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Risk factors for chronic kidney disease in primary care: A comprehensive review

Botir Turg'unpulatovich Daminov and Nodrbek Ulug'bekovich Kayumov *

Internal Medicine, Nephrology and Hemodialysis Department, Tashkent Pediatric Medical Institute, Tashkent, Uzbekistan.

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Abstract

Chronic Kidney Disease (CKD) is a significant global health challenge, with increasing prevalence and a high burden of associated morbidity and mortality. Early detection and management of CKD are essential in preventing its progression to end-stage renal disease, which often requires dialysis or transplantation. Primary care settings play a pivotal role in the early identification and management of CKD, given their accessibility and the opportunity for preventative care. This article aims to identify and review the key risk factors for CKD in primary care populations. A comprehensive literature review was conducted using data from peer-reviewed articles, clinical guidelines, and epidemiological studies, with a focus on demographic, medical, lifestyle, and genetic risk factors. The review highlights hypertension, diabetes, obesity, family history, and ethnicity as major contributors to CKD risk. Additionally, modifiable factors such as diet, smoking, and physical inactivity are emphasized. The findings underscore the importance of regular screening and early intervention in primary care to mitigate CKD progression. Primary care practitioners must prioritize CKD risk assessment, raise awareness about preventive strategies, and manage comorbidities effectively. Addressing these risk factors at the primary care level could significantly reduce the overall burden of CKD, improve patient outcomes, and alleviate healthcare costs. Public health strategies must focus on promoting early detection and equitable access to care for at-risk populations.

Keywords: Chronic Kidney Disease; Primary Care; Risk Factors; Hypertension; Diabetes; Obesity

1. Introduction

Chronic Kidney Disease (CKD) is a progressive and debilitating condition characterized by a gradual decline in kidney function, leading to an inability to adequately filter waste products from the blood. CKD is defined as the presence of kidney damage, indicated by markers such as proteinuria or a glomerular filtration rate (GFR) of less than 60 mL/min/1.73m^2 for three months or more, irrespective of the cause [1]. It is a major public health concern, with rising global prevalence and significant morbidity and mortality associated with its complications, including cardiovascular disease, end-stage renal disease (ESRD), and the need for dialysis or kidney transplantation [2]. Timely diagnosis and early intervention can significantly slow disease progression, improve patient outcomes, and reduce healthcare costs. However, CKD often remains undiagnosed until later stages due to its asymptomatic nature in the early phases, making primary care an essential setting for the identification and management of this condition.

CKD is classified into five stages based on the severity of kidney dysfunction, measured by the GFR and the level of albuminuria. Stage 1 represents the earliest stage, where kidney function is normal (GFR ≥ 90 mL/min/1.73m^2), but there may be evidence of kidney damage, such as proteinuria or structural abnormalities. Stage 2 (GFR 60-89 mL/min/1.73m^2) indicates mildly decreased kidney function, and stages 3 to 5 represent progressively worsening kidney function, with stage 3 further subdivided into stages 3a and 3b (GFR 30-59 mL/min/1.73m^2) [3]. Stage 4 (GFR 15-29 mL/min/1.73m^2) is characterized by severe kidney damage, while stage 5 (GFR < 15 mL/min/1.73m^2) signifies kidney failure, often requiring dialysis or kidney transplantation for survival. Early-stage CKD (stages 1 and 2) often

* Corresponding author: Nodrbek Ulugbekovich Kayumov

lacks overt symptoms, making it crucial for healthcare providers to identify individuals at risk and monitor kidney function over time.

Early detection and management of CKD are pivotal in reducing the risk of progression to ESRD and associated complications. At the primary care level, early identification of CKD risk factors and monitoring of at-risk individuals can lead to timely interventions such as blood pressure control, diabetes management, and lifestyle modifications, all of which have been shown to slow the progression of kidney damage [4]. Studies suggest that controlling blood pressure to below 130/80 mmHg in individuals with CKD can reduce the risk of progression to ESRD by 30-40% [5]. Moreover, the use of angiotensin-converting enzyme (ACE) inhibitors or angiotensin receptor blockers (ARBs) has been shown to protect kidney function and reduce albuminuria, a key marker of kidney damage [6]. Interventions aimed at lifestyle factors, such as dietary changes, smoking cessation, and increased physical activity, also play a significant role in managing CKD and preventing its progression [7].

However, despite the availability of effective treatments, the majority of individuals with CKD remain undiagnosed until the later stages of the disease. This delay in diagnosis is largely due to the lack of symptoms in the early stages, the absence of routine screening, and inadequate awareness of CKD among both healthcare providers and patients [8]. Therefore, primary care providers play a critical role in identifying at-risk individuals, conducting routine screenings, and initiating early treatment to prevent further kidney damage.

