Chapter

Organ Donation and Transplantation in Sub-Saharan Africa: Opportunities and Challenges

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Abstract

Sub-Saharan Africa (SSA), occupying about 80% of the African continent is a heterogeneous region with estimated population of 1.1 billion people in 47 countries. Most belong to the low resource countries (LRCs). The high prevalence of end-organ diseases of kidney, liver, lung and heart makes provision of organ donation and transplantation necessary. Although kidney and heart transplantations were performed in South Africa in the 1960s, transplant activity in SSA lags behind the developed world. Peculiar challenges militating against successful development of transplant programmes include high cost of treatment, low GDP of most countries, inadequate infrastructural and institutional support, absence of subsidy, poor knowledge of the disease condition, poor accessibility to healthcare facilities, religious and trado-cultural practices. Many people in the region patronize alternative healthcare as first choice. Opportunities that if harnessed may alter the unfavorable landscape are: implementation of the 2007 WHO Regional Consultation recommendations for establishment of national legal framework and self-sufficient organ donation/transplantation in each country and adoption of their 2020 proposed actions for organ/transplantation for member states, national registries with sharing of data with GODT, prevention of transplant commercialization and tourism. Additionally, adapting some aspects of proven successful models in LRCs will improve transplantation programmes in SSA.

Keywords: opportunities, challenges, low resource countries, end organ diseases/failure, transplant models

1. Introduction and overview

1.1 Background

Many diseases especially non-communicable diseases (NCDs) culminate in end-stage organ failures; the preferred treatment for most end-stage organ diseases is transplantation. Transplantation programme is a complex healthcare service

which entails huge costs and requires highly skilled health professionals, complex infrastructure and equipment, and well-articulated legal frameworks to enable its operationalization [1]. The need for appropriate interventions for organ failures in sub-Saharan Africa (SSA) is underscored by the high prevalence of end-organ diseases such as chronic kidney disease (CKD), chronic liver disease (CLD), chronic lung and heart diseases (interstitial lung disease, cystic fibrosis, cardiomyopathies and chronic rheumatic heart diseases) which cause increased morbidity and mortality. For example, Kaze *et al* [2] in a systematic review of prevalence studies on CKD in SSA documented the highest prevalence in West Africa 19.8%, Central Africa 16%, East Africa 14.4%, and Southern Africa 10.4%.

Globally, beside organs, tissues and cells (bone marrow cornea, etc.) are also transplanted. However, in SSA, apart from South Africa which also does liver and heart transplantation, the common organ transplanted is the kidney [3]. Though outcomes for transplantation have improved over the years due to better surgical techniques including minimal access surgeries, newer and better immunosuppressive medications, innovations in organ donation; improvement in transplant services is not apparent in SSA. Organ transplantation remains largely inaccessible and unaffordable to this population.

Sub-Saharan Africa has a disproportionate burden of communicable diseases (CDs) and NCDs compared to other world regions [4]. Currently, NCDs are responsible for a large and increasing burden of death and disability in the region. World Health Organization (WHO) in 2018, documented that NCDs killed 41 million people per year accounting for 71% of the global deaths [5]. The ages most affected were 30 to 69 years age-group, belonging to the productive workforce of any population. People from low income countries (LICs) and lower-middle income countries (LMICs) accounted for most of these deaths approximating over 85%. Four of the five commonly quoted diseases i.e. the "Big Five" (cardiovascular diseases, cancers, respiratory diseases, diabetes mellitus (DM) and mental illness) that account for most NCD deaths are drivers of CKD. Several risk factors with multiplier effect on NCDs are tobacco use, physical inactivity, harmful use of alcohol and unhealthy diets. Communicable diseases, though less common in high income countries (HICs) and upper-middle income countries (UMICs) are still prevalent in LICs and LMICs prompting WHO to highlight the double burden of diseases in these regions [6]. Both CDs and NCDs culminate in end-organ disease underscoring the high prevalence of end-organ failures, disabilities and deaths in SSA (see **Figure 1**). Unfortunately, most countries in this region lack resources to cope.

1.2 Prevalence of end-organ diseases

1.2.1 End-stage kidney disease (ESKD)

In 2014, Stanifer *et al* [7], in a systematic review and meta-analysis of 21 studies in SSA documented an overall CKD prevalence of 13·9%. According to the Institute for Health Metrics and Evaluation (IHME) data, CKD and DM were the 14th cause of death in SSA in 1990 but worsened to 11th by 2017 (see **Figure 1**). Hypertension and DM constitute the main NCDs that cause CKD globally [8]. In many low resource countries (LRCs), chronic glomerulonephritis and interstitial nephritis assume significance because of the pervading and persisting high prevalence of CDs (mainly bacterial, parasitic, and viral infections) [9]. Human Immunodeficiency virus (HIV) infection which continues to plague SSA, albeit better controlled, is a key driver of kidney disease. Of the 38 million people living with HIV globally, more than 25 million live in this region [10, 11]. The recent pandemic of COVID-19 infection which has adverse acute effects on the kidney has probable

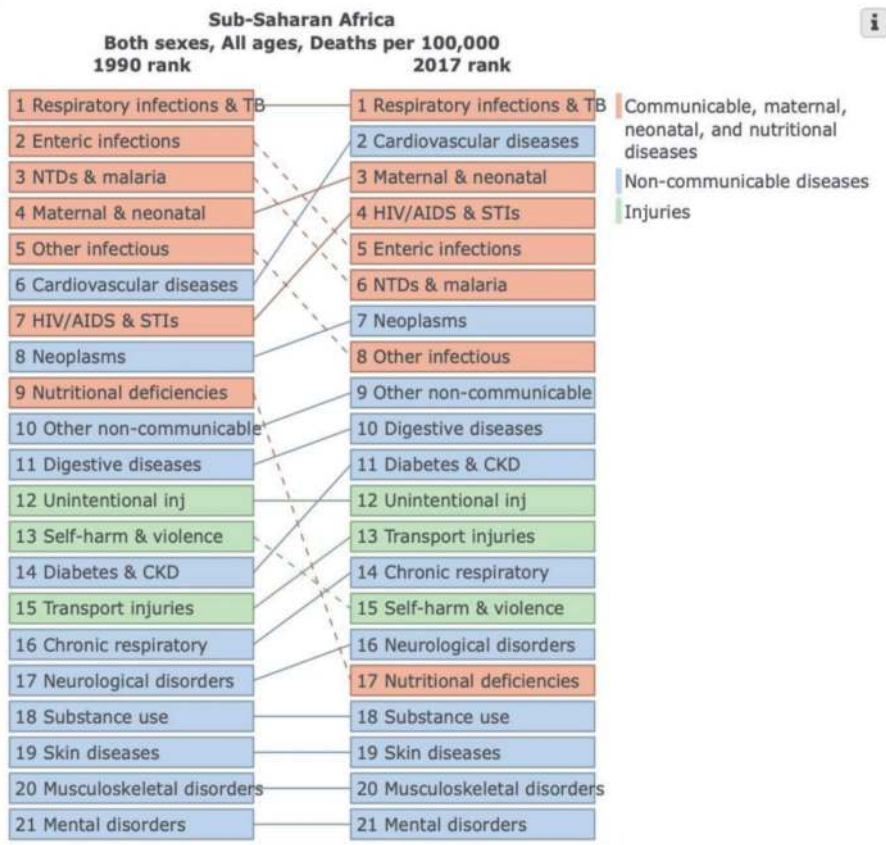

Figure 1.
Causes of deaths in sub Saharan Afirca 1990 and 2017 [from Institute for Health Metrics and Evaluation (IHME) data].

unknown long-term sequelae [12]. Both CDs and NCDs fuel the high and increasing prevalence of CKD in LRCs. Without renal registries in many LRCs, there is poor documentation of data on kidney diseases.

1.2.2 Other end-organ diseases

Viral hepatitis is prevalent in Africa with high endemicity of Hepatitis B Virus (HBV) in SSA and Hepatitis C virus (HCV) in North Africa. Africa has approximately 60–100 million of the world's 257 million viral hepatitis infections [13]. The WHO noted that between 1980 and 2010, cirrhosis-related deaths doubled in the region. The increasing burden of obesity and DM leading to non-alcoholic fatty liver disease contributes to high prevalence of CLD and end-stage liver disease (ESLD). Up to 40% of patients with chronic hepatitis may progress to liver cirrhosis and/or liver cancer [14] and without liver transplantation mortality is estimated at about 15% in one year [15]. All patients with ESLD will invariably require liver transplantation; however, liver transplants are uncommon in SSA.

There is scant information on prevalence of other end organ failures such as heart, lung, and small bowel requiring organ transplantation in SSA.

1.3 Prevalence of transplantation

The WHO in collaboration with the Organización Nacional de Trasplantes of Spain set up the Global Observatory on Donation and Transplantation (GODT) with the mandate to document the distribution of organ transplantation

programmes in the countries that report their data to the Observatory and to evaluate the access of transplantation activities worldwide [16]. Upon subsequent request of the World Health Assembly (Resolutions WHA57.18 and 63.22) that global data on the practices, safety, quality, efficacy, epidemiology and ethical issues of allogeneic transplantation be collected and documented, the GODT was inaugurated in 2007 [16]. This database has ensured provision of transparent and equitable monitoring of national transplant systems.

Currently, according to the GODT database, [17], 139,024 solid organ transplants were reported globally in 2017: 90,306 kidney (36% from living donors), 32,348 liver (19.0% from living donors), 7881 heart, 6084 lung, 2243 pancreas and 162 small bowel transplants. Africa contributes the least number of transplant activity per continent and SSA the least number per WHO World region (**Tables 1** and **2**; **Figure 2**). **Tables 1** and **2** show data from 2016 GODT Report.

Kidney transplants are available in 102 countries; living kidney transplants in 98 countries and deceased donors in 76 countries [16]. Sixteen countries representing 6.6% of the global population perform only living donor kidney transplants. In SSA, a handful of countries carry out transplantation: South Africa, Sudan, Seychelles, Ivory Coast, Namibia, Nigeria, Kenya, Ghana, Tanzania, Mauritius, Ethiopia but only five countries (Ethiopia (0.34 pmp), Kenya (1.51 pmp), Nigeria (0.47 pmp), South Africa (6.81 pmp) and Sudan (6.58 pmp)) report their data to GODT (**Figure 2**).

1.4 Characteristics of SSA

1.4.1 Geography and demography

Sub-Saharan Africa is heterogeneous and has a population estimated at 1.1billion [18]. It is projected that countries in this region would account for more than half of the world's growth by 2050 [19]. This geographical region fully or partially located south of the Sahara Desert occupies an area of about 24 million Km^2 (**Figure 3**). It is made up of 47 countries divided into 4 WHO sub-regions. Most countries in this region belong to the LICs and LMICs according to World Bank Classification of economies and are also described as LRCs. Africa is the second largest and second most populous continent; SSA occupies about 80% of the continent [20]. Although the economic growth in Africa has been remarkable in recent years, the gap between the rich and poor is wide and many people still do not have access to basic amenities such as potable water, good sanitation and basic health services [20].

Region	Countries N	Countries with data N (%)	Population millions	Population with data millions (%)
AFR	46	10 (21.7)	1139.1	506.6 (44.5)
AMR	35	21 (60.0)	986.5	968.5 (98.2)
EMR	22	15 (68.2)	656.1	535 (81.5)
EUR	53	49 (92.5)	909.7	904.2 (99.4)
SEAR	11	5 (45.5)	1928.4	1408.8 (73.1)
WPR	27	11 (40.7)	1847.7	1815.3 (98.3)
Total	**194**	**111 (57.2)**	**7467.5**	**6138.4 (82.2)**

Table 1.
Proportion of countries and population covered by the GODT database in the WHO regions. Year 2015 [17].

