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An Overview of the Risk Factors and Socio-Economic Impact of End-Stage Renal Disease Management

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Abstract

The end-stage renal disease (ESRD) is an emerging public health problem associated with morbidity and mortality. This paper is a narrative review (qualitative and quantitative) of studies on the socio-economic impact of ESRD management to bring to the attention of relevant stakeholders the risk factors, various consequences of the disease, and the need to provide sustainable, cost-effective interventions for prevention, early diagnosis of cases and timely commencement of management. The development of ESRD and the impact of management of patients with ESRD depends on the interrelated factors and influence of the healthcare system, the lifestyle, biological factors, genetic factors, and the physical and social environment. The major risk factors for developing ESRD are hypertension and diabetes mellitus which are known to have familial linkage and exposure to modifiable risk factors like sedentary lifestyle, smoking, and alcohol ingestion. The diagnosis of the disease is based on laboratory parameters and the availability of trained healthcare workers capable of detecting signs, and symptoms and interpreting the laboratory results. Timely referral of cases is critical in salvaging the kidney's functions. Hemodialysis or renal transplant are the management options for ESRD. The cost is unacceptably high, the number of facilities providing these services is currently unable to meet the demand of many patients, and there is a general lack of trained personnel capable of providing the needed services. The government and relevant stakeholders should ensure free or subsidized, services, an increased number of centers providing quality services, community and facility-based screening, and preventive intervention strategies.

Keywords: Hemodialysis, Chronic Kidney Disease, End-Stage Renal Disease, Socio-Economic burden, Kidney Transplant, Risk factors of kidney disease.

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INTRODUCTION

The end-stage renal disease (ESRD) is an important public health problem worldwide (Olanrewaju et al., 2020). The Global Burden of Disease (GBD) study ranked chronic Kidney Disease (CKD) which is the common cause of ESRD as the 19th leading cause of morbidity and mortality in 2013 (Olanrewaju et al., 2020). Globally, the age-standardized prevalence of CKD was 10.4% among men and 10% among women and was higher in low- and middle-income countries than in developed countries (Olanrewaju et al., 2020). In sub-Saharan Africa (SSA), systematic reviews found a prevalence of 13.9%, and 10.1% (Olanrewaju *et al*., 2020); The aggregated prevalence of CKD resulting in ESRD was 16% in West Africa, the highest in the African continent. The ESRD in Africa is characterized by the young age of patients, morbidity and early deaths. About 90% of patients with CKD die within 90 days of starting dialysis (Olanrewaju *et al*., 2020).

Hypertension and diabetes mellitus are the two major causes of CKD worldwide (Ijezie et al., 2018). However, chronic glomerulonephritis and interstitial nephritis are the major causes of CKD in developing countries of the world (Ijezie *et al*., 2018). This is a reflection of the high prevalence of bacterial, parasitic, and viral infections that affect the kidneys in these countries (Ijezie *et al*., 2018). The prevalence of CKD is also increasing at a more rapid rate in developing countries (Ijezie *et al*., 2018). These differences between the developed and the developing countries are due to the fact that the burden of CKD is moving away from communicable diseases and toward chronic non-communicable diseases (NCDs) in the developed countries of the world. However, in developing countries, there is a double burden of communicable diseases and NCDs (Ijezie *et al*., 2018). The attention being paid globally to CKD is attributable to five factors: the rapid increase in its prevalence, the enormous cost of treatment, recent data indicating that overt disease is the tip of an iceberg of covert disease, an appreciation of its major role in increasing the risk of cardiovascular disease, and the discovery of effective measures to prevent its progression(Ijezie *et al.,* 2018).

Over the last twenty years, the concept and techniques of renal replacement therapy for patients with ESRD continue to evolve, including the availability, and approaches in the management of patients with kidney failure. The available management approaches for renal replacement apart from kidney transplant include: peritoneal dialysis, intermittent haemodialysis and continuous renal replacement therapies Pannu, & Gibney., 2005). The choice of method depends on availability, cost, physician expertise, haemodynamic stability and the main purpose of the procedure (Pannu, & Gibney., 2005). Hemodialysis is indicated among patients with ESRD having a fall in GFR to <10 ml/min with solute imbalance/toxicity or volume overload including but not limited to diuretic resistant pulmonary oedema; hyperkalaemia refractory to medical therapy, metabolic acidosis refractory to medical therapy, uremic complications like pericarditis, encephalopathy and bleeding, dialyzable intoxications, for example, lithium, toxic alcohols and salicylates (Pannu , & Gibney ., 2005).
The National Kidney Foundation suggested the screening of individuals at increased risk of developing kidney disease and the American Diabetes Association advocates annual screening of diabetic patients (Wu *et al*., 2013).Urine dipstick for proteinuria is widely applied as the screening method to detect CKD, and while it is cheaper, it is also less sensitive. Methods to detect micro-albuminuria, on the other hand, are widely used in screening high-risk populations (Wu et al., 2013) .With earlier detection and intervention for kidney disease patients, it is more likely that disease progression will be prevented (Wu *et al*., 2013).

ESRD of unknown etiology mainly affects young working-age adults and is often fatal due to rapid disease progression and a lack of dialysis or renal transplant options in the affected areas(Fiseha & Osborne, 2023). It has resulted in thousands of deaths and placed an enormous

burden on communities and healthcare systems, and is now recognized as a serious public health concern requiring urgent action(Fiseha & Osborne., 2023). In Nigeria, CKD and consequent ESRD are increasingly recognized as a major public health threat mainly affecting young adults in their economically productive years, and seem to be of a more severe form than in developed countries (Fiseha & Osborne., 2023).

