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Meta-analysis

Exploring the application of Dietary Approaches to Stop Hypertension (DASH) in the management of patients with Chronic Kidney Disease: A systematic review and meta-analysis

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SUMMARY

Background & aim: Chronic Kidney Disease (CKD) remains a significant global non-communicable disease (NCD) that affects more than 10 % of the world's population. Attention is gradually shifting to tertiary prevention of CKD to avoid End-Stage Renal Disease (ESRD) progression. This study reviewed evidence of the use of a Dietary Approach to Stop Hypertension (DASH) and its effect on disease progression among patients living with CKD.

Methods: A comprehensive search was conducted using the Scopus, PubMed, Web of Science, ProQuest, and EBSCOHost databases for studies published from 1997 to 2025. The PICO framework guided the search, focusing on patients with CKD, DASH as the intervention, other dietary and non-dietary approaches as comparisons, and CKD progression measured by changes in estimated Glomerular Filtration Rate (eGFR) and/or Urine Albumin-to-Creatinine Ratio (UACR) as outcomes. Effect sizes with 95 % confidence intervals and pooled effects were calculated using random effects REML models and Z-tests. Percentage changes in renal function post-intervention, based on eGFR, were also computed. Cochran's Q test and the I-squared (I^2) statistic assessed study heterogeneity. This review protocol is registered with PROSPERO (CRD42024588682).

Results: Of the 174 studies screened, four met the eligibility criteria and were included in the review. All were prospective cohort studies with an average follow-up of 5.5 years and a combined patient sample size of 7033. Across studies, low DASH adherence was defined as scores in the lower half of the possible range used, and high adherence as scores in the upper half (e.g., 0–40 vs. 41–80; 0–4 vs. 5–9; 8–24 vs. 25–40). Low DASH adherence was associated with a mean eGFR improvement of 0.54 ml/min/1.73 m^2 (1.2 %) ($Z = 0.57$, $p = 0.57$), while high adherence showed a greater improvement of 3.34 ml/min/1.73 m^2 (6.8 %) ($Z = 1.77$, $p = 0.08$). Only one study assessed UACR, reporting a lower median UACR with high DASH adherence (33.6 mg/g) compared to low adherence (55.6 mg/g).

Conclusions: The DASH diet has the potential to slow CKD progression; however, consistent adherence is crucial to maximize its clinical benefits and improve renal outcomes. Although improvements in eGFR with DASH diet adherence are clinically meaningful, they lack statistical significance. These findings support global efforts towards achieving Sustainable Development Goal 3 for NCDs.

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Abbreviations

CKD	Chronic Kidney Disease
DASH	Dietary Approaches to Stop Hypertension
eGFR	Estimated Glomerular Filtration Rate
ESRD	End-Stage Renal Disease
KDOQI	Kidney Disease Outcomes Quality Initiative
KRT	Kidney Replacement Therapy
MDRD	Modification of Diet in Renal Disease
NCDs	Non-Communicable Diseases
UACR	Urine Albumin-to-Creatinine Ratio

1. Introduction

Chronic Kidney Disease (CKD) remains a public health burden affecting between 8.5 % and 11.4 % of the global population with approximately 1.2 million recorded deaths annually [1–6]. However, a systematic review and meta-analysis revealed an estimated 13.4 % global burden in all five CKD stages and 10.6 % in stages 3–5 [7]. Although CKD incidence has been reported worldwide, it is disproportionately high (80 %) in low- and middle-income countries (LMICs) [8]. China and India account for the majority of the global CKD cases (132.3 million and 115.1 million cases, respectively) [1]. Approximately 15.8 % (95 % CI: 12.1–19.9) CKD prevalence has been reported in Africa [9], with a prevalence of 13.9 % (95 % CI: 12.2–15.7) specifically in sub-Saharan Africa [10]. The prevalence of stage 3–5 CKD in South Africa, Senegal, and Congo is approximately 7.6 % [11], with that in Ghana ranging from 13 to 30 % [12–15].

CKD is a known non-communicable disease (NCD) and a chronic progressive renal abnormality characterized by a low estimated Glomerular Filtration Rate (eGFR), elevated urine albumin, and accompanying complications detectable for more than 90 days [16]. CKD significantly increases the risk of cardiovascular disease, stroke, hyperlipidemia, anemia, and metabolic bone disorders [17]. When not properly managed, particularly in individuals with comorbidities such as hypertension and diabetes, CKD can progress to End-Stage Renal Disease (ESRD), leading to further health deterioration [18]. Globally, approximately 88 % of CKD cases progress to ESRD [19], and almost 4 million people live on Kidney Replacement Therapy (KRT) [20], primarily because of the complications of hypertension and diabetes [18]. CKD is forecasted to take 5th place as the world's most common cause of years of life lost by 2040 [21].

Prevention of CKD primarily involves minimizing the risk of occurrence through a healthy lifestyle, such as reducing sedentary lifestyle and increasing physical activity, dietary restrictions, ceasing smoking and alcohol intake, and refraining from the use of unprescribed medications [22,23]. Major risk factors such as obesity, hypertension, and diabetes mellitus have been significantly associated with CKD in varying populations [11,14,24–27]. Management of CKD requires multifaceted approaches, including monitoring and control of blood pressure and blood glucose, intermittent laboratory tests to monitor renal health, prescribed medication intake, and cessation of unhealthy lifestyle [28]. Evidence shows the harmful effects of chronic and uncontrolled high blood pressure on the anatomical features of the kidney and the renal system. For instance, constriction and narrowing of the blood vessels causes inter-glomerular pressure build-up, leading to impaired glomerular filtration, uncontrolled protein filtration in urine resulting in reduced blood flow to the kidneys, impaired urine output, and extra waste fluid retention [29–32].