	Africa Region (AFR)	America Region (AMR)	Eastern Mediterranean Region (EMR)	Europe (EUR)	South East Asia Region (SEAR)	Western Pacific Region (WPR)
Kidney	488 (1.0)	31,859 (32.9)	6127 (11.5)	26,131 (28.9)	7202 (5.1)	12,540 (6.9)
Liver	67 (0.1)	10,426 (10.8)	1539 (2.9)	9582 (10.6)	1292 (0.9)	4853 (2.7)
Heart	14 (0.03)	3604 (3.7)	135 (0.3)	2646 (2.9)	40 (0.03)	584 (0.3)
Lung	12 (0.02)	2507 (2.6)	56 (0.1)	2007 (2.2)	1 (0.0)	463 (0.3)
Pancreas	5 (0.01)	1236 (1.3)	24 (0.04)	890 (1.0)	1 (0.0)	143 (0.1)
Small Bowel	0 (0.0)	147 (0.2)	4 (0.01)	43 (0.05)	0 (0.0)	1 (0.0)
Total Organs	**586 (1.2)**	**49,779 (51.4)**	**7885 (14.7)**	**41,299 (45.7)**	**8536 (6.1)**	**18,585 (10.2)**

Table 2.
Absolute numbers and rates of the organ transplant activities per WHO region. 2015 [17].

1.4.2 Dynamics of healthcare

1.4.2.1 Health systems

The WHO defines health systems as "all organizations, people and actions whose primary intent is to promote, restore, or maintain health" [21]. In LRCs, these systems have long been weak and deficient in most aspects of healthcare delivery and therefore, there is persistent need to evaluate health system challenges at all levels [22]. Health security is a crucial public health issue. It is ensured when there is protection against any health threats and also involves ability to handle emerging new health conditions by adapting and developing new approaches [23]. The epidemics in recent years (SARS, MERS and Ebola) including the COVID-19 pandemic bring to the fore the inability of the health systems in SSA to cope with health crisis and other prevalent health conditions [24].

1.4.2.2 Personnel

Some healthcare professionals have poor work ethics deriving from unsavory work environment and remunerations. Transplantation is a highly specialized service that entails full commitment of the workforce and long work hours. For a good transplant programme, the national health system and the hospitals have to commit to improving the skill set of the work force through adequate staff training and other development opportunities, incentivization of the programme and offering a very supportive work environment [25].

1.4.2.3 Health seeking behaviour

Traditions and cultures influence the mindset of a people; decision to access healthcare service is informed by many factors (accessibility, affordability, spirituality and religiosity, and knowledge of the disease condition) [26]. When ill, many people in LRCs seek alternative healthcare service including traditional health providers and religious institutions resulting in late presentation to hospitals [27].

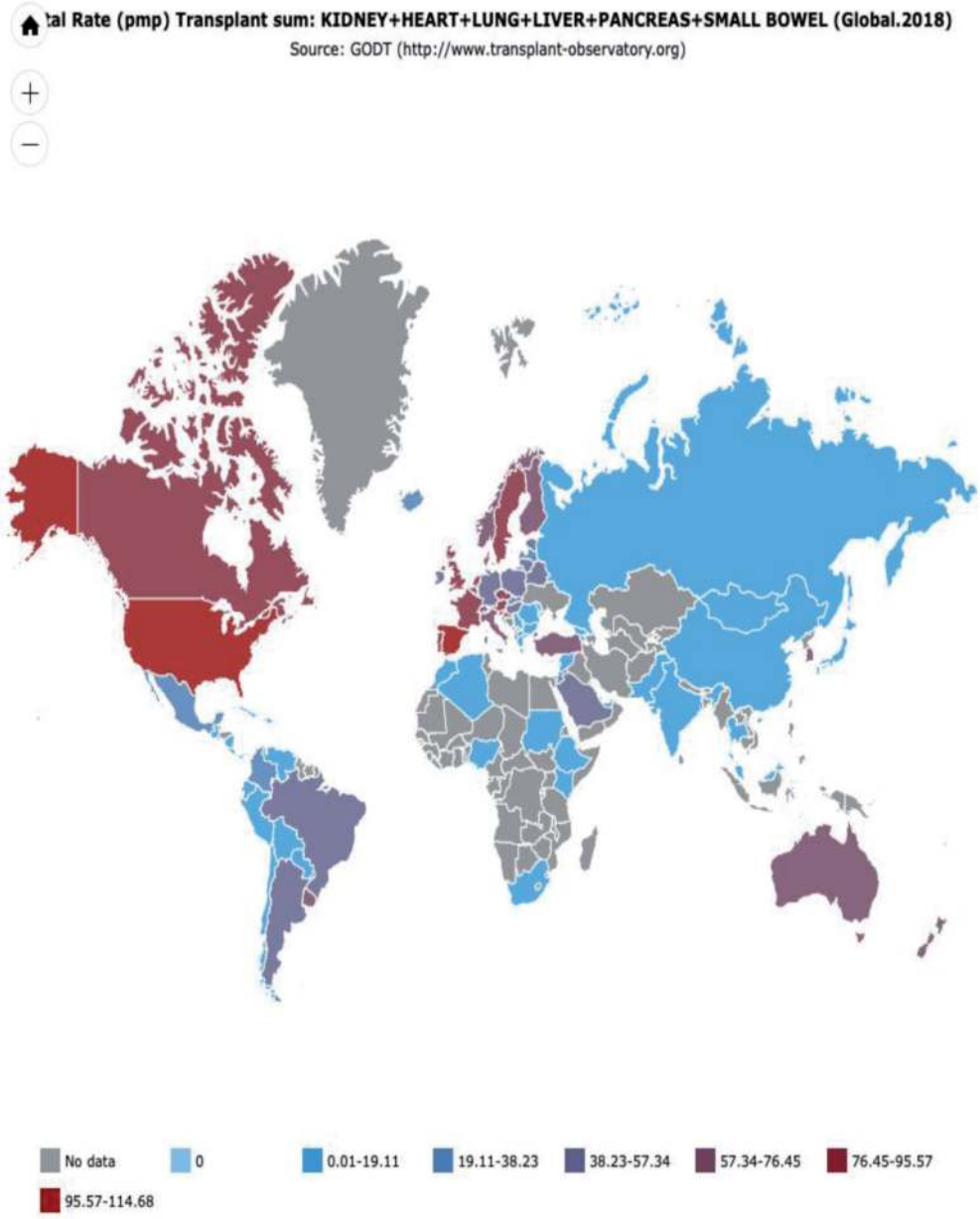

Figure 2.
World map of transplantation in 2019 showing total sum of transplants [from global Observatory of Donation and Transplantation].

1.4.3 Health financing

In 2018 and 2019, Africa's economic growth was at 3.4% and was expected to rise to 3.9% and 4.1% in 2020 and 2021 respectively [28]. Amid the COVID-19 pandemic of 2020, the dynamics changed resulting in contraction of economies globally with expected 1.7% to 3.4% contraction of Africa's economy [29].

The 2001 Abuja Declaration recommended allocation of 15% of the annual national budget to the health sector; achieving this has been challenging [30]. In 2012, 6 countries met the target; and this reduced to 4 in 2014. Currently, the preferred indicator for health financing is the percentage gross domestic product (% GDP). To achieve universal health coverage (UHC), the World Health 2010 Report suggested that a national government has to spend at least 4–5% of GDP on

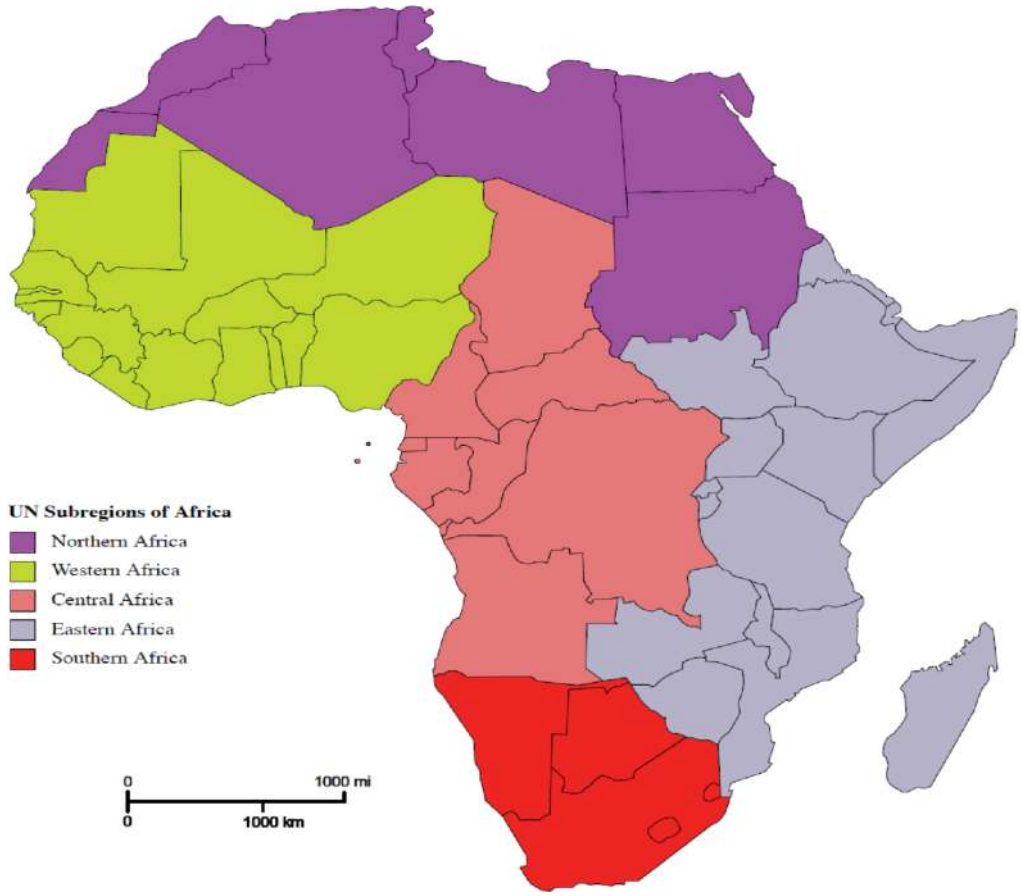

Figure 3.
Map of Africa showing UN sub-regions.

health [31]. Whilst per capita expenditure on health in America and Europe were over $1800 in 2014, the per capita expenditure on health in Africa averaged only $51.6 [32]. Further analysis shows that over the same period, in Africa, general government health expenditure was less than 50% of the total health expenditure while other sources such as out of pocket (OOP) payments and external sources (from funders) accounted for over 50% [32]. In general, transplantation service largely depends on robust and adequate finances hence the programme thrives in HICs and UMICs.

1.5 History of transplantation

1.5.1 Southern Africa

South Africa: the first organ transplantation in Africa was kidney transplant performed by Thomas Starlz and colleagues in 1966 at Wills Donald Gordon Medical Centre, Johannesburg, South Africa [33]. This was followed in 1967 by the first successful heart transplant performed in the world at Groote Shuur Hospital, Cape Town, South Africa by Christian Barnard [34, 35]. Barnard and his team championed the orthotopic and heterotopic ('piggy-back') heart transplant. From 1968 to 1983, they engaged in research on cardiac transplantation thereby laying the foundation for heart transplantation as therapy for end-stage cardiac disease. The team advanced the concept of brain death, organ and tissue donation, and ethical issues in transplantation. They also researched on methods to improve preservation

and protection of the donor heart: their studies ranged from developing appropriate hypothermic perfusion for heart storage, haemodynamics and metabolic changes in brain death to xenotransplantation [34].