Race, sex, age and family history are important risk factors of CKD which can eventually lead to ESRD (Kazancioğlu., 2013). For example, African– Americans, old age, low birth weight and family history of kidney disease are considered to be risk factors for kidney diseases (Kazancioğlu., 2013). Similarly, obesity, HTN, diabetes mellitus, exposure to heavy metals, excessive alcohol consumption, smoking and over-the-counter use of analgesic medications also constitute risks for CKD, and eventually ESRD (Zhou *et al*., 2012).

Screening and intervention can prevent kidney diseases, and where management strategies have been implemented, the incidence of kidney diseases has been reduced. Awareness of the disorder, however, remains low in many communities (Wu HY *et al*., 2013). At the primary healthcare level, a good approach that could help in the identification and prompt management of kidney diseases on time is required (Ibrahim *et al*., 2023). Hemodialysis is one of the management options for renal replacement therapy among patients with kidney diseases (Ibrahim UM *et al*., 2023). It can be utilized permanently for ESRD, which must continue for life unless a successful kidney transplant is done (Annigeri *et al*., 2017)
.
The ESRD and death from kidney diseases depend on age and comorbidities which act as modifiers of the aetiology and the quality of nephrology care helps to improve survival (Sanyaolu A *et al*., 2018). However, clinicians in developing countries including Nigeria and particularly the north-western part of the country are faced with challenges due to limited resources, lack of trained staff and equipment, cultural and socioeconomic barriers to early health-seeking behaviour, administrative barriers and government apathy to provision and maintenance of dialysis centres (Hallan , & Stevens ., 2010).

ESRD care is especially challenging in Nigeria, with large numbers of ESRD patients, inadequate facilities and funding, and a lack of renal registries(Fiseha & Osborne, 2023). Even in wealthier country South Africa, the majority of people who develop ESRD are not offered RRT because of scarce resources; social factors related to poverty and established protocols which accept only young patients without significant comorbid disease (Fiseha & Osborne, 2023). Thus, implementing cost-effective preventive interventions against ESRD is the only realistic solution for Africa and Nigeria (Fiseha & Osborne., 2023).

This review therefore is to assess the risk factors using the health-field model, and socio-economic impact of managing ESRD patients. It is important to guide future research and policy formulation in the direction of prevention, early detection and quality management of patients with ESRD patients. Similarly, it can identify a gap and therefore can serve as a foundation of scientific research.

MANAGEMENT OPTIONS FOR ESRD

CKD is defined as an eGFR <60 mL/min/1.73m^2 or the presence of proteinuria (1+ or greater dipstick proteinuria) (Muiru et al., 2020). Individuals with CKD were further classified into stages 1–5 according to the 2012 Kidney Disease: Improving Global Outcomes CKD guidelines: Stage 1: eGFR ≥90mL/min/1.73m^2 and proteinuria; stage 2: eGFR 60–89 mL/min/1.73m^2 and proteinuria; stage 3–5: eGFR <60 ml/min/1.73m^2 regardless of proteinuria(Muiru et al., 2020).

Over the last two decades, there has been an evolution in the field of renal replacement therapy and consequently the approaches in the treatment of kidney failure patients(Ibrahim *et al*, 2023). The available management modalities of renal replacement apart from kidney transplant include: peritoneal dialysis, intermittent haemodialysis and continuous renal replacement therapies (Ibrahim UM et al., 2023). The choice of modality is dependent on several factors including availability, cost, physician expertise, haemodynamic stability and the primary purpose of the procedure (Pannu N, &Gibney RN., 2005).

Dialysis treatment can be provided at home (peritoneal dialysis (PD) or home haemodialysis (HHD)), or as in-centre haemodialysis (ICHD) at a satellite dialysis unit or hospital. Conservative care is an alternative to RRT for patients who would not have a survival or quality of life benefit from RRT or who choose not to receive RRT, and only provides a means for the management of symptoms associated with CKD(Id *et al*., 2020).

RISK FACTORS OF ESRD

The development of ESRD and the impact of management of the patients with ESRD depends on the interrelated factors and influence of the healthcare system, the lifestyle, biological factors, genetic factors, and the physical and social environment as depicted by a health-field model in Figure 1(Bhutia., 2014).