Self-management is a key strategy in CKD management and is highly recommended, as it has been proven to improve CKD-related health outcomes and quality of life [33,34]. Diet plays a crucial role in the prevention and management of hypertension. Regular intake of high-sodium diets, added sugars, refined and high-energy foods, saturated fats, and low consumption of fruits and vegetables poses a high risk of developing hypertension and associated complications [35–39]. In CKD patients, the kidneys undergo physiological and biological changes that result in alterations in their regulatory, metabolic, and excretory functions that result in reduced urine output; thus, $\leq$500 ml urine per day [40]. These changes are characterized by low eGFR, fluid and electrolyte imbalance, and retention, including the retention of toxins and waste in the bloodstream [16,41]. Patients with CKD may diagnostically present with edema and high blood electrolyte concentrations, including hyperkalemia, dysnatremia, hyperphosphatemia, and metabolic acidosis [42,43]. Self-management through lifestyle and dietary modifications seeks to regulate the influx of dietary nutrients and electrolytes, such as protein, phosphorus, potassium, sodium, and calcium, which can lead to fluid-electrolyte imbalances and exacerbate hypertension, further stressing the kidneys in CKD patients [41,44].

Nutritional guidelines were developed for managing CKD first under the Kidney Disease Outcomes Quality Initiative (KDOQI) in 1996 [45]. In addition, the Modification of Diet in Renal Disease (MDRD) was deployed in randomized-controlled trials to ascertain the effect of dietary protein restriction on CKD progression using proteinuria as a urine marker of interest [46,47]. However, first published in 1997, the Dietary Approaches to Stop Hypertension (DASH) diet trial provided scientific evidence that there is a substantial reduction in blood pressure among individuals who regularly consume a diet rich in fruits and vegetables, whole grains, lean proteins, reduced saturated and total fats, and low-fat dairy foods [48]. Since then, the DASH diet has been used in the management of several NCDs, including diabetes [49], cardiovascular diseases [50], and cancers [51]. Although the DASH diet was primarily indicated for lowering blood pressure in patients with hypertension, recent studies have reported the early promise of modified versions of the DASH dietary pattern, resulting in reduced CKD progression [52–56]. A population-based study in West Asia reported a 46 % increased odds of CKD incidence among people on high-fat and high-sugar dietary patterns but a 43 % protection among those on a lacto-vegetarian dietary pattern [57]. DASH diet has been associated with reduced blood uric acid concentrations, which reduced the risk of gout [58], reduced body weight and waist circumference, blood pressure, and triglyceride concentrations in diverse populations with different clinical disorders and underlying conditions [51,59–61]. There is sufficient evidence supporting the reduced risk of CKD incidence among healthy individuals who adhere to DASH dietary patterns [62,63]. However, little is known about the applicability and effects of the DASH diet in managing patients already diagnosed with CKD. In this systematic review, we synthesized evidence on the use of DASH in managing patients with CKD and examined the effect of the DASH intervention on CKD progression.

2. Materials & methods

The current protocol was designed based on the study framework guided by the Cochrane Handbook for Systematic Reviews of Interventions (CHSRI) [64] and, evidence synthesis developed by Arksey and O'Malley, 2005 [65], which was further developed by Levac et al., 2010 [66]. This framework includes identifying the research question, planning the literature search, developing the study eligibility criteria, screening to select eligible articles, charting the eligible articles, quality appraisal, planning the results

synthesis methods, summarizing, and presenting results. This systematic review was conducted according to a pre-established review protocol registered on the PROSPERO register (registration number CRD42024588682).

2.1. Research question

This review was conducted based on the following research question: What is the effect of Dietary Approaches to Stop Hypertension (DASH) on disease progression in patients living with CKD? We employed the Population, Intervention, Comparison, and Outcome (PICO) framework, as illustrated in Table 1, to establish the literature search boundaries and line of inquiry [67].

2.2. Definition of CKD progression

CKD progression was defined as an estimated Glomerular Filtration Rate (eGFR) of <60 ml/min/1.73 m^2 and/or a Urine Albumin-to-Creatinine Ratio (UACR) ⩾30 mg/g [68]. This review synthesized evidence on the change in eGFR and/or UACR, effective direct biomarkers of CKD progression, among cohorts of patients with CKD pre- and post-DASH intervention over a follow-up period.

2.3. Literature search strategy

We performed a comprehensive and reproducible literature search in January, 2025 to identify relevant peer-reviewed studies for inclusion in this review. The search was performed following the guidelines of the Cochrane Handbook for Systematic Reviews of Interventions (CHSRI) [64] and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [69]. The literature search was performed using the following electronic databases: Scopus, PubMed, Web of Science, ProQuest, and EBSCOHost (made up of CINAHL, MEDLINE, Health Source- Consumer Edition, and Health Source: Nursing/Academic Edition). The search was performed using appropriate indexing keywords, Boolean operators, and Medical Subject Headings (MeSH) terms. The general search strategy included: (DASH OR “Dietary Approaches to Stop Hypertension” OR “Hypertension diet”) OR (“Chronic Kidney Disease” OR CKD OR “CKD Progression” OR “Chronic Kidney Disease Progression” OR “Chronic Renal Disease” OR CRD OR “Chronic Renal Failure” OR CRF OR “Chronic Kidney Insufficiency”) AND (eGFR OR “estimated Glomerular Filtration Rate” OR “albumin-creatinine ratio” OR ACR OR albuminuria* OR Microalbuminuria OR Macroalbuminuria). However, a database-targeted search was performed, and the output was provided (Supplementary File 1). The search included peer-reviewed articles from the identified databases. However, we manually searched for supplementary articles by rigorously searching the citations of the included references and bibliographies. The search did not restrict non-English language studies to prevent the risk of missing relevant studies.