Though, South Africa has the most advanced transplant programme in the continent, globally, their transplant activities remain lower than those of other countries with comparable economic capacity [35, 36]. South African liver programme has existed for about 2 decades and presently offers living-related liver transplantation. Other solid organ programmes available are combined kidney-pancreas and lung transplantation. Her donor programmes have advanced to extended criteria donors (ECD) and donors after circulatory death [37]. South Africa has high prevalence of HIV resulting in a huge HIV-positive population prompting Muller and colleagues to pioneer HIV-positive-to-positive transplant program in 2008 [38]. By 2018, this programme had successfully transplanted 43 kidneys from 25 deceased donors [39].

Namibia had first kidney transplantation in March 2016 [40] and is also reported to have done a heart transplant [41].

1.5.2 West Africa

Ghana started a kidney transplant programme in 2008 at Korle Bu Teaching Hospital, Accra in collaboration with a hospital and a charity organization in UK. Between 2008 and 2014, the programme performed 17 transplants and in 2015, they established a national registry [42].

Ivory Coast implemented the law authorizing organ donation in 2012 [43] and between 2013 and 2015, ten living-related kidney transplantations had been done [44].

Nigeria commenced organ transplantation activity in 2000 in a privately-owned hospital [45]. Currently, there are 15 centres (public 9, private 6) and over 770 transplants had been performed between 2000 and 2019 [Personal Communication].

1.5.3 East Africa

Ethiopia commenced its transplant programme in collaboration with an American hospital in September 2015 and by February 2018, had done 70 living donor kidney transplants at their only transplant centre [46].

Kenya started kidney transplantation in 2009 and by 2019 had performed 200 transplants. Their government augmented the existing infrastructures to support 10 transplants per month [47].

Mauritius began kidney transplantation in 1980 and discontinued in 1982 following poor outcomes but resumed in 1993 [48]. Although the "Human Tissue (Removal, Preservation and Transplant) Act" was promulgated in 2006 and amended in 2013, a new legislation was enacted in 2018 [49].

Sudan, according to the African Union belongs to East African sub-region even though the United Nations categorized her as North Africa. Sudan had her first kidney transplant in 1974 and for the subsequent 25 years performed very few transplants. However, in 2000, the program was reactivated; and 222 transplants were performed in 2016 [50].

Tanzania started kidney transplantation services locally in collaboration with hospitals in India and Japan in November 2017 [51]. Earlier, her program consisted of government-sponsored transplantation overseas. Recipients and donors received

pre-transplantation work-up locally and donor verification by DNA profiling was done to curtail commercialization.

Ugandan cabinet in June 2020 approved a bill to establish a legal framework for human organs, cells and tissue transplant, and to regulate donations and trade in human organs, cells and tissue [52].

1.5.4 Central Africa

No country in this sub-region has a transplant programme but Angola in March 2019 passed a law on human tissue, cell and organ transplant to enable transplantation [53].

In SSA, the national programs for donation and transplantation of organs and tissues are slow and poorly developed and they are fraught with inadequacies in infrastructures, institutional support, and technical expertise [3]. These are attributed to the huge costs and complexity of transplantation, low GDP, lack of subsidy and dearth of facilities.

Loua *et al* in 2018, documented that 62 transplant centres across seven countries in Africa had transplant activities involving kidney, heart, cornea, liver and bone marrow [3].

1.5.5 Stratification of transplant programmes

Programmes are classified into different stages of development of transplant services with those from HICs better developed than those from LMICs and LICs [54] (See **Table 3**).

Stage	Characteristic	Country
I	No existing transplant programme with little or no posttransplant and post-donation care. Transplant tourism is rife.	The poorest countries of the world
II	Faltering or poorly developed transplant programme offering only living-related donation, no nationally structured transplant program, and often no legislation. There is nonexistent deceased-donor program and proliferation of transplant tourism with little or no posttransplant and post-donation care.	Countries in sub-Saharan Africa and many other low- and middle-income countries
III	Fairly developed transplant programme offering mostly living-related donation with rudimentary deceased-donor program. Poorly developed kidney paired exchange and organ sharing programs, often with poor posttransplant and post-donation care. Some level of transplant tourism and moderate to long wait time.	Many countries in Asia, Central and South America, the Middle East, and North Africa
IV	Well-developed structured transplant programme and accompanying legislation offering deceased donation, kidney paired exchange, and organ sharing programs with good posttransplant and post-donation care. Little transplant tourism and short to moderate wait times for transplant.	Many of the developed economies belong to this stage
V	Highly developed and structured transplant programme and accompanying legislation offering mostly deceased donation, advanced donation/kidney paired exchange, and organ sharing programs with excellent posttransplant and post-donation care. There is no transplant tourism and short or no wait times for transplant.	Utopian

Table 3.
Proposed staging for transplant stratification model (transplant transition) [54].

2. Recipient and donor evaluation

2.1 Recipient

Careful evaluation of potential organ transplant recipients is necessary to detect co-existing illnesses that can adversely affect the prognosis of the transplantation. The subsisting clinical practice guidelines including the 2020 KDIGO guideline and the 2011 UK Renal Association Clinical Practice guideline (5th Edition) [55, 56] recommend the standard process of evaluation of prospective transplant recipients. Regardless of the recommendations of the practice guidelines, most transplant centres have their in-house protocols for transplant recipient evaluation. However, in SSA, the evaluation may be tailored to the available resources but should be efficient and cost-effective. The discussion below is typical for kidney transplant units in Nigeria but may apply to other organ transplantations and transplantations in other countries in the sub-region.

The evaluation of such candidates involves risk/benefit assessment and they should have at least five-year life expectancy derived from age, gender and race of the individual [57]. Many clinicians, however, consider other factors including severity of life-threatening diseases, functional status, clinical experience and knowledge of the patient to determine suitability for organ transplantation.

2.1.1 Workup for transplant candidates

The workup evaluation includes: hematological, clinical chemistry, infection profile, diagnostic procedures, imaging and immunological tests. The list of relevant investigations is shown in **Table 4**.

2.1.1.1 Hematological studies

Blood grouping establishes the candidate's blood type and determines if further evaluation should proceed. Recipient and donor must be compatible. Complete blood count and clotting profile should be optimal.

2.1.1.2 Cardiac evaluation

All candidates are assessed for presence of cardiac disease by history, physical examination and electrocardiogram. Recipients with cardiac disease, comorbidities that predispose to coronary artery disease (CAD), history of previous CAD or poor cardiac function are further assessed by cardiologists. Generally, contraindications for transplantation include severe heart disease (New York Heart Association [NYHA] Functional Class III/IV), severe CAD, left ventricular dysfunction [ejection fraction <30%] and severe valvular disease.

2.1.1.3 Pulmonary evaluation

Chest radiograph is required for all candidates while chest computerized tomography (CT) is reserved for current or former heavy smokers (≥ 30 pack-years). Candidates with lung disease are further evaluated by a pulmonologist. Severe irreversible obstructive or restrictive pulmonary diseases are contraindications for transplantation.

Blood	1. Complete blood count and differential 2. Blood group 3. INR, PTT 4. Tissue typing: CDC and flow cytometry 5. Electrolytes: sodium, potassium, calcium, magnesium 6. Kidney function: urea, creatinine 7. Liver function: bilirubin, total protein, albumin, alkaline phosphatase, ALT, AST, LDH, GGT 8. Fasting blood glucose, glycated hemoglobin 9. Total cholesterol, HDL, LDL, VLDL, TG 10. Serology: HIV, HBsAg, Anti HCV, CMV, syphilis, EBV, HSV
Radiology	1. Chest radiograph 2. Abdominal and pelvic ultrasound. 3. CT angiography
Urine	1. Urinalysis 2. Urine MCS
Immunology	1. HLA typing, HLA antibodies, crossmatching
Gynecological	1. Pap smear, mammogram for women >40 years or family history of breast cancer
Other tests	1. Electrocardiogram 2. Echocardiography 3. Colonoscopy if >50 years 4. PSA in men >50 years

Table 4.
Workup for prospective organ transplant recipients.

2.1.1.4 Tuberculosis screening

Sub-Saharan Africa has high prevalence of tuberculosis (TB). It is therefore necessary to screen for TB in prospective organ recipients with a chest radiograph and purified protein derivative (PPD) skin test. Candidates with positive TB screening tests are treated before organ transplantation.

2.1.1.5 Gastrointestinal evaluation

Candidates with history of peptic ulcer disease (PUD) are screened with oesophagogastroscopy and *Helicobacter pylori* test. Active diseases including PUD, diverticulitis, pancreatitis, cholelithiasis and inflammatory bowel disease should be controlled before transplantation.

2.1.1.6 Serologies

Serological tests for potentially transmissible diseases, like HIV, HBV, HCV, cytomegalovirus (CMV), Epstein–Barr virus and varicella-zoster virus are usually performed, and appropriate management instituted when indicated.

2.1.1.7 Cancer screening

Routine cancer screening is done for all recipients. Chest radiograph is mandatory while chest CT is reserved for current or former heavy smokers. Ultrasonography is used for screening candidates at risk of renal cell carcinoma (dialysis >3 years, family history of renal cancer, acquired cystic disease, analgesic nephropathy). Those at risk of urinary bladder cancer (high-level exposure to cyclophosphamide, heavy smoking) require cystoscopy. Patients at risk of hepatocellular carcinoma are screened with ultrasonography and serum alpha fetoprotein. Colonoscopy is done to screen for bowel cancer and inflammatory bowel disease. Females undergo PAP smear and mammography to exclude cervical and breast cancer respectively.

2.1.2 Obesity

Obesity increases the risk of post-operative complications. Many transplant centres prefer a body mass index (BMI) of <30.

2.1.3 Financial considerations and psychosocial status

These are very important aspects of the workup for prospective organ transplant recipients and will be discussed later.

2.2 Donor

Donor protection should always be taken into account during living donor selection and assessment. Organ donation should be altruistic, voluntary and never coerced. Donor evaluation is a multidisciplinary exercise, and is done before, during and after donation. Due to lack of requisite legislation, supporting infrastructure, religious and cultural beliefs, mostly living organ donations are done in SSA countries.

There are risks associated with organ donation and consequently, potential donors should receive medical, surgical and psychological screening. Pre, intra, and post-operative care as well as structured post-donation follow up are important.

2.2.1 Clinical evaluation

Potential donors should be healthy and neither too young nor too old. Medical history and physical examination could elicit risk factors for kidney disease such as: DM, hypertension, family history of kidney disease, herbal drug, non-steriodal anti-inflammatory drugs (NSAIDs), and other nephrotoxin use. History and/or presence of CLD could be suggested by jaundice and alcohol abuse. Also, history of psychiatric illness, malignancies, smoking and substance abuse, etc. should be sought and positive candidates excluded. Donors should not be morbidly obese and blood pressures should be <140/90 mmHg.

2.2.1.1 Donor work-up

For various investigations see **Table 5**.

Absence of urinary markers of disease such as proteinuria, haematuria, pyuria and casts, may rule out kidney diseases in potential donors. Glomerular filtration rate (GFR) should ideally be measured but is often estimated using serum creatinine in most LRCs. Prospective donors are screened for chronic viral diseases.

Parameters	Relevant indices
Age	>18, <60 years
History	Diabetes mellitus, hypertension, nephrotoxins, alcohol and other substance abuse, cigarette smoking, psychiatric illness, malignancy
Physical features	Jaundice, pallor, BP >140/90 mmHg, BMI >35
Laboratory features	
Hematological	FBC, PT/INR
Chemistry	SEUCr, LFT, lipid profile, FBG, HBA1C, PSA, TFT
Microbiology	Urinalysis, urine culture
Serological/ immunological	HIV, Anti HCV, HBsAg, CMV, EBV, ABO blood group, HLA A, B and DR matching, HLA antibody cross- matching
Imaging	Ultrasound, CT angiography,
Others	ECG, Echocardiography

Table 5.
Workup for potential organ transplant donors.