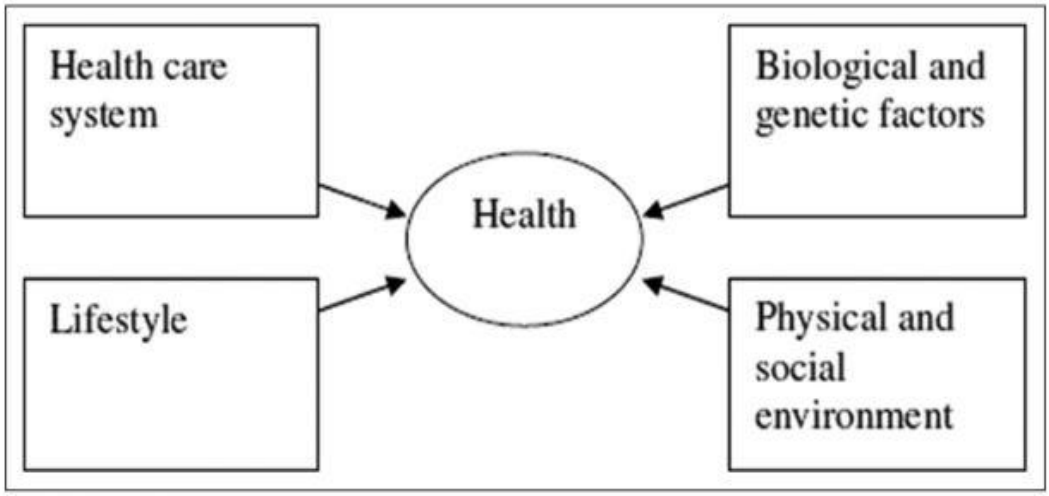

Figure 1: Lalonde Basic Health Field Model

Genetic Factors

Older age is associated with the risk of developing CKD, (Ji, 2019). The prevalence of CKD stages III–V was 27.5% in the 60–69 years age group, 36.5% in the 70–79 years age group, and 40% in the ≥80 year's age group (Malekmakan *et al*., 2013). The gene and or family history was reported to be an important facilitator of developing CKD (Anna *et al*., 2011). For example, heterozygosity to APOL 1 gene protects from infection with Trypanosoma brucei rhodesiense, and therefore, modifier loci can influence APOL1 risk for the development of kidney disease, (Kruzel-davila *et al*., 2016). A systematic review reported the observed risk factors to be old age and family history of renal disease (Ogah *et al*., 2018).

In a similar development reported by the CDC, the risk factors identified include heart disease, obesity, a family history of CKD, inherited kidney disorders, past damage to the kidneys, and older age. It is also slightly more common in women (14%) than men (12%). CKD is more common in non-Hispanic Black adults (16%) than in non-Hispanic White adults (13%)

or non-Hispanic Asian adults (13%). About 14% of Hispanic adults have CKD (CDC, 2021). Prevalence rates for CKD in adults were 4.8% overall with 1.6% during 2006 to 2009, 5.7% during 2010 to 2013, and 8.4% during 2014 to 2017 (P < .001) (Tuttle *et al*., 2019).

On the other hand, among the elderly participants (age, ≥ 65 years) had higher the odds of lower eGFR (Takamatsu *et al*., 2009). The odd ratio (OR) of developing CKD increased progressively with age, being 2.68 among the elderly with 65 years or more (95%CI 1.75 – 4.09) (Lilian *et al*., 2020). Among Sudanese patients, the minimum age at which disease was diagnosed was 13 years while maximum was 67 years, (Ahmed *et al*., 2019).

In Ekiti University Teaching Hospital, Nigeria, The age of the patient was also found to be statistically significantly associated with CKD when separately investigated (Sa, Aj, Aa, Oe, & Ro, 2019). In Bayelsa State, Nigeria, age >50 years was associated with CKD in univariate analysis but none of age, gender, body mass index, BP or hyperglycemia independently predicted it (Egbi *et al*., 2020).

Education, Occupational Status and Healthcare Factors

Diseases causing chronic kidney failure, such as diabetes mellitus, hypertension, systemic lupus erythematosus, and human immunodeficiency virus-associated nephropathy, are particularly prevalent among African-American patients. In addition to the higher prevalence, the morbidity associated with kidney complications of these diseases appears worse in African-American patients. African Americans also have worse outcomes and a relatively reduced access to kidney transplantation-the best therapy for ESRD (Chike *et al*., 2002).

Reports by CDC on risk of CKD among Americans pointed out that, diabetes and high blood pressure are the more common causes of CKD in adults (CDC, 2021). Of 1973 258 adults (75.1%) at risk, one-quarter had diabetes or prediabetes (512 299 [26.0%]), nearly half had hypertension (955812 [48.4%]), and one-quarter had both hypertension and diabetes or prediabetes (505 147 [25.6%]), (CDC, 2021). It was also found that those with CKD were more likely to come from families of unskilled workers. Moreover, NHANES results show that unemployed non-Hispanic blacks and Mexican Americans in the United States had twice more CKD prevalence than their employed counterparts. In the ARIC study those with less than high school education had 1.7 times CKD risk in comparison with those with college education (Kazanciog *et al*., 2013).

The CKD prevalence was 5.6% using the standard definition, 10.6% using only people captured by the laboratory data and 10.6% using the capture-recapture method. Of the identified cases, 46% were at high risk of progression to end-stage kidney disease (ESKD), 41% were at low risk and 13% were not classified, due to unavailable laboratory data. High risk cases had a higher burden of comorbid conditions. (Chartier *et al*.,2018)**.** The first cause of CKD for incident patients by another study was reported to be diabetes (25.0%), followed by vascular diseases (18.1%). For prevalent patients: glomerulonephritis is (16.5%), and diabetes (14.4%) were the main causes of CKD, (Díaz *et al*., 2011).

Among sickle cell disease patients (HbSS), 79 HbSS patients, 14 (18%), 28 (35%), 33 (42%) and 4 (5%) had stage 1, 2, 3 and 4 CKD, respectively. In the HbSC group, 3 (14%), 9 (43%) and 9 (43%) patients had stage 1, 2 and 3 CKD, respectively. Proteinuria was noted in 16 (20%) HbSS patients but not in any of the HbSC patients. Of the subjects aged ≤ 24 years (n = 49), 9 (18%), 18 (37%), 21 (43%) and 1 (2%) had stage 1, 2, 3 and 4 CKD, respectively. Of those aged >24 years (n = 51), 8 (16%), 19 (37%), 21 (41%) and 3 (6%) had stage 1, 2, 3 and 4 CKD, respectively. None of the subjects had stage 5 CKD (Akinola & Durosinmi, 2014).