2.4. Articles eligibility criteria

The included articles were selected based on the following criteria.

2.4.1. Inclusion criteria

Studies included were:

1. Studies showing evidence of a DASH diet intervention in patients with CKD.
2. Studies demonstrating the application of the DASH diet in the management of patients with CKD.
3. Studies reporting the effect of DASH on CKD progression measured by eGFR and/or UACR biomarkers before and after DASH intervention.
4. Studies published between 1997 and 2025.
5. Studies conducted globally.
6. Studies reporting quantitative outcomes.
7. Studies on CKD progression after DASH intervention as an outcome of interest.
8. Longitudinal (cohort) studies.

2.4.2. Exclusion criteria

We excluded:

1. Studies showing evidence of the application of non-dietary interventions in the management of CKD.
2. Studies demonstrating evidence of DASH application in the management of any medical condition other than CKD.
3. Studies demonstrating the effect of DASH on CKD incidence in healthy individuals.
4. Studies demonstrating the effect of DASH on the risk of CKD in healthy individuals.
5. Review articles, editorials, conference presentations, and letters to editors.
6. Pilot and feasibility studies, and studies with short follow-up durations.
7. Grey literature.
8. Qualitative studies.

2.5. Selection of studies

The articles extracted from the literature search were imported and screened using the Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) [70]. The articles were cleaned to remove duplicates. Two independent reviewers blindly screened the titles and abstracts based on predefined eligibility criteria. The selected articles that passed the first screening were further screened by full text to select articles that met the eligibility criteria. Disagreements during title and abstract screening were resolved through discussion. However, a third independent reviewer was consulted to resolve conflicts emanating from full text review. The selection process was documented using a PRISMA flow diagram (Fig. 1), detailing the number of articles

Table 1
PICO framework.

Population	People living with CKD globally
Intervention	Dietary Approaches to Stop Hypertension (DASH)
Comparison	Other dietary approaches and non-dietary approaches
Outcome	CKD progression measured by change in estimated Glomerular Filtration Rate (eGFR) and/or Urine Albumin-to-Creatinine Ratio (UACR)

identified, screened, excluded with reasons, and included in the final review.

2.6. Data extraction and management

Two independent reviewers extracted data using a designed data extraction form (Table 2). The data extracted included basic study information (author, year of publication, and study location or setting), the study design, study population, sample size, intervention, follow-up duration, and outcome measurements. The extracted data were verified for accuracy and completeness by the researchers. A third researcher resolved any arising discrepancies in the event of a disagreement between the two independent reviewers. When necessary, the authors contacted the authors to obtain clarification, additional information, or data. Data were marked as missing or unclear if they could not be obtained from the authors.

2.7. Data charting

Table 2 presents the selected studies eligible for the review. This chart includes the following characteristics and domains: author and year of publication, title of study, country of study, aim of the study, study design, study setting, study population, sample size, DASH diet intervention used, and measured outcomes.

2.8. Data analysis

Data were entered into Microsoft Excel (Office version 2010) and exported into Stata version 16.0 for data analysis [71]. Quantitative data were grouped and entered into a quantitative synthesis and meta-analysis. The test for heterogeneity and mean difference (effect size) with confidence intervals of individual studies and pooled effects using random effects maximum likelihood or restricted maximum likelihood (REML) models were run with accompanying Z-tests. The percentage improvement or decline in renal function post-intervention, based on the effect size of the estimated biomarkers, such as eGFR, was calculated. Results are presented in forest plots with a designated line of no difference set at 0. The tests for publication bias were performed using funnel plots and Egger's regression test. Statistical significance was set at p-value<0.05. However, studies with inadequate data to enable pooled estimates have been presented and inferences have been made in the narrative.

