



International Society of Nephrology Global Kidney Health Atlas: structures, organization, and services for the management of kidney failure in Africa

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Despite positive economic forecasts, stable democracies, and reduced regional conflicts since the turn of the century, Africa continues to be afflicted by poverty, poor infrastructure, and a massive burden of communicable

diseases such as HIV, malaria, tuberculosis, and diarrheal illnesses. With the rising prevalence of chronic kidney disease and kidney failure worldwide, these factors continue to hinder the ability to provide kidney care for millions of people on the continent. The International Society of Nephrology Global Kidney Health Atlas project was established to assess the global burden of kidney disease and measure global capacity for kidney replacement therapy (dialysis and kidney transplantation). The aim of this second iteration of the International Society of Nephrology Global Kidney Health Atlas was to evaluate the availability, accessibility, affordability, and quality of kidney care worldwide. We identified several gaps

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regarding kidney care in Africa, chief of which are (i) severe workforce limitations, especially in terms of the number of nephrologists; (ii) low government funding for kidney care; (iii) limited availability, accessibility, reporting, and quality of provided kidney replacement therapy; and (iv) weak national strategies and advocacy for kidney disease. We also identified that within Africa, the availability and accessibility to kidney replacement therapy vary significantly, with North African countries faring far better than sub-Sahara African countries. The evidence suggests an urgent need to increase the workforce and government funding for kidney care, collect adequate information on the burden of kidney disease from African countries, and develop and implement strategies to enhance disease prevention and control across the continent.

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As in many parts of the world, the demographic, socioeconomic, and political landscape of most of Africa has changed significantly since the turn of the century. Despite positive economic forecasts, stable democracies, and a significant reduction in regional conflicts, the continent continues to be plagued by poverty, excessive corruption, a lack of infrastructure, and a huge burden of communicable diseases such as human immunodeficiency virus disease, malaria, tuberculosis, diarrheal illnesses, and recurring epidemics like Ebola virus disease.¹ Given these significant challenges, addressing issues associated with noncommunicable diseases (NCDs) like chronic kidney disease (CKD) and kidney failure (KF) is a low priority for governments in Africa.² The lack of a continent-wide kidney disease registry to guide physicians and policymakers makes it even more difficult to fully grasp the scope of the disease and economic impacts in Africa. Moreover, published studies are often limited by small sample size and poor study design. Thus, the gap between those with KF and those receiving kidney replacement therapy (KRT; dialysis and kidney transplantation) is projected to continue to widen in Africa.³ The first iteration of the International Society of Nephrology Global Kidney Health Atlas (ISN-GKHA) provided a broad overview of the state of kidney care across the continent.⁴ In the second iteration, we collected more detailed information on the burden of kidney disease from more countries in Africa, as well as data on the capacity for, accessibility to, and quality of KF care. The methodology for this research is described in detail elsewhere.⁵

Results

The results of this study are presented in the tables and figures and broadly summarized into 2 categories: desk research (Tables 1^{6–16} and 2^{3,8,9,13,17,18}, Figure 1, Supplementary Table S1, and Supplementary Appendix) and survey administration (Figures 2–5 and Supplementary Figures S1–S10).

Study setting. Africa is the second largest and second-most populous continent in the world after Asia. With a land mass of about 30.3 million km² including adjacent islands, Africa covers 6% of the earth's total surface area and 20% of the earth's total land area. In 2019, Africa's population was 1.3 billion people, representing 17% of the world's population.¹⁹ It is composed of 54 countries divided into 5 geographic and economic regions: northern Africa, central Africa, eastern Africa, southern Africa, and western Africa. There are also 8 territories and 2 independent states with limited recognition on the continent. Algeria has the largest total land area in Africa (2.4 million km²), whereas Nigeria has the largest population (206 million).²⁰ Africa encompasses a rich diversity of ethnicities, cultures, religions, and languages, with English, French and numerous indigenous languages being the most prevalent means of communication.

Although it has abundant natural resources, Africa is the world's poorest and least developed continent, excluding Antarctica; its total nominal gross domestic product is lower than that of many individual countries, including the United States, China, Japan, Germany, the United Kingdom, India, and France. According to the World Bank, more than half of the extreme poor live in sub-Saharan Africa, with 413 million people living on less than US\$1.90 a day in 2015.²¹

Although sub-Saharan Africa's score on the Human Development Index—a statistical composite index of life expectancy, education, and per capita income indicators—increased from 0.402 in 1990 to 0.541 in 2018, it remained the lowest among all developing regions of the world. Scores in sub-Saharan Africa ranged from 0.377 in Niger to 0.801 in the Seychelles.²² Six of the 10 countries with the highest Gini index scores are in Africa (Lesotho, South Africa, Botswana, Namibia, Zambia, and Comoros),²³ highlighting massive gaps in wealth distribution. In addition, the proportion of government spending on health is low in Africa. In 2017, the World Health Organization reported a 70-fold difference in health care spending between high-income and lower-income countries, with the lowest spending in the countries of West, Central, and East Africa. In the same year, more than half of donor funding for health went to 14 countries, and one-fifth went to only 4 countries, 3 of which are in Africa (Kenya, Nigeria, and Uganda).²⁴

Current state of kidney care in Africa. Several reviews have been published on the state of nephrology in Africa.^{25–29} There are, however, no continent-wide or regional studies from Africa with data on CKD, KF, or KRT. A major reason for this has been the lack of a continent-wide registry on kidney disease. Recognizing the importance of a continent-wide kidney registry, the African Association of Nephrology

Table 1 | Demographics, health expenditures, and kidney replacement therapy costs in African countries that responded to the ISN-GKHA survey^{6–16}