It was found out that having health plans with OR = 1.51 (95%CI 1.28 – 1.78), as well as smoking, hypertension and high cholesterol and poor self-reported health respectively, showed a higher chance of CKD (Lilian Kelen de AguiarI & , Rogerio Ruscitto Prado, 2020). The mean time in dialysis among patients with CKD was 3.5 years (± 2.2), 48.1% were hypertensive, 11.1% were diabetics, and 34.6% presented association of the two clinical comorbidities. The development of chronic kidney disease and dependence on hemodialysis treatment in elderly patients represent challenges to health managers, professionals and family members (Mendonça *et al*., 2015), and the major psycho-social factors negatively influencing the acceptance of treatment were finance (69.3%), logistics (66.0%), no willing donors (11.0%), no medically fit donors (13.0%) and/or lack of social support (17.0%).

The prevalence of CKD was observed to be 17.2% with ~6% have CKD stage 3 or worse, (Singh *et al*., 2013). Similarly, The prevalence of chronic kidney disease among diabetic adults in North West Bank was found to be 23.6% (95% CI: 19.4–28.1%) divided as follows: 19.7% had stage 3 CKD, 2.6% had stage 4 CKD and 1.3% had stage 5 CKD. The CKD was significantly associated with Age ≥ 60 years [adjusted OR: 3.2, 95% CI: 1.8–5.9], hypertension [adjusted OR: 5.7, 95% CI: 2.2–15.2], and smoking [adjusted OR: 2.3, 95% CI: 1.3–4.2]. CKD was concluded to be very prevalent among diabetic adults in Palestine. Co-morbid hypertension, smoking and older age has been shown to increase the risk of developing CKD. Extensive screening for diabetic patients to diagnose CKD at an early stage and to follow more aggressive treatment methods for diabetes as well as other important risk factors, especially hypertension and smoking, is recommended (Nazzal, Hamdan, Masri, Abu-kaf, & Hamad, 2020). Hypertension, diabetes, anemia, hyperuricemia, hyperhomocysteinemia, hypertriglyceridemia, obesity, and LDL-C ≥ 4.1 mmol/L were found to be independently associated with the presence of CKD (Ji *et al*., 2019).

It was also identified that chronic glomerulonephritis (33%), hypertension (21.2%) and diabetes mellitus (22.2%) were found to be the leading causes of CKD. Common complications of CKD at presentation included anaemia (86.7%), pulmonary oedema (31%), high blood pressure (55%), and infection (Yaw *et al*., 2014). Similar to what was reported by a case-control study hypertension, smoking, and prevalent sample of older adults (Anthony *et al*., 2000). Similarly, the majority of the patients (40.8%) were worked up for and commenced on hemodialysis soon after presentation. Among the end-stage renal disease patient, only 7 (4.6%) had renal transplantation at referred centers. Focal segmental glomerulosclerosis was the commonest histological findings among the nephrotic syndrome patient while membranous nephropathy was documented in only 2 patients (Dada *et al*., 2019).

In Sudan, low levels of education together with low income level of employment are important factors related to ESRD (Ahmed *et al*., 2019). In the same vain, a systematic review of literature reported the major risk factors of CKD to be obesity, diabetes mellitus, hypertension, family history of hypertension, low-income occupation, and use of traditional medication, low hemoglobin, and abdominal obesity (Ogah *et al*., 2018).

Another study in Nigeria identified the overall prevalence of CKD to be 7.8%. The prevalence of some established CKD risk factors was old age, hypertension, 36.9%; diabetes mellitus, 7.9%; and family history of kidney disease, 6.4% (Okwuonu *et al*., 2017). Another Nigerian study conducted in rural and semi-urban communities in Southeast Nigeria reported 26.1% to have hypertension, 5.9% had DM, 10.4% had the metabolic syndrome, 14.9% were obese and 19% had proteinuria and/or hematuria with a prevalence of CKD to be 11.4% (Ulasi *et al*., 2013).

In Kwara State, North-Central zone of Nigeria, the age-adjusted prevalence of hypertension was 24%; diabetes 4%; obesity 8.7%; albuminuria of > 30 mg/L 7%; and dipstick proteinuria 13%. The age-adjusted prevalence of CKD by estimated GFR < 60 ml/min/1.73m2 and/or Proteinuria was 12%. Diabetes, obesity, proteinuria; female sex, and age were the identified predictors of CKD (Olanrewaju *et al*., 2020).

Another study involving newly- diagnosed, antiretroviral naïve patients with HIV/AIDS seen at the HIV clinic of the Medical Out-patient Department (MOPD) of University of Ilorin Teaching Hospital (UITH). CKD was observed in 47.6% among the patients and 16.7% of the controls. The median CD4 T-cell count was significantly lower in patients with CKD. Ninety-three (41.0%) of the (Dada *et al*., 2015) patients had dipstick proteinuria of ≥ 2. The CD4 T-cell count correlates positively with eGFR (r = 0.463, p = 0.001) and negatively with ACR (r = -0.806, p = 0.001) (Dada *et al*., 2015).

