical notes</b>	Oxygen therapy	21 (63.7%)	22 (48.9%)	17 (65.4%)	0.50
	Intravenous Insulin	4 (12.1%)	6 (13.3%)	1 (3.9%)	
	Fluid therapy for suspected AKI	3 (9.1%)	7 (15.5%)	5 (19.2%)	
	Other	1 (3.0%)	6 (13.3%)	1 (3.6%)	
	Unknown	4 (12.1%)	4 (8.9%)	2 (7.7%)	

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<b>Vital status on d/c from HDU</b>	Died on HDU	6 (18.2%)	13 (28.9%)	5 (19.2%)	0.005
	Discharged home from HDU	26 (78.8%)	18 (40.0%)	19 (73.1%)	
	Discharged to medical ward	0 (0.0%)	5 (11.1%)	0 (0.0%)	
	Unknown	1 (3.0%)	9 (20.0%)	2 (7.7%)	

@ - HIV positive patients on ART (n, % of HIV positive patients) – Phase 1 - 12 (80.0%), Phase 2 - 10 (71.4%), Phase 3 - 6 (66.7%)

# - all patients with pulmonary tuberculosis were already on treatment prior to admission to HDU

IQR – inter-quartile range, SD (standard deviation), d/c discharge, AKI – acute kidney injury

**Table 2** – Recording of key physiological variables for patients at risk of AKI on medical HDU wards at QECH. Mean (SD) calculated as days on HDU where a measurement was performed and recorded divided total number of days spent in HDU.

	<b>Pre intervention (Phase 1)</b>	<b>Immediately post intervention (Phase 2)</b>	<b>3 months post intervention (Phase 3)</b>	<b>p value</b>
<b>n in phase</b>	33	45	26	
<b>% days blood pressure measured</b>	85.6 (18.0)	75.7 (32.3)	90.3 (14.4)	0.04
<b>% days pulse measured</b>	88.3 (16.3)	75.0 (31.4)	94.7 (13.0)	0.02
<b>% days respiratory rate measured</b>	77.1 (24.3)	55.9 (35.2)	92.0 (14.7)	<0.0001
<b>% days O<sub>2</sub> saturation measured</b>	43.1 (30.2)	53.4 (37.9)	72.3 (30.6)	0.005
<b>% days with fluid therapy chart completed</b>	1.1 (6.5)	20.3 (32.4)	73.6 (41.7)	<0.0001
<b>% days with urine output recorded</b>	1.2 (6.1)	14.9 (27.9)	32.6 (30.8)	<0.0001

**Table 3** – Process of care variables for the detection of AKI on admission to HDU, n (%)

	<b>Pre intervention (Phase 1)</b>	<b>Immediately post intervention (Phase 2)</b>	<b>3 months post intervention (Phase 3)</b>	<b>p value</b>
<b>n in phase</b>	33	45	26	-
<b>Serum creatinine measured on day 1 HDU</b>	13 (39.4%)	10 (22.2%)	13 (50%)	0.23
<b>Creatinine processed<sup>@</sup></b>	4 (30.8%)	6 (60%)	7 (53.8%)	0.64
<b>Urine dipstick performed on admission to HDU</b>	0 (0.0%)	8 (17.8%)	5 (19.2%)	0.03
<b>Renal ultrasound performed during HDU admission</b>	0 (0.0%)	5 (11.1%)	0 (0.0%)	0.03

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**Table 4** – Knowledge assessment scores for all 26 trainees who completed the intervention course.  $p < 0.0001$  for phase 1 v phase 2 and phase 1 vs phase 3;  $p=0.39$  for phase 2 v phase 3.

	<b>Pre intervention (Phase 1)</b>	<b>Immediately post intervention (Phase 2)</b>	<b>3 months post intervention (Phase 3)</b>
Number of participants	26	26	26
Score (maximum 17)	10.3	15.0	15.1

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**Table 5** – Change in nursing attitudes to AKI over the 3 phases of the study. All questions scored out of 10 (10 representing “strongly agree”, 0 representing strongly disagree)

