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Outcomes of acute kidney injury in children and adults in sub-Saharan Africa: a systematic review

Wasiu A Olowu, Abdou Niang*, Charlotte Osafo, Gloria Ashuntantang, Fatiu A Arogundade, John Porter, Saraladevi Naicker, Valerie A Luyckx*

Summary

Background Access to diagnosis and dialysis for acute kidney injury can be life-saving, but can be prohibitively expensive in low-income settings. The burden of acute kidney injury in sub-Saharan Africa is presumably high but remains unknown. We did a systematic review to assess outcomes of acute kidney injury in sub-Saharan Africa and identify barriers to care.

Methods We searched PubMed, African Journals Online, WHO Global Health Library, and Web of Science for articles published between Jan 1, 1990, and Nov 30, 2014. We scored studies, and all were of medium-to-low quality. We made a pragmatic decision to include all studies to best reflect reality, and did a descriptive analysis of extracted data. This study is registered with PROSPERO, number CRD42015015690.

Findings We identified 3881 records, of which 41 met inclusion criteria, including 1403 adult patients and 1937 paediatric patients. Acute kidney injury in sub-Saharan Africa is severe, with 1042 (66%) of 1572 children and 178 (70%) 253 of adults needing dialysis in studies reporting dialysis need. Only 666 (64%) of 1042 children (across 11 studies) and 58 (33%) of 178 adults (across four studies) received dialysis when needed. Overall mortality was 34% in children and 32% in adults, but rose to 73% in children and 86% in adults when dialysis was needed but not received. Major barriers to access to care were out-of-pocket costs, erratic hospital resources, late presentation, and female sex.

Interpretation Patients in these studies are those with resources to access care. In view of overall study quality, data interpretation should be cautious, but high mortality and poor access to dialysis are concerning. The global scarcity of resources among patients and health centres highlights the need for a health-system-wide approach to prevention and management of acute kidney injury in sub-Saharan Africa.

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*These authors contributed equally

Paediatric Nephrology and Hypertension Unit, Department of Paediatrics, Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, State of Osun, Nigeria (Prof W A Olowu MBBS); **Internal Medicine-Nephrology, Cheikh Anta Diop University, Dakar, Senegal** (Prof A Niang MD); **Department of Medicine and Therapeutics, School of Medicine and Dentistry, College of Health Sciences, University of Ghana, Accra, Ghana** (C Osafo MBChB); **Department of Internal Medicine and Specialties, Faculty of Medicine & Biomedical Sciences, University of Yaounde 1, Yaounde, Cameroon** (Prof G Ashuntantang MD); **Renal Unit, Department of Medicine, Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife, State of Osun, Nigeria** (Prof F A Arogundade MBBS); **Department of Clinical Research, Faculty of Infectious and Tropical Diseases, London School of Hygiene & Tropical Medicine, London, UK** (Prof J Porter MD); **Department of Internal Medicine and Nephrology, School of Clinical Medicine, Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, South Africa** (Prof S Naicker MBChB); **and Institute of Biomedical Ethics, University of Zurich, Zurich, Switzerland** (V A Luyckx MBBCh)

Correspondence to:
Dr Valerie A Luyckx, Institute of Biomedical Ethics, University of Zurich, Winterthurerstrasse 30, Zurich 8006, Switzerland
valerie.luyckx@uzh.ch

Introduction

Acute kidney injury is associated with substantial morbidity and mortality worldwide, but data have been conspicuously missing from the Global Burden of Disease study.[1] Acute kidney injury refers to any sudden decline in kidney function, which can be reversible if detected early enough. Acute kidney injury can be community-acquired, resulting from an injury or infection before admission to hospital, or can be hospital-acquired, arising as a complication of hospital admission. Community-acquired acute kidney injury tends to occur in low-income countries, and in young people with few comorbidities, whereas hospital-acquired acute kidney injury tends to occur in high-income settings, and in older people (45–80 years), often with several comorbidities.[2] The burden of acute kidney injury in sub-Saharan Africa is unknown, but mortality is presumably high because of poor access to health care.

In a world meta-analysis,[3] the pooled incidence of acute kidney injury was 21·0% in adults and 33·7% in children, and mortality was 23·3% in adults and 13·8% in children. Only one of 154 included studies was from sub-Saharan Africa.[3] Most studies included patients with hospital-acquired acute kidney injury, contrasting with most acute kidney injury in sub-Saharan Africa, which is community-acquired.[3] Mortality was lower in countries with higher expenditure on health care, reflecting improved access to health care and dialysis in these countries.[3] In an update of this analysis, incidence and outcomes from 62 African studies were summarised in a table, but again excluded from the broader analysis.[2] The generalisability of these global findings to sub-Saharan Africa is therefore unknown.

