IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Systematic Review And Meta-Analysis Of The Epidemiology Of Chronic Kidney Disease In Nigeria

Apiyanteide F[1], Nwose EU[2], Ofili CC[1], Digban K[1]

[1]Public & Community Health Department, Novena University Ogume, Nigeria

[2]School of Health & Medical Science, University of Southern Queensland, Australia

ABSTRACT

Despite the high mortality and financial burden associated with Chronic Kidney Disease (CKD) in Nigeria, gaps still exist on the epidemiology and management of this non-communicable disease in the country. This study sought to estimate the prevalence of CKD and its distribution in Nigeria using a Systematic Review and Meta-analysis of community-based studies that were conducted across the six geopolitical zones of the country. The study employed global best standards and practices in conducting systematic review and meta-analysis. This involved drafting and registration of the work into PROSPERO which was which was reviewed and assigned the registration number: CRD42023441374; adherence to acceptable research philosophies, and use of the PRISMA Framework for identification, screening and selection of quality studies included in the review. The PECO question was raised to guide the study and search for key words while Zotero software was used to manage information that was transferred to Excel sheet (data extraction) before data analysis was done with Medcal Software version 20.009. A total of ten (10) studies that meet the inclusion criteria set in the protocol were used for the meta-regression. Seven thousand and ten (7,010) individuals formed the sample size for the study from the 10 selected articles across the six geopolitical zones of Nigeria. Test for heterogeneity was conducted using the Cochrane's Q while test for publication bias was conducted using the Eggers and Begg's test. Result showed that there was significant heterogeneity among the studies across the six geopolitical zones of the nation (P = 0.0001) despite low publication bias noted among the studies (P = 0.8510). This informed the use of the random effect model for the estimation of the pooled prevalence of CKD in Nigeria. The prevalence of CKD in Nigeria was found to be 15.432% (95% CI: 12.291% to 18.860%) which translates to 17,811,828 (95% CI: 14,186,442 to 21,768,473) Nigerians living with the condition. There is therefore an urgent need to scale up public health efforts such as health education and awareness creation against risk factors of the disease, health system strengthening, and innovations needed to manage the high burden of CKD in Nigeria.

Key Words: Chronic Kidney Disease, Pooled Prevalence, Systematic Review and Meta-analysis, Nigeria, Health Systems Strengthening

INTRODUCTION

Chronic kidney disease (CKD) is defined as an estimated glomerular filtration rate (eGFR) less than 60 ml/ min/1.73 m^2 for ≥ 3months and/or a urinary albumin to creatinine ratio (ACR) greater than or equal to 30 mg/g (Levey et al., 2007; Lv & Zhang, 2019), is a significant source of concern in medical practice that has been

recognized as one of the major silent killers responsible for deterioration in health of populations in the 21st century (Kovesdy, 2022).

Globally, the prevalence of chronic kidney disease is 13.4% (Lv & Zhnage, 2019) and from 1990 – 2017, an estimated 697.5 million cases and 1.2 million deaths due to CKD have been reported (Carney, 2020). Over this period, there has been a 41.5% rise in CKD globally and the condition accounted for 35.8 million DALYS (Carney, 2020). Hill et al. (2016) in their meta-analysis of the global prevalence of CKD recorded a prevalence of 11 – 13% with most of the cases in stage 3. In Sub-Saharan Africa, Stanifer et al. (2014) reported a prevalence of 13.9% (95% CI 12.2 -15.7). In Africa, Kaze et al. (2018) estimated a prevalence of 15.8% (95% CI 12.1 - 19.9) for CKD stages 1-5, and 4.6 (3.3 – 6.1) for CKD stages 3-5. High risk populations such as those with HIV/AIDS, hypertension, and diabetes have higher prevalence of CKD in the study. Estimates from previous community-based studies in Nigeria revealed that the prevalence of CKD ranges from 7.8% in Yenagoa, Bayelsa State (Egbi et al., 2014) to 24.3% in Kumbotso, Kano State (Nalado et al., 2016).

CKD affects individuals who are mostly in their productive age, between the 4th - 5th decade of life when they should contribute to their families and the society. Ajayi et al. (2016), opined that a vicious cycle of poverty is established as those who should keep the economy viable and productive are the once affected by the chronic condition and therefore make them reliant on family members and friends for care and financial support. A common problem with majority of cases is late presentation when little or nothing can be done, and this is affirmed by Adejumo et al. (2016) who noted that patients with CKD in Nigeria often present late with associated poor prognosis and management outcome. Majority of affected persons are often not able to afford payment for renal replacement therapy and even amongst those who start renal replacement therapy such as dialysis, the sustenance of care is often a problem while those with end stage renal failure who needs kidney transplants as a definitive management procedure often do not have the funds for such procedure and even when they struggle to get such funds to carry out the procedure, they still face the challenge in post-operation management with immunosuppressant medications and follow up (Bamgboye, 2003; Ajayi et al., 2016). The cumulative effect of these challenges are higher mortality rates from the condition and according to Odubanjo et al. (2011) the mortality rate from CKD is 40 -50% which is a cause of premature death among affected populations in Nigeria.

Studies have revealed the various non-modifiable and modifiable factors implicated with CKD. According to the World Kidney Day (2015), age plays an important role with a higher prevalence among individuals aged 65 to 74 years, more prevalent among females compared to males, those with family history and certain genetic make-up. The review noted that there is a significant burden of CKD in sub-Saharan Africa, Oceania, and Latin America, but a relatively lower burden in South and East Asia, Central and Eastern Europe, Australia, and Western Europe than expected (Carney, 2020). Kiberd & Class (2002) noted that African descendants are at increased risk for CKD and progression to end-stage renal disease (ESRD). The modifiable factors are predominantly linked with non-communicable diseases like uncontrolled hypertension and diabetes (Olatise, 2016) that are due to risk factors like sedentary lifestyle, lack of exercise, poor feeding practices and obesity (Kazancioğlu, 2013). Adoption of western lifestyles, changes in the environment, rapid urbanization (Darr,

2007) and increasing use and consumption of nephrotoxins from some herbal concoction and use of bleaching creams and soaps (Luyckx et al., 2017) have all been associated with CKD. Communicable or infectious conditions associated with CKD are HIV/AIDs and Hepatitis C (Kazancioğlu, 2013; Stanifer et al., 2014; Luyckx et al., 2017) and these risk factors are preventable through awareness creation and promotion of healthy behaviors. In recent times, Africa faces a dual burden of diseases involving high prevalence of communicable and non-communicable disease (Agyei-Mensah et al., 2010) with some communicable diseases causally linked to specific non-communicable diseases (Dimie & Onyemlukwe, 2009). On the overall, interplay of non-modifiable and modifiable factors has been linked to a consequential rise in the number of people affected by CKD in Africa (Naicker, 2010).

The Africa continent is faced with dual condition of being exposed to both communicable and non-communicable diseases. For CKD, which is a non-communicable disease, prevention should be the goal. Howbeit, timely diagnosis is of paramount importance as health systems may not be able to provide the needed renal replacement therapy when the condition is in the late stage (Kent et al., 2015). Timely diagnosis of CKD at the early stage is therefore important to ensure improved treatment outcomes when such treatments are initiated early. Doolan et al. (1962) noted that the diagnosis of CKD is based on laboratory investigation and estimation of the glomerular filtration rate (GFR) from filtration marker such as serum creatinine or cystatin C, using various formulas, or by testing the urine for presence of albumin or protein (or a combination of these). The limitations of CL_{cr} and inulin clearance inspired researchers to seek for formulas needed to estimate the GFR often described as the estimated glomerular filtration rate (eGFR) (Levey et al., 2003). Currently, there formulas are often employed in the estimation of GFR and this include: the Cockcroft-Gault (C-G) (Cockcroft and Gault, 1976) and the modification of diet in renal disease (MDRD) (Levey et al., 2000) and CKD Epidemiology formula (Levey et al., 2009). Based on these formulas, CKD is defined as:

Creatinine clearance or GFR <60 mL/min/1.73 m^2 (Zhang et al., 2008).

