Africa is a massive continent that accounts for 22.6% of the global land mass. It is divided geographically into the Sahara desert zone, and the tropical heavily cultivated Sub-Sahara and is divided politically into 5 zones: North, West, East, Central, and South (Fig 1). The continent accommodates 1.1 billion inhabitants (15.5% of the world population), with a population growth of 2.46% per year compared to the world average of 1.15% per year. This trend is projected to increase the proportion of Africans to 25% of the world population by 2050.1

Population genetic studies confirm that Africa is indeed the land of our ancestors.2 It has been the cradle of many civilizations, most famously that of the ancient Egyptians. The impact of pharaonic civilization on developments in science, engineering, art, religion, and literature is well known. Nephrology is no exception! The pharaohs equated the importance of kidneys to that of the heart, hence keeping them untouched in royal mummies to sustain their long journey to eternity. Many kidney diseases and their management were well described in ancient Egyptian medical papyri.3

Although African leadership regarding kidney disease knowledge was not sustained in subsequent eras, the continent could still catch up with modern developments in nephrology, an important benchmark of which is dialysis. However, this has turned out to be a slow and tedious process, hampered by many ecological, socioeconomic, and political factors, which constitute the subject of this review. In our opinion, understanding these obstacles is essential to guide future development in the continent while facing the anticipated increasing challenge of chronic kidney disease (CKD).

INFORMATION RESOURCES REGARDING DIALYSIS IN AFRICA

It is very difficult to obtain accurate and reliable data about medical services in Africa, let alone dialysis. For.
example, in a recent review about renal replacement therapy in Sub-Saharan Africa, data from trusted resources were available for only 15 of 47 countries. A broader scope was achieved in other reports, but based on less credible resources, such as non-peer-reviewed publications, local registries, and personal communications.

Presumably, the most reliable information is what is documented in indexed peer-reviewed periodicals. Interestingly, MEDLINE is void of publications on dialysis from Africa before 1972 and lists only one published paper that year. However, there was a progressive increase over the following years, of which about 100 papers were relevant to this review. African contributions to the world literature on dialysis have increased from 0.06% in 1973 to 1.01% in 2012, a 17-fold increase, albeit a tiny impact. It is noteworthy that this pace of increasing publications is faster in Africa than in the rest of the world (Fig 2). The quality of publications also improved, from simple statistics to now describe clinical outcomes, long-term complications, and even molecular biology and genetics.

The African Journal of Nephrology, the official journal of the African Association of Nephrology (AFRAN), is not indexed, yet it is a useful resource on dialysis activity across Africa. It also publishes abstracts of papers presented at the biennial AFRAN meetings, which provide individual-country or single-center data, as well as some collective information with reasonable credibility. The official journal of the Arab Society of Nephrology and Renal Transplantation, initially called Kidney Forum and later the Arab Journal of Nephrology and Transplantation, publishes similar data, mostly on the 7 Arab countries located in the Sahara.

There are many local African journals, most of which are neither peer reviewed nor indexed. Many of their publications are single-center experiences with few national data, the merit of which may be challengeable. Moreover, most of these are difficult to retrieve and remain trapped within local institutional libraries. However, the best of these journals can be discovered through the African Journals Online (AJOL; www.ajol.info), a
South African initiative launched in 1999. This provides the ability to search several hundred local journals that are peer reviewed, regularly published, and reasonably scholarly. It encompasses many disciplines, a few of which are medical, for example, the African Journal of Health Sciences. Though the portal is non-specialized, it can be used to retrieve interesting data and research papers in renal medicine.

Two local journals provide forums for good papers beyond their immediate domains, thereby serving as “regional.” The South African Journal of Nephrology constitutes a good information resource about Sub-Saharan Africa, whereas the Saudi Journal of Kidney Diseases and Transplantation often provides data on Africa at large, with emphasis on the Arab African countries.

For many decades, personal communication was almost the only way of obtaining data on African nephrology. This approach remains inevitable, despite the possibility of errors, if a comprehensive profile of the continent is to be captured. In addition to their valuable personal notes, many colleagues have provided relevant articles published in local journals, and they often had the privilege of accessing official national data that otherwise would not have been obtained.

**DEVELOPMENT OF DIALYSIS IN AFRICA**

All available information indicates that the development of dialysis in Africa reflects the stormy modern history of the continent, including foreign occupation, civil wars, violence, poverty, illiteracy, and disease. It is impossible to split the provision of this sophisticated treatment from the supervening sociopolitical environment in the continent during the second half of the past century. But it also is clear that committed African dreamers have challenged almost insurmountable obstacles to establish dialysis programs.