Despite the absence of data for disease burden, the drive towards providing universal dialysis for acute kidney injury, which can be life-saving, is growing. In much of sub-Saharan Africa, dialysis is paid for out of pocket, at an estimated US$300 per episode of acute kidney injury for a child, and probably more for an adult.[4] In our experience, many patients cannot meet such costs and are forced to decline treatment. If provision of dialysis is to be sustainable in sub-Saharan Africa, data are needed to inform health policy decisions. In view of the present absence of epidemiological data, we have undertaken a systematic review to assess reported outcomes in patients with acute kidney injury in sub-Saharan Africa to highlight the real-world context of

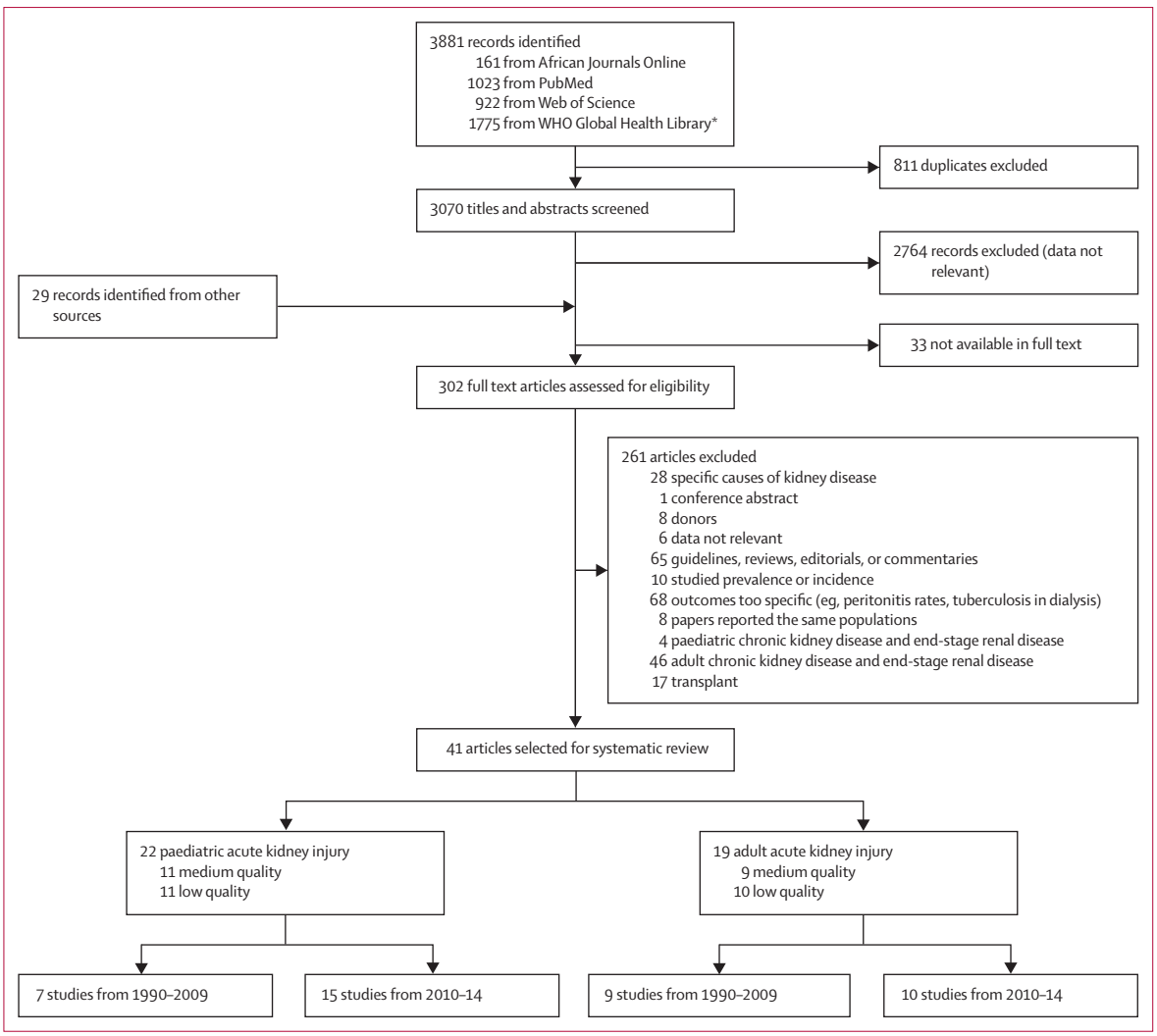

Figure 1: **Study selection**
*WHO Global Health Library includes African Index Medicus.

acute kidney injury in the region and to identify barriers to care that should be tackled to comprehensively address this important problem. This systematic review is highly relevant to understanding the challenges faced in management of acute kidney injury in sub-Saharan Africa, which are a crucial component of the disease burden.