These formulas are shown below:

Cockcroft–Gault

Creatinine clearance (mL/min) = (140–age)/(serum creatinine) × (weight/72) × (0.85 if female) (Cockcroft & Gault, 1976). Where: Serum creatinine is measured in mg/dL, age in years, weight in kg, and GFR is expressed as mL/min.

Simplified (four-variable) MDRD equation

GFR (mL/min/1.73 m^2) = 186.3 × (serum creatinine) − 1.154 × (age) − 0.203 × (0.742 if female) × (1.21 if black) (Levey et al., 1999) where: Serum creatinine is measured in mg/dL, age in years, and GFR is in mL/min/1.73 m^2**.**

CKD-EPI formula

GFR = 141 × min (Scr/κ, 1) α×max (Scr/κ, 1) −1.209×0.993 age×1.018 (if female) × 1.159 (if black) (Levey et al., 2009). Where: where Scr is serum creatinine in mg/dL, κ is 0.7 for females and 0.9 for males, α is −0.329 for females and −0.411 for males, min indicates the minimum of Scr/κ or 1, and max indicates the maximum of Scr/κ or 1. GFR is expressed as mL/min/1.73 m^2.

Following diagnosis, timely management that aims at reducing the progression of the disease to end stage is highly needed. Primary prevention interventions include lifestyle modifications to reduce risk factors such as hypertension and diabetes and this can be achieved through weight reduction, restriction of salt intake and consumption of high amounts of fruits and vegetables (Lindstrom et al., 2003; Molich et al., 2003; Appel et al., 2003)

Secondary prevention to limit deterioration of the condition among established CKD patients involves mainly the control of hypertension (Appel et al., 2003; Olatise, 2016) with a target blood pressure of <130/80mmHg in the absence of diabetes and proteinuria > 1g in 24hours urinalysis while a blood pressure target of <125/75mmHg in the presence of diabetes and proteinuria of >1g over 24hours is recommended based on clinical evidence (Klahr et al., 1994; Schrier et al., 2000; Bakris et al., 2000).

Medications identified to be effective in blood pressure control for CKD patients are Angiotensin –Converting Enzyme (ACE) or angiotensin -2-receptor blockers (Remuzzi et al., 2002; Hilgers et al., 2004). Tight glycemic control should target glycated haemoglobin of around 7% (The Diabetes Control and Complications Trial, 1995; Adler et al., 2003) using sodium-glucose transporter 2 inhibitors such as Canagliflozin (Saisho, 2020) while statins (hydroxy methylglutaryl co-enzyme A reductase inhibitors) have shown potentials of renoprotective effect among CKD patients (Zoja et al., 2002). Multi-drug therapy with ACE inhibitors, statins and other cardioprotective agents such as aspirin and antioxidants have shown to result to an 80% decline in cardiovascular events (Wald & Law, 2003).

Tertiary prevention aimed at rehabilitation of patients with end stage renal disease characterised by very poor renal function manifesting as severe metabolic acidosis, hyperkalemia and encephalopathy may require timely implementation of renal replacement therapy such as dialysis. For situation where funding is available, kidney transplant is the definitive management option for end stage disease (Olatise, 2016).

Because of the high morbidity, mortality, and economic implication of CKD during renal replacement therapy and other care, prevention of the disease should be the goal. This can be achieved through awareness creation to the general public on risk factors like nephrotoxins (herbal medications, bleaching creams and NSAIDS) associated with the condition, avoidance of high salt intake, weight reduction through proper diet and exercise (Luyckx et al., 2017). Furthermore, high risk populations can be subjected to screening for CKD as practiced in developed nations like Japan. There is also a high need for improvement in lifestyle and avoidance of risky sexual behaviors that increases the prevalence of HIV and HBV which are causally linked with CKD (Stabifer et al., 2016; Kaze et al., 2018). In Nigeria and most low- and middle-income countries, payment for healthcare services including CKD management is through out-of-pocket payments (Dodd et al., 2018) which can be

impoverishing and therefore calls for an investigation into the prevalence of the disease in order to make evidence-based decision and program design to address the condition across Nigeria.

To what extent are Nigerians affected by CKD and how many Nigerians in the various geopolitical zones currently suffer from CKD is poorly established. This study there seeks to determine the epidemiology of CKD in Nigeria.

METHOD

Study Protocol

The use of the best research design is central to obtaining the right data and conducting quality research to make valid conclusions (Toledo-Pereyra, 2012). For this study, a systematic review and meta-analysis of the prevalence of chronic kidney disease in Nigeria was done. This involved the collection of secondary data from a wide range of databases which is based on the laid down principles in the conduct of meta-analysis (White and Schmidt, 2005). This study was pre-planned and carried out in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The guideline is evidenced based and makes systematic reviews and meta-analysis reproducible and of high quality. This framework which consists of 27 items and a 4-phase diagram for identification, screening and selection of articles that meets the inclusion criteria was used. Attached is the link to the PRISMA Guideline used: https://jamanetwork.com/journals/jamasurgery/article-abstract/2778468#:~:text=In%20summary%2C%20the%20PRISMA%20guidelines,review%20to%20journals%20and%20readers. All the elements that make the review to be of high standard were adhered to. Prior to this review, our team drafted and registered the protocol for this work with PROSPERO (International prospective register of systematic review). The PROSPERO number for this review is: CRD42023441374. In this protocol, our team ensured that the study outcome that was measured, inclusive and exclusive criteria of studies are all stated. The outcome of interest measured in this meta-analysis was the prevalence of chronic kidney disease in Nigeria. Subgroup analysis to understand the distribution of CKD across Nigeria was done also done as stated in the protocol.

Search Strategy

The overall aim of this study was to determine the pooled prevalence of CKD in Nigeria. Articles were retrieved from two major databases (PubMed and Science Direct) and a registry on chronic kidney disease (Tropical Journal on Nephrology). The Population (P), Exposure (E), Comparator (C) and Outcome(s) (O) simply referred to as PECO question was designed to obtain key words in the study (Morgan et al., 2018). This include prevalence, incidence, chronic kidney disease, chronic kidney failure and Nigeria or Nigerian. Thereafter, advance search was done in PubMed and EBSCO host using the medical subject heading (MESH). The key terms used were "Prevalence" or "Incidence AND "Chronic kidney disease" or "Chronic kidney failure" and Nigeria. Boolean operators were used in the advance search to streamline articles relevant for this study. The search was done on the 24th to 27th of June 2023 using the three search engines earlier mentioned (PubMed, Science Direct, and Africa Journal Online). A manual search was also done, and two related literatures were identified and added into the review. The search resulted in a total of seven thousand five hundred and thirteen (7,513) articles being retrieved. Furthermore, a total of one thousand three hundred and eighty six (1386) were finally screened using title and abstract before it got to the final stage in the identification, screening and selection process for the meta-analysis. Ten (10) articles were finally included in the meta-analysis based on attainment of the predefined inclusion and exclusion criteria that were set in the study protocol.