**The First Steps**

The beginning of dialysis activity in Africa was in 1957, only 12 years following Willem Kolff’s breakthrough in the Netherlands. The solo general physician in Krugersdorp, a small town in South Africa, built the first dialysis machine in the continent, which was a cross between a Kolff coil and a rotating drum. He used it to treat 2 patients with acute renal failure and although both died shortly after, the event was a historic landmark.

The next attempt was made a year later in Egypt. Professor Nagy El-Mahallawy of Ein-Shams University in Cairo imported a primitive Alwall dialyzer, which he used to treat a woman with acute renal failure who died after a few sessions. Efforts were resumed in both countries in 1962 to 1963, when both peritoneal dialysis (PD) and hemodialysis were used routinely for the management of acute renal failure and poisoning in Cairo and Johannesburg university hospitals. Two North African universities in Tunisia and Algeria and one in Kenya joined the club during the same period. The first patient in the continent to receive hemodialysis by a Scribner shunt was treated at Kasr-El-Aini medical school of Cairo University in February 1964.

In the following years, dialysis services were started in Kenya (1965), Sudan (1968), Libya (1972), Zimbabwe (1972), and Morocco (1977). Dialysis for the management of acute renal failure

---

**Figure 2.** Annual MEDLINE publications for dialysis from 1950 to 2013. Lines show (left axis) global number of publications and (right axis) publications arising from Africa.
subsequently was adopted in other leading teaching institutions in the rest of Africa.\textsuperscript{8,13} Military hospitals were pivotal in introducing dialysis for treating casualties of war, which supervised for many decades during the past century. As peace was gradually achieved, certain centers started small maintenance dialysis programs, which required only a limited number of enthusiastic experts, a few machines for hemodialysis or even none for PD, and a small budget. Only a few countries could afford to expand these maintenance dialysis initiatives into national government-sponsored programs.

**Maintenance Dialysis Programs**

A previous excellent review suggested that maintenance dialysis treatment was available in 32 African countries in 2007.\textsuperscript{9} There have been many changes since, with maintenance dialysis programs being introduced in new countries and abandoned in others. Some countries offer limited short-term dialysis, including transient treatment to bridge an episode of reduced kidney function, preparation for a transplant, or tiding the patient until traveling abroad for further management.

This review includes data for 29 countries with at least one cohort of patients treated regularly by dialysis for at least 1 year (Table 1). Although these countries constitute just more than half of the 54 African countries, they collectively have 879 million inhabitants (82% of the total African population).

The timeline of initiating maintenance dialysis services in different African countries is widely variable. Personal initiative was the most important factor in starting any such program. Interestingly, it was not only doctors who were the driving force. For example, a wealthy Sudanese family supported the establishment of the first maintenance PD program in the country, which is still flourishing and contributing significantly to the national end-stage kidney disease program in Sudan.\textsuperscript{13} The first lady in a Southern Sub-Saharan country, herself a patient, pushed the development of the first maintenance dialysis program in her country, in accordance with the plan developed by her treating British physician. Similar stories can be told about many African countries.\textsuperscript{8}

It is interesting to note that economic and educational parameters did not seem to have a substantial impact on the development of these maintenance dialysis initiatives (Table 2). However, the political environment seems to have made a considerable difference. Almost all maintenance dialysis programs in Africa happened only after achievement of independence, peace, and political stability.

Africa was an easy target for imperial European military occupation in the late 1800s. Ten percent of Africa was already under European control in 1870. As a result of the “Scramble for Africa,” 90% of the continent was occupied by 1914, sparing only Liberia (which was never occupied), Ethiopia (occupied for a short while later), and South Africa (which had become independent in 1910). By 1950, when dialysis was rapidly developing as a new life-saving treatment modality all over the world, the continent was stuck under foreign military control.