	Pre intervention (Phase 1)	Immediately post intervention (Phase 2)	3 months post intervention (Phase 3)	p value
Number of trainees sampled in each phase	26	26	26	
<b>Q1.</b> How important is it that we measure urine output in AKI?	10.0 (0)	10.0 (0.0)	9.6 (1.4)	0.97
<b>Q2.</b> How important is it that we record fluid input in AKI?	10.0 (0)	10.0 (0.0)	10.0 (0.0)	1.0
<b>Q3.</b> AKI is a major problem in the patients I look after	8.6 (0.7)	9.0 (1.0)	9.4 (1.5)	0.73
<b>Q4.</b> AKI is a risk factor for death in patients admitted to hospital	9.4 (0.7)	9.8 (0.3)	9.8 (0.4)	0.21
<b>Q5.</b> Managing and detecting AKI is a major part of my working practice	8.0 (1.1)	9.0 (0.8)	8.8 (0.9)	0.24
<b>Q6.</b> I feel comfortable with the detection of cases of AKI in my working environment	4.0 (1.2)	9.2 (0.6)	9.2 (0.6)	<0.0001
<b>Q7.</b> I feel confident managing patients with AKI	6.4 (1.1)	9.6 (0.7)	9.8 (0.4)	<0.0001
<b>Q8.</b> I feel confident my level of knowledge of AKI is sufficient	5.6 (1.0)	9.4 (0.7)	9.4 (0.5)	<0.0001

**Assessment of attitudes to detecting and managing AKI**

Your unique identifier:.....

Date filed in:.....

Grade of health care worker (Dr/nurse/CO):.....

Note:

For Q1 and Q2 score is 1 = not important at all to 10 = very important (choose the number between 1 and 10 that best fits your response)

For Q3-8 score is 1 = strongly disagree 10 = strongly agree (choose the number between 1 and 10 that best fits your response)

	Your answer
<b>Q1.</b> How important is it that we measure urine output in AKI?	
<b>Q2.</b> How important is it that we record fluid input in AKI?	
<b>Q3.</b> AKI is a major problem in the patients I look after	
<b>Q4.</b> AKI is a risk factor for death in patients admitted to hospital	
<b>Q5.</b> Managing and detecting AKI is a major part of my working practice	
<b>Q6.</b> I feel comfortable with the detection of cases of AKI in my working environment	
<b>Q7.</b> I feel confident managing patients with AKI	
<b>Q8.</b> I feel confident my level of knowledge of AKI is sufficient	



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3 **Pre/post assessment on Acute Kidney Injury (AKI) for medical ward**  
4 **nurses, clinical officers and doctors**  
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7  
8 To be filled in before the AKI training course, at the end of the AKI training  
9 course and then 2 months later.  
10

11 **Are you a:** (please circle)  
12

13  
14 **Nurse**

**Clinical Officer**

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16  
17 **Doctor**  
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20 **Unique identifier:**  
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28 **1) Name four functions of the kidneys:**  
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44 **2) What is best current definition of AKI (select 1)?**  
45

- 46
- 47 A. Decreased kidney function for three months or longer
- 48
- 49 B. A rapid reduction in kidney function over hours to days
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- 52 C. Scoring based on international consensus of urine output and
- 53 creatinine
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3 **3) What is the most severe stage of AKI (select 1)?**  
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- 5 A. Stage 3  
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7 B. Stage 2  
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9 C. Stage 1  
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11 D. Stage 4  
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18 **4) AKI stage 1 has developed when there has been (select 1):**  
19

- 20 A. An elevated urea  
21  
22 B. = 1.5 x rise in creatinine or > 6 hours of low urine output  
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24 C. >3 x rise in creatinine or > 6 hrs of low urine output  
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26 D. >4 hours of low urine output  
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55 **5) What is the average expected daily urine output for an adult (select 1)?**  
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- 57 A. 50-250mls  
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59 B. 250-500mls  
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C. 600-1000mls  
D. >1000mls

**6) What is oliguria (select 1)?**

- 1  
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3 A. Low urine output  
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6 B. No urine output  
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8 C. More than adequate urine output  
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11 D. Normal urine output  
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16 **7) What is anuria (select 1)?**

- 17  
18 A. Low urine output  
19  
20 B. No urine output  
21  
22 C. More than adequate urine output  
23  
24 D. Normal urine output  
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30 **8) How much fluid should the average person consume in 24 hours (select**  
31 **1)?**

- 32  
33  
34 A. 500mls  
35  
36 B. 1 litre  
37  
38 C. 2 litres  
39  
40 D. 1.2 litres  
41  
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46  
47 **9) What should be documented on a fluid balance chart? (choose 1 best**  
48 **answer)**

