Retrospective Research Article

Evaluation of Serum Electrolyte Abnormalities and Kidney Function to Assess Risk of Kidney Disease in Hypertensive Patients at Kenyatta National Hospital

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Abstract

HTN is a known leading cause of kidney disease with over 20% of the population aged 20 years or older with HTN developing CKD. Complications from HTN and kidney disease contribute significantly to global mortality. In Kenya, data from WHO shows that about 4 million individuals suffer from CKD, with many progressing to kidney failure. The aim was to assess serum electrolyte abnormalities and kidney function among hypertensive patients at KNH. The study utilized cross-sectional retrospective data from KNH patient records. The CKD-EPI equation was used to calculate eGFR. Fisher et al.'s equation determined sample size. Data were stratified by variables such as DBP, age, sex, SBP, proteinuria, serum creatinine, urea levels, serum electrolytes, and eGFR. Data collection involved 189 patients: 82 males (43.4%) and 107 females (56.6%), with a median age of 54.00 years. 93 patients (49.20%) were <54 years and 96 (50.80%) were ≥54 years. 78.84% of HTN patients had abnormal serum creatinine levels, and 54.5% had abnormal serum urea levels. 58.7% showed proteinuria. Elevated sodium levels (>145 mmol/l) affected 39.68% of patients, while reduced potassium levels (<3.5 mmol/l) were found in 15.34%. 41.27% had elevated chloride levels above 106 mmol/l. CKD stages varied: 3.2% had G1, 17.5% had G2, 14.8% had G3a, 29.1% had G3b, 16.4% had G4, and 19.0% had G5. Reduced renal function, estimated using GFR, was prevalent among hypertensive patients (79.4%) (95% CI:72.9-82.9), notably those ≥54 years. In conclusion, the risk of progressive kidney disease was high amongst hypertensive patients and this was evident from the proportion of patients who have abnormal kidney function including proteinuria. Early screening and implementation of therapeutic strategies can improve patient's quality of life.

Key words: Systolic, diastolic, hypertensive, serum electrolytes, urea, creatinine, proteinuria.

Introduction

BACKGROUND INFORMATION.

AHA guidelines defined hypertension as "a systolic pressure of 130 mmHg and above, and diastolic pressure of 80 mmHg and above". Hypertension is often asymptomatic and can cause kidney complications [1]. CKD is defined by KDOQI and KDIGO as "abnormalities of kidney function or structure, for a duration more than 3 months, with health implications and characterized by either GFR lower than 60 ml/min/1.73 m2 or markers of damage

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to the kidney, including persistent proteinuria and albuminuria" [2]. AKI is a sudden depreciation in function of kidneys and accompanied by impairment and injury [3].

The kidneys have a crucial responsibility in controlling blood pressure through production of renin, maintaining fluid and electrolyte balance, removal of waste products, removal of acids produced by our cells and production of erythropoietin. [45]

Slightly decreased GFR and albuminuria are evident during early stages of kidney disease. Advanced stages can lead to ESRD [6], requiring transplantation or dialysis, posing a major burden to patients. In Africa, the prevalence of CKD is 10.1%, 24.7% amongst patients with diabetes mellitus and 34.5% in hypertensive patients [7].

Increased patient awareness and lifestyle changes are important in preventing kidney disease and hypertension [8]. Early detection can significantly reduce complications associated with hypertension such as cardiovascular disease, CKD and improve patient outcomes. [9]

PROBLEM STATEMENT

Abnormal serum electrolyte levels and abnormal renal function tests have significant health implications [10]. Hypertension is tied to factors like age, anemia, diabetes, and chronic kidney disease and can lead to renal failure and also being a major cause of CKD-related mortality [11]. The global increase in CKD and hypertension cases raises concerns due to their high mortality and morbidity rates [12]. Current studies done in certain regions show that in Kenya the prevalence of CKD in western Kenya was 3.7% [13]. The prevalence of hypertension according to a study done in 2018 was 24.5% [14]. This necessitates action for hypertension related CKD. In developing countries like Kenya, there is lack of effective target screening program for non-communicable diseases like hypertension and kidney disease. A surveillance program should be put in place for hypertension and it should be merged together with surveillance programs for kidney disease.[12]

JUSTIFICATION.

Hypertension and kidney conditions are often undetected until advanced stages due to limited awareness and financial constraints hindering regular check-ups[15]. Electrolyte imbalances increase hypertension and cardiovascular risks, notably hyperkalemia in renal disease and heart failure [16,17]. The research identified frequencies of abnormalities, aiding in risk assessment for HTN patients. Awareness amongst Kenyans is crucial regarding the interrelationship between unmonitored hypertension and kidney disease [14]. Data on electrolyte abnormalities and kidney function in hypertensive Kenyan patients is scarce. Study findings were essential in defining the problem, enhance patient awareness, guide screening programs, and inform management and preventative strategies at KNH. [14]

OBJECTIVES

General objectives.