Notably, CMV positivity in a donor has implication for a CMV-negative recipient, who due to subsequent immunosuppressive drug use will likely succumb to its infection. Screening for TB (CXR, Mantoux test, sputum GeneXpert) is important in SSA because 1/3 of the population is infected with M. tuberculosis [58]. The ABO blood group compatibility with recipient is mandatory; however, Rhesus factor mismatch is not a major consideration for solid organ matching. There are many HLA antigens (Class I: HLA-A, B, and C; Class II: HLA-DR, DQ and DP), but the HLA A, B and DR are usually cross-matched between donors and recipients (i.e. tissue typing).HLA antibody cross-matching is important to prevent early graft rejection. It detects the presence of HLA antibodies in recipients that can react with donor's lymphocytes, i.e. donor specific antibodies (DSA).

HLA antibody cross-matching was originally based on complement dependent cytotoxicity (CDC) assays. It is done with recipient's serum on donor lymphocytes or pooled lymphocytes of previous donors within the transplant centre's population to determine the Panel Reactive Antibodies (PRA). Reactive Antibodies (PRA). The PRA estimates the recipient's chances of tolerating allografts from that population and is useful for deceased donation.

Solid phase assays, ELISA or flow cytometry (Luminex)-based are now available and preferred. Most transplant centres in SSA, outsource tissue typing and HLA antibody cross-matching. Protocols require at least two HLA antibody cross-matches, with the last, just before the transplant procedure.

Imaging evaluation using ultrasonography and doppler in prospective donors should demonstrate normal kidneys (sizes and echotexture) and renal blood flow.

The CT-angiography helps to rule out solitary kidney or detect the presence of multiple or abnormal renal arteries, which have surgical implications for nephrectomy in donors and anastomoses in recipients.

2.2.2 Counseling

Counseling donors on short and long-term risks associated with organ donation is necessary. Possible complications such as pain, post-operative infections, blood loss, deep venous thrombosis and pulmonary embolism can occur. Studies have shown that peri-operative mortality and morbidity during organ donation,

are about 0.03% and 10% respectively [59]. Some studies show that with careful selection, kidney donors live long, although hypertension, proteinuria and reduced GFR can occur over time [60]. The risk of ESKD following kidney donation is about 0.3% [61]. Emotional consequences after organ donation should be anticipated therefore psychosocial assessment should be independently organized by the transplant team before and after donation.

2.3 Post donation follow-up

Many transplantation programmes in SSA adopt protocols from established and experienced centres.

According to US Organ Procurement and Transplantation Network (OPTN) guidelines, living donor follow-up is done at discharge (or at 6 weeks), 1 year and 2 years [62]. Parameters monitored include weight, blood pressure, lipid profile, kidney and liver functions. Healthy eating, regular exercise and the dangers of substance abuse are emphasized. After uneventful 2 years, donor follow-up is continued by the primary care physicians but for those with adverse outcomes appropriate referral is made. Post-donation follow-up is important for donor safety and wellbeing to enable diagnosis and treatment of co-morbidities.

2.4 Psychosocial evaluation

In transplantation, recipients, donors and their families are faced with various challenges including psychological and behavioral issues. Evaluation is essential in the following aspects: candidate and donor selection, counseling, pre- and post-transplant assessment, patient, caregiver and family adjustments to transplant and issues related to psyche of transplant staff.

2.4.1 Recipient

Various factors exert neuropsychiatric effects in transplantation. Studies link significant neuropsychiatric adverse effects to cyclosporine, tacrolimus, steroids and other components of treatment. Therefore, psychosocial issues should be considered and addressed in order to achieve a successful transplant.

Psychosocial evaluation of patients for transplant include [63]:

- Patient profile: relationships, education, work and legal history
- Expectations from the surgery
- Organ failure: cause, complications, course, adherence to treatment
- Ways of coping with the illness
- Support network: caregivers, family, friends, faith organizations and employers
- Psychiatric history: extant, past and family.
- Substance abuse history
- Mental status exam: neuropsychiatric tests
- Ability to give informed consent

There are known stressors before and after transplantation including depression and hopelessness, anxiety, uncertainty and aggression. These may be followed by hope, and confidence in an unpredictable pattern as recipients gradually process adaptation to the new situation.

After Transplantation, recipients pass through three phases of adaptation [64]:

- "Foreign body" phase: the organ feels strange to the recipient. Persecution anxiety or idealization could arise. The organ could be seen as fragile and precious, thereby generating excessive protective feelings towards it.
- "Partial incorporation" phase: recipient begins to integrate the organ.
- "Total incorporation" phase: recipient is no longer aware of the organ.

In the long-term postoperative period, medication side effects and associated comorbidities become central stressors affecting the recipients' quality of life (QOL). The most bothersome stressors are work related, like farming, schooling, etc. [65]. Recipients might feel stressed by the strict adherence to the medical regimen. This, in turn, can compromise their adherence after transplantation. Financial problems and legal disputes constitute other possible sources of psychological strain with health or pension insurance agencies, where available.

Enabling transplant recipients commence productive employment constitutes the main goal of transplantation and is considered an indicator of societal participation [66]. Globally, data show that 18% - 86% of recipients return to work or find new employment. [67, 68] but no data is available for SSA.

2.4.2 Donor

2.4.2.1 Donors' motives and decision-making

Multiple factors motivating donors include intrinsic factors (e.g., desire to relieve another's suffering or to act in accordance with religious convictions) and extrinsic factors (social pressures or perceived norms) that may operate simultaneously. The combination of motivational forces differs depending on whether and how the donor is related to the recipient.

Most living donors use two decision-making strategies: [69]: "moral" which involves awareness that one's actions can affect another [70] and "rational" which is focused on gathering relevant information, evaluating alternatives, selecting an alternative, and implementing the decision.

2.4.2.2 Psychological status and post-donation psychosocial outcomes

Potential donors' psychological stability has been one of the greatest concerns for living transplant programmes, particularly in the context of unrelated donation. The willingness or desire to donate to a stranger has been historically viewed with suspicion [71, 72]. Studies suggest that most potential donors do not suffer from mental illness [73, 74]. Many donors have reported positive feelings about donation however, a few have observed psychological distress, anxiety and depression. Thus, it becomes critical to identify, and mitigate key risk factors for these poorer outcomes: non-first degree relatives [75, 76], ambivalent donors [76, 77] and "black sheep" donors (persons who donate in order to compensate for past wrong doings or to restore their position in the family) are at higher risk for poorer post-donation psychosocial outcomes [76, 77].

3. Surgical aspect of transplantation

3.1 Donor surgery

The donor kidney angiogram is decisive in selecting the kidney to be harvested. The larger kidney with better blood flow is left for the donor. Minimal access donor nephrectomy and robot-assisted renal engraftment reduce postoperative complications. These, however, are not easily available in most LRCs.

3.1.1 Complications of donor nephrectomy

Post-operative donor complications occur in 7.9–22% with bleeding in about 3%. Infectious, gastrointestinal, respiratory, cardiac and psychiatric complications may occur [78–80].

3.2 Recipient surgery

The harvested kidney is covered in ice slush, wrapped in gauze piece and preserved in ice container as organ perfusion machine is not readily available in the sub-region.

Kidneys with multiple arteries are avoided but if inevitable, arteries are anastomosed side to side, end to side, or separately onto the external iliac artery (**Figure 4**). The right external iliac vessels are more superficial than the left and this side is frequently preferred for the first renal engraftment.

Anti-reflux uretero-cystostomy is performed over a size 4Fg double J-ureteric stent (**Figure 5**).

3.2.1 Pitfall in recipients surgery

Sclerosed External Iliac Vein (EIV): this results from repeated cannulation of EIV for hemodialysis. Recipient pre-operative EIV doppler ultrasound scan for patency is important. Major complications of recipient engraftment include bleeding, delayed graft function, hyperacute rejection and allograft renal vein thrombosis.

3.3 Peri and post-operative care of renal transplant recipient

Immunosuppressive regimen is divided into induction and maintenance phases.

3.3.1 Induction phase

This is required to prevent acute rejection. Due to sensitization from blood transfusions, previous pregnancies (females) and increased susceptibility to graft rejection (in blacks) recipients undergo induction [81]. A combination of anti-thymocyte globulin (ATG) and methylprednisolone is often used. Prior to this, patients receive pretreatment with acetaminophen and antihistamines to prevent cytokine release syndrome associated with ATG.

Biologic agents (Alemtuzumab, Basiliximab, Daclizumab) may be used when available in less sensitized patients.

3.3.2 Maintenance regimen

To prevent allograft rejection, maintenance immunosuppression is achieved with a combination of low dose corticosteroid (prednisolone is widely in available SSA), an antiproliferative agent (mycophenolate mofetil (MMF) or azathioprine)

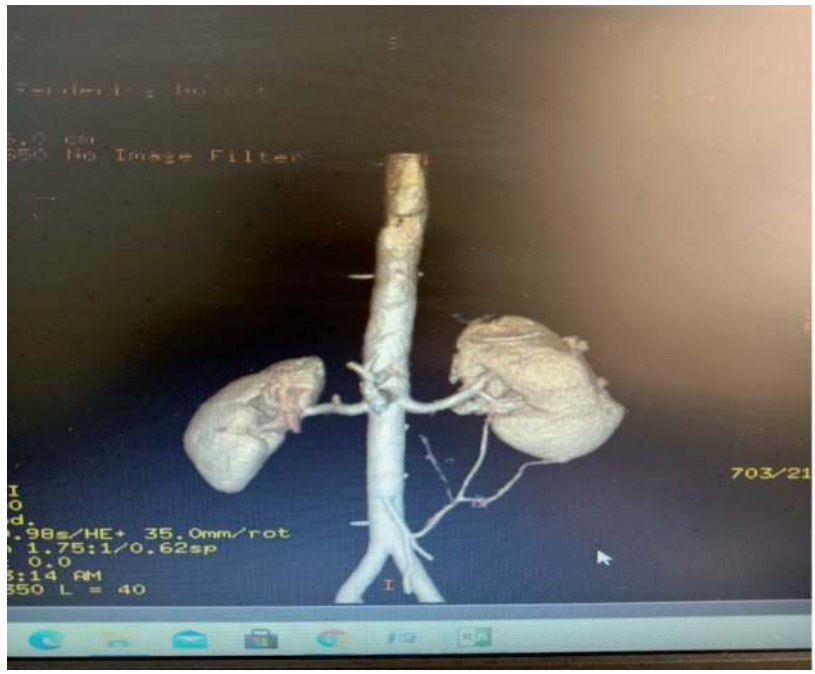

Figure 4.
Donor angiogram with multiple left renal arteries.