Inclusion and Exclusion Criteria

The inclusion and exclusion criteria for this systematic review are presented are:

Inclusion Criteria:

- **Study Location**: Community based studies conducted in Nigeria
- **Study Outcome:** Studies with a defined sample size and clearly stated number of person with CKD and/or prevalence of CKD.
- **Measurement of CKD:** Studies that measured CKD using the Cockcroft-Gault formula, Modification of Diet in Renal Disease formula and CKD EPI Formula.
- **Language**: Studies published in English Language alone
- **Age**: Studies that capture individuals who are 18years and above.

The exclusion criteria for the study include:

- **Study Location**: Hospital based studies and studies conducted outside Nigeria
- **Study Outcome:** Studies without clearly defined sample size and result that shows the number of person with CKD and/or prevalence of CKD.
- **Measurement of CKD:** Studies that measured CKD using other formulas apart from the globally accepted three formulas stated earlier.
- **Language**: Studies published in other language like Russia, China, Arabic and others which are non-English Language.
- **Age**: Studies that deals with paediatric population with individuals who are less than 18years.

Screening and Study Selection

The ability of a research to screen and select the right studies for meta-analysis is key to successful synthesis of evidence (Deakin University, 2022) and according to Waffenschmidt et al. (2019), screening refer to the stringent measures that are employed during the selection of articles for transparency and quality review. This could be single screening or the conventional double screening method involving the researcher and another reviewer which is the preferred method employed for this study.

For systematic research and meta-analysis, the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) is recommended (Pages et al., 2021). For the purpose of this study, the PRISMA was used at various steps - identification of database base and registries for the study, removal of duplicate articles identified from the two database and one registry, screening articles based on inclusion and exclusion criteria, retrieving articles included in the study and final selection and use of quality articles for the meta-analysis (Page et al., 2021). This is shown with figure 1 below.

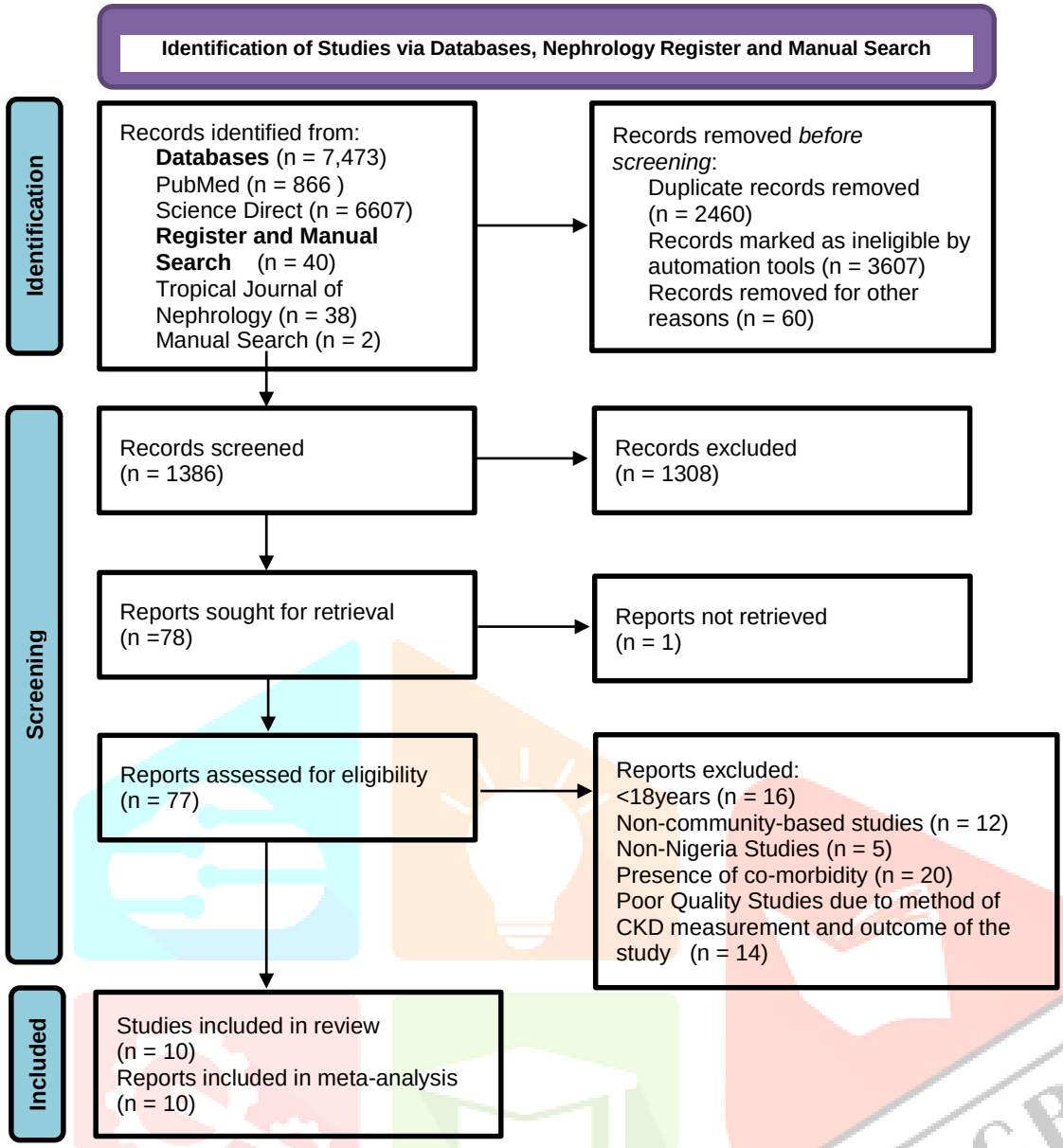

Figure1: PRISMA Diagram for the Prevalence of CKD in Nigeria

Data Extraction

After importing the studies into Zotero software where non-related and duplicate articles was removed, an Excel spread sheet was created and used to extract data included in the study (Godino, 2023). This was done using predefined criteria which include studies within Nigeria and written in English Language, community-based prevalence studies on CKD, and quality journals that made use of the Cockcroft-Gault formula, Modification for Diet in Renal Disease and CKD Epidemiology formula to estimates the prevalence of CKD in Nigeria. This approached was employed successfully in a similar study by Chukwuonye et al. (2022).

Data analysis

Following the selection of quality articles, data obtained were analysed based on the study objectives which involves the determination of the prevalence of CKD in Nigeria and the regional distribution of the disease across Nigeria. The Medcal Software Windows version 20.009 was used to carry out the data analysis. Test for heterogeneity was conducted using the Cochrane's Q while test for publication bias was conducted using the Begg's and Eggers test to determine which model to adopt for the estimation (fixed effect or random effect model). To assess publication bias, the funnel plot was done and included in the study results.

RESULT

A total of ten (10) mostly high-quality articles were included into the meta-regression. Two studies each that were community based were included from the South-South, South-West, South East and North Central region of Nigeria while only a single article (community based) was identified and included for North West and North East Nigeria.

The meta-regression result for the ten (10) selected studies are shown in Table 1 & 2 and Figure 1 and 2. Table I was the overall pooled prevalence for CKD in Nigeria while Table 2 is the geopolitical (regional) distribution of CKD in Nigeria.