Methods

Search strategy and selection criteria

See Online for appendix

We did a systematic review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (appendix).[5] We searched PubMed, African Journals Online, the WHO Global Health Library, and Web of Science with relevant medical subject headings (appendix). We selected additional references through bibliographies from identified articles. We restricted the search to articles in English or French, published between Jan 1, 1990, and Nov 30, 2014. Outcomes of interest included access to dialysis, mortality, and recovery of renal function in cohorts of all patients admitted to hospital with acute kidney injury, irrespective of cause. We included variable definitions of acute kidney injury (clinical [oliguria, hyperkalaemia, or metabolic acidosis]; laboratory [urea or creatinine]; standardised diagnostic criteria; and need for dialysis). We excluded articles focusing exclusively on cohorts with single causes of acute kidney injury (eg, malaria), since outcomes would not be generalisable to the broader acute kidney injury population.[2] We excluded case reports. FAA and VAL screened titles and abstracts for eligibility. Articles meeting inclusion criteria and obtainable as full texts were reviewed in detail. This study is registered with PROSPERO, number CRD42015015690.

	Adult studies			Paediatric studies		
	1990–2009	2010–14	p	1990–2009	2010–14	p
Total number of studies	9	10	..	7	15	..
Countries	6	5	..	3	6	..
Patient inclusion period	1972–2007	1996–2013	..	1985–2004	2000–13	..
Total patients with acute kidney injury studied (pooled)	639	764	..	720	1217	..
Study duration (years)	5·2 (6·3)	4·9 (5·8)	..	11·3 (6·3)	4·8 (3·0)	..
Male patients (pooled)	339/601 (56%; n=8)	329/627 (52%; n=6)	0·17	459/713 (64%; n=6)	514/927 (55%; n=9)	<0·0001
Male/female ratio (means of individual studies)	1·5 (0·8)	1·2 (0·3)	0·31	1·9 (0·6)	1·3 (0·6)	0·14
Definitions of acute kidney injury used (number of studies)	9	9	0·14	6	11	0·023
Clinical	1	0	..	1	1	..
Laboratory (urea or creatinine)	5	2	..	1	0	..
Laboratory and clinical	0	0	..	4	1	..
(p)RIFLE, AKIN, or ADQI	0	3	..	0	4	..
Dialysis need	3	4	..	0	5	..
Clinical presentations (means of individual studies)						
Oliguria*	59·83% (SD 23·82, n=3)	67·25% (SD 18·58, n=4)	0·66	68·73% (SD 29·00, n=3)	73·02% (SD 8·1, n=6)	0·73
Hyperkalaemia†	30·4% (n=1)	25·10% (SD 23·6, n=3)	..	13·95% (SD 12·80, n=2)	28·60% (SD 15·60, n=4)	..
Metabolic acidosis‡	No data	53·87% (SD 20·44, n=3)	..	20·10% (SD 16·97, n=2)	42·20% (SD 26·51, n=3)	..

Data are number of studies, mean (SD), or percentage of patients (number of studies with outcome). p values reported for time periods 1990–2009 versus 2010–14. (p)RIFLE=(paediatric) risk, injury, failure, loss of function, and end-stage renal disease. AKIN=Acute Kidney Injury Network. ADQI=Acute Dialysis Quality Initiative. *Oliguria defined as urine output <400 mL per 24 h in adults, <300 mL per 24 h or <1 mL/kg/h in children, anuria, or not defined. †Definitions of hyperkalaemia variable, ≥5·5 mmol/L, ≥6·5 mmol/L, or not defined. ‡Definitions of metabolic acidosis variable, ≤10 mmol/L, ≤15 mmol/L, or not defined.

***Table 1*: Acute kidney injury study populations**

Quality assessment and data extraction

The quality of each study was assessed independently by two authors (VAL plus one of: WAO, AN, CO, GA, or FAA) using a checklist modified from Stanifer and colleagues[6] (appendix). Most studies were observational case series. Because no study met high-quality criteria (predominantly because no study represented all patients with acute kidney injury, and many did not describe inclusion or exclusion rates or missing data), rather than excluding almost all identified articles, we decided not to exclude any articles, to minimise bias and reflect reality as much as possible. Half of studies met medium-quality criteria (appendix). Data from individual studies were extracted into a Microsoft Excel database for analysis.

Data analysis

Because data were not uniform, we reported results with a descriptive approach and narrative synthesis.[7,8] We stratified data into adult and paediatric groups and analysed them separately. Where possible, we reported pooled estimates of outcome frequencies combining all studies, in parallel with means of reported individual study frequencies to show variability of reported outcomes.[8] We analysed differences in means with *t* tests and comparisons of proportions using the χ^2 test. More than half of the studies were published since 2010; therefore, to assess outcomes and detect changes over time, we further stratified data by publication before or after 2010.

We did descriptive statistics using Microsoft Excel and Statistics to Use.[9]

Role of the funding source

There was no funding source for this study.