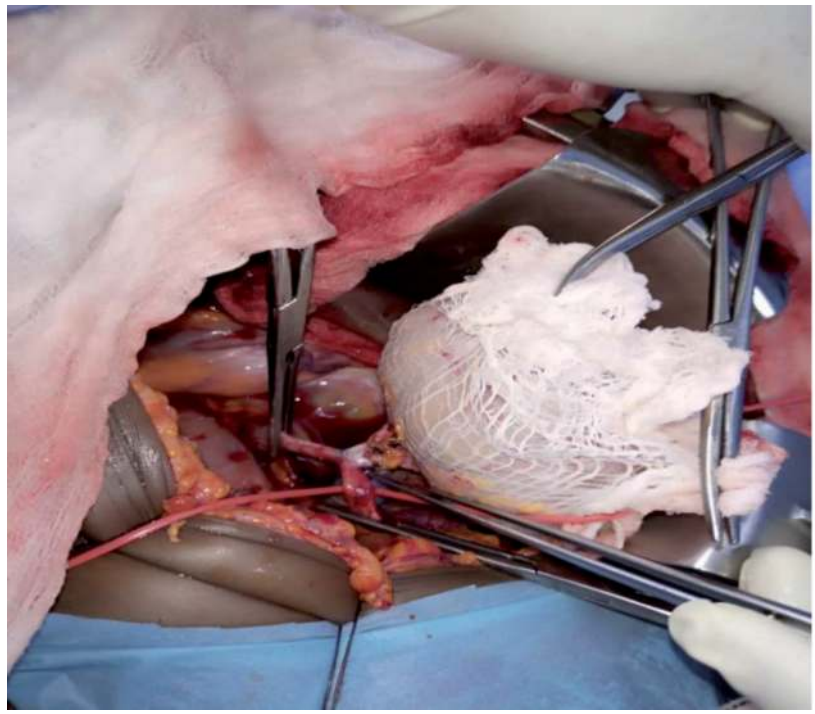

Figure 5.
End-to-side donor-recipient arterial anastomosis with kidney wrapped in gauze piece packed with saline ice slush.

and a calcineurin inhibitor (CNI) (tacrolimus (TAC) or cyclosporine (CYP)). Tacrolimus has shown superiority over cyclosporine in improving graft survival and preventing acute rejection. Thus, TAC remains an integral part of the common post-transplant immunosuppressive combination [82]. The initiating dose is titrated to achieve a trough level of 8-10 ng/ml in the first three months post-transplant.

Prophylaxis against bacteria, fungi and viruses are commenced within this time.

3.3.2.1 First post-operative week

First day post-surgery, emphasis is on haemodynamic and respiratory stability as well as urine output. By the first week, good graft function should have been established and urethral catheter is removed.

3.3.2.2 First three post-operative months

Within this period opportunistic infections are anticipated and appropriate measures taken. The ureteric stent is removed within 4 – 6 weeks.

3.4 Transplant outcomes in SSA

Absence of transplant registries in SSA precludes transplant data availability. However, between 2010 and 2015, a hospital in South Africa documented recipient survival at 1 and 5 years as 90.4% and 83.1% and that of graft 89.4% and 80% respectively [83].

4. Challenges of transplantation

Organ donation and transplantation in SSA is fraught with numerous challenges including costs of treatment, inadequate infrastructure and equipment, dearth of highly skilled health professionals, and lack of well-articulated ethico-legal framework and policies [3].

4.1 Cost of treatment

Cost of kidney transplant varies from country to country. For example, the cost is estimated at about $32,000 in Nigeria [84], $18,775 in Ghana [85], and $10,000 in Tanzania [20].

Source of funding for organ and tissue donation and transplant depends on the country: public sources in Ethiopia, Ghana, Mali, Seychelles and Comoros but private in Nigeria, Burkina Faso, Madagascar and 10 other countries See **Table 6**. Most recipients pay OOP either personally or by relatives, employers and to a lesser extent philanthropists [45]. While the National insurance pays two-thirds of the transplant cost in Kenya [47], it is free in Tanzania [51].

Post-transplant maintenance of immunosuppression is a major challenge. This is exigent since therapy must be individualized. Two perspectives associated with immunosuppression in SSA include:

- Availability, affordability and patient's adherence to prescription.
- Therapeutic drug monitoring (TDM).

4.1.1 Availability, affordability and patient's adherence to prescription

Adequate immunosuppression is key to allograft survival. In patients who pay OOP, prohibitive costs of medications may have negative impact on their finances. Furthermore, side effects of medications affect their health-related QOL. In many LRCs, these medicines are imported at high cost and not readily available. These contribute to poor adherence with subsequent allograft rejection and graft loss.

Indicator	Countries
Countries with functional transplantation programmes	
Functional transplantation programmes from living donors	Algeria, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Namibia, Nigeria, United Republic of Tanzania, Uganda, South Africa
No. of transplant centres in the region	
Kidney centres	Algeria, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Namibia, Nigeria, United Republic of Tanzania, Uganda
Corneal centres	Kenya, Nigeria, South Africa
Bone marrow centres	Nigeria, South Africa
Liver centres	South Africa
Heart centres	South Africa, others perform open heart surgeries
Countries having legal requirements	
Legal requirements in place covering organ donations and/or transplantations	Burkina Faso, Comoros, Côte d'Ivoire, Ethiopia, Kenya, Mauritius, Namibia, Nigeria, Rwanda, Senegal, Sudan, United Republic of Tanzania, Uganda, Zimbabwe
Governments intended to adopt new legal requirements	Cameroon, Chad, Eswatini, Ghana, Guinea, Madagascar, Mali, Mozambique
No legislations in place	Angola, Benin, Burundi, Cabo Verde, Congo, Eritrea, Gabon, Guinea Bissau, Seychelles, Sierra Leone
Legal requirements in place to inform living donors on the risks of the operation	Comoros, Ethiopia, Kenya, Mali, Nigeria, Rwanda, Senegal, Seychelles, United Republic of Tanzania, Uganda
Legal restrictions on the coverage of donation costs for living donors	Comoros, Mali, Rwanda, Senegal
Legal requirement to follow-up on the outcomes of living donors	Ethiopia, Mali, Senegal, Seychelles
Legal requirement to provide care to living donors in case of adverse or medical consequences	Ethiopia, Senegal, Seychelles
Prohibition of organ trafficking/transplant commercialization	Burkina Faso, Comoros, Côte d'Ivoire, Mali, Namibia, Nigeria, Rwanda, Senegal
Legal permit and regulation of financial incentives for living donors	None
Import or export of organs authorized	Ghana, Namibia, Rwanda
Import or export of organs explicitly prohibited	Burkina Faso, Seychelles
Legal requirements for organ and tissue donations from living donors[a]	Burkina Faso, Comoros, Côte d'Ivoire, Kenya, Mali, Nigeria, Rwanda, Senegal, Seychelles, United Republic of Tanzania, Uganda
No. of countries having an organization and management system	
Authorization for transplant services	Burkina Faso, Comoros, Côte d'Ivoire, Ethiopia, Ghana, Guinea, Kenya, Madagascar, Mali, Nigeria, Senegal, Uganda, Zimbabwe
Ethics Committees at the national or local level	Burkina Faso, Comoros, Côte d'Ivoire, Ethiopia, Gabon, Kenya, Mali, Nigeria, Rwanda, Senegal
Government recognized authority at the national level	Algeria, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Mali, Nigeria, Senegal, Uganda
Setting up protocols, guidelines, recommendations	Comoros, Côte d'Ivoire, Ethiopia, Mali, Senegal

Indicator	Countries
Transplant follow-up registries for post-transplant living donor and for recipients	Côte d'Ivoire, Ethiopia, Namibia, Uganda
Affiliation with an international organ allocation organization	None
Cooperation framework to allow transplantation abroad	Côte d'Ivoire, Ethiopia, Kenya, Namibia, United Republic of Tanzania, Uganda
Training programme for staff in place	Côte d'Ivoire, Ethiopia
Source of funding	
Public	Comoros, Ethiopia, Ghana, Mali, Seychelles, United Republic of Tanzania
Private	Côte d'Ivoire, Ghana, Nigeria
Public and Private	Kenya, Namibia, South Africa, Uganda
Not Specified	Eswatini, Gabon, Zimbabwe

Table 6.
Aspects of transplantation programmes in SSA modified from Loua et al [3].

4.2 Therapeutic drug monitoring (TDM)

Despite their impactful role in improving transplant outcome and graft survival, immunosuppressive medicines exhibit narrow therapeutic range between levels that inhibit rejection and toxic levels hence TDM is often required. Establishing a patient's dose requirements in the immediate post – surgery period and avoiding over immunosuppression remains a challenge. Calcineurin inhibitors have variable pharmacokinetics [86–89]. While ethnic differences have not been demonstrated in pharmacokinetics of MMF and AZA, African Americans have been shown to have 20–50% lower oral bioavailability for TAC, CYP, sirolimus and everolimus and as such require higher drug doses than Caucasians [90, 91]. This has been attributed to genetic polymorphism of key enzymes in the metabolism of these medications [90]. Genetic profiling is not readily done in SSA hence, TDM is essential. This attracts huge costs for the health system and for patients who pay OOP. It is imperative to tailor medications to patient's need. Some countries do not have the capacity to analyze drug levels, so patient's blood samples are sent overseas for analysis. Within the first-year post-transplant, TDM is done at least twice during timed follow-up visit for patients coming from rural and urban areas. However, more frequent monitoring is done when indicated. During emergency presentation for allograft dysfunction, patients are admitted, samples for TDM sent out and other possible causes of allograft dysfunction are excluded or managed if present. Decision to increase drug dosage is often delayed till TDM result is available but dose reduction or withdrawal can be done in the presence of overt signs and symptoms suggestive of toxicity. For subsequent years, TDM is done as indicated.

4.3 Lack of infrastructure and equipment

Tissue typing, cross-matching and some viral studies, which are major aspects of patient preparation, are done overseas. This tends to delay the procedure and leads to an increase in the cost of transplantation. Adequate histological evaluation of biopsy specimens are largely unavailable, making prompt management of rejections and infections problematic.

4.4 Dearth of skilled transplant workforce

Health-workforce is the backbone of any health care system. Transplantation involves collaboration of many health professionals (nephrologists, transplant surgeons, urologists, renal nurses, pathologists, etc.). Worldwide transplant workforce and training capacity remain unknown. Of the 47 countries in SSA, only 15 (32.6%) had data on the number of nephrologists in their countries. Nigeria and South Africa have the greatest number of nephrologists with rates <10 per 10,000 population while others have < two per 10,000 population [3]. The situation is worse for other specialists involved in transplantation. Opportunities for training and employment have caused brain drain to developed countries from LRCs [3].

4.5 Transplant programmes

Despite the burden of ESKD in SSA, only few countries have sustained transplant programmes [20]. There are only 62 centres across 7 countries in SSA [3]. Nigeria with a population of 206 million has 15 renal transplant centres (RTCs) with majority recording low activities ranging 1–5 transplants per year (Personal Communication). South Africa with a population of 59.37 million (2020) has 14 RTCs and did 250 to 450 kidney transplants annually between 1991 and 2015 [35].

4.6 Shortage of organs

Scarcity of organs for transplantation is a multi-factorial global problem. Living donors remain the major source of organs for transplantation in SSA with largely non-existent deceased donor programmes. This has resulted in the persistent dearth of organs in the face of continuous rise in demand [92]. Unavailable storage facilities, poor knowledge about transplantation, socio-cultural and religious beliefs (which discourage living organ donation, view deceased organ donation as a taboo or an act of mutilating the dead with violation of the person's dignity [84]) contribute to shortage of organs [93].

4.7 Poverty and unemployment

There is pervading poverty in SSA with US bureau of statistics reporting rates of 87.8%, 56.9%, 40.1%, 40% and 36.1% in Uganda, Ghana, Nigeria, Cameroun and Kenya respectively [94]. In Nigeria, 85% of ESKD patients earn between $800–7333 annually making kidney transplantation unaffordable [27, 95]. Although unemployment rate in SSA averages 6.2%, many are underemployed and earn low income [96].

4.8 Poor accessibility

Most transplant centres are located in urban cities or state capitals reducing accessibility to rural dwellers [3, 41].

4.9 Cultural and religious considerations

Christianity, Islam and African traditional religion are the major faiths in SSA. Interplay of faith, religion and cultural attitudes and their relationship with views on organ donation is complex. Response to illness as God's will negates organ

donation or reception. Belief in resurrection and reincarnation precludes organ donation since the 'new body' may have some missing parts. Desecration of the body of the deceased is reported as a factor prohibiting family members from donating body parts of their deceased relatives.