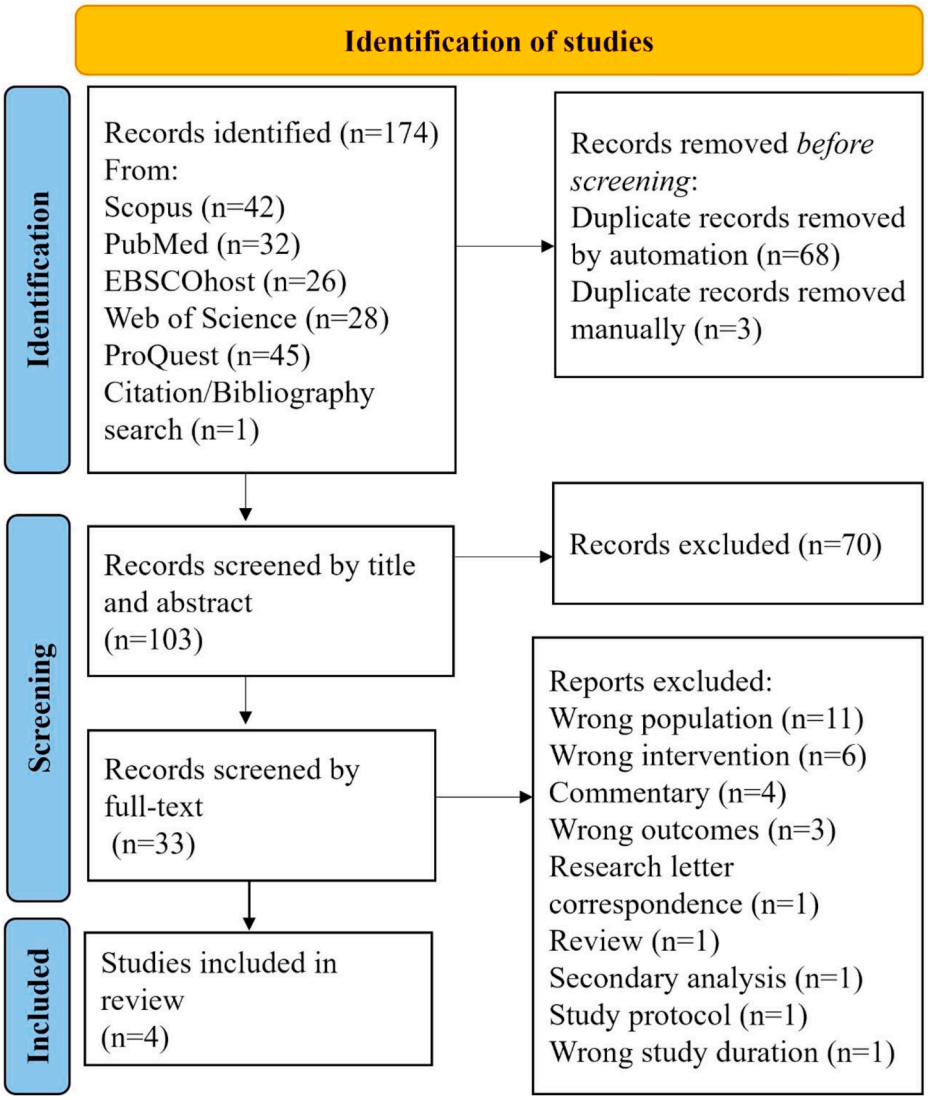

Fig. 1. PRISMA-SRv flow chart of literature search and identification of eligible studies.

Table 2
Characteristics of the included studies.

Author & Year of publication	Title of study	Country of study	Aim of study	Study design	Study population	Sample size	DASH diet intervention used	Outcome
Hu et al., 2021 [74]	Adherence to Healthy Dietary Patterns and Risk of CKD Progression and All-Cause Mortality: Findings From the CRIC (Chronic Renal Insufficiency Cohort) Study	USA	To examine the associations of four high-quality healthy dietary patterns with CKD progression and all-cause mortality among people living with CKD.	Prospective cohort study (Median follow-up time of 7 years)	Men and women aged 21–74 years with an estimated average eGFR of 47 ± 17 ml/min/ 1.73 m^2	2403	The DASH score range (8–40). Modification: 8 diet components Total vegetables, Total fruit, whole grains, low-fat dairy, sugar sweetened beverages, nuts & legumes, red/ processed meat, Sodium	Baseline eGFR: 45 ± 17 ml/min/ 1.73 m^2 Effect of DASH Low DASH scores or low adherence eGFR: 45 ± 17 ml/ min/1.73 m^2 High DASH scores or high adherence eGFR:48 ± 17 ml/ min/1.73 m^2
Heindel et al., 2020 [76]	Association between dietary patterns and kidney function in patients with chronic kidney disease: a cross-sectional analysis of the German Chronic Kidney Disease study	Germany	To investigate whether higher observance of dietary patterns (DASH diet, Mediterranean Diet, or German food recommendations) is associated with kidney health as assessed by eGFR and albuminuria and comorbidity in CKD patients from the large multicenter German Chronic Kidney Disease (GCKD) study	Prospective observational cohort study (2 years duration of follow-up)	Males and females aged 18–74 years with eGFR 30–60 ml/min/1.73m^2 (CKD stage G3, A1–3) or overt proteinuria in presence of an eGFR>60 ml/min/ 1.73m^2 (CKD stage G1-2)	2813	The overall DASH score range (0–80) and the individual diet group range from 0 to 10. Modification: 8 food groups: Grains, Vegetables, Fruits, Dairy, Meat/ poultry/fish, Nuts/ seeds/legumes, fats/ oils, and sweets	Baseline eGFR: 45.6 ± 18 ml/min/ 1.73 m^2 Median UACR (mg/g) (IQR): 46.5 (291) Effect of DASH Low DASH scores or low adherence eGFR: 44.6 ± 17.1 ml/ min/1.73 m^2 Median UACR (mg/g) (IQR): 55.6 (356.1) High DASH scores or high adherence eGFR: 47.5 ± 18.7 ml/ min/1.73 m^2 Median UACR (mg/g) (IQR): 33.6 (270.5)
Osté et al., 2018 [77]	Dietary Approach to Stop Hypertension (DASH) diet and risk of renal function decline and all-cause mortality in renal transplant recipients	Netherlands	To test the hypothesis that the DASH diet is associated with a lower risk of renal function decline and all-cause mortality among renal transplant recipients.	Observational prospective cohort study (5.3 years median follow up)	Adult renal transplant recipients (≥18 years) with a functioning graft for at least one year and no history of alcohol or drug addiction	707	DASH score range: 8-40 8 recommendations: high intake of fruits, vegetables, legumes and nuts, whole grains, low-fat dairy products and low intake of sodium, red and processed meats, and sugar-sweetened beverages.	Baseline eGFR: 52.5 ± 20.1 ml/ min per 1.73 m^2 Effect of DASH Low DASH scores or low adherence eGFR: 52.5 ± 20.6 ml/ min per 1.73 m^2 High DASH scores or high adherence) eGFR: 52.2 ± 19.3 ml/ min per 1.73 m^2
Banerjee et al., 2019 [75]	Poor accordance to a DASH dietary pattern is associated with higher risk of ESRD among adults with moderate chronic kidney disease and hypertension	USA	To examine the association of a DASH dietary pattern on the risk of end-stage renal disease (ESRD) in adults with moderate CKD.	Longitudinal cohort study (7.8 years median follow-up duration)	Adults aged 20 years and above with moderate CKD (stage 3, defined as eGFR between 30 and 59 ml/ min per 1.73 m^2)	1110	DASH diet accordance score range 0–9 The 9 target nutrients: total fat, saturated fat, protein, fiber, cholesterol, sodium, calcium, magnesium, and potassium Individuals were assigned 0.5 = intermediate target and 1 = full target to determine the DASH score	Baseline Mean eGFR: 44.5 ± 20.5 ml/ min per 1.73 m^2 Effect of DASH Low DASH scores or low adherence eGFR: 47.7 ± 8.3 ml/min per 1.73 m^2 High DASH scores or high adherence eGFR: 53.1 ± 6.0 ml/min per 1.73 m^2