Table 1: Prevalence of Chronic Kidney Disease in Nigeria

Study	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Okoye et al., 2011	476	24.370	20.577 to 28.484	6.79	10.05
Olatise, 2011	423	16.548	13.133 to 20.440	6.04	9.93
Ulasi et al., 2013	1941	11.386	10.006 to 12.883	27.66	10.85
Oluyombo et al., 2013	468	18.803	15.363 to 22.644	6.68	10.04
Egbi et al., 2014	179	7.821	4.342 to 12.775	2.56	8.66
Nalado et al., 2016	480	24.375	20.598 to 28.471	6.85	10.06
Oluyombo et al., 2017	1084	14.207	12.182 to 16.428	15.46	10.64
Okwuonu et al., 2017	328	7.622	4.993 to 11.046	4.69	9.63
Sulaiman et al., 2019	278	20.504	15.915 to 25.733	3.97	9.40
Olarenwaju et al., 2020	1353	11.973	10.291 to 13.823	19.29	10.73
Total (fixed effects)	7010	14.356	13.544 to 15.198	100.00	100.00
Total (random effects)	7010	15.432	12.291 to 18.860	100.00	100.00

Table 1 above shows the prevalence of CKD in Nigeria. A pool prevalence of 15.432% (12.291 – 18.860%) was estimated during the study period. This translates to 17,811,828 (14,186,442 – 21,768,473) adult Nigerians

18years and above. The highest prevalence of 24.375% was noted in 2016 in Kano (Nalado et al., 2016) while the least prevalence of 7.622% was noted in Umuahia in 2017 (Okwuonu et al., 2017).

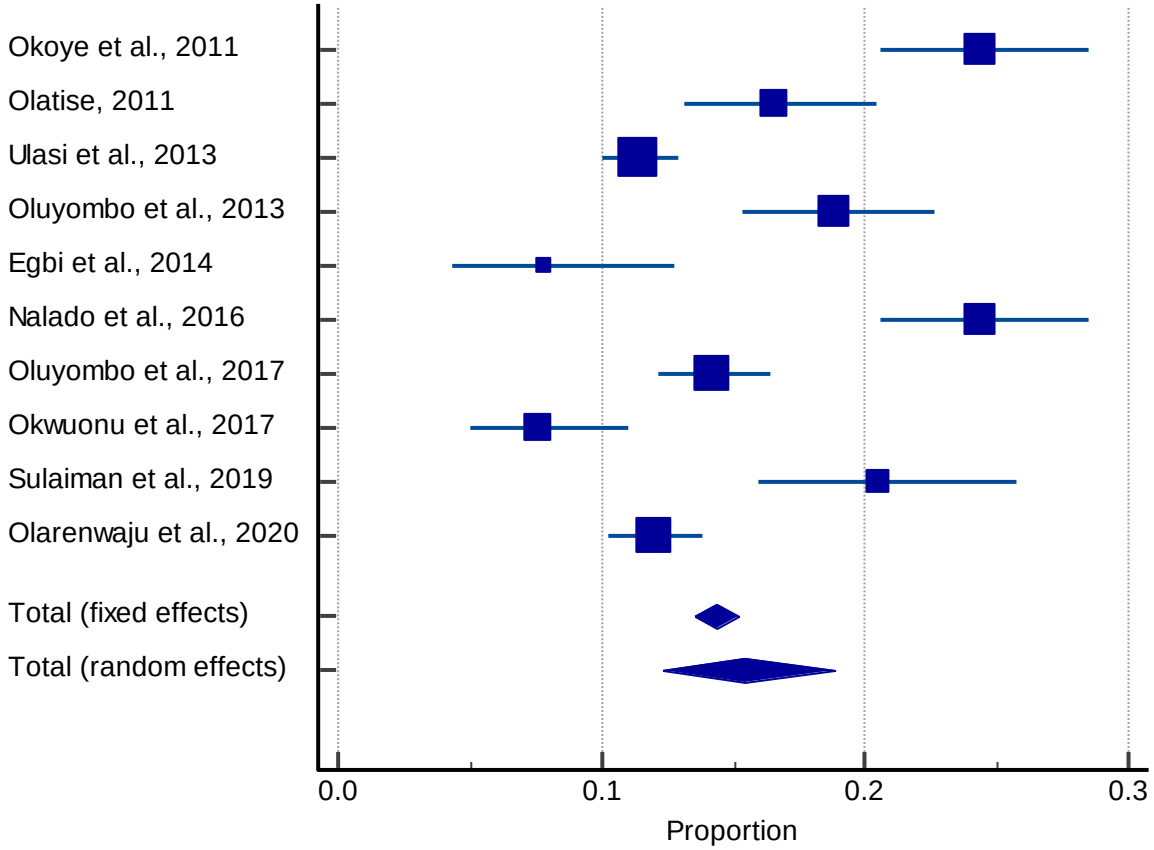

Figure 1: Forest Plot of the Prevalence of Chronic Kidney Disease in Nigeria

Figure I is the forest plot of the 10 studies analysed across the six geopolitical zones of Nigeria with the various effects of the studies shown by the proportion of the plot size. 15.432% (12.291 – 18.860%) prevalence of CKD was estimated from the meta-analysis.

Table 2: Test for heterogeneity

Q	123.2770
DF	9
Significance level	P < 0.0001
I^2 (inconsistency)	92.70%
95% CI for I^2	88.63 to 95.31

Table 2 shows the test of heterogeneity of the studies. At 95% Confidence Interval, I^2 = 92.70% and P 0.0001. This shows a high and statistically significant heterogeneity across the studies. This informed the use of the random effect model for the estimation of the prevalence of CKD in Nigeria.

Table 3: Test for Publication bias

Egger's test	
Intercept	3.8855
95% CI	-3.6262 to 11.3972
Significance level	P = 0.2671
Begg's test	
Kendall's Tau	0.1111
Significance level	P = 0.6547

Table 3 shows the publication bias for the study. At 95% Confidence interval, Egger's test shows that the Intercept was 3.8855, and P = 0.2671. Begg's test and Kendall's Tau assessment of publication bias were 0.1111 and P = 0.6547 respectively. This shows that there is no publication bias in the studies included in the meta-analysis.