Globally, the prevalence of CKD has been steadily increasing, with approximately 10% of the adult population affected worldwide [9]. In high-income countries, CKD is a leading cause of morbidity and mortality, particularly among individuals with diabetes, hypertension, and other comorbidities. In the United States, an estimated 37 million adults have CKD, with only 9% of them aware of their condition [10]. The prevalence of CKD varies by region, with higher rates observed in low- and middle-income countries due to the rising burden of diabetes, hypertension, and poor access to healthcare [11]. Despite its high prevalence, CKD remains underrecognized in primary care settings, and many individuals with early-stage disease are not adequately monitored or treated.

The role of primary care in managing CKD is indispensable due to the high number of individuals at risk who visit these settings regularly. Primary care providers are often the first point of contact for individuals with chronic diseases like diabetes and hypertension, which are significant risk factors for CKD. By integrating CKD screening into routine care, primary care physicians can detect the disease early, identify modifiable risk factors, and initiate interventions to prevent disease progression. Furthermore, primary care settings provide an opportunity to educate patients about CKD, promote healthier lifestyle choices, and ensure regular monitoring of kidney function in at-risk populations.

Need for Identifying Risk Factors in Primary Care. The identification of risk factors for CKD is essential for its prevention and management, particularly in primary care settings. Risk factors for CKD are multifactorial and include both non-modifiable factors, such as age, ethnicity, and genetic predisposition, as well as modifiable factors, such as hypertension, diabetes, smoking, and obesity [12]. Individuals with a family history of kidney disease, those of African, Hispanic, or Native American descent, and older adults are at an increased risk of developing CKD [13]. However, the most common risk factors are hypertension and diabetes, which account for the majority of CKD cases globally [14].

Primary care practitioners must be vigilant in identifying individuals at high risk for CKD and performing regular screenings, particularly among those with established risk factors. Early detection through simple and cost-effective tests, such as urine albumin-to-creatinine ratio and serum creatinine to estimate GFR, is crucial in identifying CKD at an early stage when interventions can be most effective. Additionally, educating patients about their risk factors and the importance of managing chronic conditions like hypertension and diabetes can significantly reduce the burden of CKD. The rising global prevalence of CKD necessitates a shift toward early detection and proactive management, especially within primary care settings. Identifying and managing risk factors at the primary care level not only improves patient outcomes but also reduces the overall healthcare burden of CKD. Primary care providers have a crucial role in screening, educating, and managing individuals at risk, ultimately contributing to the prevention of CKD progression and its complications.

Chronic Kidney Disease (CKD) is a progressive disorder characterized by the gradual decline in kidney function over time. This condition is associated with a range of pathophysiological mechanisms that impair the kidneys' ability to filter waste, regulate fluid balance, and maintain electrolyte homeostasis. Understanding these mechanisms is crucial for identifying early-stage CKD and developing effective management strategies, particularly within primary care settings where early diagnosis and intervention are vital.

Pathophysiology of CKD. The pathophysiology of CKD involves a complex interplay of hemodynamic, inflammatory, and fibrotic processes that result in kidney damage and dysfunction. The kidneys' filtering units, the nephrons, are progressively destroyed over time, leading to the inability to efficiently remove waste products from the blood. A key event in CKD development is glomerular hypertension, where increased pressure within the glomeruli (the tiny capillary networks responsible for filtration) leads to damage and scarring. This damage triggers a cascade of pathological events, including glomerulosclerosis (hardening of the glomeruli) and tubulointerstitial fibrosis, which further impair kidney function [15].

At the molecular level, inflammation and oxidative stress play pivotal roles in kidney injury. In response to glomerular damage, inflammatory cytokines and growth factors such as transforming growth factor-beta (TGF-β) and angiotensin II are released. These molecules promote fibrosis and vascular remodeling, contributing to the progressive loss of nephron function. Endothelial dysfunction is also commonly observed in CKD, leading to impaired vascular regulation and increased susceptibility to cardiovascular complications, which are closely linked to kidney disease progression [16].

One of the hallmark features of CKD is proteinuria (excess protein in the urine), particularly albumin, which occurs as a result of glomerular filtration barrier disruption. Proteinuria serves as both a marker of kidney damage and a key contributor to disease progression, as the presence of protein in the tubules induces further inflammation and fibrosis [17]. Furthermore, hyperfiltration, initially observed in the early stages of CKD as the kidneys try to compensate for lost nephrons, eventually leads to further damage and worsening of kidney function.