2.8.1. Assessment of heterogeneity

Cochran's Q test and the I-squared (I^2) statistic were used to evaluate the heterogeneity of the included studies, with significance assumed when the I^2 exceeded 50 % or the p-value from Cochran's Q test was less than 0.1 ($p < 0.1$).

2.8.2. Assessment of reporting bias

Funnel plots were created and used to evaluate the possibility of a publication bias. Visual examination of the funnel plots for asymmetry was performed (Supplementary File 2). Additionally, Egger's regression test was performed.

2.9. Summary and reporting of results

As presented in Fig. 1, the results from the record identification, data extraction, and screening are presented following the flow illustration guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA-SRv) [72,73].

3. Results

3.1. Screening overview

We conducted rigorous and reproducible records search in Scopus (n = 42), PubMed (n = 32), EBSCOhost (n = 26), Web of Science (n = 28) and ProQuest (n = 45). An additional search was performed using citation or bibliography (n = 1). A total of 174 studies were screened for eligibility. A total of 103 studies were retrieved after the removal of duplicates. This was followed by screening of titles and abstracts, which excluded 70 articles. The next phase of data extraction and screening involved a full text screening of the 33 remaining studies. Twenty-nine articles were excluded based on wrong population (n = 11), wrong intervention (n = 6), commentary (n = 4), wrong study outcomes (n = 3), research letter correspondence (n = 1), review articles (n = 1), secondary analysis (n = 1), study protocol (n = 1) and wrong study duration (n = 1). Ultimately, 4 studies met the inclusion criteria and were included in the review. These are presented in Fig. 1.

3.2. Characteristics of the eligible studies

The characteristics of the studies included in this review are summarized in Table 2. All 4 studies were conducted among populations in non-African countries. Of the 4 studies included, 2 were conducted in the America [74,75] and 2 in Europe [76,77]. Specifically, 2 studies were conducted in the United States of America (USA) [74,75], 1 in Germany [76] and 1 in the Netherlands [77]. All included studies were longitudinal (prospective cohort) studies with average follow-up durations of 5.5 years. The studies were published between 2018 and 2021, with a combined total sample size of 7033 participants.

3.3. Outcomes

3.3.1. Meta-analysis

All four studies were included in the meta-analysis, as shown in Table 3. These studies were included in a meta-analysis of continuous data, and the results are presented below.

3.3.2. Effects of DASH on CKD progression

Varying determinants of CKD progression were measured in this review including estimated Glomerular Filtration Rate (eGFR) and Urine Albumin-to-Creatinine Ratio (UACR) with cut-off values of <60 ml/min/1.73 m^2 and ⩾30 mg/g respectively, depicting a decline in renal function [68].

3.3.2.1. eGFR. All four studies estimated the eGFR of patients living with CKD before and after the DASH diet intervention (Tables 2 and 3), using the Modification of Diet in Renal Disease (MDRD) equation for adults [78] and the 2009 serum creatinine-based Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation [79]. The eGFR effect size were observed under two DASH diet adherence levels, defined by their DASH scores. DASH adherences are estimated by calculating the accumulated DASH scores of the study participants. In this review, the typical overall DASH score ranged from 0 to 80 with individual scores ranging from to 0–10 dependent on the DASH diet combinations used. Study participants are then classified into adherence groups by dividing the DASH scores into categories, often using tertiles or quartiles [74]. Typically, individuals with scores in the highest tertile or quartile are categorized as having high adherence to the DASH diet, whereas those in the lowest tertile or quartile are considered to have low adherence. In this review, individual studies had their adherence levels based on DASH scores. For example, one study using the typical 0–80 total DASH score had 0-40 (low DASH adherence) and 41–80 (high DASH adherence) [76], one study using the 0–9 overall DASH score had 0-4 (low DASH adherence) and 5–9 (high DASH adherence) [75] and two using the 8–40 total DASH score range had 8-24 (low DASH adherence) and 25–40 (high DASH adherence) [74,77].

Stratified by DASH adherence, low adherence was associated with a mean eGFR difference of 0.54 ml/min/1.73 m^2 (95 % CI: −1.30 to 2.38), corresponding to a 1.2 % improvement in renal function. However, the meta-analysis indicated no statistically significant difference between the baseline and post-DASH intervention eGFR ($Z = 0.57$, $p = 0.57$) (Fig. 2). In contrast, high DASH adherence was associated with a mean eGFR difference of 3.34 ml/min/1.73 m^2 (95 % CI: −0.35 to 7.02), reflecting a 6.8 % improvement in renal function. Although the meta-analysis suggested a tendency towards a difference between the baseline and post-DASH intervention eGFR, the result was not statistically significant ($Z = 1.77$, $p = 0.08$) (Fig. 2).

