



Paediatric Nephrology in Africa

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Abstract

Purpose of Review We highlight the unique facets of paediatric nephrology in Africa in terms of the spectrum of kidney diseases, available diagnostic and treatment modalities, kidney healthcare financing options, paediatric nephrology manpower and the contribution of geography and demographics.

Recent Findings Paediatric acute kidney injury in Africa is now commonly due to sepsis rather than gastroenteritis. Steroid-sensitive form of nephrotic syndrome is far more common than was two decades ago.

Summary The hot arid climate in North Africa and the tropical climate in most of sub-Saharan Africa, and the high rate of consanguinity, sickle cell disease and HIV drive the spectrum of paediatric kidney diseases in the continent. Kidney diseases are often precipitated by infectious triggers associated with poor living conditions and little access to medical care thus resulting in late presentation and often end-stage kidney disease. Although accessibility to kidney care has improved in the continent due to training opportunities provided by international professional organisations, most children still face significant barriers to kidney care because they live in rural areas, governments spend the least on healthcare and the continent has the least density of healthcare practitioners and nephrology trainees.

Keywords Acute kidney injury · HIV · Kidney transplantation · Malaria · Nephrotic syndrome · Sickle cell disease

Introduction

Africa is the second largest continent defined by land mass after Asia. The continent comprises 54 countries conveniently divided into five regions, namely Northern Africa, Western Africa, Eastern Africa, Middle/Central Africa, and Southern Africa. Geographically, most of the continent lies below the Sahara Desert and experience a tropical or temperate climate. The countries north of the Saharan desert face a hot arid climate that promotes stone formation in the urinary tract. The tropical climate in most of the countries in sub-Saharan Africa (SSA) is conducive for bacterial infections, tuberculosis and vector-borne diseases such as malaria. The continent is home to 17% of the world's population of 7.8 billion people and it is the youngest continent with a median age of 19.7 years; 40% of the continent's population is under 14 years [1, 2, 3]. In contrast, the median age of the world is 30.9 years. About half of the population of the continent reside in rural areas which is characterised by a high burden of infectious diseases and limited access to social amenities and healthcare with traditional remedies often the first remedy for any illness.

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Africa is the poorest continent with a GDP per capita that is one-sixth of the global average [2, 3]. Of the 20 countries in the world with the lowest GDP per capita, 18 are in Africa [3]. Only six African countries (South Africa, Namibia, Botswana, Gabon, Equatorial Guinea and Libya) are rated as upper middle-income countries and none as high-income country (HIC) by the World Bank [4].

Its relatively young population, high fertility rate, unique climate, and high poverty rate act in concert to shape the practice of paediatric nephrology in the continent.

Spectrum of Kidney Diseases in Children in the Continent

Acute kidney injury (AKI) and nephrotic syndrome are the most reported paediatric kidney diseases in Africa (Table 1) [5–7, 8•]. The dramatic presentations of nephrotic syndrome and severe acute kidney injury reduce the likelihood of missed diagnoses. In contrast, the prevalence of chronic kidney disease and congenital anomalies of the kidneys and urinary tract remains low due to the absence of screening or antenatal ultrasound investigation and thus often an underestimation. Apart from North Africa and the Republic of South Africa, genetic kidney diseases in children are infrequently reported in the continent due to cost and unavailability of the tests [9, 10]. In North Africa, consanguinity contributes to the high prevalence of diseases such as sickle cell anaemia, hyperoxaluria and nephronophthisis while the hot arid climate coupled with high consanguinity promotes a high burden of urolithiasis in children [5, 11]. In most parts of sub-Saharan Africa, the high burden of malaria is reflected in its frequent finding in children with AKI [12, 13••]. About 40% of the 409,000 deaths from malaria in 2019 occurred in three African countries, namely Nigeria, Democratic Republic of

Congo and Tanzania [14•]. Two recent studies that used the Kidney Disease: Improving Global Outcomes (KDIGO) consensus definition of AKI documented that 45.5–59% of children with severe malaria in two African countries developed AKI [15, 16••].