- 49  
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51 A. All input  
52  
53 B. All output  
54  
55 C. All input and output  
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3 D. It is not needed  
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7 **10) Name three causes of AKI:**  
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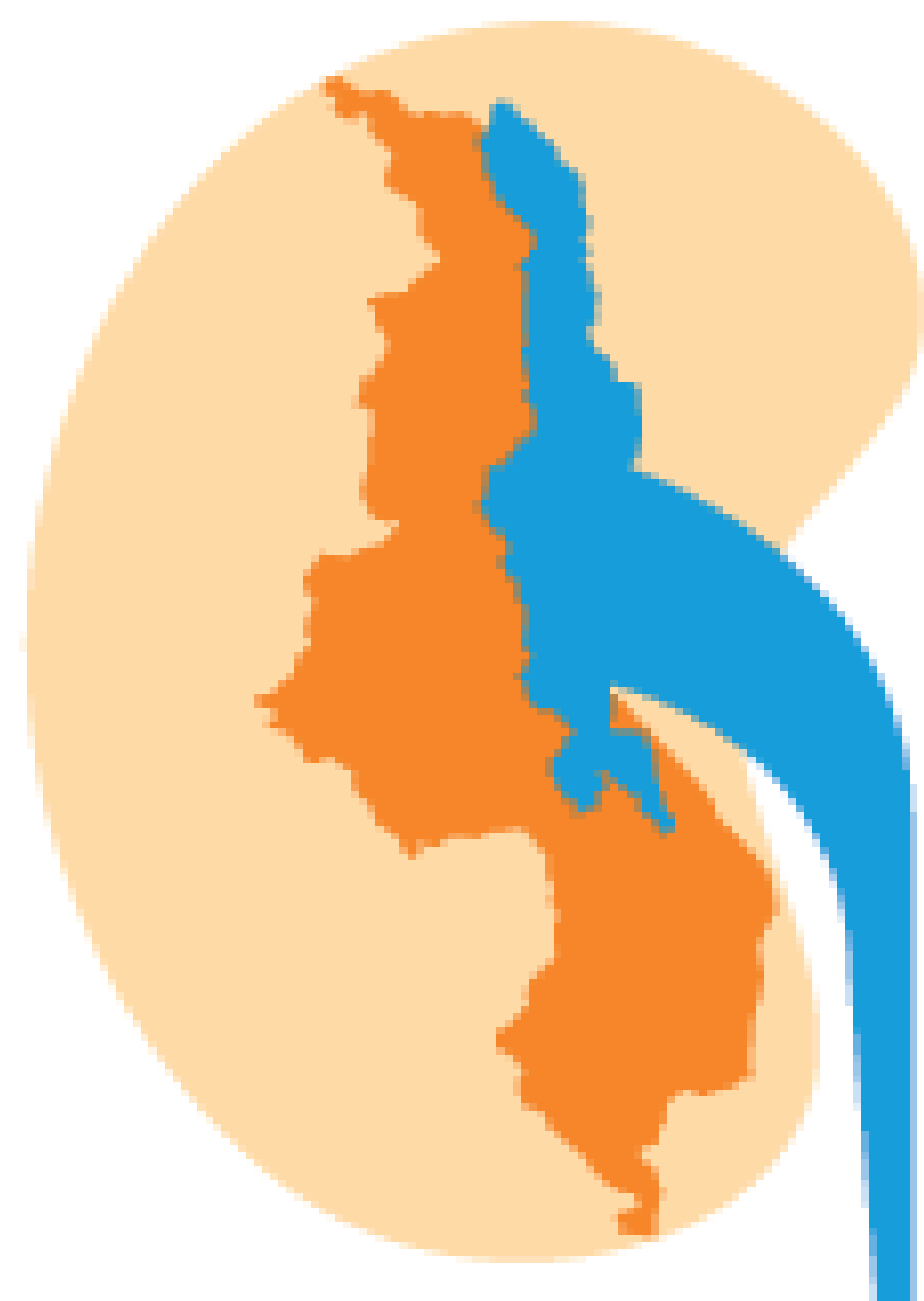
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22 **11) What are the signs of dehydration (select 1)?**  
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- 24  
25 A. Temperature, bradycardia and hypertension  
26  
27  
28 B. Dark coloured urine, thirst and low urine output  
29  
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31 C. Polyuria and temperature  
32  
33  
34 D. Low oxygen saturations and hypertension  
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40 **12) What percentage of patients admitted to QECH die of AKI on**  
41 **admission?**  
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- 43  
44 A. 7%  
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47 B. 15%  
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50 C. 47%  
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53 D. 55%  
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# STOP AKI in Malawi

## 'STOP' AKI!

### Sepsis and hypoperfusion

(Dehydration, haemorrhage, cardiac failure, liver failure, renovascular insult)

### Toxicity

(Drugs, contrast)

### Obstruction

(Tumour, stones, extrinsic compression)

### Parenchymal kidney disease

(Glomerulonephritis, rhabdomyolysis)