4.10 Poor coordination and management

Functional organizational mechanism for transplant programmes including authorization for transplant services; ethics committees, guidelines and protocols, etc. are few in the region [41, 93]. Additionally, transplant is not sufficiently integrated into national health services and collaboration between SSA countries is limited.

Absence of functional and reliable registries militate against planning and implementation of policies due to lack of data. Most countries do not include performance indicators for organ donation and transplantation in their national health information systems. In addition, there is insufficient multisectoral (schools, transport departments, NGOs, Civil Society Organizations, etc.) involvement in transplantation programmes in SSA.

4.11 Legal and regulatory policies

Some countries have legislation for organ donation and transplantation while others are in various stages of developing theirs (**Table 6**). The weak regulatory frameworks observed in these countries are often insufficient to ensure the effective oversight needed for the implementation of quality standards for organ transplantation.

4.12 Transplant tourism (TT)

The Declaration of Istanbul defines organ transplant tourism as travel for transplantation involving trafficking in persons, for the purpose of organ removal. Organ trafficking is defined as *"the recruitment, transport, transfer, harboring, or receipt of living or deceased persons or their organs by means of any form of coercion, of abduction, of fraud, of deception, of the abuse of power or of a position of vulnerability, or of the giving to, or the receiving by, a third party of payments, or benefits to achieve the transfer of control over the potential donor for the purpose of exploitation by the removal of organs for transplantation* [97]." Transplant commercialism is the buying and selling of organs i.e. treating of organs as commodities. Travel for transplantation is the transport of organs, donors, recipients, or the professionals across borders for transplantation and it becomes TT if it entails organ trafficking and/or transplant commercialism [97]. Transplant tourism has become an increasing component of medical tourism (MT) especially in SSA. The disparity between the demand for and supply of organs encourages illegal organ procurement as transplantation may the only life-saving treatment in many end-organ failure. Unavailability and high cost of healthcare, lack of faith in local health systems, widening economic gap, ease of global travel and uneven global application of laws, have led to increase in TT.

5. Transplant opportunities

Transplantation holds lots of opportunities which if well harnessed can improve healthcare in SSA.

5.1 Availability of organs for transplantation

For sustainable transplantation programme, individuals, community and governmental commitment and collaboration are required. Availability of organs can be increased through heightened public enlightenment campaigns emphasizing preventive medicine and change in the community's organ donation perception. This can be achieved by partnering with religious bodies, individual, family and community education, inclusion of transplantation and donation in school syllabus, alliance with the department of motor vehicles (DMV) and novel donation programmes (kidney paired donation, extended criteria organ donation and altruistic non-directed donation).

5.2 Comprehensive legislation and regulation

Transplantation has significant medico-legal implications requiring robust legal framework. This should cover organ donation legitimacy, regulatory bodies, criteria and processes of accreditation, certification and standardization of transplant centres [98]. Transplantation programmes afford SSA opportunities to learn and adapt legislation from other regions. In 2008, Israeli parliament accepted two laws from their Ministry of Health - the Brain-Respiratory Death for determination of brain death and the Organ transplantation laws [99]. These laws defined the ethical, legal and organizational aspects of organ donation, allocation and transplantation with prioritization of registered donors, donor reimbursement and life insurance [99]. These and stoppage of illegal TT reimbursement significantly increased living and deceased organ donation by 2011 [99, 100].

5.3 Manpower development

The Multidisciplinary nature of transplant programmes demands highly skilled manpower often not obtainable in many parts of SSA, hence the need for collaboration with advanced transplant centres. Such patnership enables capacity development and training of specialized workforce which will serve the local and sister institutions.

5.4 Transplant protocols and registry

Successful transplantation requires protocols for recipient and donor care. Transplant centres in LRCs can develop or adapt protocols from advanced centres, international organizations like United Network for Organ Sharing, Donation and Transplant Institute etc. National registries of organ transplant and outcomes are essential for documentation of transplant activities, reporting of short and long-term outcomes, and for planning and budgeting.

5.5 Developing transplant programmes

Each country should establish a sustainable transplant programme. Development of such services will curb organ trafficking and TT [101]. It entails infrastructural, legislative and manpower development with national government's political will [35, 102]. A well-defined mode of funding which includes transplantation in national health insurance coverage ensures sustainability.

Transplantation programme can be established in a staged fashion [101]: enacting transplantation related laws and regulations, capacity building, extensive public

enlightenment campaigns and transplant beginning with live-donor and subsequently, deceased-donor.

5.5.1 Transplant models

Models that can be adapted include:

5.5.1.1 The Pakistani model

In the Pakistani model [103, 104], following intense public enlightenment, the community assumed ownership of the programme through donations as individuals, communities and NGOs. Government provided 30–40% of required cost, infrastructure, staff training and emolument enabling patients to receive free nephrology and transplantation care plus post-transplant rehabilitation. Accountability, transparency and equity ensured the success of this model.

5.5.1.2 Iranian model

Following development of indigenous transplant programme in 1985, there was an unwieldy transplant waiting list necessitating government-sponsored live-unrelated transplant with donor compensation [105]. This programme successfully eliminated waiting list by 1999 increasing kidney transplantation to 28 pmp per year. The Dialysis and Transplant Patients Association facilitated donor-recipient matching excluding third party. Donors also received government-funded life health insurance and gifts. Government additionally supported importation and free distribution of immunosuppressive medications to recipients. Deceased donor transplantation has steadily increased since 2000.

These models emphasize the indispensable roles of community, government and NGOs in ensuring the existence of a sustainable transplantation programme.

6. Other aspects of transplantation in sub-Saharan Africa: guidance efforts by international organization

The World Health Assembly (WHA) adopted resolutions WHA57.18 and WHA63.22 [106, 107], and the WHO guiding principles on human cell, tissue and organ transplantation to guide transplantation programmes and activities [108]. The United Nations General assembly adopted these resolutions to strengthen and promote effective measures and international cooperation to prevent and combat organ trafficking [109]. The Istanbul declaration on organ trafficking and TT recommends a legal and professional framework to govern organ donation and transplantation activities, transparent regulatory oversight system to ensure donor and recipient safety, enforce standards and prohibit unethical practices in all countries [97]. A Task Force to check unwholesome practices in transplantation was set up and inaugurated by WHO in 2017 [110].

During the 2013 Global Alliance of Transplantation (GAT) meeting organized by Southern African Transplant Society in Durban [3], the transplantation society (TTS) sponsored a meeting for countries in SSA to assess the need for and ability to optimize or develop local transplant programmes. In 2015, the South African Renal Society–African Association of Nephrology in collaboration with European Renal Association-European Dialysis and Transplant Association held a pre-congress workshop to encourage SSA countries to develop renal registries [111]. Attempts

at establishing renal registries in SSA have met with challenges. The International Society of Nephrology (ISN) is supporting establishment of renal registries worldwide through her SHARing Expertise (https://www.theisn.org/initiatives/data-collection/). Leveraging on such programmes can help SSA countries establish reliable registries.

To improve kidney disease patients' care and capacity building worldwide, ISN pioneers these programs: fellowship, ISN continuing medical education, sister renal centre (SRC), sister transplant centre (STC) and educational ambassadors programme. Through ISN- TTS-STC program, ISN encourages establishment and development of transplant centres (www.theisn.org/programs). In ISN- TTS STC programme, SSA centres (emerging centres) can partner with developed centres (supporting centre) for capacity building through institutional and exchange training programmes at no cost to the individual or his home institution. This partnership is superior to the intermittent use of paid expatriates in some SSA countries.

7. Recommendations

Improvement in the transplant landscape of SSA can be achieved by adapting models that have proven successful in LRCs such as those of Pakistan and Iran. Implementing the 2007 World Health Organization Regional Consultation recommendations: establishment of national legal framework and self-sufficient organ donation and transplantation in each country, transparent transplantation practices, and prevention of commercialized transplantation and TT will improve transplantation programmes in SSA. Also, adopting the WHO Regional Committee for Africa's proposed actions on organ transplantation for member states and establishment of national registries for organ transplantation in each country are needed.

8. Conclusion

Sub-Saharan Africa, comprising of 47 countries and occupying an area of about 24 million Km^2 is heterogeneous with estimated population of 1.1 billion people. Most of the countries belong to the LICs and LMICs according to World Bank Classification of economies. This region has a high prevalence of end-organ diseases including CKD, CLD, chronic lung diseases and chronic heart diseases resulting from CDs and NCDs.

Although South Africa performed Africa's first kidney transplant in 1966 and pioneered heart transplantation in 1967, SSA lags behind the developed world in transplant activity. According to WHO, SSA contributes the least number of transplant activity per WHO World region. Cost of treatment, low GDP, inadequate infrastructural and institutional support, dearth of facilities and technical expertise and absence of subsidy have all adversely affected organ donation and transplantation.

The health-care systems in SSA are weak and deficient. Peoples' decision to access healthcare services is influenced by knowledge of the disease condition, accessibility to health-care facility, affordability, religious and trado-cultural practices. Many people in LRCs patronize alternative healthcare service including traditional health providers and religious institutions as first choice resulting in late presentation to hospitals.

These challenges can be surmounted by adopting the 2007 World Health Organization Regional Consultation recommendations of establishment of national

legal framework, self-sufficient organ donation and transplantation in each country, transparent transplantation practice, and prevention of commercialized transplantation and TT. In addition, establishment of national registries of organ transplantation is essential.

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References

[1] Freeman KJ. Transplant Program Personnel, Organization, and Function. In: Dunn SP, Horslen S, editors. Solid Organ Transplantation in Infants and Children, Organ and Tissue Transplantation, Springer International Publishing Switzerland; 2016. p. 1-13. DOI 10.1007/978-3-319-08049-9_4-1.

[2] Kaze AD, Ilori T, Jaar BG, Echouffo-Tcheugui JB. Burden of chronic kidney disease on the African continent: a systematic review and meta-analysis. BMC Nephrology. 2018;**19**:125 https://doi.org/10.1186/s12882-018-0930-5

[3] Loua A, Feroleto M, Sougou A, Kasilo OMJ, Nikiema JB, Fuller W, et al. A review of policies and programmes for human organ and tissue donations and transplantations, WHO African Region. *Bulletin of the World Health Organization* 2020;98:420-425. doi: http://dx.doi.org/10.2471/BLT.19.236992

[4] Dalal S, Beunza JJ, Volmink J, Adebamowo C, Bajunirwe F, Njelekela M, et al. Non-communicable diseases in sub-Saharan Africa: what we know now. International Journal of Epidemiology. 2011;**40**:885-890. DOI: 10.1093/ije/dyr050

[5] World health statistics 2018: monitoring health for the SDGs, sustainable development goals. Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO. (Internet). 2018 Available from https://www.who.int/docs/default-source/gho-documents/world-health-statistic-reports/6-june-18108-world-health-statistics-2018.pdf (Accessed 10th September 2020).

[6] World Health Organization. The Double Burden: Emerging Epidemics and Persistent Problems. (Internet). Available From https://www.who.int/whr/1999/en/whr99_ch2_en.pdf?ua=1 (Accessed 10th September 2020).

[7] Stanifer JW, Jing B, Tolan S, Helmke N, Mukerjee R, Naicker S, et al. The epidemiology of chronic kidney disease in sub-Saharan Africa: a systematic review and meta-analysis. Lancet Glob Health. 2014;**2**:e174-e181 http://dx.doi.org/10.1016/S2214-109X(14)70002-6

[8] Atkins RC. The epidemiology of chronic kidney disease. *Kidney International*, Vol. 67, Supplement 94 (2005), pp. S14–S18.