In Kano, a CKD risk factors screening study revealed majority had a positive history of use of traditional medications, followed by the use of analgesic drugs, while very few (less than 5% each) admitted to alcohol ingestion or use of bleaching creams. While there was a significant family history of hypertension and diabetes, only about 3% had positive family history of kidney disease. Proteinuria was found to be present in 19.4%. Other risk factors found include hypertension (29.8%), obesity (11%), and diabetes mellitus (3.6%) (Nalado *et al*., 2012).

Environmental Factors

Heavy Metals

Lead
Potential sources include lead paint (pre-1977), water from lead pipes, leaded gasoline, adulterated alcohol (moonshine), food contaminated during processing, and contamination of water, soil, and air in areas close to lead smelters, old mines, or garages (Obrador *et al*., 2017).

Cadmium
Potential sources include tobacco smoke, certain foods (seafood, cereals, and vegetables), nickel-cadmium batteries, fuel combustion, industrial and household waste, sewage, Indian medicinal herbs, and residence in contaminated areas (Obrador *et al*., 2017).

Arsenic
Potential sources include food contaminated by pesticides, seafood, groundwater, traditional remedies, and wood preservation products (Obrador *et al*., 2017).

Mercury
Potential sources include fish contamination from water, fuel combustion, contaminated water, whitening creams, dental amalgam (controversial), and cereals (treated with ethyl mercury as pesticide). A typical example from the1950s is Minamata disease in Japan, where the local food supply (mainlyfish) was contaminated by the water of Minamata Bay due to mercury-containing waste from a chemical factory (Obrador *et al*., 2017).

Uranium
Contaminated food or groundwater, uranium mining, dermal exposure in children playing in contaminated areas (Obrador *et al*., 2017).

Exposure to occupational chemicals and toxic substances other than metals, such as methylene chloride, carbon tetrachloride, trichloroethylene, toluene, and arsine gas, may lead to acute tubular necrosis, although CKD has rarely been reported; exposure to occupational solvents accelerates the progression of underlying kidney disease even if the primary lesion is unrelated to the exposure (Obrador *et al*., 2017). Toxic elements such as arsenic, cadmium, lead, and mercury are typically found in drinking water, foods, dust, fish, dental amalgams, consumer products, and old pesticides (Sears & Genuis, 2012).

A cross-sectional study was conducted to determine the prevalence estimate of CKDu in male rice farmers in West Java, Indonesia; and analyze the relationship between CKDu and environmental and occupational factors. The overall prevalence of CKD was 24.9% and CKDu was 18.6%. For the environmental factors, farm location (high altitude versus low altitude location) was associated with CKDu (Prevalence Odds Ratio (POR): 2.0; 95% CI: 1.2–3.5). For the occupational factors, although not significant, the risk of CKDu increased with the longer use of insecticide and with the more frequent of insecticide use (Fitria *et al*., 2020).
A case-control study that evaluated the relationships between key demographic, cultural, and occupational variables as risk factors for CKDu in Sri Lanka, with a primary interest in pesticide exposure both occupationally and through its potential use as an ingredient in brewed kasippu alcohol. Occupational pesticide exposure and alcohol consumption were not found to be significant risk factors for CKDu. However, a statistically significant association with CKDu was observed with chewing betel, age, owning a pet dog, water treatment and pests in the house (Pry *et al*., 2021).

Air Pollution

A nationally representative sample of 101,919 deaths from kidney diseases was collected from the Chinese Center for Disease Control and Prevention from 2015 to 2019. Each 10 $\mu g/m^3$ increment in lag 0–1 mean concentrations of air pollutants was associated with a percent increase in death from kidney disease: 1.33% (95% confidence interval [CI]: 0.57% to 2.1%) for PM_1, 0.49% (95% CI: 0.10% to 0.88%) for $PM_{2.5}$, 0.32% (95% CI: 0.08% to 0.57%) for PM_{10}, 1.26% (95% CI: 0.29% to 2.24%) for NO_2, and 2.9% (95% CI: 1.68% to 4.15%) for SO_2, (Cai *et al*., 2023).

Water Quality

A study conducted in Srilanka following Physico-chemistry of more than 50% of the water samples revealed higher electric conductivity, salinity, total dissolved solids, total hardness and Na levels compared to drinking water standards in Sri Lanka (Gobalarajah *et al*.,2020). The relationships between exposure to environmental contaminants in water and chronic kidney disease (CKD) was investigated, and the associations of 61 water attributes with the prevalence of CKD and ESRD using data from 2005 to 2011 from all 22 counties and cities in the main island of Taiwan. A total of over 45,000 observations obtained from the Taiwan Environmental Water Quality Information Database. The association analysis adjusting for gender, age, and annual effects showed that the zinc (Zn), ammonia, chemical oxygen demand (COD), and dissolved oxygen in rivers were weakly correlated with CKD, but none for ESRD. Moreover, an unusually high CKD prevalence was related to arsenic contamination in groundwater (Chang *et al*., 2018).

Pesticides and Agricultural Chemicals

Lower eGFR was observed among pesticide applicators who ever used the herbicides pendimethalin, atrazine, and dicamba compared with never users of each pesticide. Atrazine use within the last year was associated with lower eGFR and elevated odds of CKD when compared with never users, and observed exposure-response associations with intensity-

weighted lifetime days among recent users, while use of several other pesticides was associated with higher eGFR (Shearer *et al*., 2021).