Although the spectrum of kidney diseases in children in the continent may be similar to those of children in other regions of the world, there are unique features that bear material impact on the course of kidney diseases in the continent. Acute kidney injury in Africa is frequently community-acquired and due to sepsis, malaria, perinatal asphyxia and, less commonly to, gastroenteritis due to unsafe water and sanitation [12, 13••, 17–20]. Acute kidney injury due to perinatal asphyxia is partly driven by the high out-of-facility delivery of newborns that is prevalent in the continent [21]. Late presentation to medical facilities colours the presentation and course of many diseases in Africa [22, 23]. It is not unusual for children with nephrotic syndrome to present to healthcare with fluid oozing out from the skin. In addition, there are many children with congenital anomalies of the kidneys and urinary tract (CAKUT), such as posterior urethral valve (PUV), who present for the first time after the age of five years or in adolescence with little residual kidney function [24•]. Not uncommonly, despite the increased availability of ultrasonography, many children with CAKUT are not diagnosed before birth [25, 26]. This underlines a need for manpower training but may also reflect the grim situation where about 35% of births in the continent occur outside health facilities [21]. In practice, the paediatric nephrologist in the continent is frequently caring for children with common kidney diseases who have the most severe forms with little residual kidney function.

Secondary causes of glomerular diseases are relatively more common than in high-income countries. The continent is home to the largest population of people living with

Table 1 Pattern of childhood kidney diseases in some African countries

Study ID	Ali [5]	Ladapo [7]	Antwi [6]	Obiagwu [8•]
Country	Sudan	Nigeria	Ghana	Nigeria
Region	North Africa	West Africa	West Africa	West Africa
Publication date	2012	2014	2015	2019
Year of study	2000–2004	2008–2011	2010–2012	2015–2017
Number of children	200	320	664	244
Kidney diseases (%)				
Acute kidney injury	6.0	20	31	13.9
Nephrotic syndrome	17.0	22.8	27.3	33.6
Acute glomerulonephritis	12.0	10	11.9	25.8
Chronic kidney disease	4.0	4.2	13.0	13.9
CAKUT	10.0	17.5	7.4	7.8
Stones	15.5	-	-	2.9
Urinary tract infection	30.0	3.1	3.0	2.0

CAKUT, congenital anomalies of the kidneys and urinary tract

HIV. As a result, HIV-related kidney diseases are frequently reported in both children and adults [27, 28•]. Furthermore, the high prevalence of sickle cell disease in the malaria-endemic region of Africa (most of Western, Middle and Eastern Africa) drives the burden of secondary glomerular disease [27, 29]. Again, in contrast to HIC, childhood nephrotic syndrome in Africa was historically likely to be steroid resistant. However, two large recent studies among Black children in Côte d'Ivoire and Nigeria reported a steroid sensitivity rate more than 80% similar to rates observed in European and Asian children with nephrotic syndrome [30••, 31]. Furthermore, a recent systematic review documented increasing rates of steroid-sensitive form of childhood nephrotic syndrome compared with resistant form [32]. Acute glomerulonephritis due to streptococcal infection remains a commonly reported kidney disease in children in Africa (Table 1), but more children with glomerular diseases due to systemic lupus erythematosus are increasingly being recognised [33, 34].

The absence of a comprehensive paediatric renal registry for the continent (there is an active renal registry in South Africa) means the true burden of end-stage kidney disease (ESKD) in children is largely unknown and infrequently reported. Hence, there are few reports of the burden of ESKD in children in Africa. The scant data available suggest that the prevalence of paediatric ESKD is much lower in Africa than in North America and Europe. A recent single-centre study in Nigeria put the incidence of ESKD among children < 15 years at 4 per million at risk population [22]. Overall, in contrast to CAKUT as the leading cause of ESKD in children in Europe and North America, glomerular diseases are the frequently reported causes of paediatric ESKD in the continent (see Table 2) [22, 35, 36]. It does appear that in regions of Africa where non-Black children predominate, CAKUT is the most common cause of chronic kidney disease (CKD) and the converse is the case in regions

where Blacks predominate. For example, in Egypt and Cape Town, South Africa, CAKUT is the leading cause of CKD, whereas, in Nigeria, KwaZulu-Natal, South Africa, and among Blacks in Johannesburg, South Africa, glomerular diseases were the most frequent causes of CKD [22, 36–39].