Evaluate serum electrolyte abnormalities and kidney function in hypertensive patients at KNH.

Specific objectives.

- Determine the proportion of hypertensive patients with abnormal kidney function.
- Correlate hypertension and kidney function.
- Determine prevalence of proteinuria among hypertensive patients.
- Identify the most affected age and gender.

RESEARCH QUESTIONS.

- Proportion of hypertensive patients with abnormal kidney function at KNH?
- Association between hypertension and kidney function at KNH?
- Prevalence of proteinuria among hypertensive patients at KNH?
- Most affected age and gender?

CHAPTER TWO: LITERATURE REVIEW.

INTRODUCTION.

Hypertension is an increase in systemic arterial blood pressure ≥130/80 mmHg [18]. HTN and CKD are interrelated. CKD etiology, genetic factors, albuminuria contribute to HTN severity. Hypertension affects a large number of patients than CKD in the general population [19]. Uncontrolled hypertension gradually causes decreased kidney function, ultimately leading to worsening of blood pressure[20].

THEORETICAL REVIEW.

Mechanism of renal dysfunction in hypertension.

Hypertension and chronic kidney disease are interconnected pathophysiologically. Studies say that CKD is the commonest form of secondary HTN [21]. Factors like increased retention of sodium, reduction in nephron mass, extracellular volume expansion, endothelial dysfunction, hormonal activation including the renin-angiotensin system contribute to this complexity [22]. Uncontrolled high blood pressure (HBP) leads to increased force on the blood vessels supplying the nephrons, causing arterial damage [23]. The link between glomerular hypertension and renal dysfunction is often complex [24]. Increased blood pressure stresses the glomerulus, enlarging its diameter, allowing increased water and solute influx. This stress damages arteries, reducing blood delivery to kidney tissues, resulting in kidney damage, decreased blood filtration, and compromised blood pressure regulation[25,26]

Prevalence of HTN and CKD.

Globally, CKD prevalence is 13.4%. Estimated global chronic kidney disease prevalence is between 11.7% to 15.1% [27]. Hypertension has an increasing prevalence especially in low- and middle-income countries. In 2010, 31.1% of adults were hypertensive. Higher in countries with middle and lower income, 31.4%, than countries with high income, 28.4% [28]. In the United States, 30% of adults have HTN and 15% of adults have CKD. [19].

In Africa, hypertension prevalence is around 48%, with varying CKD prevalence from 10.7% to 13.9%. [29–31]

In Kenya, the prevalence of HTN is 28.7% [32]. The precise prevalence of CKD in HTN patients is not well known. In 2018, Mwenda *et al.* study showed estimated prevalence of 38.6% in general population, attributed to factors such as lifestyle and demographic factors[33]. WHO indicates that 20% of the total population were at high risk of hypertension, 21% males and 19% females. Percentage of hypertension in countries with low income and higher income was 28% and 18% respectively [34]. Data insufficiency exists in describing CKD prevalence in hypertensive patients in Nairobi and Kenya at large.

CRITIQUES AND GAPS

Many researchers in Kenya have focused on kidney disease prevalence and risk factors in the general population and in select populations such as brain injury and cholera patients [35–37]. This study focused on evaluating serum electrolyte abnormalities and kidney function in hypertensive patients notably at Kenyatta National Hospital. Assessment of these factors helped determine the magnitude of the problem.

SUMMARY

Effective targeted screening programs for non-communicable diseases like hypertension are essential [12]. While limited, existing research indicates alarming CKD and HTN rates, especially in Nairobi [33]. Hypertension plays a major role in CKD progression, emphasizing the importance of monitoring hypertensive patients to prevent renal failure [7] .

Materials and Methods

Study design

Retrospective study involving assessment of medical records of hypertensive patients at KNH to describe the relationship between various clinical parameters.

Study area

Kenyatta National Hospital, largest public referral and teaching hospital, situated in the Upper Hill district of Nairobi County Kenya.

Study population

Hypertensive patients attending KNH from January 2021 to August 2021.

Sampling technique

Convenience sampling from KNH medical records from January 2021 to August 2021.

Criteria

Inclusion criteria

Patients of age 18 years and older with hypertension history.

Exclusion criteria

Patients with known history of renal disease, pregnant women, diabetes, or cardiac heart failure.

Techniques.

Data on blood pressure tests, dipstick urinalysis, and biochemical blood tests were obtained for analysis.

Sample size determination.

Fisher *et al*. 1998 formulae and an adjustment produced a sample size of 181 hypertensive patients. [38]

Data Collection and analysis.

Data on age, blood pressure, serum creatinine, electrolytes, urea, and proteinuria were obtained from medical records and analyzed by SPSS. GFR was calculated using CKD-EPI equation.