Climatic Factors

Findings showed that with a 1°C increase in temperature, the risk of kidney-related morbidity increased by 1% (RR 1.010; 95% CI: 1.009–1.011), with the greatest risk for urolithiasis. Heat waves were also associated with increased morbidity with a trend observed with heat wave intensity. During low-intensity heat waves, there was an increase of 5.9% in morbidity, while during high-intensity heat waves there was a 7.7% increase. There were greater RRs for males, people aged ≤64 years, and those living in temperate climate zones. Similarly, for every 1 °C temperature increase, there was a 3% (RR 1.031; 95% CI: 1.018–1.045) increase in the risk of kidney-related mortality, which also increased during heat waves (Liu *et al*., 2021).

Occupational Exposure

The risk of CKD was found to be significantly associated with an increasing working conditions risk score. Individuals with a working conditions risk score of 4 had an 88.0% (95% CI = 1.05, 3.35) higher risk of developing CKD when compared to those with a working conditions risk score of 0 (Lan *et al*., 2023).

SOCIO-ECOMINC IMPACT OF ESRD AND ITSMANAGEMENT

Economic Impact of ESRD Management

The prevalence of treated ESRD in the United States has more than doubled in the past decade(Hsu, 2003). The population living with ESRD is projected to increase to 650,000 by the year 2010 with associated Medicare expenditures of $28 billion(Hsu, 2003). A scoping review reported that the annual societal and healthcare costs increased with the progression of each CKD stage, regardless of the cause of CKD or the country of origin(Id et al., 2020).

Across the world, the provision of health care is expensive, and countries face challenges about how to most efficiently deliver a package of health services(Etheredge & Fabian, 2017). Whether an upper-income country or a low-income country, governments are obliged to consider both the health needs of their populations(Etheredge & Fabian, 2017), and the fundamental premises of their national health policies, and provide health services and interventions on this basis. This requires rationing, which necessitates the prioritization of certain conditions over others, and perhaps the prioritization of preventative over curative care(Etheredge & Fabian., 2017).

ESRD is a disease condition that is covered by Medicare regardless of the individual's age or disability status(Hajj & Laudanski ., 2017). ESRD population accounts for less than 1% of the Medicare beneficiaries but utilizes around 7% of Medicare fee-for-service spending or around $33 billion. This constitutes a disproportionate share of the overall Medicare spending which is primarily reflecting the increase in the number of patients (Hajj & Laudanski ., 2017). Following the implementation of the bundled payment system (PPS), the fee for service of ESRD spending continued to grow modestly by around 3.3% in the year 2013–2014(Hajj & Laudanski, 2017). Several modes of dialysis can be offered in a variety of settings and applying certain policies may affect the changes long-term. However, early research completed a couple of years after the PPS implementation demonstrated a modest increase in the use of the Peritoneal dialysis (PD) modality but there was no effect on HHD (Hajj & Laudanski ., 2017). This is in striking contrast to Medicare stakeholders estimating that 50% of ESRD patients could be eligible for home dialysis. However, they set a more reasonable target of 25% which has not been attained (Hajj & Laudanski, 2017). Many impediments may currently preclude

the increase in the use of home hemodialysis treatment; and these are: (1) the nature of Medicare reimbursement to facilities; (2) the nature of Medicare reimbursement to physicians; and (3) the utilization of the Kidney Disease Education (KDE) benefits

The cost of management of ESRD is prohibitive (Ijoma et al, 2010.). In developing countries in places where RRT is available, it is unaffordable for most patients. In Nigeria as in most other developing countries, there is no social security system or health insurance scheme in place to assist the patient, and the burden is borne solely by the patient and relatives(Ijoma *et al*, 2010.). ESRD is a regional public health epidemic in sub-Saharan Africa with an unacceptably high cost of management(Agada-amade *et al* ., 2023). In Africa, the annual cost varies from $7,370 to $42,800 per patient (Agada-amade *et al*., 2023), far more than most African countries' gross national product (GDP) per capita. The cost of hemodialysis varies geographically and between the public and private providers of renal care services in Nigeria(Agada-amade *et al*., 2023). The cost per session ranges between $62 and $250 or an average of $744 to $3,000 monthly, assuming three times weekly sessions, while the monthly minimum wage in Nigeria is below $100(Agada-amade *et al*., 2023).

Caring for those with kidney disease is expensive(Saran et al., 2019). The total Medicare spending on CKD and ESRD patients exceeded $114 billion in 2016 (Saran *et al*., 2019). Accompanying chronic diseases such as diabetes and heart failure compound the cost of caring for these individuals(Saran *et al*., 2019). In sharp contrast to this high burden and cost, the USRDS continues to highlight low awareness about the presence of the condition among patients with laboratory evidence of early stages of kidney disease (CKD stages 1-3)(Saran *et al*., 2019). Encouragingly, in recent years, awareness has increased among those with CKD stage 4(Saran *et al*., 2019).

A scoping review of cost implications in the developed countries highlighted that From a health system perspective, the per-patient mean annual total health care costs ranged from $1,600 to $25,037 for patients with CKD stages 1–3, whereas patients with CKD stages 4–5 incurred higher costs ranging from $5,367 to $53,186(Id et al., 2020). ESRD costs were even higher, ranging from $20,110 to $100,593. From a societal perspective of financial cost, non-dialysis costs of CKD stages 1–3 were in the range of $4,803-$15,001, whereas CKD stages 4–5 showed the highest costs ranging from $10,750 to $28,428 in Europe(Id *et al*., 2020).