3.3.2.2. UACR. Only one study reported evidence of CKD progression using UACR biomarker [76], making it inappropriate to pool

Table 3
Summary of baseline and post-DASH intervention eGFR outcomes pooled for meta-analysis.

Study	Baseline	Post-DASH intervention	
	Mean eGFR±SD (ml/min/1.73 m^2)	Mean eGFR±SD (ml/min/1.73 m^2)	
		Low DASH adherence or score	High DASH adherence or score
Hu et al., 2021 [74]	45 ± 17.00	45 ± 17.00	48 ± 17.00
Heindel et al., 2020 [76]	45.6 ± 18.00	44.6 ± 17.10	47.5 ± 18.70
Osté et al., 2018 [77]	52.5 ± 20.10	52.5 ± 20.60	52.2 ± 19.30
Banerjee et al., 2019 [75]	44.5 ± 20.50	47.7 ± 8.30	53.1 ± 6.00

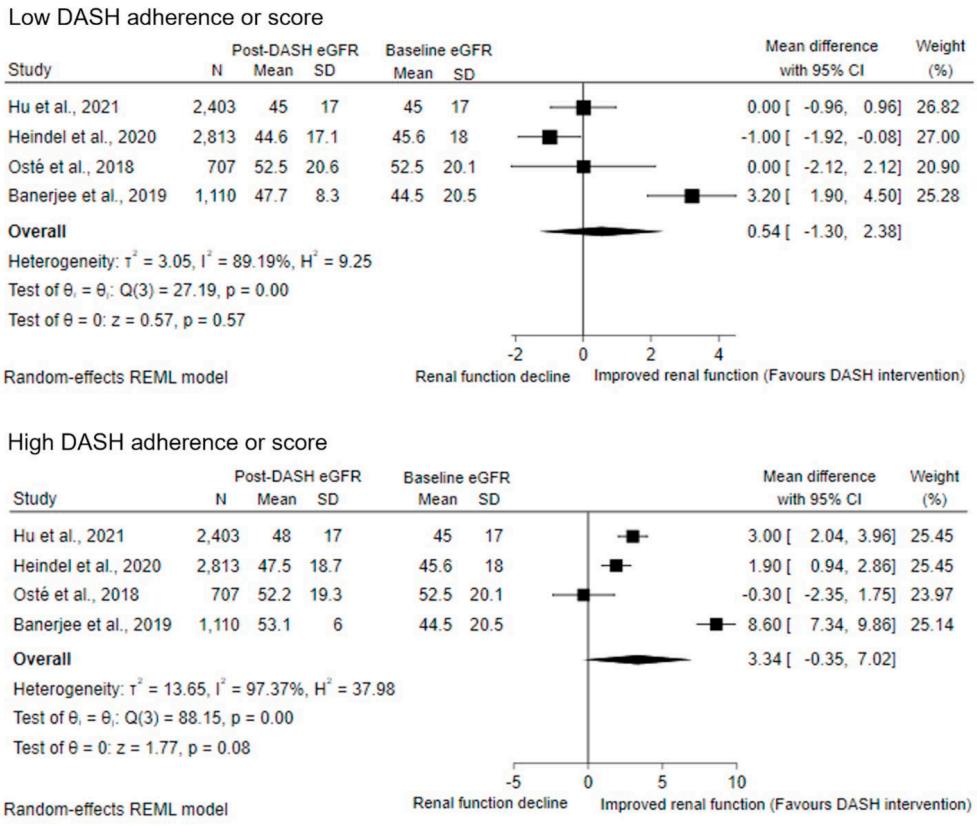

Fig. 2. The effect of DASH on renal function measured by eGFR.

outcomes in the meta-analysis. Furthermore, the outcome was reported using the median and interquartile range (IQR), which complicated the calculation of effect size using the mean difference. Consequently, while pooling of evidence was not possible due to the limited number of studies examining the effect of DASH on UACR, an important biomarker for CKD progression, the qualitative examination of the available outcomes provides valuable insights for this evidence synthesis. Specifically, the use of UACR in one study highlights the need for further research to establish standardized methods for assessing renal function changes across different populations. According to Heindel et al. [76], at baseline, the median UACR (mg/g) was recorded as 46.5 (IQR: 291). Following the DASH diet intervention, the median UACR (mg/g) was 55.6 (IQR: 356.1) for low DASH adherence and 33.6 (IQR: 270.5) for high DASH adherence.

3.3.3. *Quality of evidence, heterogeneity, and risk of bias*

The methodological quality of the included studies was appraised using the JBI critical appraisal tool for cohort studies [80]. All the included studies met 8 out of 11 criteria (Supplementary File 3). Overall, this level of adherence reflects high methodological quality. However, in line with the JBI checklist, some perceived discrepancies were noted, although they were not actual discrepancies. For example, all the studies included participants who already had the outcome of interest (CKD) but focused on measuring the progression of the outcome through a mitigation intervention, namely the DASH diet. From a research perspective, this is not considered a bias, but rather a well-designed study approach that diverges from the typical practice of recruiting participants without the outcome of interest in prospective cohort studies. However, the included studies did not assign participants to exposed and unexposed groups. Additionally, visual inspection of the funnel plots revealed some dispersion of studies around the pooled effect size, particularly in the eGFR mean difference for the low DASH adherence intervention group, suggesting publication bias (Supplementary File 2). However, the observed asymmetry is due to the heterogeneity among the limited available studies included in the analysis thus, I^2 of 89.19 % and 97.37 % in low and high DASH adherence respectively. This is supported by Egger's regression test, which found no evidence of publication bias for the eGFR mean difference in either the low DASH adherence group ($p = 0.598$) or the high DASH adherence group ($p = 0.986$).