Results

We identified 3070 studies through the literature search once duplicates were excluded. After screening titles and abstracts, we assessed 302 studies for eligibility (figure 1). 42 studies[10–50] from 13 countries satisfied inclusion criteria, reporting outcomes in all children and adults admitted to hospital with acute kidney injury. Two studies reported on the same patient cohort, therefore only the study with the most outcomes was included. Eight studies were prospective, 32 were retrospective, and one was cross-sectional. Studies are outlined in detail in the appendix. 13 adult and six paediatric studies included only patients

	Children (n=1643)*	Adults (n=993)†
Infection	380 (23%)	274 (28%)
Septicaemia	370	232
HIV	6	0
Tetanus	4	1
Pyelonephritis	0	12
Typhoid	0	7
Cholera	0	22
Glomerular disease	350 (21%)	76 (8%)
Acute glomerulonephritis	183	57
Nephrotic syndrome	115	10
Rapidly progressive acute glomerulonephritis	46	4
Lupus nephritis	5	5
Membranoproliferative acute glomerulonephritis	1	0
Nephrotoxin	270 (16%)	182 (18%)
Haemoglobinuria from:		
Plasmodium falciparum malaria haemolysis	198	34
G6PD deficiency haemolysis	18	0
Infection	0	41
Transfusion reaction	0	2
Autoimmune haemolytic anaemia	2	0
Herbal remedies ingestion	6	8
Holy water	0	7
Henna (para-phenylenediamine)	0	12
Unspecified drugs	0	17
Furosemide	5	0
ACE inhibitors	5	0
Cytotoxic drugs	5	0
Unspecified	31	61
Intravascular volume depletion or hypoperfusion	174 (11%)	50 (5%)
Gastroenteritis	169	42
Inadequate volume replacement before and after surgery	4	0
Severe haemorrhage	1	0
Unspecified	0	8
Obstructive uropathy	146 (9%)	46 (5%)
Renal stone	60	16
Congenital anomaly of the kidney and the urinary tract		
Posterior urethral valves	32	0
Renal agenesis	4	0
Prune belly syndrome	1	0
Prostate	0	9
Malignancy	0	2
Schistosoma	0	2
Unspecified	49	17
Vascular disease or haemolysis	116 (7%)	11 (1%)
Haemolytic uraemic syndrome	111	1
Thrombotic thrombocytopenic purpura	2	0
Purpura fulminans	1	0
Renal vein thrombosis	1	1
Sickle cell crisis	1	0
Haemolysis, other	0	9
Medical, other	0	36 (4%)
Liver disease	0	15
Cardiac	0	8
Malignant hypertension	0	13
Malignancy	40 (2%)	19 (2%)
Birth asphyxia	27 (2%)	0
Obstetric or gynaecological	0	157 (16%)
Septic abortion	0	66
Pre-eclampsia or eclampsia	0	43
Pre-partum or post-partum haemorrhage	0	30
Ureter ligation after hysterectomy	0	7
Unspecified	0	11
Surgical	0	54 (5%)
Trauma, burns, or fractures	0	43
Postoperative	0	1
Other	0	10
Unspecified	140 (9%)	88 (9%)

(Table 2 continues in next column)

(Continued from previous column)

G6PD=glucose-6-phosphate dehydrogenase. ACE=angiotensin converting enzyme. *17 paediatric studies. †14 adult studies.

Table 2: **Causes of acute kidney injury in children and adults**

with acute kidney injury who received or needed dialysis; two adult studies included intensive care unit populations; and two adult studies included a small proportion of paediatric patients. Pooled studies included patients enrolled between April, 1972, and December, 2013.

Study populations are outlined in table 1. Pooled patients with acute kidney injury included 1403 adults and 1937 children. Six adult and nine paediatric studies described patients presenting with predominantly community-acquired acute kidney injury, and two paediatric studies reported the proportions of community-acquired acute kidney injury to be 72·8% and 82·9%.[14,16] In the remaining studies, most cases were probably community-acquired. Children ranged from birth to age 17 years, and mean age in adult studies ranged from 28·7 years to 44·4 years (appendix). The pooled proportion of male patients was significantly larger than that of female patients (57% men; p=0·005). Male predominance did not change in adults, but declined significantly in children over time (table 1). Reported frequencies of hyperkalaemia, metabolic acidosis, and oliguria are outlined in table 1. Acute kidney injury was attributed to intrinsic renal disease in 200 (pooled 56%) of 359 adults (across four studies) and 200 (pooled 41%) of 491 children (across six studies; data not shown). Detailed causes of acute kidney injury are shown in table 2. In adults