Modalities of Treating Kidney Diseases

Availability of diagnostic and treatment modalities for kidney diseases in Africa is among the poorest in the world. The Global Kidney Health Atlas 2019, which detailed the 2018 survey of the ISN, documented that only 4 and 10% of patients with ESKD in low-income countries (LIC) and low middle-income countries (LMIC), respectively, received kidney replacement therapy compared with 60% in Western Europe [40••]. Furthermore, most of the countries with the least chronic haemodialysis (HD) and peritoneal dialysis (PD) centre densities are in Africa. In most countries in Africa, the survey estimated the chronic HD centre density at < 1.2 per million population (pmp). In Chad and Mozambique, for example, the density was 0.1 pmp. In addition, chronic PD was only available in 15 of the 42 African countries surveyed. In the continent, access of children to kidney care lags those for adults and is frequently inferior to adult services. The survey confirmed large disparities in ESKD care and access to KRT between children and adults within the same country. The disparity is more marked in LIC and LMIC to which about 90% of the countries in Africa belong. In LIC, the survey respondents reported disparity in ESKD care and KRT access in 61% and 57% of the countries, respectively, compared to 19% and 9%, respectively, in HIC. Some of the disparities are evident in the non-availability of size-compatible consumables for urodynamic investigations, catheters for haemodialysis and peritoneal dialysis and blood lines for haemodialysis [41]. Not infrequently, adult-sized

Table 2 Major causes of chronic kidney diseases in African children

Country Region	North Africa		South Africa			West Africa
	Sudan [35]	Egypt [39]	Johannesburg [38]	Cape Town [37]	KwaZulu Natal [36]	Nigeria [22]
Study year	2001–2006	2012–2013	1984–2003	1968–2006	1994–2006	2005–2012
Number of children	205	1018	153*	149	126	53
CKD definition	GFR < 50	CKD 1–5	ESKD	Transplant	CKD 2–5	CKD 5
Major aetiologies, <i>n</i> (%)						
CAKUT	36 (17.5)	468 (46)	56 (36.6)	69 (46)	27 (21.4)	11 (20.8)
Glomerular diseases	52 (25.4)	156 (15.3)	47 (30.7)	52 (35)	68 (54)	41 (77.4)
Hereditary nephropathy	14 (6.8)	68 (6.7)	13 (8.5)	7 (4.7)	-	-
Urolithiasis	19 (9.3)	-	-	-	-	-
Unknown	80 (39.1)	210 (20.6)	-	-	-	-

CAKUT, congenital anomalies of the kidneys and urinary tract; CKD, chronic kidney disease; ESKD, end-stage kidney disease; GFR, glomerular filtration rate; *183 children received 283 kidney grafts; aetiologies of ESKD were presented for only 153 children

dialysis lines are primed with blood in order to safely dialyse smaller children, which reduces the likelihood of finding a compatible kidney graft when kidney transplantation becomes necessary. The lower density of kidney health manpower for children compared with adults further worsens the disparity in kidney care in the continent. The near absence of kidney services in rural areas, where almost 50% of the population lives further accentuates the disparity [42]. For example, in Kenya, there are four centres offering paediatric haemodialysis in the capital city, one in Eldoret and none in other parts of the country. A similar finding was reported by Antwi [43] in Ghana where all the dialysis centres were situated in the southern part with none in the northern two-thirds of the country. A weak referral system together with limited and unreliable transportation between the rural areas and the cities in Africa exaggerates the disparities in kidney care, especially in paediatric care, received in the continent.

Kidney transplantation (KTx) is present in 16 African countries, namely, all the countries in North Africa, Republic of South Africa and Namibia in South Africa, Kenya, Tanzania, Ethiopia, Mauritius and Seychelles in East Africa and Nigeria, Ghana and Cote D'Ivoire in West Africa [40••, 44, 45]. The median incidence of kidney transplantation in the continent is estimated at 4.6 pmp compared with the global median of 14 [46•]. African countries with advanced KTx services, namely Republic of South Africa and the countries in North Africa, provide KTx for all age categories of children. However, in the other countries, only older children have such access. For example, a recent study in Nigeria reported that <3% of the kidney transplants performed in Nigeria were in children and more than 40% of the children were at least 15 years at the time of transplantation [47•]. In many of the countries with no or limited KTx, it is a common practice for patients whose families could afford it to emigrate to other countries or to get the kidney transplantation done overseas; India represents the most common choice for the latter [48•, 49]. Deceased kidney transplantation is only available in Morocco, Algeria, Tunisia and South Africa [40•]; this option requires legislation around brain death and its absence in many of the countries negatively impacts the pool of kidney grafts and worsens access of children to KTx.