Statistical analysis

SPSS version 26 was utilized for statistical data analysis and presentation.

Ethical consideration.

The study adhered to the Declaration of Helsinki principles, maintaining patient confidentiality and securing approval from TUM Ethical Review Committee and KNH in November 2021. Data was analyzed and strictly used for study purposes.

Results

Demographic characteristics.

Study involved 189 patients; 82 (43.4%) males and 107 (56.6%) females, all aged 18 years and older. Median age was 54.0 years (IQR 24.0). Hypertensive patients below 54 years were 93 (49.20%) whereas patients 54 years and older were 96 (50.80%).

Table 1: characteristics of the hypertensive patients at KNH, 2021.

Variable	Description	Frequency (%)	Percent (%)
AGE (Years)	18 – 29	19	10.1%
	30 – 41	32	16.9%
	42 – 53	42	22.2%
	54 and above	96	50.8%
GENDER	Males	82	43.4%
	Females	107	56.6%

Prevalence of proteinuria and serum biochemical abnormalities.

Prevalence of proteinuria amongst hypertensive patients was 58.7% (95% CI: 51.4-65.8) while 78.84% had high abnormal creatinine levels. High serum urea levels were found in 54.5% patients. Elevated sodium levels above 145mmol/l appeared in 39.68% whereas patients with reduced potassium levels below 3.5 mmol/l represented 15.34% and those with elevated potassium level above 5.5 mmol/l were 28.04%. Patients with elevated chloride levels above 106 mmol/l were 41.27%. CKD stages were distributed as follows: G1 (3.6%), G2 (17.5%), G3a (14.8%), G3b (29.1%), G4 (16.4%) and G5 (19.0%). Decreased renal function estimated using GFR was high amongst hypertensive patients with a prevalence of 79.4% (95% CI: 72.9-82.9), especially among patients aged ≥ 54 years.

Table 2: Prevalence of proteinuria and serum biochemical abnormalities among hypertensive patients at KNH, 2021.

Parameters	Frequency		
	Population (n=189)	Male (n=82)	Female (n=107)
Serum creatinine > 130 mmol/l	149 (78.84%)	62 (41.61%)	87 (58.39%)
Serum urea > 8.2 mmol/l	103 (54.5%)	39 (37.86%)	64 (62.14%)
Proteinuria (Positive)	111 (58.7%)	46 (41.44%)	65 (58.56%)
Serum sodium > 145 mmol/l	75 (39.68%)	32 (42.67%)	43 (57.33%)
Serum potassium < 3.5 mmol/l	29 (15.34%)	11 (37.93%)	18 (62.07%)
Serum potassium > 5.5 mmol/l	53 (28.04%)	14 (26.42%)	39 (73.58%)
Serum chloride > 106 mmol/l	78 (41.27%)	31 (39.74%)	47 (60.26%)

Table 3: CKD staging by eGFR [39]

CKD Stage	eGFR (ml/ min/1.73m2)
I	≥ 90
II	60 – 89
IIIa	45 – 59
IIIb	30 – 44
IV	15 – 29
V	< 15

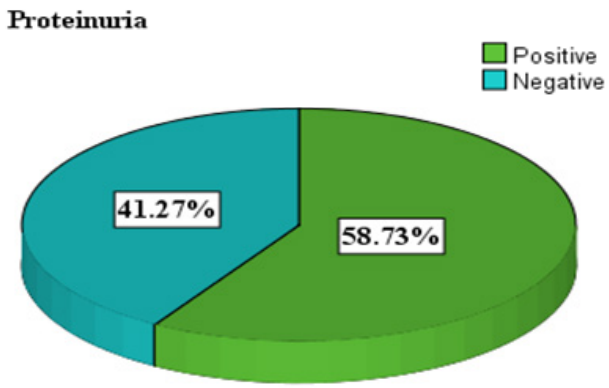

Figure 1: Proportion of hypertensive patients who had proteinuria.

Table 4: CKD stage by 2021 CKD-EPI Creatinine

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	G1	6	3.2	3.2	3.2
	G2	33	17.5	17.5	20.6
	G3a	28	14.8	14.8	35.4
	G3b	55	29.1	29.1	64.6
	G4	31	16.4	16.4	81.0
	G5	36	19.0	19.0	100.0
	Total	189	100.0	100.0	