A study that reported the global cost implication of managing ESRD found that the annual direct costs associated with CKD management rose by an average factor of 4 in each country/region upon progression from stage G3a to G5(Jha & Guisen, 2023). Mean annual costs per patient increased considerably more from early stages versus dialysis (stage G3a, mean: $3060 versus hemodialysis, mean: $57,334; peritoneal dialysis, mean: $49,490); with estimates for annual costs of transplant also substantially higher (incident: $75,326; subsequent: $16,672)(Jha & Guisen, 2023). The mean annual per-patient costs of complications were $18,294 for myocardial infarction, $8463 for heart failure, $10,168 for stroke, and $5975 for acute kidney injury(Jha & Guisen, 2023). The costing definitions by the study varied significantly in granularity and/or definition across all countries/regions(Jha & Guisen, 2023).

A study conducted in Nigeria reported the mean direct cost of hemodialysis was $152.20 per session (providers: $123.69; and patients: $28.51) and $23,742.96 annually (providers: $19,295.64; and patients: $4,447.32) (Agada-amade *et al*., 2023). Additionally, patients spent an average of $2,968.23 managing comorbidities (Agada-amade *et al*., 2023). The drivers of providers' hemodialysis costs were personnel and supplies. Residing in other towns, lacking

health insurance, attending private health facilities, and having more than six hemodialysis sessions per month significantly increased the patient's out-of-pocket spending on hemodialysis and ESRD(Agada-amade *et a*l., 2023). It was proposed that twice-weekly dialysis to lowers the total cost of haemodialysis since twice-weekly dialysis has non-inferior survival rates compared with thrice-weekly therapy(Agada-amade *et al*., 2023). Other drivers of patient costs include comorbidities with additional chronic diseases, use of publicly owned university hospitals, attending private health facilities, age, residence environment, income and wealth index(Agada-amade *et al*., 2023).

A cross-sectional survey design was used to identify from both the healthcare provider and consumer perspectives and estimate the provider and patient direct costs of haemodialysis and managing ESRD in Abuja, Nigeria(Agada-amade *et al*., 2023). Data were collected from public and private tertiary hospitals (n = 6) and ESRD patients (n = 230) receiving haemodialysis in the selected hospitals(Agada-amade et al., 2023). The study estimated the direct providers' costs using fixed and variable costs. Patients' direct costs included drugs, laboratory services, transportation, feeding, and comorbidities. Additionally, data on the socio-demographic and clinical characteristics of patients were collected (Agada-amade *et al*., 2023). The costs were summarized in descriptive statistics using means and percentages. A generalized linear model (gamma with log link) was used to predict the patient characteristics associated with patients' cost of hemodialysis (Agada-amade *et al*., 2023). The mean direct cost of hemodialysis was $152.20 per session (providers: $123.69; and patients: $28.51) and $23,742.96 annually (providers: $19,295.64; and patients: $4,447.32). Additionally, patients spent an average of $2,968.23 managing comorbidities(Agada-amade *et al*., 2023).

The drivers of providers' hemodialysis costs were personnel and supplies. Residing in other towns (HD:$\beta = 0.55$, $\rho = 0.001$; ESRD:$\beta = 0.59$, $\rho = 0.004$), lacking health insurance (HD:$\beta = 0.24$, $\rho = 0.038$), attending private health facility (HD:$\beta = 0.46$, $\rho < 0.001$; ESRD: $\beta = 0.75$, $\rho < 0.001$), and greater than six hemodialysis sessions per month (HD:$\beta = 0.79$, $\rho < 0.001$; ESRD: $\beta = 0.99$, $\rho < 0.001$) significantly increased the patient's out-of-pocket spending on hemodialysis and ESRD (Agada-amade et al., 2023).

The economic impacts of managing patients with of ESRD patients are high, therefore, providing public subsidies for dialysis and expanding social health insurance coverage for ESRD patients might reduce the costs(Agada-amade *et al*., 2023).

Social Impact of ESRD Management

It has long been known that black Americans experience a disproportionate burden of ESRD in the United States com- pared with whites (Hsu, 2003), but the exact reasons for this remain unclear. Previous studies have shown that racial differences in age, the prevalence of diabetes and hypertension, socioeconomic status, and access to health care explain only part of the excess incidence of ESRD among blacks(Hsu, 2003).

In a recent international study, patients with ESRD who were receiving hemodialysis (HD) named the ability to work as one of their top ten priority outcomes (Kutner & Zhang, 2017). The ability to sustain employment is associated not only with economic benefits but also with benefits for an individual's sense of self-worth and maintenance of social relationships(Kutner & Zhang, 2017). However, employment is a life area that may be dramatically disrupted for individuals with kidney disease who require ongoing renal replacement therapy (RRT), especially those who receive maintenance dialysis. Most working-age persons with ESKD who initiate maintenance dialysis treatment were employed before the start of treatment, but

fewer than half of these persons report being "able" to work after RRT is initiated(Kutner & Zhang, 2017).

In Africa, CKD and consequent ESRD is increasingly recognized as a major public health threat mainly affecting young adults in their economically productive years, and seem to be of a more severe form than in developed countries(Fiseha & Osborne, 2023). ESRD care is especially challenging in Africa, with large numbers of ESRD patients, inadequate facilities and funding, and lack of renal registries(Fiseha & Osborne, 2023). Even in wealthier countries like South Africa, the majority of people who develop ESRD were not offered RRT because of scarce resources; social factors related to poverty, and established protocols that accept only young patients without significant comorbid disease(Fiseha & Osborne, 2023).