Diagnostic modalities for kidney disease in children in the continent have improved with widespread availability of sonography. However, modalities such as urodynamics and nuclear medicine scans are still largely unavailable. For example, in Nigeria, there is only one functioning nuclear medicine centre for the country with a population of 211 million [1, 50•]. Medications for kidney diseases have become more available compared to several decades ago, largely as a result of cheaper and good-quality generics. Calcineurin inhibitors, mycophenolic acid and its derivatives, monoclonal antibodies, are now available but remain largely

unaffordable to most children and are in tablets or capsule formulations that are not easy to administer to younger children.

Health Manpower for Kidney Care

Africa has the least density of health manpower in the world. The World Health Organization (WHO) in its Global Health Observatory in 2018 estimated that there were 2.1 medical doctors and 9.94 nurses and midwives per 10,000 population in SSA with North Africa faring slightly better [51•]. However, both regions are well below the global average of 17.54 medical doctors and 39.05 nurses and midwives per 10,000 population. In contrast for example, Europe has 20 times more doctors per 10,000 population than SSA. The population of medical specialists in kidney care is even worse. The global survey conducted by the International Society of Nephrology showed that in 2018, the global median number of nephrologists was 9.95 per million population and 0.6 pmp in Africa [40••]. In a recently published textbook, *Nephrology Worldwide*, the authors reported that the number of nephrologists per million population ranged from 0.22 in Uganda to 2.5 in the Republic of South Africa [52•]. The picture is bleaker for children who make up 42% of the 1.1 billion population in the continent; the number of paediatric nephrologists per million population is well below 1. For example, in Lagos, Southwest Nigeria, there are only two paediatric nephrologists for the 20 million inhabitants of the state. This is a major challenge not only for clinical management but also for advocacy for children with kidney disease. Furthermore, the few kidney specialists in the continent are found in large hospitals located in urban centres. With about 50% of the continent living in rural areas, most children have no access to kidney care. This is another driver of missed diagnosis of kidney diseases in the continent.

In recent years, professional organisations such as the International Pediatric Nephrology Association (IPNA), International Society of Nephrology (ISN) and International Society of Peritoneal Dialysis (ISPD) have supported the training of manpower in paediatric nephrology in the continent by providing training grants and linking trainees with established centres, mostly in Egypt and South Africa [48, 53•, 54•]. This has resulted in over 35 paediatricians trained in nephrology from South Africa alone. For example, three of the authors (CIE, BA, RE) enjoyed training support from IPNA and ISN to undergo training in paediatric nephrology at Red Cross War Memorial Children's Hospital, Cape Town, South Africa, under two of the authors (PN, MM). In addition, the Saving Young Lives Program, a collaborative effort of these professional associations, has supported the training of teams of medical doctors and nurses in initiating and strengthening acute peritoneal dialysis services in

several countries in Africa [55]. The COVID-19 pandemic, despite the immense negative impact on healthcare delivery, has facilitated on-line learning and attendance of virtual congresses which promotes continuing medical education. These learning opportunities were largely previously unavailable to the paediatric nephrologists in low-resource countries who could not afford the cost of travels.

However, despite the modest gain in health manpower for kidney care, like all other aspects of healthcare in the continent, migration to better resourced regions of the world remains a perennial threat. For example, 38% of the hospital doctors in the National Health Service (NHS) in England gained their medical degree outside the UK while 22 out of every 1000 NHS staff identified as Africans [56]. Furthermore, a national poll conducted in Nigeria in 2018 found that 88% of the medical doctors polled were currently seeking to work abroad with the UK, USA and Canada being the top three destinations [57]. The net migration of healthcare workers out of the continent may persist during and after the COVID-19 pandemic as more governments in OECD countries promote faster integration of migrant healthcare workers into their systems [58]. The prospect of better job satisfaction, standard of living and increased income remains potent push factors from the continent. With only 0.4 pmp nephrology trainee reported in Africa, compared with 5.8 pmp in Western Europe, the gap in kidney care in the continent may worsen with time [40••, 46]. It is reassuring to note that the feeling of making a difference and helping to build resources in one's own country may counteract these push factors to some degree as the majority of paediatric nephrologists trained by IPNA and ISN have indeed returned and stayed in their countries of origin.