## Remember.... Prevent AKI!

### The 4 'M's

#### Monitor Patient

(vital signs, regular blood tests, fluid charts, urine volumes)

#### Maintain Circulation

(hydration, resuscitation, oxygenation)

#### Minimise Kidney Insults

(e.g. nephrotoxic medications, surgery or high risk interventions, hospital acquired infection)

#### Manage The Acute Illness

(e.g. sepsis, heart failure, liver failure)

## You can make a difference!

**REMEMBER** – ALWAYS CHECK THE FLUID BALANCE CHART

**THINK** BEFORE YOU PRESCRIBE NSAIDS, GENTAMICIN, ACE-I

## Introduction

Acute kidney injury (AKI) is common in the developed world with more than 5% of general hospital admissions (Selby et al. 2012) and 50% of critically ill patients experiencing an episode of AKI (Ostermann & Chang 2007). AKI, even in its mildest form, has a significant impact on survival and the development of long-term chronic kidney disease (CKD) (Mehta et al. 2002; Ishani et al. 2009; Amdur et al. 2009; Lo et al. 2009). Consequently, there is a major international campaign to improve the prevention, recognition, treatment and outcome of AKI (International Society of Nephrology 2014).

The detection of AKI requires clinical awareness of its risk factors, including, but not limited to increasing age, diabetes mellitus, hypertension and CKD as well as identifying common aetiologies such as sepsis, dehydration and nephrotoxic medications. In addition, simple bedside monitoring of urine output and where possible, blood tests, are important diagnostic tools. Treating the underlying cause of AKI and ensuring adequate volume resuscitation early in the patient's care, has the potential to reduce mortality and improve renal outcomes (Kolhe et al. 2015).

The epidemiology and incidence of AKI in sub-Saharan Africa is poorly understood. While it is likely that the causes and risk factors for AKI are broadly similar in low resourced compared to well-resourced medical settings (Cerdá et al. 2008), an episode of AKI is associated with a higher morbidity and mortality (Olowu et al. 2016). This recent systematic review (Olowu et al. 2016) has collated the available published data, despite its low quality, and has produced a pragmatic insight into AKI mortality and the impact of the lack of expert medical care and essential resources for managing AKI, especially renal replacement therapy (Olowu et al. 2016).

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3 Malawi in south-eastern Africa, has a population of 16.2 million, with approximately 62% of  
4 the population living on less than US\$1.25 per day (UNICEF). There are currently no  
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6 Malawian nephrologists working in the private or public sector (dialysis units are run by  
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8 general physicians with an interest in nephrology) and local expertise from intensive care  
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10 units in managing severe and complex AKI is limited, in part due to a lack of access to  
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12 haemofiltration and vasopressor medications. Queen Elizabeth Central Hospital (QECH) in  
13  
14 Malawi is a national, public sector, and tertiary referral hospital with 1,300 beds. Preliminary  
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16 data from QECH has demonstrated that the crude in-patient mortality after an episode of AKI  
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18 is 47% (Dreyer, personal communication 2014), which is comparable with the data collated  
19  
20 by Olowu et al. (2016)  
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24  
25 Although resources at QECH are limited, blood tests, antibiotics, intravenous fluids and  
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27 haemodialysis services are available and free at the point of access. The QECH nursing  
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29 staff in the medical high dependency units (HDU), are responsible for the documentation of  
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31 urine output and fluid therapy as well as performing venepuncture as requested by medical  
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33 staff but, despite these positive factors of 'clinical ownership', our experience has been that  
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35 the majority of AKI cases at QECH go unrecognized or are referred late in the more  
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37 advanced phase of AKI due to low awareness of AKI among medical and nursing staff.  
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42 There are a number of general and more specific local reasons for this. There are significant  
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44 barriers to nursing (undergraduate and post graduate) education both in Malawi and other  
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46 resource-poor health care settings. A high volume of complex cases, limited training for  
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48 nursing cadres, lack of enthusiasm and minimal, if any, financial investment in teaching  
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50 resource have previously all been identified as reasons for lack of continued professional  
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52 development (Msiska et al. 2014; Chilomo & Mondywa 2014). Data from our group concludes  
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54 that competing health priorities in a setting of resource limitation and lack of health policy  
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56 advocacy for detecting and managing AKI are all major factors in the AKI knowledge gap in  
57  
58 QECH (Evans et al. 2015). Our experience of nurse training also correlates with similar  
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3 findings in Malawi in general (Bvumbwe et al. 2015) i.e. poor teaching environment,  
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5 unsupportive working environment and lack of knowledge of trainers. There is also a  
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7 recognition that educators need to broaden their approach to nurse education in Malawi,  
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9 moving away from direct teaching strategies to more interactive style this improving the  
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11 interaction between educator and student (Mbirimtengerenji & Adejumo 2015).  
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15 With a view to overcome some of these learning barriers we used our collective expertise in  
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17 teaching and clinical experience of managing patients with AKI from both QECH and the UK  
18  
19 to hypothesise that a nurse-led education programme (with facilitative classroom and 'hands  
20  
21 on' teaching) combined with a poster campaign in the medical HDUs at QECH would  
22  
23 improve the awareness and management of AKI, creating a knowledge and skills legacy that  
24  
25 could empower intervention for AKI and still be present and clinically effective 3 months  
26  
27 later.  
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## 30 31 **Methods**