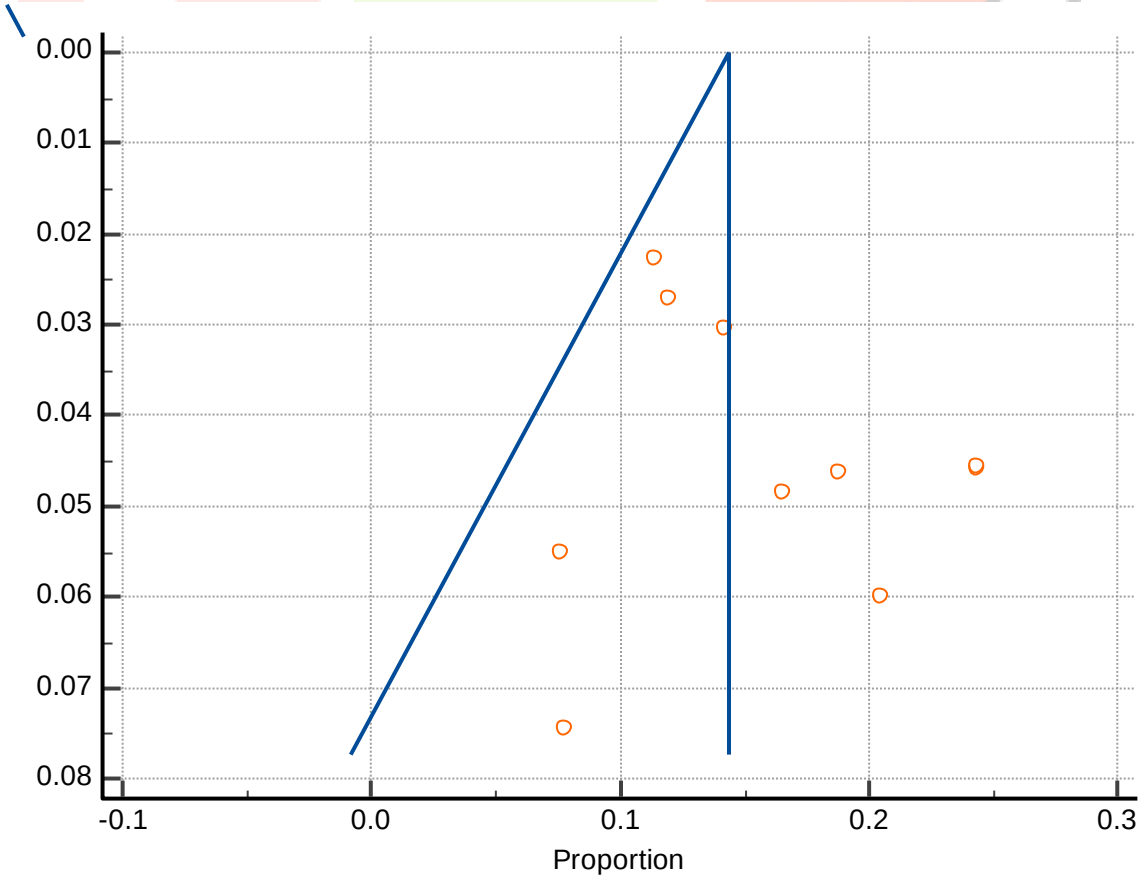

Figure 2:

Funnel Plot for the Study

Figure 2 shows the funnel plot for the study which revealed that there is no asymmetry in the distribution of the studies. This affirms the fact that there is no publication bias and high quality studies were included in the meta-analysis for the prevalence of CKD in Nigeria.

Table 4: Regional Distribution of the Prevalence of CKD in Nigeria

Study South-South	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Okoye et al., 2011	476	24.370	20.577 to 28.484	72.60	50.82
Egbi et al., 2014	179	7.821	4.342 to 12.775	27.40	49.18
Total (fixed effects)	655	19.244	16.297 to 22.470	100.00	100.00
Total (random effects)	655	15.468	3.193 to 34.593	100.00	100.00
Study South-East	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Ulasi et al., 2013	1941	11.386	10.006 to 12.883	85.51	58.11
Okwuonu et al., 2017	328	7.622	4.993 to 11.046	14.49	41.89
Total (fixed effects)	2269	10.838	9.588 to 12.189	100.00	100.00
Total (random effects)	2269	9.798	6.512 to 13.668	100.00	100.00
Study South-West	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Oluyombo et al., 2013	468	18.803	15.363 to 22.644	30.18	46.12
Oluyombo et al., 2017	1084	14.207	12.182 to 16.428	69.82	53.88
Total (fixed effects)	1552	15.581	13.812 to 17.482	100.00	100.00
Total (random effects)	1552	16.310	12.064 to 21.056	100.00	100.00
Study North Central	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Olatise, 2011	423	16.548	13.133 to 20.440	23.85	45.39
Olarenwaju et al., 2020	1353	11.973	10.291 to 13.823	76.15	54.61
Total (fixed effects)	1776	13.047	11.515 to 14.702	100.00	100.00
Total (random effects)	1776	14.023	9.847 to 18.799	100.00	100.00
Study North West	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Nalado et al., 2016					
Total (random effects)	480	24.375	20.598 to 28.471	6.85	10.06
Study North East	Sample size	Proportion (%)	95% CI	Weight (%)	
				Fixed	Random
Sulaiman et al., 2019					
Total (random effects)	278	20.504	15.915 to 25.733	3.97	9.40

Table 4 shows the regional prevalence of CKD in Nigeria. They include: 24.375% in North West, 20.504% in North East, 16.310% in South West, 15.468 in South-South, 14.023 in North Central and 9.798% in South East from the highest prevalent region to the least in that order. The overall prevalence of CKD in Nigeria is 15.432% (12.291 – 18.860%) (Table 1). Some regions have a higher prevalence while other regions have a lower prevalence of CKD when compared with the national estimate.

Table 5: Gender Distribution of the Prevalence of CKD in Nigeria

Gender	Male	Female
Male : Female Ratio	1	1.9
Arithmetic mean	38.0000	72.0000
95% CI for the mean	14.0145 to 61.9855	39.4323 to 104.5677
Variance	1124.2222	2072.6667
Standard deviation	33.5294	45.5265
Standard error of the mean	10.6029	14.3968

F-test for equal variances	P = 0.376
D'Agostino-Pearson test for Normal distribution	accept Normality (P=0.4823)

Table 5: shows the gender distribution of the CKD, result shows a 1:1.9 male to female ratio on the distribution of CKD in Nigeria. A test for normality was done and it shows P = 0.4823 that accepts the normality before the independent t-test done. Arithmetic mean was 38.0000 for male and 72.0000 for females with CKD in Nigeria.

DISCUSSION

Prevalence of Chronic Kidney Disease (CKD) in Nigeria

Ten studies across the six geographical zones in Nigeria with a total sample size of 7010 were included in the study. These studies are community or population based which dates from 2011 - 2020 and used any of the three formulas earlier described in the estimation of the prevalence of CKD among populations across the six geopolitical zones of Nigeria. The meta-analysis revealed that the pooled prevalence of CKD in Nigeria was 15.432% (12.291 – 18.860%). When compared with the prevalence in other nations, the prevalence in Nigeria from this study is higher than studies in Tanzania, Africa by Hill et al. (2016) who observed 13.6% in their study and also report of 12.6% prevalence in England, United Kingdom, Europe by Hounkpatin et al. 2020. The result also showed a higher prevalence of CKD in Nigeria than sub-Sahara Africa prevalence of 13.9% reported by Stanifer et al. (2014) in their systematic review and meta-analysis of CKD for the region. Furthermore, a higher prevalence of CKD was noted in Nigeria than the global prevalence of 9.1% estimated in 2017 by Cockwell et al. (2020) in the Lancet series. This high prevalence could be attributed to the increased exposure to the risk factors of the condition among Nigerians with poor awareness and practice of preventive measures against the disease. The high prevalence of 15.432% in translates to an estimated 17,811,828 Nigerians with CKD. Unfortunately, majority of these patients lack access to renal replacement therapy such as dialysis and

kidney transplant that is very expensive and so, majority cannot afford timely and effective care needed for the management of their condition (Ajayi et al., 2003).

Regional Distribution of CKD in Nigeria

The findings from this study also revealed a variation in the prevalence of CKD across the six geopolitical zones in Nigeria with the highest prevalence reported in North West Nigeria (24.4%), where almost one in four persons have the condition and the least prevalence was noted in South-East Nigeria (9.8%) where almost one in ten persons have CKD. This variation could be explained by an increase in the risk factors for CKD in the North West region when compared to the South East region (Table 4). The prevalence of CKD reported in the North West Nigeria is higher than the global prevalence of CKD which is 13.4% (Lv & Zhnage, 2019). It is also higher than the prevalence of CKD in the Sub-Sahara Africa which was 13.9% (Stanifer et al., 2014). The findings are a clear expression of the fact that adequate control and prevention of the risk factors against CKD is needed to bring about a decline in the incidence of the disease and the mortality associated with the condition (Odubanjo et al., 2011). This should be a top government priority of every government who actualize SDG Target 3.4 which deals with the reduction of premature mortality from non-communicable diseases by one third through prevention and treatment and promotion of mental health and well-being.