4. Discussion

This review synthesizes evidence on the use of DASH in managing patients living with CKD and examines its effect on CKD progression, as measured by the eGFR and UACR biomarkers. The DASH diet is among a cluster of dietary recommendations that have been proven to optimize the slowing of the progression of CKD [53]. However, in this review, there is no evidence of DASH diet application in managing CKD patients in Africa as studies were centralized in Europe and America.

This review generally found evidence of a notable reduction in mean eGFR associated with the DASH diet [74–77]. Specifically, individuals with high adherence to the DASH diet exhibited a larger effect size (3.34 ml/min/1.73 m^2 vs. 0.54 ml/min/1.73 m^2) and a greater percentage improvement in renal function (6.8 % vs. 1.2 %) compared to those with low adherence. However, although these findings were not statistically significant, clinical inferences can be made supporting several similar prospective cohort studies and reviews that provide evidence of the impact of DASH

intervention on the CKD progression in patients with CKD and the incidence of CKD and ESRD in healthy individuals. For example, evidence suggests that in patients with CKD, adherence to the DASH diet significantly slows the progression to ESRD and is associated with improved prognosis [63]. Again, renal transplant recipients have been proven to benefit mostly from DASH diet intervention. Evidence shows that the DASH diet lowers the risk of both renal function decline and all-cause mortality hence producing positive long-term outcomes in renal transplant recipients [81]. Evidently, DASH diet plays a crucial role in CKD self-management. The DASH diet promotes healthy eating habits that aid in weight management and reduce the risk of obesity, which can worsen CKD [82]. Additionally, it helps balance electrolytes and reduces the risk of metabolic complications, such as hyperkalemia, which is common among patients with CKD [83]. By preventing fluid retention, lowering blood pressure, and reducing the workload on the kidneys, the DASH diet contributes to slowing CKD progression [35–39]. A review study found that in healthy individuals, a predominantly DASH dietary pattern was associated with a 30 % lower incidence of CKD and a 30 % reduced risk of renal function decline, as measured by eGFR [62]. Similarly, a review study showed a 21 % reduced risk of CKD among healthy individuals on DASH diet [63].

Only one study reported UACR [76], and the use of median and IQR data limited its inclusion in the meta-analysis. This highlights a critical gap in the literature and underscores the need for standardized reporting of UACR using means and standard deviations or providing sufficient data for conversion. Consistent and transparent reporting of UACR across studies is essential to enable meaningful synthesis, facilitate comparison, and strengthen evidence on the renal effects of interventions, such as the DASH diet. However, the evidence from the UACR biomarker showed an increased UACR among patients with CKD with low adherence to the DASH diet, while UACR decreased significantly in those with high adherence (46.5 mg/g at baseline, 55.6 vs. 33.6 for low and high adherence, respectively). These findings suggest that high adherence to the DASH diet may reduce the UACR, potentially benefiting CKD progression, whereas low adherence may be associated with worsening kidney function. This finding highlights the importance of adherence to a DASH diet for optimal renal health outcomes. Although UACR is recognized as an effective biomarker for assessing CKD progression [68], there are few, if any, studies that have used this marker to examine the effect of dietary patterns on CKD progression. A study by Bach et al. is one of the closest to utilizing this marker; however, their research focused solely on the albumin component, finding that a dietary pattern predominantly based on DASH reduced the risk of albuminuria by 23 % [62]. This highlights the underutilization of effective biomarkers in assessing CKD progression.

This review highlights the successful application of the DASH diet in the management of CKD. While there is substantial evidence supporting its effectiveness in reducing the risk of CKD incidence, there is limited evidence to fully confirm its ability to halt or reverse disease progression among people with CKD to prevent ESRD. Overall, adherence to the DASH diet may lead to better long-term outcomes by slowing disease progression and improving quality of life, enabling CKD patients to actively preserve kidney function and enhance their overall health. However, the effectiveness of diet effectiveness is more easily achievable in systems where adherence to dietary patterns is encouraged and tracked for compliance and effective monitoring of patient conditions. Notably, there is no evidence of the DASH diet being applied in managing CKD patients in Africa, likely due to the high costs associated with randomized-controlled trials and the long follow-up periods required to observe the intended effects of the intervention. Additionally, adherence to the DASH diet in resource-limited settings, particularly in Africa, may be hindered by multiple factors, further exacerbated by the high economic burden that CKD places on patients and their families [84]. The cost of fresh fruits, vegetables, low fat dairy, and lean proteins, which are key components of the DASH diet, can be high for many households, making long-term adherence difficult [85]. In addition, the limited availability and accessibility of these foods in local markets, especially in rural or underserved areas, further restricts dietary choices. Cultural dietary preferences, lack of awareness about the DASH diet, and inadequate nutrition education among patients and healthcare providers may also hinder its effective implementation [86,87]. Addressing these barriers requires context-specific strategies, such as culturally adapted dietary guidelines, subsidies for healthy foods, and integration of nutrition counseling into primary healthcare services.