	Adult studies			Paediatric studies		
	1990–2009	2010–14	p	1990–2009	2010–14	p
Dialysis distribution	..	..	<0·0001	..	..	0·57
Haemodialysis	411 (82%; n=8)	558 (97%; n=8)	..	5 (4%; n=2)	114 (20%; n=5)	..
Peritoneal dialysis	86 (17%; n=2)	17 (3%; n=1)	..	122 (96%; n=6)	446 (77%; n=8)	..
Both	1 (<1%)	0	..	0	22 (4%; n=1)	..
CRRT	2 (<1%)	0	..	..	..	..
Studies with dialysis received as an inclusion criterion*	5	8	..	0	6	..
Indication for dialysis in acute kidney injury (pooled)	94/132 (71%; n=3)	84/121 (69%; n=1)	0·76	372/608 (61%; n=5)	670/964 (70%; n=6)	0·001
Access to dialysis (pooled)	44/94 (47%)	14/84 (17%)	..	119/372 (32%)	547/670 (82%)†	<0·0001
Access to dialysis (means of individual studies)	59·8% (SD 44·2)	16·7%	..	34·2% (SD 37·2)	54·0% (SD 28·9)	0·35

Data are number of patients (%) or number of studies. p values for 1990–2009 versus 2010–14. CRRT=continuous renal replacement therapy. *Studies with dialysis required or received as an inclusion criterion provided no information on non-dialysed patients or patients with acute kidney injury who did not need dialysis and therefore were excluded from this analysis. †When two studies from South Africa and Sudan are excluded, the dialysis access rate decreases to 31% and does not differ between 1990–2009 and 2010–14.

***Table 3*: Indication for dialysis and access to dialysis in children and adults with acute kidney injury**

and children, infection, including malaria, accounted for more than 30% of acute kidney injury.

Delays of up to 3 weeks between onset of symptoms and presentation to hospital were described in three adult studies.[31,36,38] One paediatric study reported a mean delay of 6 days between symptom onset and presentation, and two studies described delay in presentation among 50–80% of children (appendix).[11,15,29]

Definitions used for diagnosis of acute kidney injury have changed over time (table 1). Standardised diagnostic criteria for acute kidney injury (risk, injury, failure, loss of function, and end-stage renal disease [RIFLE] and paediatric RIFLE [pRIFLE]; Acute Kidney Injury Network [AKIN]; and Acute Dialysis Quality Initiative) were used in 35% of studies that reported definitions used published after 2010 compared with none before 2010.

1075 adults and 609 children received dialysis (table 3). Haemodialysis predominated among adults (969 [90%] of 1075) and peritoneal dialysis predominated among children (568 [80%] of 709). 19 of the 41 studies included only patients who needed or received dialysis and therefore could not be used to calculate dialysis indication or access rates.

Access to dialysis was defined as the proportion of patients with acute kidney injury who received dialysis when indicated (table 3). In four studies, 178 of 253 adults needed dialysis, giving a pooled dialysis indication rate of 70%. Among these 178 adults, the pooled dialysis access rate was 33%. The mean dialysis access rate across adult studies was 49·1% (SD 42·3). 11 studies reported dialysis need in 1042 of 1572 children with acute kidney injury, giving a pooled dialysis indication rate of 66% (table 3). In these 1042 children, the dialysis access rate was 64%. The mean dialysis access rate across studies was 45·0% (SD 32·8; range 9·7–100). In pooled analyses, dialysis indication rate and dialysis access rate in children increased significantly over time (table 3; p<0·0001). However, when data from South Africa and Sudan (countries with government-sponsored dialysis and paediatric acute kidney injury access rates of 100% and 95%, respectively) were excluded from this analysis, the pooled dialysis access rate after 2010 decreased to 31% (156 of 509 children received dialysis), which does not differ significantly from the rate before 2010.

One study described a delay of 3·3 days (SD 1·9; range 1–9) between admission to hospital and initiation of dialysis owing to the search for resources to pay for dialysis, others reported patient deaths while the search for resources was underway, or patients leaving hospital against medical advice because of inability to afford dialysis (appendix).[13,25,45]

Mortality was reported in 17 adult studies and 21 paediatric studies (table 4). Of 1077 adults, 346 died, giving a pooled mortality of 32%. Of 1842 children, 627 died, giving a pooled mortality of 34%. Pooled mortality decreased significantly in both adults and children over time, although the ranges of individual study mortalities were highly variable (p<0·0001). Mortality associated with specific causes of acute kidney injury is shown in the appendix.

When stratified by whether dialysis, when indicated, was received or not, pooled mortality was significantly higher in adults (86% *vs* 30%; p<0·0001) and children (74% *vs* 30%; p<0·0001) who did not receive at least one dialysis session. Nine studies reported consistent findings in adults and children from the same cohort, suggesting this may not merely be a centre effect (appendix). Mortality in children was not different between those who received haemodialysis and those who received peritoneal dialysis. Overall mortality reported in children with acute kidney injury who did not need dialysis was lower than in those who received dialysis (16·22% *vs* 28·54%; p=0·13).