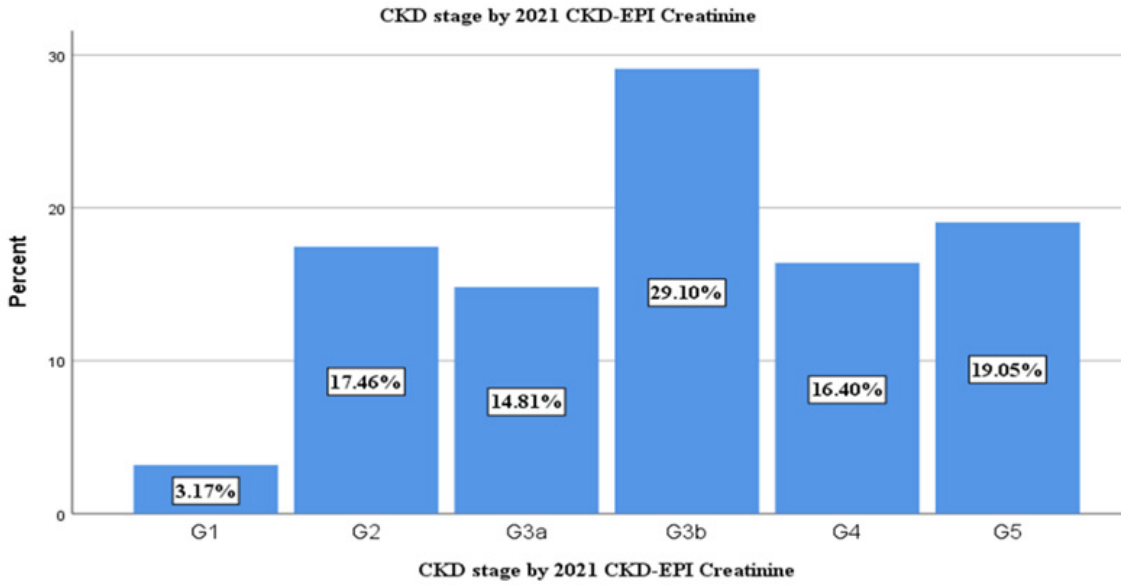

Figure 2: Bar graph showing CKD stage of hypertensive patients at KNH, 2021.

Table 5: Overall, age and gender-specific CKD prevalence at KNH, 2021.

Variable		CKD-EPI, 2021 % (95%CI)
Overall prevalence		79.4% (72.9 – 84.9)
Age (years)	18 – 29	2.65%
	30 – 41	10.05%
	42 – 53	16.93%
	54 +	49.74%
Gender	Male	32.80%
	Female	46.56%

Association between hypertension and kidney function at KNH, 2021.

Correlations between hypertension and kidney function indicators (serum creatinine, serum urea and eGFR) were statistically significant. Systolic blood pressure correlated strongly with serum creatinine ($r = .640$, $p < 0.001$, $n = 189$) for a two tailed test. Notably, SBP correlated at .677 with serum urea and at -.764 with estimated GFR (both $p < 0.001$, $n = 189$). Diastolic blood pressure correlated with serum creatinine, serum urea, and GFR at .374, .372, and -.405 respectively and all were statistically significant ($p < 0.001$, $n = 189$).

Table 6: Correlations between various biochemical parameters amongst hypertensive patients at KNH,2021.

Correlations								
		Age	**Gender**	**SBP mmHg**	**DBP mmHg**	**Creatinine conc. in umol/l**	**Urea conc. in mmol/l**	**eGFR in ml/min/1.73m2**
Age (years)	Pearson Correlation	1	.057	.581**	.239**	.437**	.522**	-.658**
	Sig. (2-tailed)		.438	.000	.001	.000	.000	.000
	N	189	189	189	189	189	189	189
Gender	Pearson Correlation	.057	1	.180*	.056	.173*	.131	-.354**
	Sig. (2-tailed)	.438		.013	.442	.017	.072	.000
	N	189	189	189	189	189	189	189
SBP in mmHg	Pearson Correlation	.581**	.180*	1	.587**	.640**	.677**	-.764**
	Sig. (2-tailed)	.000	.013		.000	.000	.000	.000
	N	189	189	189	189	189	189	189
DBP mmHg	Pearson Correlation	.239**	.056	.587**	1	.374**	.372**	-.405**
	Sig. (2-tailed)	.001	.442	.000		.000	.000	.000
	N	189	189	189	189	189	189	189

Continue.....

Creatinine conc. in umol/l	Pearson Correlation	.437**	.173*	.640**	.374**	1	.685**	-.703**
	Sig. (2-tailed)	.000	.017	.000	.000		.000	.000
	N	189	189	189	189	189	189	189
Urea conc. in mmol/l	Pearson Correlation	.522**	.131	.677**	.372**	.685**	1	-.729**
	Sig. (2-tailed)	.000	.072	.000	.000	.000		.000
	N	189	189	189	189	189	189	189
eGFR in ml/ min/1.73m2	Pearson Correlation	-.658**	-.354**	-.764**	-.405**	-.703**	-.729**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	
	N	189	189	189	189	189	189	189
**. Correlation is significant at the 0.01 level (2-tailed).								
*. Correlation is significant at the 0.05 level (2-tailed).								