Country	World Bank income level	Area (km ²)	Total population (2018)	GDP (PPP), \$ billions ^a	Total health expenditures (% of GDP) ^a	Annual cost KRT ^b (US\$) and out-of-pocket cost/% paid by patient from total cost ^c		
						HD	PD	KT (first year)
Global median	—	—	—	—	6.5	22,617	20,524	25,356
Africa median	—	29,974,508	1,255,518,570	118.5	6.1	15,800	17,542	16,312
Algeria	Upper-middle	2,381,741	41,657,488	630.0	6.6	9,152/0	—/0	—/0
Angola	Lower-middle	1,246,700	30,355,880	193.6	2.9	—/0	—/0	—
Benin	Low	112,622	11,340,504	25.4	3.9	—/0	—/0	—/0
Botswana	Upper-middle	581,730	2,249,104	39.0	5.5	—/100	—/100	—
Burkina Faso	Low	274,200	19,742,715	35.9	6.8	—/>75	—	—
Burundi	Low	27,830	11,844,520	8.0	6.2	12,480/1–25	—	—
Cabo Verde	Lower-middle	4033	568,373	3.8	5.2	—/0	—	—
Cameroon	Lower-middle	475,440	25,640,965	89.5	4.7	1560/1–25	—	—
Cen. African Rep.	Low	622,984	5,745,062	3.4	4.3	—	—	—
Chad	Low	1,284,000	15,833,116	28.6	4.5	—/100	—	—
Comoros	Lower-middle	2235	821,164	1.3	7.6	—	—	—
Congo, Dem. Rep.	Low	2,344,858	85,281,024	68.6	3.9	43,902/>75	34,165/100	—
Congo, Rep.	Lower-middle	342,000	5,062,021	29.4	4.6	—/1–25	—/26–50	—
Cote d'Ivoire	Lower-middle	322,463	26,260,582	97.2	4.4	—	—	—
Djibouti	Lower-middle	23,200	884,017	3.6	3.5	—	—	—
Egypt	Lower-middle	1,001,450	99,413,317	1204.0	4.6	3217/0	6979/0	7482/0
Equatorial Guinea	Upper-middle	28,051	797,457	31.5	3.4	—	—	—
Eritrea	Low	117,600	5,970,646	9.4	3.0	—	—	—
Ethiopia	Low	1,104,300	108,386,391	200.6	4.0	—/100	—	—/1–25
Gabon	Upper-middle	267,667	2,119,036	36.7	2.7	—/1–25	—	—
Gambia	Low	11,300	2,092,731	5.6	6.7	—/0	—	—
Ghana	Lower-middle	238,533	28,102,471	134.0	5.9	—/>75	—	—/100
Guinea	Low	245,857	11,855,411	28.0	4.5	—	—	—
Guinea-Bissau	Low	36,125	1,833,247	3.2	6.9	—	—	—
Kenya	Lower-middle	580,367	48,397,527	163.7	5.2	17,736/1–25	13,302/26–50	—/51–75
Lesotho	Lower-middle	30,355	1,962,461	6.7	8.4	—	—	—
Liberia	Low	111,369	4,809,768	6.1	15.2	—	—	—
Libya	Upper-middle	1,759,540	6,754,507	62.0	5.0	—/>75	—/>75	—/51–75
Madagascar	Low	587,041	25,683,610	39.9	5.2	—/>75	—/>75	—
Malawi	Low	118,484	19,842,560	22.4	9.3	—/0	—	—
Mali	Low	1,240,192	18,429,893	41.2	5.8	—	—	—
Mauritania	Lower-middle	1,030,700	3,840,429	17.3	4.6	—/1–25	—	—
Mauritius	Upper-middle	2040	1,364,283	28.3	5.5	—	—	—
Morocco	Lower-middle	446,550	34,314,130	298.6	5.5	5282	6812	7357
Mozambique	Low	799,380	27,233,789	37.1	5.4	—/26–50	—	—
Namibia	Upper-middle	824,292	2,533,224	26.6	8.9	27,159/1–25	27,159	—/1–25
Niger	Low	1,267,000	19,866,231	21.9	7.2	—	—	—
Nigeria	Lower-middle	923,768	203,452,505	1121.0	3.6	23,606/100	35,582	21,460/100
Rwanda	Low	26,338	12,187,400	24.7	7.9	—	—	—
Sao Tome & Principe	Lower-middle	964	204,454	0.7	9.8	—	—	—
Senegal	Lower-middle	196,722	15,020,945	54.8	4.0	20,311/1–25	19,404/1–25	20,510
Seychelles	High	455	94,633	2.8	3.4	—	—	—
Sierra Leone	Low	71,740	6,312,212	11.6	18.3	—/100	—	—
Somalia	Low	637,657	11,259,029	20.4	—	—	—	—

(Continued on following page)

Table 1 | (Continued) Demographics, health expenditures, and kidney replacement therapy costs in African countries that responded to the ISN-GKHA survey⁶⁻¹⁶

Country	World Bank income level	Area (km ²)	Total population (2018)	GDP (PPP), \$ billions ^a	Total health expenditures (% of GDP) ^a	Annual cost KRT ^b (US\$) and out-of-pocket cost/% paid by patient from total cost ^c		
						HD	PD	KT (first year)
South Africa	Upper-middle	1,219,090	55,380,210	767.2	8.2	10,736/0	13,302/0	23,827/0
South Sudan	Low	644,329	10,204,581	20.0	2.5	—	—	—
Sudan	Lower-middle	1,861,484	43,120,843	177.4	6.3	11,639/1-25	13,202/1-25	15,680/1-25
Swaziland	Lower-middle	17,364	1,087,200	11.6	7.7	—/0	—	—
Tanzania	Low	947,300	55,451,343	162.5	6.1	28,446/1-25	—	—/1-25
Togo	Low	56,785	8,176,449	13.0	6.6	—	—	—
Tunisia	Upper-middle	163,610	11,516,189	137.7	6.7	5980/1-25	5520/1-25	17,870/1-25
Uganda	Low	241,038	40,853,749	89.2	7.3	—/26-50	—	—
Zambia	Lower-middle	752,618	16,445,079	68.9	5.4	—/1-25	—/1-25	—
Zimbabwe	Lower-middle	390,757	14,030,368	34.3	10.3	—/>>75	—/>>75	—

—, Data not reported/unavailable; Cen., Central; Dem. Rep., Democratic Republic; GDP, gross domestic product; GKHA, Global Kidney Health Atlas; HD, hemodialysis; ISN, International Society of Nephrology; KRT, kidney replacement therapy; KT, kidney transplantations; PD, peritoneal dialysis; PPP, purchasing power parity; Rep. Republic.

^aEstimates are in US\$ 2017.

^bDetailed reference list on annual cost of KRT is available in the [Supplementary Appendix](#).

^cCosts are in \$US 2016.

(AFRAN) and the African Paediatric Nephrology Association embarked on the establishment of a continental kidney registry in 2015.³⁰ It is thought that this initiative could make a substantial impact on the practice of nephrology and the provision of services for adults and children with KF in many African countries. Currently, the only source of comprehensive information on kidney disease in Africa is the ISN-GKHA from 2017.⁴

Characteristics of participating countries. Among the ISN regions, Africa had the highest number of survey respondents (n = 63); these represented 42 countries with a population of 1.2 billion (95.04% of the African population) ([Figure 1](#)). The World Bank classifies 7 (16.7%) of these countries as upper-middle, 16 (38.1%) as lower-middle, and 19 as low (45.2%) income.⁶ The sole high-income country in Africa, the Seychelles, did not respond to the survey. Health care expenditure as a percentage of gross domestic product ranged from 2.7% in Gabon to 18.3% in Sierra Leone ([Table 1](#)).⁷ Respondents included nephrologists (n = 48, 76%), non-nephrology physicians (n = 8, 13%), nonphysician health care professionals (n = 3, 5%), hospital administrators or policymakers (n = 2, 3%), and others (n = 2, 3%), with a regional response rate of 70%.