5. Implications for practice

The management of people living with CKD is gradually evolving from the use of tertiary prevention to monitoring and preventing complications that may lead to ESRD. This tertiary prevention includes tracking and enforcing modifiable patient behaviors through self-management interventions [55,88]. This review suggests the effectiveness of adherence to dietary patterns in CKD management. However, strict and early adherence to the daily servings of DASH diet components, which include the nutrient-based and food-based DASH compositions, has the potential to reduce the progression of CKD to ESRD. Although the observed effect size, as measured by improvements in eGFR with DASH diet adherence, were not statistically significant, they may reflect a meaningful relationship with potential clinical relevance. This highlights the importance of considering practical significance alongside statistical findings when interpreting clinical data. The findings in this review may be highly applicable and recommended in clinical practice for all classes of healthcare providers especially, managers of CKD patients, and in dialysis centers including nurses, physicians, nutritionists, and dietetics. However, this requires further context-specific evidence, particularly in Africa as the evidence available in this review are restricted to America and Europe.

6. Implications for research

The systematic review established that there is limited published research on the DASH diet and its derivatives in the management of patients with CKD. There was limited published evidence of the effect of the DASH diet and its derivatives on people living with CKD. The few pieces of evidence available were established in high-income and resourceful settings. Currently, there is no record of primary studies on the application of the DASH diet and its modifications in African populations and by African researchers. The region is known for challenges in conducting randomized-controlled trials including poor financial resourcing [89]. This is evident in less than 10 % of general trials conducted in Africa despite the 20–30 % of trials conducted in low- and middle-income countries globally [90].

7. Strengths and limitations

A rigorous and comprehensive literature search in relevant electronic databases was conducted. We thoroughly conducted a citation search in the reference lists of relevant and eligible studies to enlarge the scope of the search and to ensure that no eligible study is missing from the review. The literature search protocol

was carefully drafted to ensure a strategic and effective search. We carefully defined the inclusion and exclusion criteria and set search boundaries spanning from the inception of DASH interventions to the present (1997–2025). No language restrictions were applied. We employed many keywords and used MeSH terms, a language that is easily understood by electronic databases. The included studies were subjected to a quality appraisal. The screening was blindly done by two independent screeners. A final screening was conducted by a third reviewer to resolve discrepancies in the included articles. This review could therefore be used to design future interventions for patients with CKD, particularly in resource-limited settings. However, our study met some limitations. All the studies included in this review assessed DASH compliance or accordance using self-reported dietary intake or food frequency questionnaire. The reliance on self-reported dietary adherence introduces recall and social desirability bias, which may compromise the validity of the findings by overestimating or underestimating true adherence levels. To enhance accuracy in future studies, objective measures such as dietary biomarkers (e.g., urinary sodium, potassium, or specific nutrient metabolites) should be incorporated to validate self-reported data and provide more reliable assessments of DASH diet adherence. The results do not permit the establishment of temporal relationships due to the one-time assessment of diet and possible recall bias. Additionally, funnel plot asymmetry observed in this review (Supplementary File 2) suggests potential publication bias, specifically in the eGFR mean difference for the low DASH adherence intervention group which may have led to an overestimation or underestimation of the true effect size. This limits the generalizability of the findings. The observed heterogeneity among the included studies may be attributed to the limited number of available studies on this important topic. While subgroup or meta-regression analysis could have helped explore potential sources of variability, the small number of studies limited our ability to conduct such analysis. Finally, only one study reported on UACR, and the use of median and IQR limited its inclusion in the meta-analysis. This lack of standardized UACR reporting across studies hindered quantitative synthesis and highlights the need for consistent reporting formats in future research.

8. Conclusion

This review summarized the applicability of the DASH diet and its effect on CKD progression, as measured by eGFR and UACR, in the management of individuals living with CKD. Evidence suggests a reduction in eGFR and UACR following DASH intervention, highlighting the potential benefits of the diet. However, adherence to the diet is critical for achieving a synergistic effect on these biomarkers. Consistent adherence enhances the effectiveness of the DASH diet in slowing disease progression and improving renal outcomes, highlighting the importance of patient compliance in maximizing the therapeutic potential of dietary interventions. This aligns with Sustainable Development Goal 3 (Good Health and Well-being), particularly in promoting health through the management and prevention of chronic NCDs like CKD.

9. Recommendations

None of the eligible studies were conducted in Africa, highlighting the need for primary research in this region to evaluate the applicability, effectiveness, and feasibility of the DASH diet in managing CKD. This recommendation is especially relevant given the high CKD prevalence in Africa and sub-Saharan Africa, estimated at 15.8 % (95 % CI: 12.1–19.9) [9] and 13.9 % (95 % CI: 12.2–15.7) [10] respectively. We, therefore, recommend enough primary studies in Africa using African populations. In addition, more attention should be paid to resource-limited settings to monitor the possible adherence to the DASH diet in these settings due to the skewed energy-giving food staples and delicacies available in abundance. We also recommend primary studies that will investigate the barriers and enablers of the application of the DASH diet in varying settings and populations including dialysis centers, self-care homes, and the general population, and develop solutions to address these challenges. Finally, there is a need for refresher training for healthcare providers and caregivers who manage patients with CKD to be abreast with this effective means of retrogressing CKD to reduce the burden of ESRD.

Ethical considerations

This systematic review synthesized evidence from existing literature from peer-reviewed studies from electronic databases therefore ethical approval was not required.

Credit authorship contribution statement

YBGA: Conceptualization, Study design, Data curation, Investigation, Methodology, Project Administration, Writing-original draft and Writing-review & editing. FEAH, GD, and GAA: Conceptualization, Study design, Methodology, Validation, Writing-review & editing. SM: Data curation, Investigation, and Methodology. ED, TVB and PA: Conceptualization, Study design, Data curation, Formal analysis, Methodology, Visualization, Writing-original draft and Writing-review & editing. All authors read and approved the final manuscript.

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Declaration of competing interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2025.08.030.

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