Discussion

This retrospective study involved 107 women (56.6%) and 82 men (43.4%), showing a higher hypertension prevalence among women, aligning with previous research by Beth L [40]. Most hypertensive patients (50.80%) were aged 54 years and above, similar with a study in Kenya with HTN prevalence of 52.8% among patients aged ≥50 years [41]. Hypertension prevalence rises with age, with adults aged 60 to 69 years at higher risk [14].

Proteinuria was common among hypertensive patients (58.7%), exceeding rates in Uganda (13%) and Ghana (28.9%) [42,43] due to differences in study design. Uncontrolled hypertension can harm kidneys thereby reducing GFR, impacting protein reabsorption and causing proteinuria [44,45].

Reduced renal function prevalence among hypertensives was 79.4% (95% CI; 72.9 to 84.9), increasing with age, notably among women and this was in line with research in the United States where CKD risk was slightly greater in women at 14% than in men, 12% [46]. This prevalence was high compared to that in Ghana (46.9%) and among osteoarthritis patients in Kenya (61.9%) due to differences in study approaches and participants [47,48]

Electrolyte abnormalities were evident: 39.68% had hypernatremia, 28.04% hyperkalemia, and 41.27% slightly elevated chloride levels, similar to another study in Kenya where electrolyte abnormalities were noted in CKD [33]. Electrolyte imbalances have been known to contribute to high blood pressure [49]. Hyperkalemia occurred in hypertensives with reduced eGFR, primarily due to decreased kidney function leading to impaired potassium excretion. This condition was linked to risk factors such as CKD [50]. Hypertensives in stage G3b had high risk of progressive renal disease (29.1%), G3a had moderate risk (14.8%) and G1 exhibited the lowest risk (3.2%).

Studies have shown that renal function declines with age [51,52].

There was a significant, strong, positive and linear relationship between blood pressure, creatinine and urea levels which indicated that an increased blood pressure resulted into higher levels of these markers because hypertension gradually damages kidneys impacting filtration of these waste products [53].

There was a significant, strong, negative relationship between blood pressure and estimated GFR, indicating that high blood pressure resulted into decreased GFR. Contrary to findings by Eriksen, where the impact of hypertension on GFR was unclear, this study suggests a negative effect [54].

Limitations of the study.

The study was retrospective and calculated GFR based on a single serum creatinine level, possibly

causing slightly higher CKD prevalence than other studies. Also based on the single creatinine levels obtained, it didn't distinguish AKI and CKD due to data limitations, leading to a potential high CKD prevalence amongst hypertensives at KNH.

CONCLUSION, RECOMMENDATIONS, CONFLICT OF INTEREST AND SOURCE OF FUNDING STATEMENT.

Conclusion

The prevalence of reduced kidney function was high in hypertensives at Kenyatta National Hospital, shown by proteinuria and eGFR. Electrolyte imbalances were common. CKD rates were high with hypertension. Significant links existed between hypertension and abnormal serum parameters, particularly affecting females more and adults aged ≥50 years. It's paramount that early screening and treatment strategies can improve the quality of life for hypertensive patients.

RECOMMENDATIONS.

1. Implementation of early target screening programs for hypertension and kidney disease at Kenyatta National Hospital.
2. Implement a nation-wide surveillance program for hypertension and kidney disease including high risk groups such as CVD, obesity and diabetic patients to enable early detection.

SOURCE OF FUNDING. This retrospective study was funded by support from my parents and relatives who selflessly and greatly contributed to the success of the research.

CONFLICT OF INTEREST. There was no conflict of interest during the study.

APPENDIX

ABBREVIATIONS AND ACRONYMS

TUM:	Technical University of Mombasa.
HTN:	Hypertension.
NKF:	National Kidney Disease.
CKD:	Chronic Kidney Disease.
KNH:	Kenyatta National Hospital.
BP:	Blood Pressure.
eGFR:	estimated Glomerular filtration rate.
RBP:	Resting Blood Pressure.
AHA:	American Heart Society.
mmHg:	millimeters of mercury.
ESRD:	End stage renal disease.
RRT:	Renal replacement therapy.
KDIGO:	Kidney Disease Improving Global Outcomes.
KDOQI:	Kidney Disease Outcomes Quality Initiative.
HBP:	High Blood Pressure.
CVD:	Cardiovascular disease.
CKD-EPI:	ChronicKidneyDiseaseEpidemiology Collaboration.

OPERATIONAL DEFINITIONS

Hypertension: A condition characterized by persistent high blood pressure levels. AHA defines it as above 130/80 mmHg and 180/120 mmHg is considered severe.

Systolic pressure: The amount of pressure in the arteries as the heart muscle contracts.