### 32 33 34 35 **Study design**

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37 This was a three phase, prospective interventional pilot study conducted between  
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39 15/11/2013 and 15/2/2014 at QECH in Blantyre, Malawi. Ethical approval was received from  
40  
41 the Malawi College of Medicine Research Ethics Committee (ethical approval reference  
42  
43 P.08/13/1446). Individual patient consent was not required, as the study team did not collect  
44  
45 any data beyond that which was collected in the course of routine clinical care. All data were  
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47 fully anonymised, using unique study numbers rather than individual level identifiers and  
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49 stored on secure computers to which only the study team had access.  
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### 52 53 54 **Study objectives**

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3 The primary objective was to implement a nurse-led education programme to improve the  
4 general knowledge and understanding of AKI, among nurses and medical staff working on  
5 the medical HDUs at QECH. The secondary objectives were to demonstrate improvement  
6 of clinical skills for the detection and management of AKI by measuring process of care  
7 variables for AKI including improved use of fluid balance charts, recording of urine output  
8 and availability of results for serum creatinine and furthermore, to demonstrate that acquired  
9 knowledge and clinical skills were intact 3 months later.  
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### 20 **Study setting**

21 QECH adult medical HDUs care for the most unwell medical patients in the hospital and are  
22 thus predicted to have a high prevalence of AKI. The male and female high dependency unit  
23 (HDU) wards each contain seven beds with a nurse to patient ratio of 1:7 and care for  
24 patients aged over 16 years. Twice daily medical ward rounds are conducted on each HDU  
25 and the higher nurse to patient ratio supports more regular nursing review and interventions  
26 including provision of fluid therapy, drug administration and routine clinical observations.  
27 Our experience of the case mix on the HDU is that patients at risk of AKI are common due to  
28 the high prevalence of risk factors for AKI including, but not limited to sepsis and volume  
29 depletion. We chose this environment rather than the 4 bed intensive care unit at QECH  
30 (which for local practical reasons primarily acts as a post operative facility) since we and  
31 other senior medical staff at QECH identified this clinical arena as an area of need for  
32 education and intervention, with a high volume of patients to make a training programme  
33 more valuable and therefore yield a higher clinical impact on the case load of AKI in patients  
34 admitted under the medical service at QECH.  
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### 51 **Study activity**

#### 52 **Phase 1: Baseline assessment of AKI management in medical HDU wards at QECH.**

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54 Baseline data regarding the clinical care of patients considered at risk of AKI were collected  
55 in the medical HDU at QECH before the teaching intervention was made. The study team  
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3 utilised a standardised AKI data collection tool for use in the 3 phases of the audit (see  
4 supplementary information). The study team scrutinised the medical notes to determine  
5 which of the key AKI clinical parameters the clinical team on the HDU wards had recorded.  
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7 The clinical care parameters observed for comparison across the three phases of the study  
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9 are shown in box 1.  
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14 **Box 1** - clinical and process of care measures recorded during audit of AKI care  
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- Demographic data: age, gender, HIV status, co-morbidity, reason for admission to HDU, vital status at end of stay on HDU
  - Physiological measurements - % of days of HDU admission vital parameters were recorded (blood pressure, pulse, oxygen saturations, respiratory rate, urine output, fluid therapy)
  - Laboratory data – measures of serum creatinine and urine dipstick on admission to HDU, availability of renal ultrasound result.