Burden of CKD, KF, and risk factors in Africa. The prevalence of CKD in Africa was 6.28%, which was lower than the global prevalence of 9.46%. Mauritius, an upper-middle income country, had the highest prevalence of CKD in Africa (17.63%), whereas Uganda, a low-income country, had the lowest prevalence (4.87%). The percentage of deaths attributable to CKD ranged from 0.57% in Zambia to 10.36% in Mauritius, and the percentage of disability-adjusted life years ranged from 0.58% in Nigeria to 6.85% in Mauritius. Among CKD risk factors, obesity was most prevalent in Libya (31.8%), high blood pressure was most prevalent in Niger (33.4%), and smoking was most prevalent in Tunisia (19.9%) ([Supplementary Table S1](#)). Although available data on the prevalence of treated KF were scant, significant disparities were observed in the reported prevalence across countries, ranging from as low as 4.4 per million population (pmp) in Rwanda to 1018 pmp in Tunisia ([Table 2](#)).^{3,8,9,17}

Health finance and service delivery for kidney care in Africa. The 2 major modalities of funding for kidney care and service delivery in Africa were (i) a mix of public and private funding and (ii) solely private and out-of-pocket (OOP) payments. For example, a combination of public and private systems funded nondialysis CKD and KRT in 31% and 29% of countries, respectively, whereas services such as hemodialysis (HD) fistula creation, peritoneal dialysis (PD) catheter insertion, and surgery for kidney transplantation were mainly paid for solely OOP in 29%, 26%, and 29% of countries, respectively ([Figure 2](#)). In most countries around the world, these services were covered by public funding and were free at the point-of-care delivery. The annual costs of HD and PD were generally more than US\$10,000 higher in sub-Saharan Africa than in North Africa. KRT was not affordable in most countries, in as much as only 22% and 12% of countries required no

Table 2 | Kidney replacement therapy and nephrology workforce statistics in African countries^{3,8,9,13,17,18}

Country	World Bank income level	Treated KF (pmp)	Prevalence of long-term dialysis (pmp)			Long-term dialysis centers (pmp)		Kidney transplantation (pmp)		Nephrology workforce (pmp)	
			HD	PD	Total (HD+PD)	HD	PD	Incidence	Centers	Nephrologists	Nephrology trainees
Global median	—	787.0	310.0	25.0	359.0	4.5	1.3	14.0	0.4	10.0	1.4
Africa median	—	541.0	13.8	2.1	16.9	0.5	0.1	4.6	0.2	0.6	0.4
Algeria	Upper-middle	—	240.3	11.1	251.4	7.7	0.2	4.3	0.2	12.0	1.9
Angola	Lower-middle	—	23.6	0.0	23.6	0.3	0.0	—	—	1.0	0.4
Benin	Low	—	30.2	0.0	30.2	0.4	—	—	—	0.9	0.5
Botswana	Upper-middle	—	—	18.3	18.3	2.2	0.9	—	—	0.7	0.9
Burkina Faso	Low	—	—	—	—	0.2	—	—	—	0.7	0.9
Burundi	Low	—	—	—	—	0.2	—	—	—	0.2	—
Cabo Verde	Lower-middle	—	—	—	—	1.8	—	—	—	3.5	3.5
Cameroon	Lower-middle	—	12.2	0.0	12.2	0.4	—	—	—	0.6	0.3
Cen. African Rep.	Low	—	—	—	—	—	—	—	—	—	—
Chad	Low	—	—	—	—	0.1	—	—	—	0.2	—
Comoros	Lower-middle	—	—	—	—	—	—	—	—	—	—
Congo, Dem. Rep.	Low	—	0.3	0.3	0.6	0.2	0.0	—	—	0.3	0.0
Congo, Rep.	Lower-middle	—	0.4	0.3	0.7	1.0	—	—	—	1.6	0.0
Cote d'Ivoire	Lower-middle	—	23.3	0.0	23.3	0.3	0.0	—	0.04	1.0	0.2
Djibouti	Lower-middle	—	—	—	—	—	—	—	—	—	—
Egypt	Lower-middle	624.0	517.7	0.1	517.8	3.0	0.1	15.5	0.2	23.1	3.0
Equatorial Guinea	Upper-middle	—	—	—	—	—	—	—	—	—	—
Eritrea	Low	—	—	—	—	0.3	—	—	—	—	—
Ethiopia	Low	—	5.8	0.0	5.8	0.2	—	—	0.0	0.1	0.1
Gabon	Upper-middle	—	103.0	0.0	103.0	2.8	—	—	—	4.7	—
Gambia	Low	—	—	—	—	0.5	—	—	—	0.5	0.5
Ghana	Lower-middle	—	4.4	0.0	4.4	0.5	—	—	0.0	0.3	0.1
Guinea	Low	—	—	—	—	0.2	—	—	—	0.5	0.7
Guinea-Bissau	Low	—	—	—	—	—	—	—	—	—	—
Kenya	Lower-middle	—	9.2	1.1	10.3	0.8	—	0.6	0.1	0.6	0.1
Lesotho	Lower-middle	—	—	—	—	—	—	—	—	—	—
Liberia	Low	—	—	—	—	—	—	—	—	0.2	0.0
Libya	Upper-middle	—	351.8	12.6	360.1	9.5	0.7	—	0.2	—	—
Madagascar	Low	—	5.1	0.0	5.1	0.2	—	—	—	0.2	0.2
Malawi	Low	—	—	—	—	—	0.1	—	—	0.0	0.0
Mali	Low	—	3.9	0.0	3.9	—	—	—	—	—	—
Mauritania	Lower-middle	—	80.5	0.0	80.5	4.2	—	—	—	1.6	1.6
Mauritius	Upper-middle	—	—	—	—	—	—	—	—	—	—
Morocco	Lower-middle	541.0	185.0	0.6	185.6	9.6	0.1	1.5	0.2	12.5	2.2
Mozambique	Low	—	0.9	0.0	0.9	0.1	0.0	—	—	0.1	0.1
Namibia	Upper-middle	—	16.8	9.6	26.4	2.0	—	—	0.4	0.8	1.0
Niger	Low	—	—	—	—	0.2	—	—	—	0.4	0.0
Nigeria	Lower-middle	—	7.4	0.0	7.4	0.7	—	0.3	0.1	0.9	0.5
Rwanda	Low	4.4	—	—	2.8	—	—	—	—	—	—
Sao Tome & Principe	Lower-middle	—	—	—	—	—	—	—	—	—	—
Senegal	Lower-middle	—	9.7	1.6	11.3	—	—	—	—	2.0	4.3
Seychelles	High	—	—	—	—	—	—	—	—	—	—