Kidney Function and How It Declines Over Time. Kidney function is primarily assessed through two main measures: glomerular filtration rate (GFR) and albuminuria. GFR is a measure of the kidneys' ability to filter blood and is considered the most accurate indicator of kidney function. It is commonly estimated using serum creatinine levels, with adjustments for factors such as age, sex, and ethnicity. As kidney function declines, GFR decreases, reflecting the loss of functional nephrons. An eGFR (estimated GFR) below 60 mL/min/1.73m^2 is indicative of CKD, with more severe stages associated with increasingly lower GFR values [18].

The decline in kidney function occurs over a prolonged period, often spanning years or decades. Initially, compensatory mechanisms, such as glomerular hyperfiltration, may mask the onset of kidney dysfunction. However, as nephron loss progresses, these mechanisms become overwhelmed, leading to worsening kidney function. The rate of decline in GFR varies between individuals, with some experiencing rapid progression, particularly in the presence of additional risk factors like uncontrolled hypertension or diabetes [19]. In later stages of CKD (stages 4 and 5), GFR drops significantly, and patients may develop symptoms of uremia, such as fatigue, nausea, and swelling, which are indicative of kidney failure.

Stages and Classification of CKD. CKD is classified into five stages based on the level of GFR and the degree of kidney damage. This classification helps guide treatment strategies and predict outcomes:

- Stage 1: Kidney function is normal or mildly decreased (GFR ≥ 90 mL/min/1.73m^2), but there is evidence of kidney damage (e.g., proteinuria, abnormal imaging).
- Stage 2: Mildly decreased kidney function (GFR 60-89 mL/min/1.73m^2) with evidence of kidney damage.
- Stage 3a: Moderate decrease in kidney function (GFR 45-59 mL/min/1.73m^2).
- Stage 3b: Moderate decrease in kidney function (GFR 30-44 mL/min/1.73m^2).
- Stage 4: Severe decrease in kidney function (GFR 15-29 mL/min/1.73m^2).
- Stage 5: Kidney failure (GFR < 15 mL/min/1.73m^2), often requiring dialysis or kidney transplantation for survival.

The staging of CKD is critical for determining appropriate management strategies, as individuals in the earlier stages may benefit from interventions to slow progression, while those in later stages require more intensive treatments such as dialysis or transplant [20]. Alongside GFR, albuminuria is another important diagnostic criterion, as higher levels of urinary albumin indicate more severe kidney damage and are associated with worse outcomes.

Consequences of Uncontrolled CKD. If left untreated or poorly managed, CKD can lead to numerous complications that significantly impact a patient's quality of life and overall survival. One of the most serious consequences is the progression to end-stage renal disease (ESRD), where kidney function declines to the point that dialysis or kidney transplantation becomes necessary. ESRD is a major contributor to healthcare costs worldwide, with patients requiring lifelong treatment through hemodialysis or peritoneal dialysis, or an organ transplant, both of which are associated with significant morbidity and mortality [21].

Cardiovascular disease (CVD) is a common and often fatal complication of CKD. The risk of CVD increases as kidney function declines, and patients with CKD have a higher incidence of myocardial infarction, heart failure, and stroke compared to the general population. This increased cardiovascular risk is largely attributed to shared risk factors such as hypertension, diabetes, and dyslipidemia, as well as the direct effects of kidney dysfunction on vascular health, including endothelial dysfunction and increased arterial stiffness [22].

In addition to cardiovascular complications, CKD is also associated with a number of other systemic issues, such as electrolyte imbalances (e.g., hyperkalemia, hypocalcemia), anemia (due to impaired erythropoietin production), and bone mineral disease (resulting from dysregulated calcium and phosphate metabolism) [23]. The accumulation of toxins in the bloodstream due to impaired filtration leads to uremia, which can cause a range of symptoms, including nausea, vomiting, fatigue, and mental confusion. Ultimately, uncontrolled CKD leads to a significant reduction in life expectancy. Studies suggest that individuals with CKD are more likely to die from cardiovascular events than to progress to ESRD, further emphasizing the intertwined nature of kidney and cardiovascular health [24]. CKD is a complex and progressive disease that affects millions of individuals worldwide. The pathophysiological mechanisms driving CKD involve a combination of hemodynamic, inflammatory, and fibrotic processes, with GFR and albuminuria serving as key indicators of kidney function and disease progression. Without timely intervention, CKD leads to serious complications, most notably cardiovascular disease and kidney failure, which significantly impact patient outcomes. Early detection and appropriate management are crucial to mitigating these complications and improving the prognosis for individuals with CKD.

Risk Factors for Chronic Kidney Disease in Primary Care. Chronic Kidney Disease (CKD) is a multifactorial condition influenced by a combination of demographic, medical, lifestyle, genetic, and environmental factors. Primary care providers play a critical role in identifying these risk factors early, allowing for the implementation of interventions that can prevent or slow the progression of CKD. In this section, we review the most significant risk factors for CKD, focusing on those that are commonly encountered in primary care settings.