In Nigeria, the situation is such that CKD represents about 8–10% of hospital admissions (Ijoma et al, 2010.). This may be a huge underrepresentation of the true situation(Ijoma et al, 2010.). It is well known that CKD is under-recognized and underdiagnosed, patients with end-stage renal failure (ESRD) are thought to represent the tip of the iceberg of the entire burden of CKD(Ijoma et al, 2010.). This is more so in developing countries where patients often present late or not at all to health facilities for several reasons which range from prohibitive cost of health care services to use of alternative treatment like spiritual healing and traditional/native healers(Ijoma *et al*., 2010.).

Management of ESRD is a lifelong treatment that significantly and sometimes adversely affects patients' physical and mental abilities, with depression, anxiety, and fatigue being common issues(Stavropoulou *et al*., 2017). There are also a plethora of additional stressors, including biochemical imbalance, physiological changes, neurological disturbances, cognitive impairment, and sexual dysfunction, all associated with ESRD (Stavropoulou *et al*., 2017). For hemodialysis, patients who spend a considerable portion of their life receiving treatment, nursing care is of pivotal importance, and the identification of the bottlenecks hampering nursing care would contribute to an ameliorated relationship between nephrology nurses and patients and inevitably, to a better quality of life for the latter. However, literature is scarce on the experience and beliefs of ESRD patients receiving care(Stavropoulou *et al*., 2017).

The nursing care offered to hemodialysis patients entails unique characteristics in relation to other nursing plans. Frequent patient visits (usually three times a week) lead to an increased proximity to the nursing staff (Stavropoulou *et al*., 2017). Moreover, the clinical environment where hemodialysis nurses are called to serve is demanding and stressful, leading many nurses to develop burnout syndrome (Stavropoulou *et al*., 2017). In particular, one of the main obstacles to the provision of nursing care among ESRD patients concerns the increased workload, augmented by various factors such as the need for different care services, the limited number of employed nurses and other health professionals, and the lack of a strategy for systematic education and guidance of patients (Stavropoulou *et al*., 2017). However, according to a cohort study performed among 320 hemodialysis patients from 14 general hospitals situated in Athens and the peninsula of Peloponnese, the majority of patients reported satisfaction with regard to the availability of information prior to the initiation of hemodialysis and the provision of nursing care(Stavropoulou *et al*., 2017). Moreover, patients were very/extremely satisfied with the provided care in terms of the duration of the changing sera/intravenous solutions, the kindness and empathy expressed by nurses, as well as their professionalism and applied techniques, throughout the provided care (Stavropoulou *et al*., 2017). However, some international studies have reported a lack of information concerning the available treatments (Stavropoulou *et al*., 2017), and low satisfaction with the provided nursing care(Stavropoulou *et al*., 2017).

Medical Impact of ESRD Management

ESRD patients face a lifelong burden and the nature of this burden is very much dependent on the treatment modality(Hajj & Laudanski., 2017). Home hemodialysis (HHD) may lessen the patient's disease burden and improve quality of life while preserving clinical measures of success but it remains underutilized(Hajj & Laudanski., 2017).

According to data from the National Health and Nutrition Examination Survey (NHANES), the prevalence of CKD among US adults is estimated at just fewer than 15%, indicating that over 30 million American adults may have CKD(Saran *et al*., 2019). This is likely due to the high prevalence of risk factors for the disease, including an ageing population, diabetes, hypertension, obesity, cardiovascular disease, and other conditions (Saran *et al*., 2019).

The trend in falling hospitalization rates is shown to be countered by rising rates of emergency room visits and short-term observation stays for those on dialysis (Saran *et al*., 2019). People with CKD are also subject to additional risks, most notably a substantially increased risk of cardiovascular disease and death(Weiner., 2010). This is most marked in the dialysis population, where the cardiovascular death risk for a 20-year-old receiving dialysis is identical to that of an 80-year-old in the general population(Weiner., 2010). Even in earlier stages of CKD, there is a significantly increased risk of cardiovascular disease, for both de novo and recurrent cardiovascular events(Weiner., 2010).

Once these individuals are receiving dialysis therapies for ESRD, attempts to modify cardiovascular risk have largely been discouraging (Weiner., 2010). This reflects several factors: 1) there are multiple competing risk factors for mortality in dialysis patients and modification of a single factor may have a limited impact on overall risk; 2) dialysis patients have been excluded from general population studies of cardiovascular interventions; and 3) few adequately powered trials have been conducted examining risk factor modification in dialysis patients(Weiner, 2010).

CONCLUSION

Managing patients with ESRD is a huge challenge in Nigeria. This has medical, social, financial and psycho-social consequences. Potentially, hypertension and diabetes are the major risk factors for developing ESRD which when properly managed, or when identified early, can significantly reduce the burden of kidney damage that can facilitate the development of ESRD. Management of ESRD is not covered by the National Health Insurance, as such out-of-pocket payment is the major way of financing and seeking care even among those employed in the formal sectors. The out-of-pocket payment invariably predisposes to financial catastrophe among the patients with resulting socio-economic and psycho-social consequences. The government should consider: subsidizing management of ESRD patients, inclusion of ESRD in the National Health Insurance coverage for enrollees, and development of policy and guidelines that can support the lower cadre healthcare workers to screen for risk factors and refer patients for prompt management and improved social mobilization and communities' engagement to adopt behavior change for the prevention of risk factors.

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