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Table 2 | (Continued) Kidney replacement therapy and nephrology workforce statistics in African countries^{3,8,9,13,17,18}

Country	World Bank income level	Prevalence of long-term dialysis (pmp)				Long-term dialysis centers (pmp)			Kidney transplantation (pmp)			Nephrology workforce (pmp)	
		Treated KF (pmp)	HD	PD	Total (HD+PD)	HD	PD	Centers	Incidence	Centers	Nephrologists	Nephrology trainees	
													HD
Sierra Leone	Low	—	—	—	—	1.0	0.1	—	—	—	0.2	0.0	
Somalia	Low	—	—	—	—	0.3	—	—	—	—	0.3	0.9	
South Africa	Upper-middle	181.0	134.3	23.3	157.6	0.5	—	—	4.6	—	2.7	0.4	
South Sudan	Low	—	—	—	—	—	—	—	—	—	—	—	
Sudan	Lower-middle	—	67.9	2.5	70.4	4.7	0.3	—	5.3	0.2	1.3	0.4	
Swaziland	Lower-middle	—	15.4	0.0	15.4	1.7	0.1	—	—	0.0	0.9	0.9	
Tanzania	Low	—	0.5	0.0	0.5	2.8	0.9	—	—	0.0	0.2	0.1	
Togo	Low	—	8.3	0.0	8.3	—	—	—	—	—	—	—	
Tunisia	Upper-middle	1018.0	722.8	36.8	759.6	0.3	—	—	11.1	0.0	15.6	5.5	
Uganda	Low	—	1.2	0.7	1.8	14.8	0.7	—	—	—	0.2	—	
Zambia	Lower-middle	—	1.7	0.0	1.7	0.2	—	—	—	—	0.3	0.1	
Zimbabwe	Lower-middle	—	2.8	0.0	2.8	0.4	0.3	—	—	—	0.4	0.0	

—, Data not reported/unavailable; Cen., Central; Dem. Rep., Democratic Republic; HD, hemodialysis; KF, kidney failure; PD, peritoneal dialysis; pmp, per million population; Rep. Republic.

copayment at the point-of-care delivery for HD and PD, respectively (Supplementary Figure S1). The annual cost for HD was lowest in Cameroon (US\$1560; OOP cost of 1% to 25%) and highest in the Democratic Republic of Congo (US\$43,902; OOP cost of >75%). The annual cost for PD was highest in Nigeria (US\$35,582) (Table 1).^{6–8,10–16}

Health workforce for kidney care in Africa. Data on the available workforce for kidney care revealed stark differences between Africa and the rest of the world. In Africa, the number of nephrologists was 0.62 pmp, compared with 9.95 pmp globally, and the number of nephrology trainees was 0.36 pmp, compared with 1.42 pmp globally. Among the 42 responding countries in Africa, 27 (income: 2 upper-middle, 8 lower-middle, 17 low) reported <1 nephrologist pmp; collectively, these countries had a population of 850 million people (67.3% of Africa's total population). All countries in North Africa (except Libya) had >10 nephrologists pmp. Overall, there were significant shortages of other health care workers needed for kidney care, including transplantation surgeons, dialysis access surgeons, dialysis technicians, interventional radiologists, transplantation coordinators, and dialysis nurses (Supplementary Figure S2).

Capacity for KRT service provision in Africa. Among responding countries in Africa, 100% reported that long-term HD services were available, whereas only 41% reported that long-term PD services were available. The highest prevalence of long-term dialysis (both HD and PD) was found in North Africa, in Tunisia (759.6 pmp), Egypt (610.0 pmp), Libya (360.1 pmp), Algeria (251.4 pmp), and Morocco (185.6 pmp). Tanzania had the lowest prevalence of long-term dialysis (0.5 pmp) (Table 2).^{3,8,9,17} Only 51% of countries reported HD to be generally available as a modality of choice (vs. 10% for PD); home HD was not available in Africa (Figure 3). Only 44% of countries reported the capacity to adhere to standard HD prescriptions (3 treatments per week, 3 to 4 hours per session) and just 17% reported the capacity to perform 3 to 4 PD exchanges daily. Efficient transport services for PD patients were generally available in only 15% of countries in the region. PD was not the predominant form of dialysis in any country and was not readily available in many countries. In Africa, the median number of HD centers was 0.53 pmp (vs. 4.46 pmp globally), and the median number of PD centers was 0.09 pmp (vs. 1.27 pmp globally) (Figure 3).

The capacity to diagnose complications of KF in Africa was comparable to, albeit lower than, global capacity. Analog and automated BP monitoring as well as the capacity to measure hemoglobin and serum electrolytes were generally available in >75% of countries. However, basic treatments for complications of KF were not readily available; oral sodium bicarbonate, potassium exchange resins, parenteral iron, and non-calcium-based phosphate binders were available in just 32%, 39%, 56%, and 12% of countries, respectively (Figure 4). Access to KRT was very limited in Africa. More than 50% of patients had access to HD in just 34% of countries, and 26% to 50% of patients were able to initiate KRT with PD in just