Normal: ≤ 120mmHg, Elevated: 120-129mmHg, Stage 1 HTN: 130-139mmHg, Stage 2 HTN: ≥ 140mmHg, HTN crisis: ≥180 mmHg.

Diastolic pressure: The pressure within the arteries that occurs between heartbeats.

Normal: ≤ 80mmHg, Stage 1 HTN: 80-89mmHg, Stage 2 HTN: ≥ 90mmHg, Hypertensive crisis: ≥120mmHg.

Biochemical alterations: shift in biochemistry parameters from the normal range.

Serum electrolytes: minerals found in the serum that carry an electric charge and keep the internal environment balanced, nervous system, and muscles functioning.

Serum creatinine: Waste product of breakdown of creatine phosphate from muscle tissue.

Proteinuria: Presence of abnormal protein quantity in the urine.

GFR: Rate at which extra fluids and waste are filtered from the blood by kidneys.

End stage renal disease: An advanced stage loss of kidney function.

Spectrophotometry: An analytical method used to measure how much an analyte absorbs light intensity at different wavelengths.

Pathophysiology: Physiological process associated with disease or injury

Renin-angiotensin system: A collection of hormones that regulate blood pressure and water content in the body.

REFERENCES

1. Whelton PK, Carey RM, Aronow WS, Casey DE, Collins KJ, Himmelfarb CD, et al. Guideline for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Pr. Hypertension. 2018;71(6): e13–115.
2. Andrew Levey, MD F. What's New About the New CKD Guideline? [Internet]. NATIONAL KIDNEY FOUNDATION. 2021 [cited 2021 Jun 4]. Available from: https://www.kidney.org/professionals/CKDGuideline#:~:text=The KDIGO definition for CKD, of kidney damage%2C including albuminuria.
3. Makris K, Spanou L. Acute Kidney Injury: Definition, Pathophysiology and Clinical Phenotypes. Clin Biochem Rev. 2016 May;37(2):85–98.
4. Ogobuiro I FTuma. NCBI [Internet]. Physiology, Renal. [Updated 2020 Aug 29]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. 2020. Available from: https://www.ncbi.nlm.nih.gov/books/NBK538339/
5. Suzanne R. Steinbaum D. High blood pressure and kidney disease. [Internet]. Hypertension. 2019. Available from: Suzanne R. Steinbaum, DO
6. AKF. Kidney failure (ESRD) causes, symptoms and Treatment. [Internet]. American Kidney Fund. 2021 [cited 2021 Jul 14]. Available from: https://www.kidneyfund.org/kidney-disease/kidney-failure/
7. Abd El Hafeez S, Bolignano D, D'Arrigo G, Dounousi E, Tripepi G, Zoccali C. Prevalence and burden of chronic kidney disease among the general population and high-risk groups in Africa: a systematic review. BMJ Open. 2018 Jan;8(1): e015069.
8. Suzanne R. Steinbaum D. High blood pressure and kidney disease. [Internet]. Hypertension. 2019. Available from: Suzanne R. Steinbaum, DO
9. Abdalrahim AK and M. Knowledge, attitudes, and practices towards prevention and early detection of chronic kidney diseases. Int Nurs Rev. 2014;61(2):237–45.
10. Molla MD, Degef M, Bekele A, Geto Z, Challa F, Lejisa T, et al. Assessment of serum electrolytes and kidney function test for screening of chronic kidney disease among Ethiopian Public Health Institute staff members, Addis Ababa, Ethiopia. BMC Nephrol. 2020;21(1):494.
11. American Kidney Fund. Kidney Disease Causes and Risk Factors. [Internet]. American Kidney Fund. 2021. Available from: https://www.kidneyfund.org/prevention/are-you-at-risk/
12. A.S. Levey et al. chronic kidney disease as a global public health problem: Approaches and initiatives – a position statement from Kidney Disease Improving Global Outcomes. Kidney Int. 2017;72(3):247–59.
13. Muiru AN, Charlebois ED, Balzer LB, Kwarisiima D, Elly A, Black D, et al. The epidemiology of chronic kidney disease (CKD) in rural East Africa: A population-based study. PLoS One. 2020 Mar 4;15(3): e0229649.
14. Mohamed SF, Mutua MK, Wamai R, Wekesah F, Haregu T, Juma P, et al. Prevalence, awareness, treatment and control of hypertension and their determinants: results from a national survey in Kenya. BMC Public Health. 2018 Nov 7;18(Suppl 3):1219.
15. Irene Labuschagne JN. Chronic kidney disease is still a major health challenge in Africa [Internet]. HEALTH+MEDICINE. 2017. Available from: https://theconversation.com/chronic-kidney-disease-is-still-a-major-health-challenge-in-africa-73977#:~:text=There are three main challenges, thirdly%2C there are treatment failures.
16. Iqbal S, Klammer N, Ekmekcioglu C. The Effect of Electrolytes on Blood Pressure: A Brief Summary of Meta-Analyses. Nutrients [Internet]. 2019 Jun 17;11(6):1362. Available from: https://pubmed.ncbi.nlm.nih.gov/31212974