Financing Kidney Care and Research in the Continent

Public spending on health in the continent is among the lowest in the world. In 2018, the WHO estimated that the current health expenditure per capita in Africa was a meagre 132 US dollars [59]. Furthermore, African governments spent the least percentage of its expenditure on health at 6.69%; only four African governments in 2018 spent more than 10% of its domestic expenditure on health [59]. Not surprising, only in six of the 42 African countries surveyed in 2018 by ISN was non-dialysis CKD care funded by the government and free at the point of delivery [40••]. Consequently, for most families in the continent, paying for kidney care is exorbitant, unplanned and out of pocket. In the face of high burden of neonatal morbidities and infection-related diseases such as malaria, pneumonia and diarrhoeal diseases, financing kidney care is not a priority for most African governments and multilateral donor agencies. As a result of the austere

level of spending on overall health and kidney care, many children present late to care and are unable to afford essential kidney care. The meagre spending on healthcare contributes to the unavailability of many health diagnostic and therapeutic modalities in the continent. Also, the low spending on healthcare is a major driver of brain drain and a strong disincentive to those aspiring to pursue a career in paediatric nephrology and its allied specialties. Overall, these factors act in concert to worsen the care and outcome of children with kidney diseases in the continent.

Although African governments pledged in 2007 to contribute 1% of their GDP to research and development, the pledge has never been met in almost all the countries in the continent. In 2017, for example, only an average 0.4% of the GDP of SSA was committed to R&D [60]. Funding for research in the continent is uniquely from the public sector like the government and international agencies, unlike in the developed world where the private sector is the major donor source [61]. Major international sources of funding for health research in the continent include the National Institutes of Health (NIH), UK Medical Research Council European and Developing Countries Clinical Trials Partnership and Wellcome Trust [62]; it is not uncommon that the donors' research priorities are sometimes at variance with the continent's priorities. The low funding for research means many important research into the unique paediatric kidney diseases in the continent are not undertaken or they are funded poorly from the researchers' meagre income.

Of notable mention is the ongoing Human Heredity and Health in Africa (H3A) Kidney Disease Research Network (part of the larger H3A consortium) which is funded by the NIH to investigate the genetic and environmental underpinnings of common kidney diseases in Africans in the continent [63•]. In addition, the research efforts aim to build crucial research capacity in genomics, ethics, social implications of research, bioinformatics, biobanking, networking and academic publication. It is currently enrolling children with idiopathic childhood nephrotic syndrome and sickle cell disease in more than 10 centres in Ghana and Nigeria with centres in South Africa and Cameroon expected to join soon.

The Role of Preventive Paediatric Nephrology in Africa

Taken together, the unique features of healthcare in the continent support the primacy and cost-effectiveness of measures aimed at preventing and detecting early kidney diseases in children. The measures that may potentially have the most impact on paediatric kidney care in the continent include improving access to safe drinking water and sanitation [64], use of long-lasting insecticide-treated mosquito nets and

prompt treatment of malaria [65], improving childhood and maternal nutrition especially just before and during pregnancy [66], increasing facility births and antenatal diagnosis of CAKUT and scaling up routine childhood immunisation and universal healthcare [67, 68]; where universal healthcare already exists, kidney services should be included in the coverage. In Africa, the continent with the least density of paediatric kidney manpower, training of non-medical doctors and non-paediatric nephrologists to manage children with kidney diseases will have a major salutary effect on kidney outcome as it increases the pool of knowledgeable and skilful manpower and improves access to care.

Conclusion

Paediatric nephrology in Africa has its own peculiar challenges not only in terms of the unique kidney pathologies but also in terms of lack of available treatment modalities including both acute and chronic dialysis and access to transplantation for children. Advocacy for paediatric nephrology remains a priority as adults are often prioritised in the management of kidney disease. Human manpower has improved in the last two decades largely due to training input of international professional organisations. However, sustained support of paediatric nephrologists is needed to prevent them from migrating to better-resourced regions of the world. On-line education and support from training centres as well as attendance of virtual congresses has fostered continuing medical education but affordable investigations including genetic testing, equipment and facilities for paediatric dialysis and kidney transplantation remain a major challenge.

Declarations

Conflict of Interest The authors declare no competing interests.

Human and Animal Rights and Informed Consent This article is not a report involving human or animal subjects performed by any of the authors.

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