36 **Phase 2: Baseline AKI knowledge assessment and a nurse-led teaching intervention**  
37

38 Twenty-six Malawian health care professionals including 20 nurses, four doctors and two  
39 clinical officers were purposively chosen from acute areas of QECH. Although the main  
40 focus of the study was care of patients at risk of AKI on the medical HDU wards, we trained  
41 staff from all of the hospital acute areas (medical high dependency and intensive care units,  
42 obstetric and gynaecological ward, surgical wards, the burns unit and the emergency  
43 department) to ensure maximum dissemination of skills. Course participants completed a  
44 locally relevant AKI knowledge assessment and an evaluation of their attitudes to the  
45 detection and management of AKI which focused on key pragmatic issues of recording urine  
46 output and monitoring fluid therapy as well as a more general assessment of the importance  
47 of AKI in daily clinical care (see supplementary info). These data helped to establish the  
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3 baseline level of understanding amongst the health care professionals to ensure the  
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5 intervention was focused correctly.  
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9 The nurse-led intervention used an established AKI training outline ([www.londonaki.org](http://www.londonaki.org)),  
10  
11 which was adapted for relevance to QECH based on our local experience of managing AKI,  
12  
13 and discussion with senior nurse trainers at QECH. Two full days of classroom teaching  
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15 were completed which comprised of both didactic lectures and group work. The lecture  
16  
17 style teaching covered the definition and causes of AKI, how to prevent recognise and  
18  
19 manage it on a day-to-day basis, types of fluid therapy, urine dipstick testing and issues  
20  
21 surrounding the use of availability of renal replacement therapy. After each session students  
22  
23 were encouraged to ask questions to ensure they fully understood the teaching. The  
24  
25 students were then split into groups of 8-9 with a member of faculty dedicated to each. Good  
26  
27 and bad examples of fluid balance charts were reviewed, with the opportunity to practice  
28  
29 completing them. Another session covered common case scenarios including those of  
30  
31 patients who had previously presented to QECH. Following the classroom work, three days  
32  
33 of practical teaching on the medical HDU's were completed, which included 1:1 teaching on  
34  
35 how to assess the vital signs and hydration status of individual patients to help guide the  
36  
37 management of AKI.  
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41 Box 2 summarises the topics covered during the education programme. To enhance ease of  
42  
43 access to important components of caring for patients at risk of AKI, awareness posters (see  
44  
45 supplementary material) were also displayed in both HDU wards, providing an easy to  
46  
47 access frame of reference based on the education programme.  
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**Box 2.** Teaching topics delivered

- Definition and causes of AKI
- How to prevent, diagnose and manage AKI
- Fluid therapy for AKI
- Urine dipstick testing
- The importance of and skills in completing fluid balance charts
- How to assess the volume status of patients
- Locally relevant clinical AKI scenarios
- Indications for renal replacement therapy

**Phase 3: Assessment of knowledge and clinical skills legacy**

Three months after the nurse-led teaching intervention, the same AKI knowledge and attitude assessments were completed by the clinical staff trained in phase 2 of the study. A third and final collection of the same clinical and process of care data in phases 1 and 2 was completed in the medical HDUs, to determine if improvement in the clinical care of patients at risk of AKI was present 3 months after the education programme.

**Statistical analysis**

Data are presented as mean (standard deviation (SD)), median (interquartile range (IQR)) and absolute or relative frequencies as percentages depending on the distribution of the data. Differences between groups were compared using parametric (Student's t test), non-parametric (Mann-Whitney-U and Pearson's chi-square ( $\chi^2$ )) testing and one-way analysis of variance (ANOVA) where appropriate. All statistical analysis was carried out using Stata version 10 software ([www.stata.com](http://www.stata.com)). A p value of < 0.05 was considered to represent statistical significance.

## Results

### Demographic and Clinical Outcome Data.

We reviewed 104 patients over the three phases of the study (mean age 44.9 (1.7) years; 50 (48.1%) male. The demographic and co-morbidity data of the patients is shown in Table 1. There were no significant differences in HIV status or co-morbidity across all phases of the study, however, in phase 2, more patients died on HDU compared with phases 1 and 3. The main reason for admission to the HDU was oxygen therapy in all 3 phases, since the medical HDU is the only clinical area where oxygen therapy can be delivered.

### Recording of physiological parameters

Table 2 demonstrates that baseline measures of physiology (blood pressure, respiratory rate, pulse and oxygen saturations) were generally well recorded by the medical HDU nurses across all three phases of the study. Following the intervention, there were significant improvements in the completion of fluid charts and recording of urine output in phase 2 and phase 3 compared to phase 1 (Table 2).

### Specific investigations for kidney disease

Table 3 shows significant improvements in the number of patients who had a urine dipstick recorded on admission to HDU but the total numbers were small (20%). Serum creatinine measurements were low across all three phases of the study. There was very limited access to renal ultrasound scans during all 3 phases of the study.