17. Montford JR, Linas S. How Dangerous Is Hyperkalemia? J Am Soc Nephrol [Internet]. 2017/08/04. 2017 Nov;28(11):3155–65. Available from: https://pubmed.ncbi.nlm.nih.gov/28778861

18. Martínez-Rueda AJ, Olivas-Martínez A, Vega-Vega O, Fonseca-Correa JI, Correa-Rotter R. New 2017 American College of Cardiology/American Heart Association High Blood Pressure Guideline. Hypertension. 2019 Jan 1;73(1):142–7.

19. Horowitz B, Miskulin D, Zager P. Epidemiology of hypertension in CKD. Adv Chronic Kidney Dis. 2015 Mar;22(2):88–95.

20. Tedla FM, Brar A, Browne R, Brown C. Hypertension in Chronic Kidney Disease: Navigating the Evidence. Whaley-Connell AT, editor. Int J Hypertens. 2011;2011:132405.

21. Leticia Buffet CR. Chronic Kidney Disease and Hypertension: A Destructive Combination. Pharmacists Resource for Clinical Excellence. 2021;

22. Ku E, Lee BJ, Wei J, Weir MR. Hypertension in CKD: Core Curriculum 2019. American Journal of Kidney Diseases. 2019 Jul 1;74(1):120–31.

23. American Heart Association. How high blood pressure can lead to kidney damage or failure. High Blood Pressure. 2016;

24. Hamrahian SM, Falkner B. Hypertension in Chronic Kidney Disease. Adv Exp Med Biol. 2017;956:307–25.

25. Ku E, Lee BJ, Wei J, Weir MR. Hypertension in CKD: Core Curriculum 2019. American Journal of Kidney Diseases [Internet]. 2019 Jul 1;74(1):120–31. Available from: https://doi.org/10.1053/j.ajkd.2018.12.044

26. American Heart Association. How high blood pressure can lead to kidney damage or failure. High Blood Pressure [Internet]. 2016; Available from: https://www.heart.org/en/health-topics/high-blood-pressure/health-threats-from-high-blood-pressure/how-high-blood-pressure-can-lead-to-kidney-damage-or-failure

27. Lv JC, Zhang LX. Prevalence and Disease Burden of Chronic Kidney Disease. Adv Exp Med Biol. 2019;1165:3–15.

28. Mills KT, Stefanescu A, He J. The global epidemiology of hypertension. Nat Rev Nephrol. 2020;16(4):223–37.

29. Matsha TE, Erasmus RT. Chronic kidney disease in sub-Saharan Africa. Lancet Glob Health [Internet]. 2019 Dec 1;7(12):e1587–8. Available from: https://doi.org/10.1016/S2214-109X(19)30467-X

30. George JA, Brandenburg JT, Fabian J, Crowther NJ, Agongo G, Alberts M, et al. Kidney damage and associated risk factors in rural and urban sub-Saharan Africa (AWI-Gen): a cross-sectional population study. Lancet Glob Health. 2019;7(12):e1632–43.

31. Norberto Perico GR. Chronic kidney disease in sub-Saharan Africa: a public health priority. Lancet Glob Health [Internet]. 2014;2(3). Available from: https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(14)70014-2/fulltext

32. Mkuu RS, Gilreath TD, Wekullo C, Reyes GA, Harvey IS. Social determinants of hypertension and type-2 diabetes in Kenya: A latent class analysis of a nationally representative sample. Barengo NC, editor. PLoS One. 2019 Aug 19;14(8):e0221257.

33. Mwenda V, Githuku J, Gathecha G, Wambugu BM, Roka ZG, Ong'or WO. Prevalence and factors associated with chronic kidney disease among medical inpatients at the Kenyatta National Hospital, Kenya, 2018: a cross-sectional study. Pan Afr Med J. 2019 Aug 23;33:321.

34. Damasceno A. Noncommunicable Disease. Heart of Africa: Clinical Profile of an Evolving Burden of Heart Disease in Africa. 2016. 155–157 p.

35. Rotich Joyce Cherono. The Prevalence and Risk Factors for Chronic Kidney Disease in Kericho County, Kenya. INTERNATIONAL JOURNAL OF NURSING. 2017;4(2).