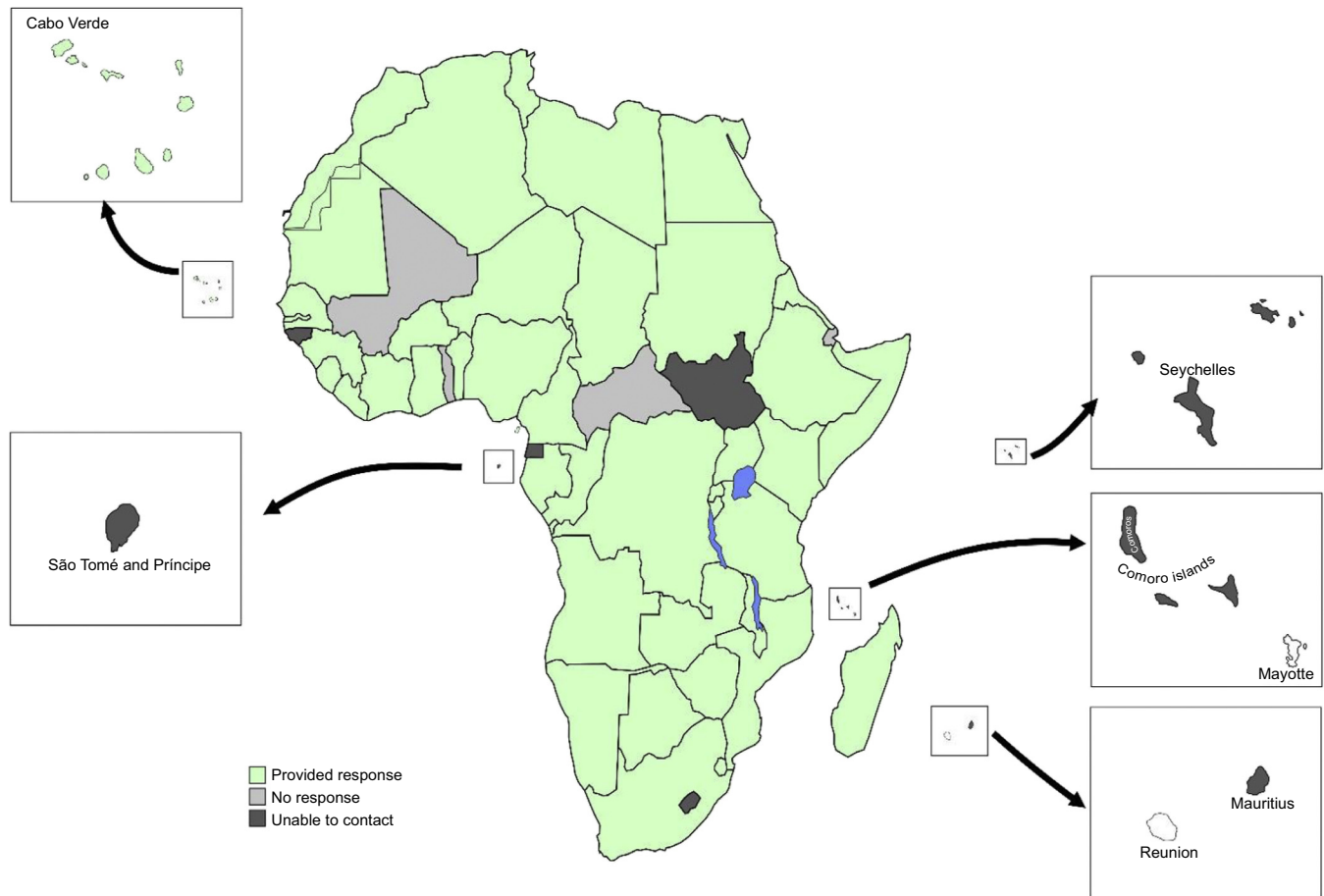


Figure 1 | African countries participating in the International Society of Nephrology Global Kidney Health Atlas survey.

2% of countries (Supplementary Figure S3). When factors influencing access to dialysis were considered, geography played a big role in 54% of countries. Patient characteristics played a limited role in determining access to HD and PD (Supplementary Figure S4).

Data on kidney transplantation in Africa were scant; among countries with available data, the reported incidence was highly variable, ranging from 0.3 pmp in Nigeria to 15.5 pmp in Egypt (Table 2).^{3,8,9,17} The median number of kidney transplantation centers in Africa was 0.15 pmp (vs. 0.42 globally), and the availability of transplantation-related services was generally low. For instance, availability of standard organ procurement frameworks, access to operating space, and availability of immunosuppression and antirejection treatments were generally available in just 12%, 15%, and 24% of countries, respectively (Figure 3). There was no access to transplantation in 68% of countries, and 15% reported geography-based variations in access (Supplementary Figures S3 and S4). There was limited monitoring and reporting of KRT quality indicators in Africa. Indices such as hemoglobin and blood pressure were well monitored and reported in HD and PD patients. Other indices, such as small solute clearance, technique survival, and patient-reported outcome measures, were not as well monitored or reported (Supplementary Figures S5–S7).

Although conservative care was available in 80% of reporting countries in Africa, only 44% offered choice-restricted conservative care or a form that was chosen or medically advised. Conservative care was easily accessible in just 12% of countries, and 10% of countries provided additional training in conservative care to care providers (Figure 3). Shared decision-making tools and a multidisciplinary approach to care were generally available in 22% and 27% of countries, respectively.

Health information systems, statistics, and national health policies in Africa. Various health information services for kidney care, including registries and advocacy groups for kidney care, were mostly unavailable in many countries in Africa (Figure 5). Few countries in Africa had official registries for CKD (7%), dialysis (44%), transplantation (15%), and/or acute kidney injury (10%). For dialysis registries, participation was mandatory in 65% of countries and coverage was national in 72% of countries; registries typically collected data about the causes of KF (78%) and modality of dialysis (83%), with modest reporting on patient-based outcome measures such as hospitalization (33%), quality of life (17%), and mortality (67%) (Supplementary Figure S8).

Supplementary Figures S9A–S9D summarize national health policies for NCDs and for advocacy efforts related to CKD and KF in Africa. Among reporting countries in Africa,