Gender Distribution of CKD in Nigeria

This study further revealed that females have higher prevalence of CKD in Nigeria with a male to female ratio of almost 1:2 which was not statistically significant (Table 5). This finding is in synchrony with studies conducted by the World Kidney Day (2015) who noted that females have higher risk of coming down with CKD then males. Kovesdy (2022) also reported a higher prevalence of CKD among females than male. The cause of this pattern is largely unknown but could be due to interplay of complex factors including a higher exposure of women to the risk factors such as nephrotoxins from creams and other items they use or possibly as a result of genetic and physiological make up that are yet to be elucidated (Kovedy, 2022). This find is also in alignment with an Iran study by Khajehdehi et al. (2014) who also noted that women had higher odds of developing CKD than men. Other factors they highlighted was high body mass index, hypertension and age and this calls for effectiveness awareness creation and health education to address the risk factors as well as the improvement in the health care system to address this menace.

CONCLUSION

The burden of CKD in Nigeria is very high with almost one in five having the condition and majority not having access to care and when access is secured, they cannot afford to pay for renal replacement therapy which is needed for their treatment and wellbeing. Females have a higher prevalence of the condition than men while aged individual also have a higher risk of the condition. Based on the geopolitical distribution of the disease, highest prevalence is noted in Northwest Nigeria while the least prevalence is noted in South-east Nigeria. The high prevalence of this disease is worrisome and therefore calls for immediate action in awareness creation for prevention of the disease and health systems strengthening needed to manage the high cases of the disease in Nigeria.

Data Sharing Statement

Data used for this meta-analysis are included in as appendix 1.

Acknowledgement

I want to specially thank all the authors that conducted community/population-based studies on this subject. Their contribution to knowledge is appreciated in this study.

Authors Contributions

All the authors included in this review played a key role in the study from conception of the idea, drafting the protocol of the study, data collection, writing the article, review of the article, conducting the meta-analysis and submission of the article for publication.

Disclosure

There is no competing interest in the development of this article.

REFERENCES

Adejoro, L. (2023). UK licenses 162 Nigerian doctors in 42 days. Available at: https://punchng.com/uk-licenses-162-nigerian-doctors-in-42-days. [Accessed 9th June, 2023].

Adejumo, O.A., Akinbodewa, A.A., Okaka, E.I., Alli, O.E., & Ibukun, I.F. (2016). Chronic kidney disease in Nigeria: Late presentation is still the norm. *Niger Med J*. 57:185-9

Adler, A.I., Stevens, R.J., Manley, S.E., Bilous, R.W., Cull, C.A., Holman, R.R. & UKPDS GROUP (2003). Development and progression of Nephrolpathy in type 2 diabetes; The United Kingdom prospective Diabetes Study (UKPDS 64). *Kidney Int.* 63:225-232.

Agyei-Mensah, S., & de-Graft, A. A. (2010). Epidemiological transition and the double burden of disease in Accra, Ghana. *J Urban Heal Bull New York Acad Med.* 87: 879–897. doi: 10.1007/s11524-010-9492-y

Ajayi, S. Yemi, R., Temitope, B., Lanre, J., & Babatunde, S. (2003). Unaffordability of Renal Replacement Therapy in Nigeria. *Hong Kong Journal of Nephrology* 18. doi:10.1016/J.HKJN.2015.11.002.

Appel, L.J. (2003). Lifestyle modification as a means to prevent and treat high blood pressure. *J Am Soc Nephrol*. 14: S99–102.

Arora, P., Vasa, P., Brenner, D., Iglar, K., McFarlane, P., Morrison, H., & Badawi, A. (2013). Prevalence estimates of chronic kidney disease in Canada: results of a nationally representative survey. *CMAJ*. 185(9):E417-23. doi: 10.1503/cmaj.120833.

Bakris, G.L, Williams, M., & Dworkin, L., Elliott, W.J., Epstein, M., Toto, R., Tuttle, K., Douglas, J., Hsueh, W., & Sowers, J. (2000). Preserving renal function in adults with hypertension and diabetes: a consensus approach. *Am J Kidney Dis*. 36: 646–661.

Bamgboye, E. L. (2003). Haemodialysis: Management problems in developing countries, with 12. Nigeria as a surrogate. *Kidney Int*. 63 (suppl 83): s93-s95.

Carney, E.F. (2020). The impact of chronic kidney disease on global health. *Nat Rev Nephrol* 16, 251 https://doi.org/10.1038/s41581-020-0268-7

Chukwuonye, I.I., Ogah, O.S., Anyabolu, E.N., Ohagwu. K.A., Nwabuko, O.C., Onwuchekwa, U., Chukwuonye, M.E., Obi, E.C., & Oviasu, E. (2018). Prevalence of chronic kidney disease in Nigeria: systematic review of population-based studies. *Int J Nephrol Renovasc Dis*.22;11:165-172. doi: 10.2147/IJNRD.S162230.

Cockcroft, D.W., & Gault, M.H. (1976). Prediction of creatinine clearance from serum creatinine. *Nephron*. 16(1):31–41.

Cockwell, P., & Fisher, L.A. (2020). The Global Burden of Chronic Kidney Disease. *The Lancet*, 395 (10225): 662–64. doi:10.1016/S0140-6736(19)32977-0.

Critical Appraisal Skills Programme (2018). CASP Checklists Available at: https://casp-uk.net/casp-tools-checklists/. Accessed January, 2023.

Daar, A.S., Singer, P.A., Persad, D.L., Pramming, S.K., Matthews, D.R., Beaglehole, R., Bernstein, A., Borysiewicz, L.K., Colagiuri, S., & Ganguly, N., et al. (2007). Grand challenges in chronic non-communicable diseases. *Nature*. 450(7169):494–6.

Deakin University (2022). Systematic and systematic-like review toolkit. Available from: https://deakin.libguides.com/systematicreview/step3[Accessed 10 December 2022].

Dodd, R., Palagyi, A., Guild, L., Jha, V., & Jan, S. (2018). The impact of out-of-pocket costs on treatment commencement and adherence in chronic kidney disease: a systematic review. *Health Policy Plan*, 1;33(9):1047-1054. doi: 10.1093/heapol/czy081.

Doolan, P.D., Alpen, E.L., Theil, G.B. (1962). A clinical appraisal of the plasma concentration and endogenous clearance of creatinine. *Am J Med.* 32:65–79.

Egbi, O.G., Okafor, U.H., Miebodei, K.E., Kasia, B.E., Kunle-Olowu, O.E., & Unuigbe, E.I. (2014). Prevalence and correlates of chronic kidney disease among civil servants in Bayelsa state, Nigeria. *Niger J Clin Pract.* 17(5):602-7. doi: 10.4103/1119-3077.141426.

Federal Republic of Nigeria, (2009). Report on the Census of 2006 Final Report. Available at: https://gazettes.africa/archive/ng/2009/ng-government-gazette-dated-2009-02-02-no-2.pdf, Accessed July, 2023.

Franca Gois, P.H., Wolley, M., Ranganathan, D., & Seguro, A.C. (2018). Vitamin D Deficiency in Chronic Kidney Disease: Recent Evidence and Controversies. *Int J Environ Res Public Health.* 15(8):1773. doi: 10.3390/ijerph15081773.

Godino, L. (2023). How to structure Microsoft Excel documents for systematic reviews. *Nurse Res*. 31(1):40-46. doi: 10.7748/nr.2023.e1866.

Hilgers, K.F., Dotsch, J., Rascher, W., & Mann, J.F. (2004). Treatment strategies in patients with chronic renal disease: ACE inhibitors, angiotensin receptor antagonists, or both? *Pediatr Nephrol*. 19: 956–961.