### Evaluation of knowledge and attitudes towards AKI

Table 4 demonstrates that scores from the AKI knowledge test were lower in phase 1 compared to phases 2 and 3 ( $p < 0.0001$ ), indicating knowledge retention among trainees 3 months after the delivery of the education package. Table 5 demonstrates that there was good baseline understanding of the importance of urine output and fluid balance measurement (Q 1,2) in patients with AKI. Furthermore, the awareness of the importance of

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3 detecting and managing AKI as well as its effect on mortality was high prior to our  
4 intervention and these scores remained high in the follow up surveys (Q 3,4,5). However,  
5 before the intervention, clinical staff did not feel confident detecting or managing patients  
6 with suspected AKI (Q 6,7,8). The nurse-led intervention significantly improved the  
7 confidence of clinical staff around detecting and managing AKI and this learning legacy  
8 remained three months later.  
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## 17 **Discussion**

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19 To the best of our knowledge, this is the first study evaluating the effect of a nurse-led  
20 teaching intervention designed to improve the knowledge, detection and management of AKI  
21 in sub-Saharan Africa. We achieved our primary objective, demonstrating that a nurse-led  
22 teaching intervention, contextualised to local operational pragmatics, can successfully  
23 improve the knowledge of AKI and clinical skills in the detection and management of AKI in a  
24 resource limited, hospital setting in sub-Saharan Africa. Our approach leaves a legacy of  
25 knowledge and skills that are present at least 3 months following the intervention which has  
26 been found in other AKI education studies (Xu et al. 2014). The finding that education  
27 improves lasting knowledge and patient intervention are not in isolation (Xu et al. 2014).  
28 Although there are no directly comparable studies, there are many educational intervention  
29 studies across different specialties, which show broadly similar benefits to ours. For  
30 example, Green et al (2015) demonstrated improved competence and confidence amongst  
31 nurses treating obstetric emergencies following specific education programme, which was  
32 retained 6 months later (Green et al. 2015). Closer to Malawi, a study in Zimbabwe improved  
33 health care worker education, which subsequently improved patient recruitment to clinic  
34 (Adamolekun et al. 1999) all of which is further encouragement that our approach can result  
35 in reproducible benefit.  
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56 The teaching programme considerably improved confidence around detecting and managing  
57 AKI and this may be reflected in the fact that there was a trend for more patients to be  
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3 admitted to HDU for fluid therapy for suspected AKI. The practical aspects of the teaching  
4 programme were based on the care bundle approach (which focuses attention on important  
5 parameters to detect and implementation of simple interventions to improve outcomes)  
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7 which aid the management of many clinical scenarios, for example sepsis, catheter related  
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9 blood stream infections as well as AKI, in more developed economies (Kolhe et al. 2015;  
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11 Dellinger et al. 2013; Bion et al. 2012). We observed dramatic improvements in the recording  
12  
13 of urine output and the completion of fluid therapy charts on the medical HDUs immediately  
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15 after the teaching programme and 3 months later.  
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21 We did not observe an improvement in the measurement of serum creatinine, urine dipsticks  
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23 or renal ultrasound scans. However, there are pragmatic limitations in Malawi that may  
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25 explain these results such as lack of availability of reagents for measuring serum creatinine,  
26  
27 time for results to return from the laboratory to the ward (usually 48 hours), unpredictable  
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29 supplies of urine dipsticks, and the difficulty in transporting sick patients from the medical  
30  
31 HDU for an ultrasound scan where a portable scanning service is not available. However,  
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33 KDIGO guidelines acknowledge the importance of reduced urine output as a diagnostic  
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35 feature for AKI (KDIGO-AKI 2012) and the problems QECH and other resource poor  
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37 healthcare systems have in providing a reliable blood testing service reinforce the need for  
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39 improved urine output measurement which we were able to demonstrate after our  
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41 intervention.  
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46 Overall, we feel that the impact of the teaching intervention will improve the knowledge  
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48 relating to, and management of patients with AKI that in turn has the potential to reduce the  
49  
50 high mortality, which we have previously observed at QECH. While we have demonstrated  
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52 important and clinically relevant changes, we remain sanguine about the fact that more work  
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54 needs to be done in this field both locally and globally to further improve the detection and  
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56 management of AKI and to further validate our teaching programme.  
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3 This study was specifically designed to use education and the staff already working at QECH  
4 as the resource to improve care and did not require the purchase of new consumable  
5 agents, which would have direct costs to health care providers. For its impact, demonstrating  
6 a knowledge and skill legacy 3 months later, we feel that a relatively low, one off cost (~US\$  
7 5,000) which covered educator's travel expenses as well as teaching and education  
8 materials, provided a excellent value for money. The costs could be reduced significantly  
9 further by investing in training local healthcare workers to teach others and champion the  
10 management of AKI in their region with a small investment in teaching materials and aide-  
11 mémoires. As mentioned in the introduction, the empowerment of educators greatly  
12 improves the learning experience in this and similar settings. The positive change in  
13 attitudes to AKI that we observed supports the concept that our intervention can improve  
14 motivation as well as clinical skills demonstrating our intervention has broad applicability in  
15 similar settings globally (International Society of Nephrology 2014).  
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31 Another important strength of the study is that it was based in a 'free at the point of access'  
32 health care system and so availability and access to diagnostic tests was not predicated by  
33 the financial means of the patients admitted to the HDU wards. We also feel that although a  
34 single centre study, the information gathered and care delivered represents a real life  
35 nursing cohort and patient mix which suggests this study could be generalizable in similar  
36 Sub-Saharan populations.  
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45 Our study has a number of limitations. The number of patients in each of the phases of the  
46 study was relatively small, however there were no material differences in the patient's  
47 characteristics across the study. Consequently, and supported by the fact the study team  
48 did not influence which patients were admitted to HDU, our data is a true reflection of routine  
49 admissions at QECH. As mentioned the unpredictable availability of urine dipsticks and  
50 laboratory reagents makes it hard to determine whether this was the reason the tests were  
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3 not done or if they were not performed by HDU nurses when these reagents were actually  
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5 available.  
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9 For practical reasons, this study concentrated on patients in the high dependency wards  
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11 where we predicted there would be at a high risk for AKI given the acuity of their illness and  
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13 co-morbidities. However, at QECH in other similar hospitals, many patients on general  
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15 medical wards need to be admitted to an HDU environment but are managed on a medical  
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17 ward. Nursing ratios on the general wards at QECH are approximately 1:20 and so we  
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19 cannot determine if our intervention will be successful on general wards even if these wards  
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21 contain patients with same degree of acuity that we evaluated on the HDU wards.  
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25 We also have no specific validation of our teaching programme. It was designed based on  
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27 combined (but extensive) experiences in AKI and clinical management from the UK and  
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29 Malawi to create a local pragmatic tool for education taking into account some of the known  
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31 barriers to education in this particular setting as described in the introduction. Articles such  
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33 as 'AKI:its easy as ABCDE' (Forde et al. 2012) and 'The role of the nurse in the  
34  
35 management of AKI' (Murphy & Byrne 2010) were a useful reference points for our idea, but  
36  
37 others such as Xu et al (Xu et al. 2014) were published after our study had begun. There are  
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39 no comparators to this work in Malawi or Sub-Saharan Africa and this remains the only such  
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41 study at the time of submission but we hope that this work will be built on.  
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#### 45 46 **Implications for practice**