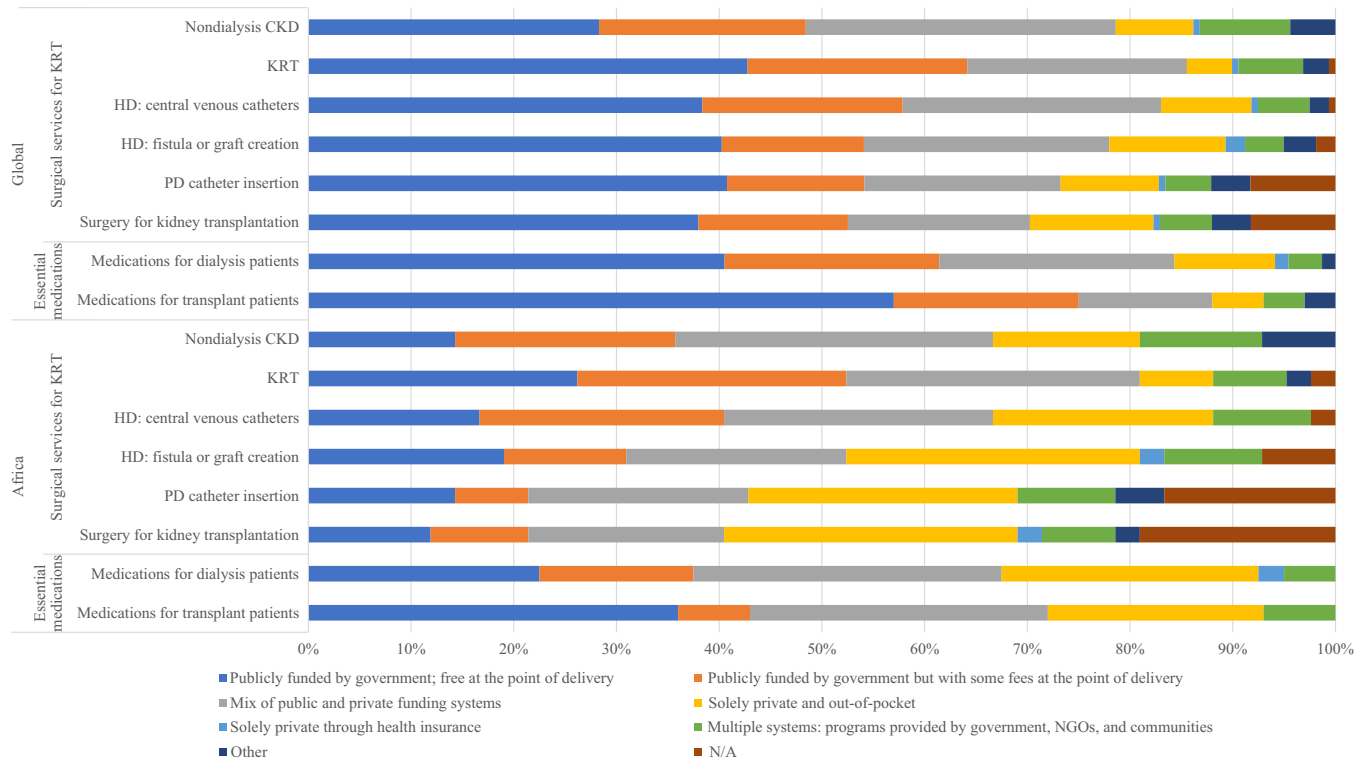


Figure 2 | Funding structures for nondialysis chronic kidney disease (CKD) and kidney replacement therapy (KRT) care. Values represent absolute number of countries in each category expressed as a percentage of total number of countries. HD, hemodialysis; N/A, not provided; NGOs, nongovernmental organizations; PD, peritoneal dialysis.

34% had a developed national NCD strategy (vs. 47% of countries globally), and only 10% had a specific national strategy to improve care for CKD patients; 24% of countries

reported that CKD strategies were incorporated into NCD strategies. National NCD strategies covered nondialysis CKD patients, dialysis patients, and transplantation patients in

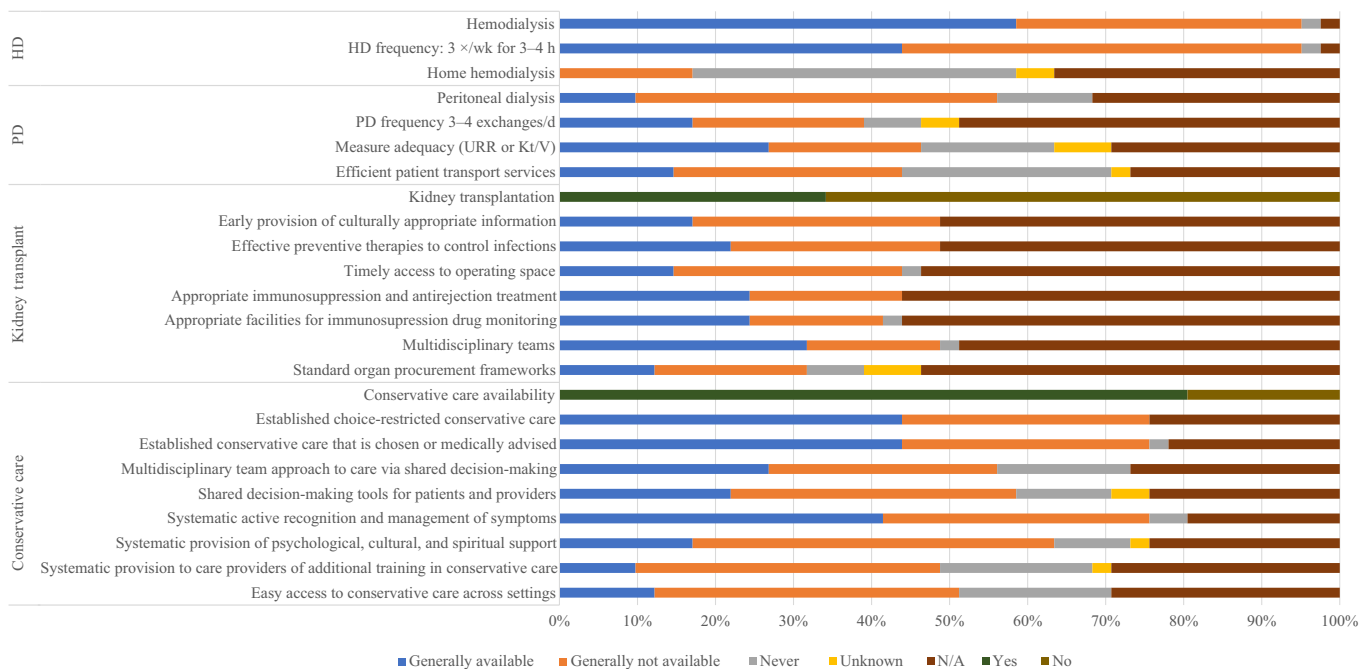


Figure 3 | Availability of choice in kidney replacement therapy or conservative care for patients with kidney failure. Values represent absolute number of countries in each category expressed as a percentage of total number of countries. HD, hemodialysis; Kt/V, measure of dialysis adequacy; N/A, not provided; PD, peritoneal dialysis; URR, urea reduction ratio.