Major predictors of poor outcomes in several studies were late presentation and inability to pay for dialysis.[18,36] Numbers of patients lost to follow-up or leaving against medical advice were high in some studies (table 4), showing the challenges of patient care and clinical research in sub-Saharan Africa.

Renal recovery, defined as independence from dialysis, improvement in serum creatinine after acute kidney injury,

	Adult studies			Paediatric studies		
	1990–2009	2010–14	p	1990–2009	2010–14	p
Overall mortality						
Mortality (pooled)	237/639 (37%; n=9)	109/438 (25%; n=8)	<0·0001	285/720 (40%; n=7)	342/1122 (30%; n=14)	<0·0001
Mortality (means of individual studies)	38·7% (20·6)	29·2% (24·5)	0·40	40·5% (8·3)	30·4% (14·4)	0·11
Mortality without dialysis when needed						
Mortality without dialysis when needed (pooled)	43/50 (86%; n=2)	NA	..	179/247 (72%; n=4)	45/57 (79%; n=3)	0·32
Mean mortality without dialysis (means of individual studies)	82·4% (12.8)	NA	..	72·9% (18·8)	90·0% (17·3)	0·27
Mortality with dialysis						
Mortality with dialysis (pooled)	161/500 (32%; n=8)	78/288 (27%; n=6)	0·13	28/119 (24%; n=5)	184/585 (31%; n=10)	0·09
Mean mortality with dialysis (means of individual studies)	28·0% (15·7)	35·1% (26·1)	0·54	16·4% (11·5)	34·6% (20·1)	0·09
Mean mortality haemodialysis (means of individual studies)	27·3% (14·13; n=7)	33·46 % (27·00; n=6)	0·61	57·0% (39·9; n=3)		0·27*
Mean mortality peritoneal dialysis (means of individual studies)	25% (n=1)	NA	NA	33·6% (27·4; n=9)		..
Mortality when dialysis not indicated						
Mortality when dialysis not indicated (pooled)	23/43 (53%†; n=2)	NA	..	36/232 (16%; n=4)	43/285 (15%; n=4)	0·84
Mortality, acute kidney injury not needing dialysis (means of individual studies)	30·3% (42·8)	NA	..	22·2% (17·1)	10·2% (8·4)	0·25
Other outcomes						
Recovery of renal function in survivors (pooled)	58/78 (74%; n=2)	72/159 (45%; n=4)	<0·0001	152/172 (88%; n=3)	515/714 (72%; n=8)	<0·0001
Residual chronic kidney disease in survivors (pooled)‡	6/73 (8%; n=1)	18/113 (16%; n=2)	0·1	23/143 (16%; n=2)	45/533 (8%; n=3)	0·007
Left hospital against medical advice (pooled)	0	6/62 (10%; n=1)	..	10/183 (5%; n=2)	33/814 (4%; n=5)	0·4
Lost to follow-up (pooled)	28/264 (11%; n=2)	6/17 (35%; n=1)	..	116/334 (35%; n=2)	20/700 (3%; n=2)	<0·0001

Data are mean % (SD) or mean (%; number of studies with outcome). p values for 1990–2009 versus 2010–14. *Comparison between haemodialysis and peritoneal dialysis in children. †One study included high-comorbidity patients in intensive care units. ‡Chronic kidney disease not specifically defined, generally non-requirement for dialysis but non-return of renal function to normal parameters by discharge or loss to follow-up.

Table 4: **Outcomes in children and adults with acute kidney injury**

or both, was reported in 17 studies (table 4). The pooled rate of renal recovery was 130 (55%) of 237 (six studies) in adult survivors and 667 (75%) of 886 (11 studies) in child survivors. The pooled rate of residual chronic kidney disease, defined as persistence of renal dysfunction but not needing dialysis at time of discharge, was 24 (13%) of 186 adults (three studies) and 68 (10%) of 676 children (five studies). These outcomes were not routinely reported or systematically defined, and some studies had substantial loss to follow-up, so the true rates remain unknown.

Discussion

The aim of this systematic review was to describe the real-world context of patients diagnosed with acute kidney injury in sub-Saharan Africa. We identified 41 studies published during 25 years reporting access to dialysis when needed, mortality, and renal outcomes in cohorts of all patients with acute kidney injury.

Most patients presented with severe acute kidney injury, with 70% of adults and 66% of children needing dialysis (stage 3 acute kidney injury). This dialysis need contrasts strongly with the pooled world need for dialysis in patients with acute kidney injury of 11%, because 80% of all patients worldwide had stage 1 (mild) acute kidney injury.[4] These opposing observations suggest that acute kidney injury is a more aggressive disorder in sub-Saharan Africa than elsewhere; however, this is more likely to be a result of late presentation to hospital and reliance on clinical criteria for diagnosis, which might only become apparent at an advanced stage. Many studies commented on delay in patient presentation, not uncommonly with oliguria and advanced uraemia at diagnosis.