It took 70 years from the independence of South Africa for all of the remaining African countries to gain freedom. Notably, no African country started a maintenance dialysis program while under foreign occupation. Soon after obtaining their independence, many African countries fell into civil and territorial wars, army insurgencies, massacres, and genocides.\textsuperscript{14} Of the 20 countries for which the date of starting a maintenance dialysis program could be obtained, only one started its program during a civil war; 5, after 1 to 5 years of peace; 4, after 6 to 10 years; and 10, after more than 10 years of stability (Fig 3). Countries that have taken relatively longer than their peers in starting maintenance dialysis programs tended to be embroiled in war (Burkina Faso, Ethiopia, Guinea-Bissau, Mali, and Morocco) or experienced major economic shortages due to climatic or sociopolitical issues (Ghana, Cameroon, Senegal, and Togo). Of the 25 countries that still are not known to provide maintenance dialysis, many have experienced unrest since independence (Fig 3).

**National Maintenance Dialysis Programs**

With the success of initial maintenance dialysis programs in Africa, it was natural to face an overwhelming demand from the huge number of patients with end-stage kidney disease owing to ecological, demographic, and socioeconomic factors.\textsuperscript{10} Eight African countries had the resources to achieve sustained national programs capable of accommodating treatment for 100 dialysis patients per million population (pmp): Egypt, Libya, Algeria, Tunisia, Morocco, South Africa, Mauritius, and Gabon. These countries accommodate only 21% of the total African population. Two other countries (Sudan and Mauritania) have reached about 75 pmp (Table 1). In all these programs, governments entirely cover the dialysis expenses in state hospitals and partially support private dialysis wherever available.

**CHALLENGES FACING DIALYSIS TREATMENT IN AFRICA**

Outcomes of dialysis in Africa generally are suboptimal, with annual survival ranging from 20%
to 70% and relatively poor quality of life. Both the unavailability and the inadequacy of dialysis services have been attributed to insufficient financial and human resources and illiteracy, in addition to malnutrition and concomitant infections such as hepatitis C virus in the Sahara, HIV (human immunodeficiency virus) in the Sub-Sahara, and tuberculosis and parasitic infections throughout the continent. In most countries, suboptimal primary care often fails to prevent and treat chronic noncommunicable conditions, such as diabetes, hypertension, and CKD complications.

### Financial Obstacles

As shown in Table 2, the average economic and educational parameters of the 8 countries that support national maintenance dialysis programs are distinctly superior to those that offer only short-term dialysis or have maintenance dialysis programs that are not national in scope. However, it is noteworthy that there is considerable variability in the per capita gross domestic product among countries with national
maintenance dialysis programs (US $5,040-$16,370), as well as in countries that have maintenance dialysis programs but at less than the 100-pmp threshold (US $370-$5,490). Thus, maintenance dialysis programs exist in nations with very different economic circumstances.

One way of coping with the demand facing limited budgets has been to place constraints on which patients are accepted for treatment, for example, determining whether there is the potential of eventual transplantation. In some countries, a patient treated with maintenance dialysis who refuses an offered transplant is denied ongoing dialysis treatment. In the United States and other wealthier nations, when committees had to select patients for dialysis, are today’s policies in many African countries. Such inevitable policies have received legal validation, as when the Constitutional Court of South Africa denied the right of a diabetic patient with a complicated course from receiving maintenance dialysis in “due consideration to the limited economic resources of the country.”

Another policy is to offer PD as the first option for maintenance treatment. In contrast to the North African countries where PD is seldom used (0%-5%), several Sub-Saharan countries have successfully integrated this modality in their national health care systems, currently accounting for ~10% of dialysis patients in Kenya; 20% in Uganda; 34% in Zambia, South Africa, and Senegal; 41% in Sudan; 56% in the Democratic Republic of the Congo; and 60% in Rwanda. There are questions about the sustainability of this form of dialysis due to frequently reported high rates of infection and the cost of importing the dialysis fluid if it cannot be manufactured locally.

Twelve countries have adopted a radical approach by opting to focus on transplantation programs. Interestingly, 6 of these countries (Ghana, Kenya, Malawi, Nigeria, Rwanda, and Sudan) have done so while their prevalent rates of maintenance dialysis treatment were low (Table 1). Despite the cost-effectiveness of this approach, there are still incremental financial, logistic, and social obstacles.