36. Ndege BW. Acute Kidney Injury And Electrolyte Abnormalities Among Patients Admitted With Cholera In Kenyatta National Hospital In Nairobi, Kenya, In The Year 2017. 2018 [cited 2021 Jul 24]; Available from: http://erepository.uonbi.ac.ke/handle/11295/109619#.YPvhBvPWepg.mendeley

37. Mwenda V, Githuku J, Gathecha G, Wambugu BM, Roka ZG, Ong'or WO. Prevalence and factors associated with chronic kidney disease among medical inpatients at the Kenyatta National Hospital, Kenya, 2018: a cross-sectional study. Pan Afr Med J [Internet]. 2019 Aug 23;33:321. Available from: https://pubmed.ncbi.nlm.nih.gov/31692795

38. Charan J, Biswas T. How to calculate sample size for different study designs in medical research? Indian J Psychol Med. 2013 Apr;35(2):121–6.

39. Kidney International Supplements. KDIGO K. Clinical Practice Guideline Update for the Diagnosis, Evaluation, Prevention and Treatment of Chronic Kidney Disease-Mineral and Bone Disorder (Ckd-Mbd). 2017. 1–59 p.

40. Beth L. Abramson, Kajenny Srivaratharajah LLD. Women and Hypertension: Beyond the 2017 Guideline for Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults. AMERICAN COLLEGE of CARDIOLOGY. 2018;

41. Gatimu SM, John TW. Socioeconomic inequalities in hypertension in Kenya: a decomposition analysis of 2015 Kenya STEPwise survey on non-communicable diseases risk factors. Int J Equity Health. 2020;19(1):213.

42. Lunyera J, Stanifer JW, Ingabire P, Etolu W, Bagasha P, Egger JR, et al. Prevalence and correlates of proteinuria in Kampala, Uganda: a cross-sectional pilot study. BMC Res Notes. 2016;9(1):97.

43. Osafo C, Mate-Kole M, Affram K, Adu D. Prevalence of Chronic Kidney Disease in Hypertensive Patients in Ghana. Ren Fail. 2011 May 1;33(4):388–92.

44. Beddhu S, Shen J, Cheung AK, Kimmel PL, Chertow GM, Wei G, et al. Implications of early decline in eGFR due to intensive BP control for cardiovascular outcomes in SPRINT. Journal of the American Society of Nephrology. 2019;30(8):1523–33.

45. Shibata M, Sato KK, Uehara S, Koh H, Kinuhata S, Oue K, et al. Blood pressure components and the risk for proteinuria in Japanese men: The Kansai Healthcare Study. J Epidemiol [Internet]. 2017/07/11. 2017 Nov;27(11):505–10. Available from: https://pubmed.ncbi.nlm.nih.gov/28709559

46. National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, Bethesda M. United States Renal Data System. 2016 USRDS annual data report: Epidemiology of kidney disease in the United States. NATIONAL KIDNEY FOUNDATION. 2016;

47. Osafo C, Mate-Kole M, Affram K, Adu D. Prevalence of Chronic Kidney Disease in Hypertensive Patients in Ghana. Ren Fail [Internet]. 2011 May 1;33(4):388–92. Available from: https://doi.org/10.3109/0886022X.2011.565140

48. Muyodi M. Prevalence and Risk Factors associated with Chronic Kidney Disease among Osteoarthritis patients at Kenyatta Nationa l Hospitaal. [Internet]. EREPOSITORY.UONBI.AC.KE. 2018. Available from: http://erepository.uonbi.ac.ke/bitstream/handle/11295/153674/Muyodi_Prevalence of and factors associated with Chronic Kidney Disease in Osteoarthritis patientsyatta National Hospital.pdf?sequence=1

49. Iqbal S, Klammer N, Ekmekcioglu C. The Effect of Electrolytes on Blood Pressure: A Brief Summary of Meta-Analyses. Nutrients. 2019 Jun 17;11(6):1362.

50. Lakkis JI, Weir MR. Hyperkalemia in the Hypertensive Patient. Curr Cardiol Rep. 2018 Mar;20(2):12.

51. Toyama T, Kitagawa K, Oshima M, Kitajima S, Hara A, Iwata Y, et al. Age differences in the relationships between risk factors and loss of kidney function: a general population cohort study. BMC Nephrol. 2020;21(1):477.

52. Staff PONE. Longitudinal Study of the Decline in Renal Function in Healthy Subjects. PLoS One. 2015;10(8):e0135992.

53. Rayamajhi S, Wang L, Herzallah K. RELATIONSHIP BETWEEN BLOOD PRESSURE AND RENAL INDICES AMONG CHRONIC RENAL INSUFFICIENCY PATIENTS IN A LARGE COHORT STUDY. J Hypertens. 2019;37.

54. Eriksen BO, Stefansson VTN, Jenssen TG, Mathisen UD, Schei J, Solbu MD, et al. Blood pressure and age-related GFR decline in the general population. BMC Nephrol [Internet]. 2017;18(1):77. Available from: https://doi.org/10.1186/s12882-017-0496-7.