When dialysis was needed, the pooled dialysis access rate was 33% in adults and 64% in children, although rates were as low as 10% in some studies. Results of a survey of availability of paediatric services in Nigeria showed that more than 50% of facilities did not have dialysis capability.[51] When patients did gain access to dialysis, most adults received haemodialysis, showing the absence of peritoneal dialysis in many centres.[32,34,36] In

children, peritoneal dialysis predominated, owing to body size limitations and absence of haemodialysis facilities.[11,23,28] Paediatric peritoneal dialysis was sometimes done with modified alternative catheters and fluids when appropriate resources were unavailable.[23]

The overall pooled mortality was 32% in adults and 34% in children with acute kidney injury. These rates are much higher than the pooled world rates of 23·3% in adults and 13·8% in children, possibly showing the increased severity of documented acute kidney injury in sub-Saharan Africa and low access to dialysis.[3] The more than two times higher mortality in children in sub-Saharan Africa compared with worldwide mortality is especially concerning. How the overall data might be skewed by the high proportion of studies exclusively on dialysed patients is difficult to predict. Pooled mortality in those who received dialysis was 30% in adults and children, lower than the world mortality among dialysed patients with acute kidney injury of 46%.[2] The lower dialysis mortality in sub-Saharan Africa compared with elsewhere might reflect the relative absence of patient comorbidities and more frequent community-acquired acute kidney injury, despite frequent premature discontinuation of dialysis because of cost.[38]

However, a substantial proportion of patients with acute kidney injury in sub-Saharan Africa did not receive dialysis when needed and experienced very high mortality rates. These poor outcomes show the severity of patient illness and delayed presentation, delays imposed by searching for funds after admission to hospital, and the erratic infrastructure.[13,18,29,38,45] However, mortality among these undialysed patients was not inevitable, emphasising the value of conservative management and prompt treatment of underlying disease in the absence of dialysis.[24] Availability of the needed resources might also be inconsistent in sub-Saharan Africa. Resources reported during the included studies are listed in the appendix. A survey of 66 intensive care facilities in the Democratic Republic of the Congo reported that crystalloids were available in 100% of units, but that availability of antibiotics and other necessities was variable.[52] Serum creatinine was never available in 75·8% of units. Dialysis was not available in any units.

Most adults and children surviving acute kidney injury recovered renal function, although roughly 10% had residual renal dysfunction. This high rate of persistent renal dysfunction might be a result of the initial severity of acute kidney injury, or might highlight the challenges in excluding underlying chronic kidney disease without access to diagnostic tests. Very few cohorts had long-term follow-up, therefore these percentages could be an overestimate and some patients might have continued to improve over time.

Several barriers to access to care for acute kidney injury were identified through this study, as shown in figure 2. First, the low overall patient numbers reported suggest that many patients with acute kidney injury are not diagnosed or treated. Second, male patients predominate, probably showing some discrimination against women. Third, poor patient resources led to delays in admission to hospital and use of traditional medicine, which might be especially harmful in the setting of dehydration, for example, and worsen kidney injury. Fourth, delays occur in referral from peripheral health-care sites to sites where renal care is available. Finally, delays occur after admission to hospital because patients need to search for funds to pay for dialysis or because supplies, staffing, or resources of the hospital are erratic. Each of these delays might have a seemingly obvious cause, but if a holistic approach is to be taken to prevent acute kidney injury, much research, including clinical, epidemiological, and anthropological study, is needed to investigate all contributors to such barriers. The expectation that most patients can pay for dialysis, even when heavily subsidised, is probably unrealistic, since even meagre user-fees are a hindrance to access to basic health care in low-income settings.[53] The predominance of male