Facing these difficulties, 3 models of foreign support have emerged in different countries. One model is the charity-based program called WORTH (World Organization of Renal Therapies) in Cameroon, which has been operating since 2006 in University of Yaoundé Central Hospital, with plans for expansion to other centers in the same country. The second model is the philanthropic initiative of pharmaceutical companies, endorsed by international organizations to ensure transparency and credibility. An example is the Baxter CAPD (continuous ambulatory PD) program proposed for Tanzania. The International Society of Nephrology (ISN) was encouraged to endorse this initiative because one of its fellows trained in South Africa was the technical supervisor. Despite this ideal setting, as recorded in the ISN archives, the program stumbled under bureaucratic obstacles and Baxter had to withdraw. The third model of foreign support is commercial, in which private dialysis centers are established, such as the FAB Mercy program in Ghana. In our opinion, although all these initiatives may help with some of the demand, an equitable nationwide dialysis program can be driven only by funds generated within the country.

### Shortage of Human Resources

There is a gross shortage of nephrologists, dialysis nurses, and technicians in Africa. This has been highlighted consistently in excellent review articles, as well as ISN-Global Outreach reports. However, there is a striking...
Figure 3. The effect of wars and other forms of violence on the development of maintenance dialysis programs in Africa (explanation in text). *Independence pre-1950: South Africa, 1910; Egypt, 1922; Ethiopia, 1941. **Malawi started maintenance dialysis program in 2011.
discrepancy in the numbers cited in these reports, reflecting the difficulty capturing accurate reports from most African countries. Table 1 provides the highest numbers cited in the mentioned resources in 29 countries, where such information was available across the period from 2008 to July 2014.

According to the most optimistic estimate, there may be 1,985 nephrologists in the continent, with an average of 1.85 pmp compared with 17 pmp in the United States and only 0.79 pmp in India. However, this is a misleading figure because the distribution of nephrologists across the continent is extremely variable, ranging from 11.9 pmp in Egypt to <1 pmp in 18 of 29 countries. Only 6 countries have a distribution of nephrologists ≥5 pmp. Even within the same country, there is a remarkable difference between the number of nephrologists in the capital cities versus urban and rural territories.

Comparing the recent estimates with those published by El-Matri et al in 2008, it appears that the main expansion in the number of nephrologists has occurred in the North Saharan countries, Sudan and Nigeria. There has been hardly any change in most Sub-Saharan countries and even a decrease in South Africa, largely due to brain drain to the West.

We could not obtain reliable information for the numbers of nurses and dialysis technicians in Africa, though information in relevant publications and surveys consistently reflects a marked shortage in numbers and experience. Data obtained from a few countries suggest a ratio ranging from 3 to 10 nurses to one nephrologist. Some countries have legislation that requires a certain ratio of nurses to dialysis patients, usually 1:4.

Illiteracy

Illiteracy typically is blamed for patients’ nonadherence to treatment, including skipping of dialysis sessions upon feeling well, disregarding dietary constraints, and neglecting interdialytic medications, thereby leading to poor dialysis outcomes. Unfortunately, the available World Bank data for literacy in Africa are incomplete. We could capture relevant information for only 25 countries. Nevertheless, there is an apparent correlation between literacy levels and extent of dialysis services offered (Table 2).

EDUCATIONAL INITIATIVES TO PROMOTE DIALYSIS IN AFRICA

Physician Training Programs

As would be expected, almost all pioneers of nephrology in their respective countries during the 1960s and 1970s received their training in Western countries, ironically most often in nations that once occupied their own countries. British- and French-based training started even before the end of the respective colonization, which mirrors the current divide of Anglophone versus Francophone AFRAN countries. The subsequent generations of nephrologists were trained mainly in their own countries. Formal training programs currently are recognized in 5 countries, namely Egypt, South Africa, Morocco, Tunisia, and Nigeria. These provide 24 to 50 hours of undergraduate and 3 to 6 months of postgraduate nephrology education as a part of internal medicine courses. For specialization in nephrology, additional education and hands-on training is required for 2 to 4 years to obtain a “fellowship” (Egypt and Nigeria), “diploma” (Morocco), or “masters degree” (Egypt, Tunisia, and South Africa). A doctorate degree is granted in Egypt (MD) and South Africa (PhD).

In addition, several international organizations offer training opportunities for African nephrologists in dialysis, as well as clinical nephrology and transplantation. For example, the Fellowship Program of the ISN has offered training opportunities to 148 young nephrologists from 25 African countries over the past 31 years. The host countries were mainly the United States, United Kingdom, Canada, and France. From information available in the ISN archives, exchange programs have been established from 1999 onward to provide training within the continent’s centers of excellence in Egypt, South Africa, Algeria, and Senegal, which to date have trained 50 fellows throughout the continent. Other initiatives include continuing medical education, visiting scholars, short-term fellowships, and sister-center relations.