[9] Abd ElHafeez S, Bolignano D, D'Arrigo G, Dounousi E, Tripepi G, Zoccali C. Prevalence and burden of chronic kidney disease among the general population and high-risk groups in Africa: a systematic review. BMJ Open. 2018;**8**:e015069. DOI: 10.1136/bmjopen-2016-015069

[10] HIV/AIDs: Key Facts. (Internet). 2020. Available from: https://www.who.int/news-room/fact-sheets/detail/hiv-aids (Accessed 20th September 2020).

[11] UNAIDS Fact Sheet. (Internet). 2020. Available from: https://www.unaids.org/sites/default/files/media_asset/UNAIDS_FactSheet_en.pdf (Accessed 20th September 2020).

[12] Benedetti C, Waldman M, Zaza G, Riella LV and Cravedi P (2020) COVID-19 and the Kidneys: An Update. Front. Med. 7:423. doi: 10.3389/fmed.2020.00423

[13] WHO. New hepatitis data highlight need for urgent global response. (Internet). 2017. Available from: https://www.who.int/news-room/detail/21-04-2017-new-hepatitis-data-highlight-need-for-urgent-global-response (Accessed 20th September 2020)

[14] Fattovich G, Guistina G, Degos F, Tremolada F, Diodati G, Almasio P. Morbidity and mortality in

compensated cirrhosis type C: A retrospective follow-up study of 384 patients. Gastroenterology. 1997;**112**:463-472

[15] Kim WR, Thermeau TM, Benson JT, Kremers WK, Rosen CB, Gores GJ, et al. Deaths on the liver transplant waiting list:An analysis of competing risks. Hepatology. 2006;**43**:345-351

[16] Mahillo B, Carmona M, Alvarez M, Marco J, Nuñez JR, López-Fraga M, et al. Worldwide distribution of solid organ transplantation and access of population to those practices. Transplantation. 2018;**102**:7S

[17] GODT. International Report on Organ Donation and Transplantation Activities Executive summary 2017. (Internet). 2017. Available from: http://www.transplant-observatory.org/ (Accessed 10th September 2020).

[18] World Bank Data. Population, total - Sub-Saharan Africa. (Internet). 2019. Available from: https://data.worldbank.org/indicator/SP.POP.TOTL?locations=ZG (Accessed 20th September 2020)

[19] United Nations, Department of Economic and Social Affairs, Population Division (2019). *World Population Prospects 2019: Data Booklet* (ST/ESA/SER.A/424). (Internet). 2019. Available from. https://population.un.org/wpp/Publications/Files/WPP2019_DataBooklet (Accessed 24th September 2020)

[20] Kobayashi S, Hidaka S. Can we still ignore renal replacement therapy in sub-Saharan Africa? All living beings are created equal. (2020) 6:5 https://doi.org/10.1186/s41100-019-0243-6

[21] World Health Organization (WHO). Everybody's business: Strengthening health systems to improve health outcomes-WHO's framework for action. 2007. Geneva: WHO

[22] Ayanore MA, Amuna N, Aviisah M, Awolu A, Kipo-Sunyehzi DD, Mogre V, et al.., 2019. Towards Resilient Health Systems in Sub-Saharan Africa: A Systematic Review of the English Language Literature on Health Workforce, Surveillance, and Health Governance Issues for Health Systems Strengthening. *Annals of Global Health* 2019: 85(1), p.113. DOI: http://doi.org/10.5334/aogh.2514

[23] Aldis W. Health security as a public health concept: A critical analysis. *Health Policy and Planning*. 2008; 23: 369-375. DOI: https://doi.org/10.1093/heapol/czn030

[24] Ojong N. The COVID-19 Pandemic and the Pathology of the Economic and Political Architecture in Cameroon. *Healthcare* 2020; *8*: 176; doi:10.3390/healthcare8020176

[25] Bryan L, Conway M, Keesmaat T, McKenna S, Richardson B. A practical approach to health system strengthening in sub-Saharan Africa. Health International 2009; 9: 80 – 95. (Internet). Available from: https://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/Healthcare%20Systems%20and%20Services/Health%20International/HI09_Africa.ashx (Accessed 24th September 2020).

[26] Jacobs B, Ir P, Bigdeli M, Annear PL, Damme WV. Addressing access barriers to health services: an analytical framework for selecting appropriate interventions in low-income Asian countries. Health Policy and Planning 2011; 1-13 doi:10.1093/heapol/czr038.

[27] Ulasi II, Ijoma CK. The enormity of chronic kidney disease in Nigeria: the situation in a teaching hospital in South-east Nigeria. *Journal of Tropical Medicine 2010*. 2010, Article ID 501957, 6 pages. doi:10.1155/2010/501957;2010.

[28] African Economic Outlook 2020. (Internet). 2020. Available from:

https://www.afdb.org/en/knowledge/publications/african-economic-outlook (Accessed 2oth September 2020).

[29] African Economic Outlook 2020 Supplement Amid COVID-19. (Internet). 2020. Available from: https://dataportal.opendataforafrica.org/wozrhgf/african-economic-outlook-supplement-amid-covid-19 (Accessed 2oth September 2020).

[30] Jowett M, Brunal MP, Flores G, Cylus J. Spending targets for health: no magic number. Geneva: World Health Organization; 2016 (WHO/HIS/HGF/HFWorkingPaper/16.1; Health Financing Working Paper No. 1); http://apps.who.int/iris/bitstream/10665/250048/1/WHO-HIS-HGF- HFWorkingPaper-16.1-eng.pdf

[31] World Health Organization, Public financing for health in Africa: from Abuja to the SDGs. 2016, WHO: Geneva.

[32] Atlas of African Health Statistics 2018: universal health coverage and the Sustainable Development Goals in the WHO African Region. Brazzaville: WHO Regional Office for Africa; 2018. Licence: CC BY-NC-SA 3.0 IGO.

[33] Fabian J, Maher H, Bentley A, Gaylard P, Crymble K, Rossi B et al. Favourable outcomes for the first 10 years of kidney and pancreas transplantation at Wits Donald Gordon Medical Centre, Johannesburg, South Africa. S Afr Med J 2016;106(2):172-176. https://doi.org/10.7196/SAMJ.2016.v106i2.10190

[34] Brink JG, Hassoulas J. The first human heart transplant and further advances in cardiac transplantation at groote schuur hospital and the University of Cape town. *Cardiovasc J Afr* 2009; 20: 31-35.

[35] Moosa MR. The state of kidney transplantation in South Africa. S Afr Med J 2019;109(4):235-240. DOI:10.7196/SAMJ.2019.v109i4.13548

[36] Delmonico FL, Domínguez-Gil B, Matesanz R,Noel L. A call for government accountability to achieve national self-sufficiency in organ donation and transplantation. Lancet 2011; 378(9800): 1414-1418. https://doi.org/10.1016/S0140-6736(11)61486-4

[37] Muller E. Organ donation and transplantation in South Africa – an update. Continuing Medical Education 2013; 31 (6). http://www.cmej.org.za/index.php/cmej/rt/printerFriendly/2764/3004

[38] Muller E, Kahn D, Mendelson M. Renal transplantation between HIV-positive donor and recipients. N Engl J Med 2010; 362(24): 2336-2337.

[39] Muller E, Barday Z. HIV-Positive Kidney Donor Selection for HIV-Positive Transplant Recipients. J Am Soc Nephrol. 2018 Apr; 29(4): 1090-1095. doi: 10.1681/ASN.2017080853.

[40] Bento I. First-ever kidney transplant in Namibia a success. (Internet). 2016. Available from: https://www.nampa.org/index.php?model=feature&function=display&id=124269 (Accessed 26th September 2020).

[41] WHO: Regional Committee for Africa. Status of Human Organ and Tissue Donation and Transplantation in the Who African Region. Report of the Secretariat AFR/RC70/12 30 June 2020. (Internet). 2020. Available from: https://www.afro.who.int/sites/default/files/2020-07/AFR-RC70-12%20Status%20of%20human%20organ%20and%20tissue%20donation%20and%20transplantation.pdf (Accessed 10th October 2020).

[42] Osafo C, Morton B, Ready A, Jewett-Harris, Adu D. Organ Transplantation in Ghana. Transplantation 2018: 102 (4): 539 – 541.

[43] Lagou DA, Ackoundou-N'guessan KC, Njapom TL, Sekongo YM, Guei CM, Tia MW. Characteristics and Outcome of Living Kidney Donors After Donation: A Report from Cote d'Ivoire. Saudi J Kidney Dis Transpl 2016;27(3):563-568.

[44] Ackoundou-N'Guessan C, Hoang AD, Ben Abdallah T, Gnionsahe DA, Dollo I, Ripoche C, et al. Living Kidney Donor Transplantation in a Resource-limited Country: The Ivory Coast Experience. Transplant Proc. Jul-Aug 2015;47(6):1580-4. doi: 10.1016/j.transproceed.2015.03.053.

[45] Ulasi II, Ijoma CK. Organ Transplantation in Nigeria. Transplantation ! April 2016; 100 (4): 695 -697.

[46] Ahmed MM, Tedla FM, Leichtman AB, Punch JD. Organ Transplantation in Ethiopia. Transplantation 2019; 103 (3): 449 – 451.

[47] Ministry of Health, Kenya. 10 years and 200 transplants later! KNH celebrates a milestone. (Internet) 2019. Available from: https://www.health.go.ke/10-years-and-200-transplants-later-knh-celebrates-a-milestone/ (Accessed 23rd September 2020).

[48] The Evolution of Renal Transplantation in Mauritius (1980 – 1997). Transplant Int 2001; 14: 115 – 116.

[49] Gopee N. The Renal Transplantation issue. (Internet) 2018. Available from: http://www.mauritiustimes.com/mt/the-renal-transplantation-issue/ (Accessed 23rd September 2020).

[50] Ahmed IAM, Musa EA, Shaikh Q, Elsharif ME. Kidney Transplantation in Sudan. Transplantation 2018; 102 (10): 1583 – 1585.

[51] Furia FF, Shoo J, Ruggajo PJ, Kilonzo K, Basu G, Yeates K, et al. Developing nephrology services in low income countries: a case of Tanzania. BMC Nephrology (2019) 20:378 https://doi.org/10.1186/s12882-019-1568-7

[52] Kazibwe K. Cabinet approves bill that allows body organ donation, transplant. (Internet). 2020 Available from: https://nilepost.co.ug/2020/06/07/cabinet-approves-bill-that-allows-body-organ-donation-transplant/ (Accessed 23rd September 2020).

[53] Jahora R. Angola Paves the Way for Organ Transplants. (Internet) 2019. Available from: http://www.ahora.cu/en/sport/15-section/world/4740-angola-paves-the-way-for-organ-transplants (Accessed 24th September 2020).

[54] Ulasi I, Ijoma C, Onodugo O, Arodiwe E, Okoye J, Onu U, et al. Posttransplant care of kidney transplant recipients and their donors in Nigeria. Exp Clin Transplant 2019; 17 (Suppl 1): 50 – 56.

[55] KDIGO Clinical Practice Guideline on the Evaluation and Management of Candidates for Kidney Transplantation. *Transplantation* 2020;104: S1–S103

[56] Renal Association Clinical Practice Guideline on the Assessment of the Potential Kidney Transplant Recipient. Nephron Clinical Practice 2011;118 Suppl 1(Suppl. 1):c209-24

[57] Knoll G, Cockfield S, Blydt-Hansen T, Baran D, Kiberd B, Landsberg D et al. Canadian Society of Transplantation: consensus guidelines on eligibility for kidney transplantation. CMAJ : Canadian Medical Association Journal = Journal de L'association Medicale Canadienne. 2005 Nov;173(10):S1-25. DOI: 10.1503/cmaj.1041588.

[58] Dye C, Scheeles S, Dominic P, et al. Global burden of tuberculosis: Estimated incidence, prevalence and

morbidity by country. JAMA 1999; 282: 677-686.