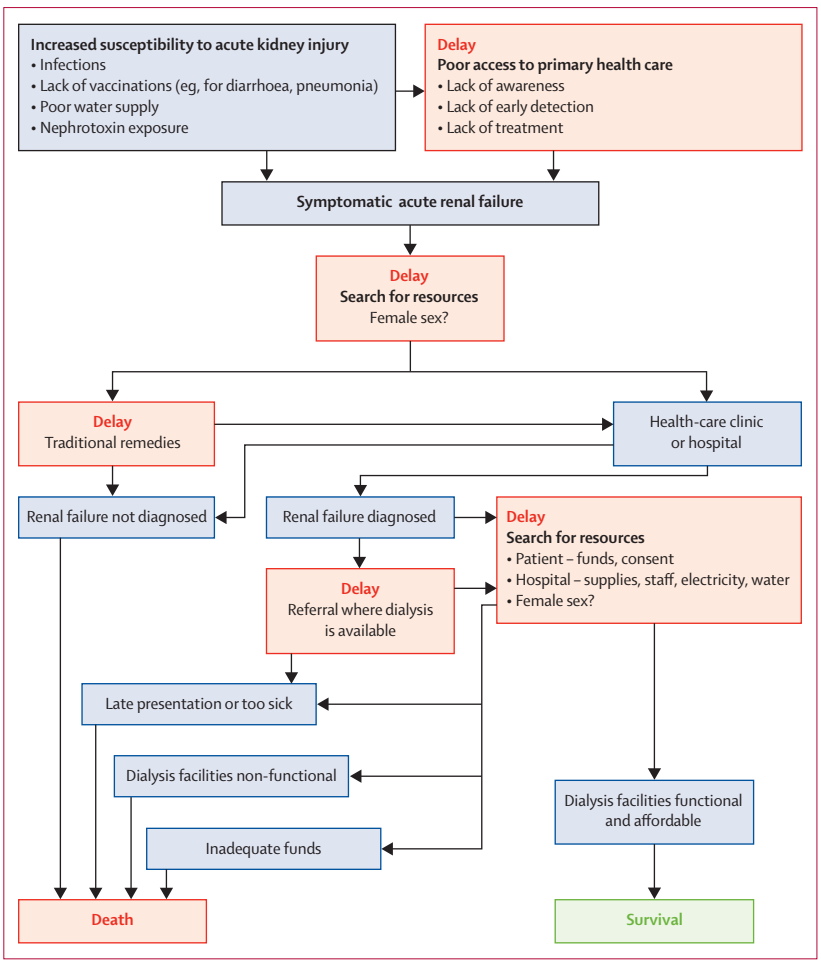

Figure 2: **Barriers to care in acute kidney injury**
Outcomes shown for each pathway (survival or death) are the most likely outcomes, but are not inevitable (table 4).

patients might reflect a true increased susceptibility to renal disease (eg, urogenital abnormalities in boys), but more probably reflects the relative absence of economic and decision-making power among women, and is consistent with findings in other low-resource regions.[54,55]

Although reported observations seem to be mostly consistent across studies, this systematic review has substantial limitations. In most countries in sub-Saharan Africa, access to diagnosis and specialist renal care for acute kidney injury is scarce, and is heavily reliant on out-of-pocket payments by patients. The patients reported in the reviewed studies are therefore those who had the resources to be diagnosed with acute kidney injury, some of whom were also able to access dialysis. These studies do not represent the many patients with acute kidney injury in sub-Saharan Africa for whom the needed health services are beyond reach.

The observational and historical nature of most studies, coupled with a high proportion of missing data, frequent patient loss to follow-up, variability in acute kidney injury definitions, and representation of data from only 13 countries all diminish the robustness of data interpretation. Such weaknesses have led to exclusion of these studies from existing meta-analyses, and acute kidney injury in sub-Saharan Africa has therefore remained a so-called black box in the world scientific literature on acute kidney injury. Our decision to include all obtainable studies was intentional to try to mitigate publication bias that would be exacerbated with further study selection, and to best capture the reality of daily challenges faced by patients and nephrologists in sub-Saharan Africa. Our inclusion of all comers also strengthens the generalisability of the findings to the general acute kidney injury population. However, descriptive analysis cannot account for different study weights or quality, and the conclusions are therefore less robust than in a meta-analysis. The severity of reported acute kidney injury might show a bias towards testing the most symptomatic patients, which could overestimate poorer outcomes, although patients who survived the delay in presentation to hospital might have a propensity to survival. Abstracts of nine acute kidney injury articles were not obtainable in full text, but the outcomes described suggest consistency with the main findings of this study and would therefore be unlikely to alter the conclusions.

Highlighting real-world outcomes and challenges, despite study limitations, is important to inform health-systems-wide planning and policy development for acute kidney injury in regions where resources are scarce and many health-care priorities are competing. The increasing number of publications over time highlights growing expertise, but also an urgency in the specialty. This study also highlights the important limitations of previous studies. Study quality scores and checklists should be considered prospectively in any ongoing or planned research on acute kidney injury in sub-Saharan Africa to optimise study design, data collection, and accuracy of reporting, so that future studies can further understanding of the true burden of acute kidney injury in sub-Saharan Africa and reliably inform policy making.

The published outcomes of acute kidney injury in patients in sub-Saharan Africa show the complexities of access to timely and appropriate renal care in the region. Several barriers to diagnosis and care of acute kidney injury are evident, the most consistent of which are delays in reaching hospital, cost of care, erratic functioning or supply of hospital resources, and female sex. If a programme for prevention and treatment of acute kidney injury is to be effective and sustainable, each barrier will need to be understood and overcome.

Contributors

WAO and AN scored the papers, analysed data, and wrote the manuscript. CO and GA scored the papers and wrote the manuscript. FAA did the literature search, scored papers, and wrote the manuscript. SN and JP interpreted data and wrote the manuscript. VAL did the literature search, scored papers, analysed data, and wrote the manuscript. All authors contributed to development of study concept and editing of the manuscript. All authors approved the final manuscript.

Declaration of interests

We declare no competing interests.

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