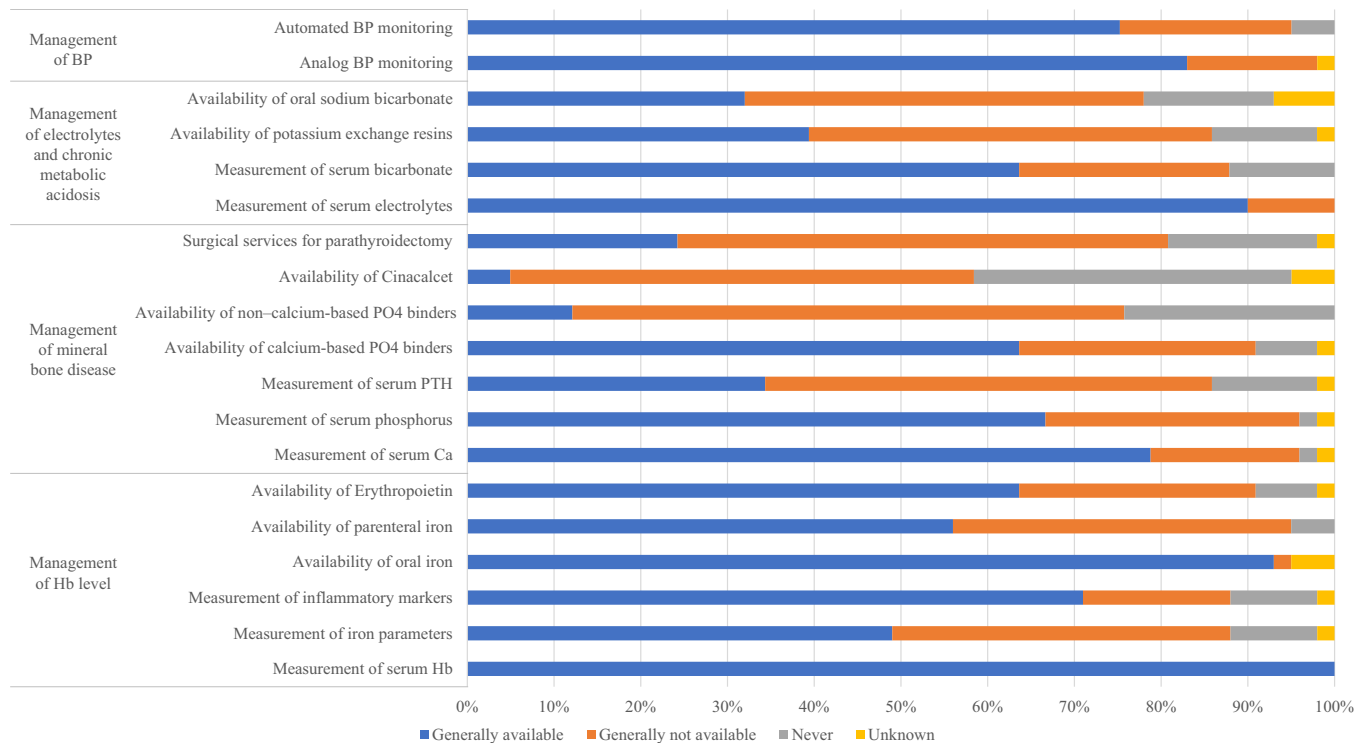


Figure 4 | Available services to diagnose and treat complications of kidney failure. Values represent absolute number of countries in each category expressed as a percentage of total number of countries. BP, blood pressure; CA, calcium; Hb: hemoglobin; PO4, phosphate; PTH, parathyroid hormone.

60%, 40%, and 10% of countries, respectively. There were very few advocacy groups for CKD (29%) and KRT (29%) in Africa, and only 51% of countries recognized CKD as a health priority.

Barriers to optimal KF care in Africa. The proportion of countries reporting barriers to optimal KF care was higher in Africa than in the rest of the world (Supplementary Figure S10). Several countries reported a lack of nephrologists (83%), challenges with the health care system (83%), and economic factors (95%) as significant barriers to optimal care.

Discussion

CKD is a public health problem.³¹ Nowhere is this truer than in low-income and middle-income countries, particularly in Africa, where resources to tackle the severe burden of CKD are severely lacking.²⁵ Moreover, owing to challenges associated with health transition, Africa is experiencing a significant double burden of communicable and noncommunicable diseases to which many health care systems are not prepared to respond.^{32,33} Thus, although the prevalence of CKD is projected to increase in Africa, the gap between those needing and those receiving KRT is widest in Africa than in other regions,³ and mortality among patients with KF in Africa remains alarmingly excessive.³⁴

The results of our study highlight significant gaps in the capacity to provide kidney care in Africa. The gaps are apparent when measured against global data; however,

significant variations exist among African countries in the capacity to provide KRT and the ability to access it. The main findings of our study are (i) severe workforce shortages, particularly with regard to the number of nephrologists; (ii) low government funding for kidney care; (iii) limited availability, accessibility, reporting, and quality of provided KRT; and (iv) weak national strategies and advocacy for kidney disease.

Workforce shortages, especially of nephrologists, constitute a major constraint to the delivery of kidney care in Africa. Compared with the rest of the world, where the average number of nephrologists is 9.95 pmp, the number in Africa is 0.62 pmp, with significant variations between North Africa and sub-Saharan Africa (Table 2).¹⁸ A sufficient health workforce has been described as the cornerstone of a country’s health care system, without which universal health coverage and sustainable development goals cannot be attained.^{35–37} Health workers often provide leadership and advise governmental decision makers responsible for developing policies and establishing health care priorities. The shortage of nephrologists in many African countries may explain why various aspects of kidney care remain weak across the continent. Among several factors contributing to the low number of nephrology workers worldwide, several are relevant to Africa, including the increasing burden of CKD, lack of exposure to nephrology among students and residents, inflexible work schedules, and inadequate training

Country	Availability of KRT and CKM				Funding for medications		Availability of official registry				Advocacy		
	Long-term HD	Long-term PD	Kidney transplant	CKM	Dialysis medications	Transplant medications	CKD	Dialysis	Transplantation	AKI	CKD	AKI	KF / KRT
Algeria													
Angola													
Benin													
Botswana													
Burkina Faso													
Burundi													
Cabo Verde													
Cameroon													
Chad													
Congo, Dem. Rep.													
Congo, Republic													
Cote d'Ivoire													
Djibouti													
Egypt													
Eritrea													
Ethiopia													
Gabon													
Gambia, The													
Ghana													
Guinea													
Kenya													
Liberia													
Libya													
Madagascar													
Malawi													
Mali													
Mauritania													
Morocco													
Mozambique													
Namibia													
Niger													
Nigeria													
Rwanda													
Senegal													
Sierra Leone													
Somalia													
South Africa													
Sudan													
Swaziland													
Tanzania													
Togo													
Tunisia													
Uganda													
Zambia													
Zimbabwe													

Yes
 No
 Unknown

Figure 5 | Country-level scorecard for kidney care in Africa. AKI, acute kidney injury; CKD, chronic kidney disease; CKM, conservative kidney management; Dem. Rep., Democratic Republic; HD, hemodialysis; KF, kidney failure; KRT, kidney replacement therapy; PD, peritoneal dialysis.

resulting from a lack of trainers and the necessary infrastructure for training.^{28,38}

The ISN Fellowship Program was specifically established to mitigate shortages in the nephrology workforce, especially in developing countries.³⁹ Data show that Africa benefitted immensely from the ISN Fellowship Program and other ISN programs geared toward augmenting the workforce or

equipping members of the existing workforce to improve kidney disease care in Africa.⁴⁰ “Brain-drain” of African nephrologists to greener pastures in North America, Europe, or Australia because of difficult working environments, economic hardships, or personal security challenges also contributes to the low number of nephrologists in Africa.^{41,42} Workforce shortages in Africa also extend beyond

nephrologists to other workers, including dialysis nurses, access surgeons, dialysis technicians, and interventional radiologists (Supplementary Figure S2).