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48 Our study highlights the value of nurse-led education for AKI in resource limited settings but  
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50 should be considered as a smaller part of a much larger global issue. Further refinement of  
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52 our teaching programme will be required in different health care systems to make it locally  
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54 appropriate and additional iterations of our interventions are required to confirm its efficacy in  
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56 other countries and tiers of health care delivery. Scaling up our project to be deliverable by  
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58 health care staff from within a nation rather than relying on international experts will be an  
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3 important step forward and could be achieved with on line teaching resources supported by  
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5 mentoring from international AKI nurse experts and champions.  
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9 There are also some exciting developments relating to the practical diagnosis of AKI that  
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11 may be more practical for QECH and similar settings. The salivary urea nitrogen (SUN) strip  
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13 is a cheap, simple and practical technology that can detect significant changes in renal  
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15 function without the need for blood tests or complex diagnostic machinery (Calice-Silva et al.  
16  
17 2014). If proven to be clinically practical in patients from Sub-Saharan Africa, the SUN strip  
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19 could dramatically improve the detection of AKI and, in conjunction with an education  
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21 programme based on the one we describe, could make a significant impact in the detection  
22  
23 management and outcome of AKI. Clinical trials are on going into the practical application of  
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25 the SUN strip in Malawi, but large-scale trials involving clinical intervention will then be  
26  
27 needed to demonstrate an overall improved outcome.  
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### 30 31 **Conclusion**

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33 A low cost, nurse-led AKI educational intervention improved the knowledge and  
34  
35 management of AKI at QECH, which was still evident 3 months later. Our intervention could  
36  
37 be easily applied and / or adapted for other resource-limited settings. Further research into  
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39 practical technologies that can improve the detection of AKI and subsequent intervention  
40  
41 studies are needed to demonstrate improvements in AKI outcomes across Sub Saharan  
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43 Africa  
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