Professional and Patient Organizations

According to ISN archives, there currently are 9 national societies of nephrology in the continent, exclusively in countries that have at least 17 nephrologists. In addition, a Tanzanian society of nephrology is affiliated to the ISN, yet we have no information about the dialysis activity in that country. Activities of these societies vary, mostly focused on scientific meetings and annual or biennial local conferences in which speakers, international and regional experts, and attendees from neighboring African countries participate. The national societies of leading countries such as South Africa, Egypt, Tunisia, and Morocco also have registries for members, dialysis units, patients with end-stage kidney disease, etc.

Nurses are excluded from membership in the renal societies in most African countries, with the exception of Nigeria and Tunisia. Renal care societies including dialysis nurses and technicians are established in South Africa (1974) and Kenya (2007).
AFRAN is the exclusive regional professional society in Africa. It was established in Cairo in 1987, and its constitution was approved in 1988 in the presence of representatives of 13 countries and the ISN. South Africa joined in 1995, after the end of the apartheid era (1948-1994). Other countries successively joined and now AFRAN encompasses all of Africa, with multiple leading foci in each zone. AFRAN holds a biennial meeting by rotation, has a registry, and publishes the African Journal of Nephrology. AFRAN has been of great help in supporting dialysis activities in many countries through establishing regional links including fellowships, expert exchange, and joint research.


**FUTURE PERSPECTIVE**

Despite the significant progress already achieved, Africa still has a long way to go before it can provide adequate management of its patients with CKD. Although the incidence of infection-related CKD may decline, the overall incidence of kidney failure probably will increase with the escalating rates of diabetes, obesity, hypertension, and smoking. This review suggests that the 3 key elements in this context are fair prioritization for treatment, properly directed training, and targeted motivation, all of which require interaction among health professionals, health authorities, and the public.

In our view, maintenance dialysis programs should not be seen as a top priority in most African countries amid much more drastic health issues such as primary care, maternal and child health, and infectious diseases. Even kidney disease at large cannot be considered a priority because “uremia” accounts for only 1% to 2% of total mortality. The epidemiologic importance of CKD is magnified with the understanding that most of the harm is attributed to cardiovascular events. As we see it, this supports the case for targeted screening for CKD, rather than developing maintenance dialysis programs. The incremental financial burden of maintenance dialysis treatment can be checked only by a parallel transplantation program, which we would argue needs to be a higher priority than dialysis itself; this strategy has already been adopted in 12 African countries. It follows that given this low priority, dialysis must be developed in underprivileged African countries to a very limited scale and only as a bridge to transplantation in those who are not detected or treated at early stages of CKD through an effective screening program.

In this review, we highlight the critical importance of human resources in the development of dialysis at all levels. For Africa to catch up, it has to generate its own task force by promoting local training of doctors, nurses, and technicians. However, because the primary target should be prevention, it may be more fruitful to focus training on primary care than on dialysis. Specialized training related to kidney replacement therapy also needs to be promoted, yet within the quantitative limits of need, which can be achieved by local, regional, and international collaboration.

Personnel motivation is fundamental in order to avoid the brain drain to the West. A good practice and research environment promising potential for advancement and adequate financial incentives may convince trained health professionals to serve where they are badly needed in their home countries.

Motivation also includes the health authorities, media, and politicians to promote public education and awareness, as well as the assignment of adequate budgets to implement an overall plan for early detection and better care of renal patients, in accordance with evidence-based priorities.

**CONCLUSION**

This review describes the process of development of renal services in Africa over a spectrum ranging from basic short-term to fully developed maintenance dialysis programs and further on to transplantation. It discusses the obstacles that have hindered the process during the past half-century, including foreign occupation, wars and political unrest, financial shortages, lack of a trained health professionals task force, and poor public awareness. The review highlights certain countries’ visionary initiatives to limit the burden of maintenance dialysis, as early transplantation and screening/prevention programs. Understanding the obstacles in the past may help the continent face the anticipated increasing challenges in the future by proper planning, as well as training and motivating personnel, in close collaboration with the health authorities, media, and political leaders.

**ACKNOWLEDGEMENTS**

Support: None.

Financial Disclosure: The authors declare that they have no relevant financial interests.

**REFERENCES**


44. Arougundade FA, Barsoum RS. CKD prevention in Sub-Saharan Africa: a call for governmental, nongovernmental,