Hill, N.R., Fatoba, S.T., Oke, J.L., Hirst, J.A., O'Callaghan, C.A., Lasserson, D.S., & Hobbs. F.D. (2016). Global Prevalence of Chronic Kidney Disease - A Systematic Review and Meta-Analysis. *PLoS One.* 11(7):e0158765. doi: 10.1371/journal.pone.0158765.

Hounkpatin, H.O., Harris, S., Fraser, S.D.S., Day, J., Mindell, J.S., Taal, M.W., O'Donoghue, D., & Roderick, P.J. (2003). Prevalence of chronic kidney disease in adults in England: comparison of nationally representative cross-sectional surveys from 2003 to 2016. *BMJ Open*. 10(8):e038423. doi: 10.1136/bmjopen-2020-038423.

Kazancioğlu, R. (2013). Risk factors for chronic kidney disease: an update. Kidney Int Suppl (2011). 3(4):368-371. doi: 10.1038/kisup.2013.79.

Kaze, A.D., Ilori, T., Jaar, B.G., & Echouffo-Tcheugui, J.B. (2018). Burden of chronic kidney disease on the African continent: a systematic review and meta-analysis. *BMC Nephrol*. 19(1):125. doi: 10.1186/s12882-018-0930-5.

Kaze, A.D., Ilori, T., Jaar, B.G. & Echouffo-Tcheugui, J.B. (2018). Burden of chronic kidney disease on the African continent: a systematic review and meta-analysis. *BMC Nephrol*. 19: 125.

Kent, S., Schlackow, I., Lozano-Kühne, J. Reith, C., Emberson, J., Haynes, R., Gray, A., Cass, A., Baigent, C., Landray, M.J., Herrington, W., Mihaylova, B. & SHARP Collaborative Group. (2015). What is the impact of chronic kidney disease stage and cardiovascular disease on the annual cost of hospital care in moderate-to-severe kidney disease?. *BMC Nephrol.* 16:65. doi:10.1186/s12882-015-0054-0

Khajehdehi, P., Malekmakan, L., Pakfetrat, M., Roozbeh, J., & Sayadi, M. (2014). Prevalence of chronic kidney disease and its contributing risk factors in southern Iran: a cross-sectional adult population-based study. *Iran J Kidney Dis*. 8(2):109-15.

Kiberd, B.A., & Clase, C.M. (2002). Cumulative risk for developing end-stage renal disease in the US population. *Journal of the American Society of Nephrology*. 13(6):1635–44.

Klahr, S., Levey, A.S., Beck, G.J, Caggiula, A.W., Hunsicker, L., Kusek, J.W., & Striker G. (1994). The effects of dietary protein restriction and blood-pressure control on the progression of chronic renal failure. *N Engl J Med.* 330: 877–884.

Kovesdy, C. P. (2022). Epidemiology of Chronic Kidney Disease: An Update 2022. *Kidney International Supplements* 12(1): 7–11. doi:10.1016/J.KISU.2021.11.003.

Levey, A.S., Atkins, R., Coresh, J., Cohen, E.P., Collins, A.J., Eckardt, K.U., Nahas, M.E., Jaber, B.L., Jadoul, M., Levin, A., Powe, N.R., Rossert, J., Wheeler, D.C., Lameire, N., & Eknoyan, G. (2007). Chronic kidney disease as a global public health problem: approaches and initiatives - a position statement from Kidney Disease Improving Global Outcomes. *Kidney Int.* 72(3):247-59. doi: 10.1038/sj.ki.5002343.

Levey, A.S., Bosch, J.P., Lewis, J.B., Greene, T., Rogers, N., & Roth, D. A. (1999). More accurate method to estimate glomerular filtration rate from serum creatinine: a new prediction equation. Modification of Diet in Renal Disease Study Group. *Ann Intern Med*. 130(6):461–470.

Levey, A.S., Coresh, J., Balk, E., Kausz, A.T., Levin, A., Steffes, M.W., Hogg, R.J., Perrone, R.D., Lau, J., Eknoyan, G. & National Kidney Foundation. (2003). National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Ann Intern Med*. 139(2):137-47. doi: 10.7326/0003-4819-139-2-200307150-00013.

Levey., A.S., Greene, T., Kusek, J.W., & Beck, G.J. (2000). A simplified equation to predict glomerular filtration rate from serum creatinine. *J Am Soc Nephrol*. 11:155A.

Levey, A.S., Stevens, L.A., Schmid, C.H., Zhang, Y.L., Castro, A.F. Feldman, H.I., Kusek, J.W., Eggers, P., Van Lente, F., Greene, T., Coresh, J. & CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration). (2009). A new equation to estimate glomerular filtration rate. *Ann Intern Med*. 150(9):604–612.

Lindstrom, J., Eriksson, J.G., Valle, T.T, Aunola, S., Cepaitis, Z., Hakumäki, M., Hämäläinen, H., Ilanne-Parikka, P., Keinänen-Kiukaanniemi, S., Laakso, M., Louheranta, A., Mannelin, M., Martikkala, V., Moltchanov, V., Rastas, M., Salminen, V., Sundvall, J., Uusitupa, M., & Tuomilehto, J. (2003). Prevention of diabetes mellitus in subjects with impaired glucose tolerance in the Finnish Diabetes Prevention Study: results from a randomized clinical trial. *J Am Soc Nephrol*. 14: S108–113.

Luyckx, V.A., Tuttle, K.R., Garcia-Garcia, G., Gharbi, M.B., Heerspink, H.J.L., Johnson, D.W., Liu, Z.H., Massy, Z.A., Moe, O., Nelson, R.G., Sola, L., Wheeler, D.C., & White, S.L. (2017). Reducing major risk factors for chronic kidney disease. *Kidney Int Suppl*. 7(2):71-87. doi: 10.1016/j.kisu.2017.07.003.

Lv, J. & Zhang, L. (2019). Prevalence and Disease Burden of Chronic Kidney Disease. *Adv Exp Med Biol*. 1165:3-15. doi: 10.1007/978-981-13-8871-2_1.

Mann, C. C. (1990). Choosing an Indigenous Official Language for Nigeria. Available at: https://files.eric.ed.gov/fulltext/ED397681.pdf. Accessed July, 2023.

Molich, M., Fujimoto, W., Hamman, R.F., Knowler, W.C. & Diabetes Prevention Program Research Group. (2003). The Diabetes Prevention Program and its global implications. *J Am Soc Nephrol*. 14: S103– 107.

Morgan, R.L., Whaley, P., Thayer, K.A., & Schünemann, H.J. (2018). Identifying the PECO: A framework for formulating good questions to explore the association of environmental and other exposures with health outcomes. *Environ Int.* 121(Pt 1):1027-1031. doi: 10.1016/j.envint.2018.07.015.

Morrison, K. (2017). Dissecting the literature: the importance of critical appraisal. Available at: https://www.rcseng.ac.uk/library-and-publications/library/blog/dissecting-the-literature-the-importance-of-critical-appraisal/. Accessed January, 2023.

Naicker, S. (2010). Burden of end-stage renal disease in sub-Saharan Africa. *Clin Nephrol*. 74(Suppl 1):S13–6.

Nalado, A., Abdu, A., Adamu, B., Aliyu, M.H., Arogundade, F.A., Sanusi, A.A., Wali, S.S., & Akinsola, A. (2016). Prevalence of chronic kidney disease markers in Kumbotso rural Northern Nigeria. *Afr J Med Med Sci*. 45(1):61-65.

Nigeria, CIA World Fact Book, (2019). The World Fact Book – Explore all Countries – Nigeria. Available at: https://www.cia.gov/the-world-factbook/countries/nigeria/. Accessed June, 2023.