When developing strategies to tackle the rising burden of CKD in Africa, governments must improve funding for training health care workers in nephrology. Given the time and funding needed to train nephrology specialists, immediate strategies may include task shifting and task sharing to improve the primary care treatment of patients with kidney disease.⁴³ AFRAN also needs to work with the ISN Fellowship Program to identify key areas of need across the continent, standardize nephrology training in the region, and engage in advocacy by sensitizing various governments to the need to support workforce development through increased funding.

Inadequate funding of various aspects of kidney care together with the lack of political will are also important barriers to the effective delivery of kidney care in Africa. Over half of the world's extreme poor live in Africa,²¹ where annual dialysis costs exceed US\$10,000, a high proportion of which is covered by OOP payments. It thus should come as no surprise that KRT is accessible to relatively few people. For example, in a study performed in the Democratic Republic of Congo, the monthly mean cost of dialysis was US\$1270; yet, among participants with KF who needed dialysis, monthly income was US\$205 for 52.8% of patients, US\$525 for 34% of patients, and US\$750 for 13.2% of patients.¹⁴ In the Democratic Republic of Congo, which has a population of >85 million, the prevalence of HD and PD is 0.6 pmp, and the current estimated annual cost for HD is US\$43,902 per year (Tables 1 and 2).^{9,13} Other studies have attributed the inability to continue treatment (for ≤ 90 days) and the excessive mortality associated with KF in Africa to the significant financial burden of KF treatment.³⁴ Our findings likewise showed that economic factors constituted one of the largest barriers to optimal KF care in Africa (Supplementary Figure S10).

Health care spending by governments in Africa is low. According to the Abuja Declaration, governments are expected to allocate 15% of their total national budgets to health care; however, progress toward this target has been slow, and health spending continues to be viewed as "consumption" rather than "investment."⁴⁴ There is no doubt that the double burden of disease, especially the higher burden of communicable diseases, plays a role in determining what should be spent on NCDs. However, adequate health care service provision should be a key objective of every governmental intervention in the region. African institutions such as the African Union, the Southern African Development Community, the West African Health Organization, and others could potentially play stronger roles in advocating and developing policies that ensure adequate allocation of health care budgets to the provision of kidney care in the region.

Although all countries in the region reported the availability of dialysis services, access varies on the basis of geography and the quality of HD or PD provided (Figure 3 and Supplementary Figure S4). Several reports from Africa show a skewed distribution of KRT services in favor of a few large

cities.^{28,45} With the low utilization of PD and few services available to transport patients to PD centers (Figure 3), millions of people in rural areas are left with no access to treatment or must travel several hundred kilometers to receive it.⁴⁶ There is a need to ramp up available services to diagnose and treat KF complications to improve conservative care services in the region. For example, Chad, the Gambia, Malawi, and Zambia reported that potassium exchange resins are never available, and 19 other countries reported that they are generally not available. Even when KRT is unavailable or inaccessible, the diagnosis and treatment of common complications such as metabolic acidosis, hyperkalemia, and fluid retention should be mandatory in all countries. Even though it is important to follow standard guidelines for KRT delivery, there is a need to assess the impacts of different treatment patterns in the region, given the excessive OOP costs for dialysis. Previous findings showed no difference in outcomes between standard dialysis treatment (i.e., 3 times weekly) and twice-weekly dialysis treatment.⁴⁷ These results suggest that treatment patterns with lower frequency may be able to be leveraged in Africa without sacrificing health outcomes.

Owing to the substantial challenges encountered in the provision of kidney care in Africa, prevention of CKD should play a dominant role. Effective prevention requires coordinated national strategies for tackling NCDs and CKD risk factors. The burdens of NCDs, such as hypertension and diabetes mellitus, are increasing or are projected to rise sharply in Africa over the next decade.^{48,49} However, only 34% of African countries have an existing NCD strategy in place, and just 10% have a dedicated strategy to improve care for CKD patients (Supplementary Figure S9). National nephrology associations and the regional body for nephrology (AFRAN) should collaborate with NCD specialists to develop or adapt existing strategies for NCDs that include measures to prevent and treat risk factors and CKD in the population. They should also leverage their important roles in the health care community to advocate for governments to increase funding and implement programs that enhance kidney care across the continent.

Finally, it is important to establish an Africa-wide registry of kidney diseases because the current value of good data cannot be overemphasized. Such information will be valuable for understanding disease burden (incidence and prevalence), economic impacts of CKD and KF, mortality, and quality of life, just to name a few, and it could highlight discrepancies in the provision of services within and between countries and therefore encourage governments to allocate more resources for kidney care. The South African Renal Registry^{50,51} has published data consistently for nearly a decade and could be leveraged as a model for an Africa-wide registry. AFRAN should encourage participation in this registry, commit funds to support it, and make it operational by the end of this decade.³⁰

In summary, this study has uncovered numerous gaps regarding kidney disease care in Africa. Although it is

important to address all areas of need, there is an urgent need to focus on issues such as attending to workforce shortages, increasing government funding, reporting more information on kidney disease, and implementing strategies for disease prevention and control in Africa.

DISCLOSURE

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SUPPLEMENTARY MATERIAL

[Supplementary File \(PDF\)](#)

Table S1. Burden of chronic kidney disease and its risk factors in countries of Africa.

Figure S1. Affordability of kidney replacement therapy (proportion of out-of-pocket payments made by patients) in Africa.

Figure S2. Shortages in kidney re providers identified by responding countries in Africa.

Figure S3. Accessibility of kidney replacement therapy in Africa.

Figure S4. Geographic and patient-based factors influencing accessibility to kidney replacement therapy in Africa.

Figure S5. Hemodialysis quality indicators monitored and reported in Africa.

Figure S6. Peritoneal dialysis quality indicators monitored and reported in Africa.

Figure S7. Kidney transplantation quality indicators monitored and reported in Africa.

Figure S8. Characteristics of acute kidney injury, chronic kidney disease, dialysis, and transplantation registries in Africa.

Figure S9. Strategies and advocacy efforts: (A) national NCD strategy, (B) national strategy to improve care for CKD patients, (C) population covered by national CKD-specific and general NCD strategy, (D) national advocacy for CKD/KF.

Figure S10. Barriers to optimal kidney failure care in Africa.

Supplementary Appendix Reference list for annual cost of kidney replacement therapy (for [Table 1](#)).

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