[59] Ghods A J. Living kidney donation: The outcomes for donors. Int J Organ Transplant Med 2010; 1(2): 63-71.

[60] Fehrman-Ekholn I, Elinder CG, Stenbeck M, et al. Kidney donors live longer. Transplantation 1997; 64: 976-978.

[61] Ibrahim HN, Foley R, Tan LP, et al. Long term consequences of kidney donation. N Engl J Med 2009; 360:459-469.

[62] Organ Procurement and Transplantation Network Living Donor Committee: Living donation. Available from. http://optn.transplant.hrsa.gov/Policies and Byelaws2/policies/pdf/policy .

[63] House RM 1993. Cited in Erick M, Christine E Skotzko CE. Psychiatric assessment in transplantation Rev. Saúde Pública, 34 (4): 415-20, 2000 www.fsp.usp.br/rsp.

[64] Castelnuovo TP (1981) "Transplantation: psychological implications of changes in body image" in Psychonephrology. Psychological factors in hemodialysis and trasplantion; Levy (Ed). Plenum Press, New York.

[65] De Baere C, Delva D, Kloeck A, et al. Return to work and social participation: does type of organ transplantation matter? Transplantation. 2010;89(8):1009-1015.

[66] Van der Mei SF, Krol B, van Son WJ, de Jong PE, Groothoff JW, van den Heuvel WJ. Social participation and employment status after kidney transplantation: a systematic review. Qual Life Res. 2006;15(6):979-994.

[67] Paris W, White-Williams C. Social adaptation after cardiothoracic transplantation: a review of the literature. J Cardiovasc Nurs. 2005; 20(5 Suppl):S67–S73.

[68] Huda A, Newcomer R, Harrington C, Keeffe EB, Esquivel CO. Employment after liver transplantation: a review. Transplant Proc. 2015;47(2):233-239.

[69] Mata AJ, Garvey CA, Jacobs CL, Kahn JP. Non-directed donation of kidneys from living donors. New Engl J Med 2000, 343(6), 433-436.

[70] Simmons RG, Marine SK, Simmons RLSimmons RG. Gift of life: The social and psychological impact of organ transplantation. NY: Wiley, 1977. Reprinted with additions, Brunswick, NJ: Transaction Books,1987.

[71] Goetzmann L, Irani S, Moser KS, Schwegler K, Stamm M, Spindler A, et al. Goetzmann Psychological processing of transplantation in lung recipients: a quantitative study of organ integration and the relationship to the donor. Br J Health Psychol. 2009; 14(pt 4):667-680.

[72] Heinrich TW, Marcangelo M. Psychiatric issues in solid organ transplantation. Harv Rev Psychiatry. 2009;17(6):398-406.

[73] Smith GC, Trauer T, Kerr PG, Chadban SJ. Prospective psychosocial monitoring of living kidney donors using the Short Form-36 Health Survey: Results at 12 months. Transplantation 2004, 78(9), 1384-1389.

[74] Olbrisch ME, Benedict SM, Cropsey KL. Psychological, social and behavioral characteristics of living donor candidates for adult liver transplantation. Biennial meeting on Psychiatric, Psychosocial and Ethical Issues in Organ Transplantation, February, 2005, Santa Monica, CA.

[75] Hirvas J, Enckell M, Kuhlback B, Pasternack A. Psychological and social

problems encountered in active treatments of chronic uraemia. The living donor. ActaMedicaScandinavica, 1976, 200, 17-20.

[76] Simmons RG, Anderson CR. Related donors and recipients: five to nine years post-transplant. Transplant Proc 1982, 14, 9-12.

[77] Simmons RG. Related donors: Costs and gains. Transplant Proc 1977, 9, 143-145.

[78] Chevrollier GS, McCune K, Sha AP, Live Donor Nephrectomy; Contemporary Kidney Transplantation pp1-21, Organ and Tissue Transplantation Springer International Publishing AG, part of Springer Nature 2018 C.G.B. Ramirez, J. McCauley (eds.).

[79] Doria C, Margetich L; Recipient Renal Transplantation pp1-11, Contemporary Kidney Transplantation pp1-21, Organ and Tissue Transplantation Springer International Publishing AG, part of Springer Nature 2018 C.G.B. Ramirez, J. McCauley (eds.)

[80] McCauley J,A History of Kidney Transplantation, Contemporary Kidney Transplantation pp1-23, Organ and Tissue Transplantation Springer International Publishing AG, part of Springer Nature 2018 C.G.B. Ramirez, J. McCauley (eds.)

[81] Kasiske BL,Cangro CB, Hariharan S et al. The evaluation of renal transplant candidates: clinical practice guidelines. Am J Transplant 2001;1 [Suppl 2]:1-95.

[82] Khan T, Kamal S, Koshaji B, et al. Delayed graft function in living donor kidney transplantation. Ann Transplant, 2013;18:434-5.

[83] Davidson B, Du Toit T, Jones ESW, Barday Z, Manning K, Curdie F, et al. (2019) Outcomes and challenges of a kidney transplant programme at Groote Schuur Hospital, Cape Town: A South African perspective. *PLOS ONE* 14(1): e0211189. https://doi.org/10.1371/journal.pone.0211189

[84] Bakari AA, Jimeta USA, Abubakar MA, Alhassan SU, Nwankwo EA. Organ Transplantation: Legal, Ethical and Islamic Perspective in Nigeria. Nigerian Journal of Surgery 2012; 18 (2): 53 – 60.

[85] Boima V, Ganu V, Dey V, Yorke E, Yawson A, Otchere Y, et al. Kidney transplantation in Ghana; Is the public ready? Clin Transplant 2017; 31(10). doi: 10.1111/ctr.13061.

[86] Kim I, Noh H, Ji E, Hong SH, Ha J, Burckart et. al.Identification of factors affecting tacrolimus level and 5- year clinical outcome in kidney transplant patients. Basic clin pharmacol toxicol 2012;111:217-223 https://doi.org/10.1111/j.1742-7843.2012.00892.x

[87] Hu RH, Lee PH, Tsai MK. Clinical influencing factors for daily dose, trough level, and relative clearance of tacrolimus in renal transplant recipients. Transplant Proc 2000;32: 1689-1692.

[88] Fitzsimmons WE, Bekersky I, Dressler D, Raye K, Hodosh E, Mekki Q. Demographic considerations in tacrolimus pharmacokinetics. Transplant Proc. 1998;30: 1359-1364.

[89] Braun F, Schütz E, Christians U, Lorf T, Schiffmann JH, Armstrong VW, et al. Pitfalls in monitoring tacrolimus (FK 506). Ther Drug Monit 1997;19:628-31.

[90] Dirks NL, Huth B, Yates CR, Meibohm B. Pharmacokinetics of immunosuppressants: a perspective on ethnic differences. International journal of clinical pharmacology and therapeutics 2004;42:701-718.

[91] Neylan, JF. Racial differences in renal transplantation after immunosuppression with tacrolimus versus cyclosporine. FK506 Kidney Transplant Study Group. Transplantation 1998;65:515-23.

[92] Leichtman AB, Cohen D, Keith D, O'Connor KO, Goldstein M, McBride V. et al. Kidney and pancreas transplantation in the United States,1997-2006: the HRSA Breakthrough Collaboratives and the 58 DSA Challenge. Am J Transplant, 2008 8(Part 2): 946 – 957.

[93] Muller E, White SL, Delmonico F. Regional perspective; Developing organ transplantation in Sub-Saharan Africa. Transplantation 2014, 97(10): 975-976.

[94] World Bank. Poverty and Equity Brief – Sub Saharan Africa. (Internet). 2020. Available from: https://databank.worldbank.org/data/download/poverty/33EF03BB-9722-4AE2-ABC7-AA2972D68AFE/Global_POVEQ_SSA.pdf (Accessed 10th October 2020).

[95] Arogundade FA. Kidney transplantation in a low-resource setting: Nigeria experience. Kidney Int Suppl (2013) 3:241-245.

[96] Sub-Saharan Africa Unemployment Rate 1991-2020. (Internet). 2020. Available from: https://www.macrotrends.net/countries/SSF/sub-saharan-africa-/unemployment-rate (Accessed 10th October 2020).

[97] The declaration of Istanbul on organ trafficking and transplant tourism. Kidney International (2008) 74, 854-859; doi:10.1038/ki.2008.388.

[98] O'Connell PJ, Brown M, Chan TM, Granado RC, Davies SJ, Eiam-Ong S *et. al*. The role of kidney transplantation as a component of integrated care for chronic kidney disease. Kidney International Supplements (2020) 10, e78–e85; https://doi.org/10.1016/j.kisu.2019.11.006

[99] Lavee J, Ashkenazi T, Stoler A, Cohen J, Beyar R. Preliminary marked increase in the national organ donation rate in Israel following implementation of a new organ transplantation law. Am J Transplant 2013;13(3):780-785. https://doi.org/10.1111/ajt.12001

[100] Lavee J, Brock DW. Prioritizing registered donors in organ allocation: an ethical appraisal of the Israeli organ transplant law. Curr Opin Crit Care 2012, 18:000-000. DOI:10.1097/MCC.0b013e328357a2e2

[101] Akoh JA. Renal transplantation in developing countries. Saudi J Kidney Dis Transpl 2011;22(4):637-650.

[102] Chugh KS, Jha V. Problems and outcomes of living unrelated donor transplants in the developing countries. Kidney Int 2000;57: S131-5.

[103] Rizvi A, Naqvi A. Need for increasing transplant activity: A sustainable model for developing countries. Transplant Proc 1997; 29:1560-1562.

[104] Rizvi SAH, Naqvi SAA, Zafar MN et al: A Renal Transplantation Model for developing countries. Am J Transplant 2011: 11: 2302-2307.

[105] Ghods AJ, Savaj S. Iranian Model of Paid and Regulated Living-Unrelated Kidney Donation. *Clin J Am Soc Nephrol* 1: 1136-1145, 2006. doi: 10.2215/CJN.00700206

[106] WHA57/18. Human organ and tissue transplantation. In: Fifty-seventh World Health Assembly, Geneva, 17-22 May 2004. Resolutions and Decisions. Geneva: World Health Organization; 2010. (Internet). Available from: https://apps.who.int/gb/ebwha/pdf_files/WHA57/A57_R18-en.pdf (Accessed 23rd September).

[107] WHA63/22. Human organ and tissue transplantation. In: Sixty-third World Health Assembly, Geneva, 17-21 May 2010. Geneva: World Health Organization; 2010. (Internet). Available from: https://apps.who.int/gb/ebwha/pdf_files/WHA63/A63_R22-en.pdf?ua=1 (Accessed 23rd September).

[108] WHO Guiding Principles on human cell, tissue and organ transplantation. Geneva: World Health Organization; 2010. (Internet). Available from: https://www.who.int/transplantation/Guiding_principlestransplantation_WHA63.22en.pdf?Ua=1 (Accessed 29th September 2020).

[109] United Nations General Assembly Resolution 71/322. Strengthening and promoting effective measures and international cooperation on organ donation and transplantation to prevent and combat trafficking in persons for the purpose of organ removal and trafficking in human organs. 2017 (Internet) Available from: https://undocs.org/pdf?symbol=en/A/RES/71/322 (Accessed 29th September 2020).

[110] WHO Task Force on Donation and Transplantation of Human Organs and Tissues. 2017 (). Available from: https://www.who.int/transplantation/donation/taskforce-transplantation/en/ (Accessed 29th September 2020).

[111] Davids MR, Eastwood JB, Selwood NH, Arogundade FA, Ashuntantang G, Benghanem Gharbi M, et al. A renal registry for Africa: first steps. Clinical Kidney Journal, vol. 9, no. 1, 162-167; 2016