Nigeria, the World Fact Sheet, (2023). Nigeria – Country Summary. Available at: https://www.cia.gov/the-world-factbook/countries/nigeria/summaries/. Accessed July, 2023.

Odubanjo, M.O., Oluwasola, A.O., & Kadiri, S. (2011). The epidemiology of end-stage renal disease in Nigeria: the way forward. *Int Urol Nephrol*. 43(3):785-92. doi:10.1007/s11255-011-9903-3.

Ogoina, D., & Onyemelukwe, G.C. (2009). The role of infections in the emergence of non-communicable diseases (NCDs): Compelling needs for novel strategies in the developing world. *Journal of Infection and Public Health*, 2, 14 - 29.

Okoye, O., Okoye, A., Oviasu, E., & Ojogwu, L. (2011). Prevalence of chronic kidney disease and its risk factors amongst adults in a rural population in Edo State, Nigeria. *J US China Med Sci*. 8(8):471–481.

Okunola, O., Akinsola, A., & Ayodele, O. (2012). Kidney diseases in Africa: aetiological considerations, peculiarities and burden. *Afr J Med Med Sci.* 41(2):119-33.

Olanrewaju, T.O., Aderibigbe, A., Popoola, A. Braimoh, K.T., Buhari, M.O., Adedoyin, O.T., Kuranga, S.A., Biliaminu, S.A., Chijioke, A., Ajape, A.A., Grobbee, D.E., Blankestijn, P.J., Klipstein-Grobusch, K. & Ilorin Renal Study Group (2020). Prevalence of chronic kidney disease and risk factors in North-Central Nigeria: a population-based survey. *BMC Nephrol*. 21, 467. doi:10.1186/s12882-020-02126-8

Olatise, O.O. (2011). Community based screening for Chronic Kidney Disease and its risk factors amongst adults in Howlshe, Jos. Thesis Submitted to The National Postgraduate Medical College of Nigeria. Pp 9 -10.

Oluyombo, R., Ayodele, O.E., Akinwusi, P.O., Okunola, O.O., Akinsola, A., Arogundade, F.A., Sanusi, A.A., & Onayade, A. A. (2013). community study of the prevalence, risk factors and pattern of chronic kidney disease in Osun State, South West Nigeria. *West Afr J Med*. 32(2):85-92.

Oluyombo, R., Olamoyegun, M.A., Ayodele, O.E., Akinwusi, P.O., & Akinsola, A. (2017). Clustering of chronic kidney disease and cardiovascular risk factors in South-west Nigeria. *J Nephropathol.* 6(3):196–203.

Oxford Brookes University (2022) CASP checklists. Available from https://www.brookes.ac.uk/students/academic-development/online-resources/casp-checklists/[Accessed 10 December 2022].

Page M.J, et al. (2021) The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ ;372:n71. doi: 10.1136/bmj.n71

Price Water Coopers, (2016). Restoring Trust in the Nigeria Healthcare System. Available at: https://www.pwc.com/ng/en/assets/pdf/restoring-trust-to-nigeria-healthcare-system.pdf. Accessed June, 2023.

Remuzzi, G., Ruggenenti, P., & Perico, N. (2002). Chronic renal diseases: renoprotective benefits of renin-angiotensin system inhibition. *Ann Intern Med* . 136: 604–615.

Saisho, Y. (2020). SGLT2 inhibitors: the star in the treatment of type 2 diabetes? Diseases. 8(2):14.

Schnaper, H.W. (2014). Remnant nephron physiology and the progression of chronic kidney disease. *Pediatr Nephrol*. 29(2):193-202. doi: 10.1007/s00467-013-2494-8.

Stanifer, J.W., Jing, B., Tolan, S., Helmke, N., Mukerjee, R., Naicker, S., & Patel, U. (2014). The epidemiology of chronic kidney disease in sub-Saharan Africa: a systematic review and meta-analysis. *Lancet Glob Health*. 2(3):e174-81. doi: 10.1016/S2214-109X(14)70002-6.

Stanifer, J.W., Muiru, A., Jafar, T.H. & Patel, U.D. (2016). Chronic kidney disease in low- and middle-income countries. *Nephrol Dial Transplant*. 31: 868–874.

Stel, V.S., Brück, K., Fraser, S., Zoccali, C., Massy, Z.A., & Jager, K.J. (2017). International differences in chronic kidney disease prevalence: a key public health and epidemiologic research issue. *Nephrol Dial Transplant*. 1;32(suppl_2):ii129-ii135. doi: 10.1093/ndt/gfw420.

Stony Brook University Libraries (2022) SYSTEMATIC REVIEW GUIDE. Available at: https://guides.library.stonybrook.edu/c.php?g=1145804&p=8375401. Accessed the January, 2023.

Sulaiman, M.M., Shettima, J., Ndahi, K., Abdul, H., Baba, M.M., Ummate, I.1., & Hussein, K. (2019). Chronic kidney disease of unknown origin in Northern Yobe, Nigeria: Experience from a regional tertiary hospital in Northeastern Nigeria. *Borno Medical Journal*, 16 (2):1-8.

The Diabetes Control and Complications Trial (DCCT) Research Group. (1995). Effect of intensive therapy on the development and progression of diabetic nephropathy in the DCCT. *Kidney Int*. 47: 1703–1720.

Toledo-Pereyra (2012). Ten Qualities of a Good Researcher, *Journal of Investigative Surgery*, 25:4, 201-202. doi:10.3109/08941939.2012.701543

Ulasi, I.I., Ijoma, C.K., Onodugo, O.O., Arodiwe, E.B., Ifebunandu, N.A., & Okoye, J.U. (2013). Towards prevention of chronic kidney disease in Nigeria: a community-based study in Southeast Nigeria. *Kidney Int Suppl*. 3(2):195–201.

Ulasi, I.I., & Ijoma, C.K. (2010). The enormity of chronic kidney disease in Nigeria: the situation in a teaching hospital in South-east Nigeria. *J Trop Med.* 2010:501957.

University of Bath Library, (2022). Systematic reviews: Introduction. Available at: https://library.bath.ac.uk/systematic-reviews. Accessed January, 2023.

Waffenschmidt, S., Knelangen, M., Sieben, W., Bühn, S., & Pieper, D. (2019). Single screening versus conventional double screening for study selection in systematic reviews: a methodological systematic review. *BMC Med Res Methodol*. 19(1):132. doi: 10.1186/s12874-019-0782-0.

Wald, N.J., Law, M.R. (2003). A strategy to reduce cardiovascular disease by more than 80%. *BMJ*. 326: 1419–1422.

White, A., & Schmidt, K. (2005). Systematic literature reviews. *Complement Ther Med*. 13(1):54-60. doi: 10.1016/j.ctim.2004.12.003.

World Kidney Day (2015). Campaign Material. Available at: https://www.worldkidneyday.org/resource-year/2015/. Accessed June, 2023.

World Kidney Day (2022). The Impact Report of World Kidney Day. Available at: https://www.worldkidneyday.org/2022-campaign/impact-report-2022/#:~:text=In%202022. Accessed January, 2023.

Zhang, Q.L., & Rothenbacher, D. (2008). Prevalence of chronic kidney disease in population-based studies: systematic review. *BMC Public Health*. 8:117.

Zoja, C., Corna, D., Camozzi, D., Cattaneo, D., Rottoli, D., Batani, C., Zanchi, C., Abbate, M., & Remuzzi, G. (2002). How to fully protect the kidney in a severe model of progressive nephropathy: a multidrug approach. *J Am Soc Nephrol*. 13: 2898–2908.