2. Demographic Factors

2.1. Age

Age is one of the most significant non-modifiable risk factors for CKD. The prevalence of CKD increases with advancing age due to the natural decline in kidney function that occurs with aging. Kidney function typically begins to decrease around the age of 30, with a gradual reduction in the glomerular filtration rate (GFR) as individuals age [25]. By age 60 and beyond, a substantial proportion of the population exhibits early stages of CKD, even in the absence of overt kidney disease. Older adults are also more likely to have comorbid conditions such as hypertension and diabetes, which further increase the risk of CKD. Furthermore, age-related changes in kidney structure, such as a reduction in nephron number and a decline in renal blood flow, contribute to the progressive decline in kidney function over time.

2.2. Gender

Gender differences in CKD prevalence have been widely observed, with men generally at a higher risk of developing CKD than women, particularly in the earlier stages. This difference is largely due to the greater prevalence of risk factors such as hypertension and diabetes among men, as well as differences in kidney structure and function between the sexes. However, women with CKD are more likely to experience adverse outcomes, including progression to end-stage renal disease (ESRD) [26]. Additionally, some studies have suggested that women are more likely to develop complications related to proteinuria and cardiovascular disease, both of which are linked to kidney damage. These gender-based disparities highlight the importance of tailored strategies for prevention and management in primary care.

2.3. Ethnicity

Ethnicity plays a significant role in the risk of developing CKD, with certain racial and ethnic groups being at a higher risk than others. For instance, African Americans, Hispanic Americans, and Native Americans are disproportionately affected by CKD. This elevated risk is partly due to genetic factors, but social determinants of health, such as access to healthcare and socioeconomic status, also contribute. African Americans, in particular, have higher rates of hypertension and diabetes, both of which are leading causes of CKD. Additionally, genetic conditions such as **APOL1 gene variants**, which are more common in individuals of African descent, have been associated with an increased risk of kidney disease [27]. Similarly, Mexican Americans and Native Americans experience higher rates of obesity and diabetes, further exacerbating the risk for CKD.

Medical History. Hypertension is one of the most significant and modifiable risk factors for CKD. High blood pressure damages the blood vessels in the kidneys, leading to glomerular injury, proteinuria, and, eventually, kidney fibrosis. Over time, uncontrolled hypertension results in a vicious cycle, as kidney damage worsens the ability to regulate blood pressure, exacerbating the condition. Studies have shown that people with hypertension are at greater risk for CKD and that effective blood pressure control can significantly slow the progression of kidney disease [28]. In primary care, regular monitoring of blood pressure and early intervention with antihypertensive medications such as ACE inhibitors or angiotensin receptor blockers (ARBs) can prevent or delay the onset of CKD in hypertensive patients.

Diabetes, particularly poorly controlled diabetes, is a leading cause of CKD. Hyperglycemia leads to glomerular hyperfiltration, which over time causes damage to the glomerular basement membrane, resulting in proteinuria. As the disease progresses, individuals with diabetic nephropathy often develop decreased GFR and eventual kidney failure. Tight glycemic control, early detection of albuminuria, and the use of medications such as SGLT2 inhibitors have been shown to reduce the risk of CKD progression in diabetic patients [29]. Primary care providers are crucial in managing diabetes through lifestyle interventions and pharmacological therapies to prevent or mitigate kidney damage.

Cardiovascular disease (CVD) is both a cause and a consequence of CKD. The close relationship between heart and kidney health is evident, as individuals with CKD are at increased risk for cardiovascular events such as heart attack and stroke. The shared risk factors for CKD and CVD—such as hypertension, diabetes, and hyperlipidemia—contribute to the increased cardiovascular morbidity in CKD patients. Furthermore, kidney dysfunction itself promotes atherosclerosis and endothelial dysfunction, which accelerates cardiovascular disease progression [30]. In primary care, managing cardiovascular risk factors and providing regular screening for CKD can help reduce the burden of both conditions.

Obesity is a significant risk factor for CKD, as excess body weight contributes to insulin resistance, hypertension, and increased levels of inflammatory cytokines, all of which can accelerate kidney damage. Obesity-related conditions such as sleep apnea, non-alcoholic fatty liver disease, and metabolic syndrome further exacerbate CKD progression. Recent studies have demonstrated that weight loss and the management of obesity through diet and physical activity can slow kidney function decline in at-risk populations [31]. Primary care physicians should focus on addressing obesity through dietary modifications, increased physical activity, and, when appropriate, pharmacological interventions.

2.4. Lifestyle Factors

Diet plays a critical role in the development and progression of CKD. A diet high in sodium, protein, and phosphorus can contribute to kidney damage. Excessive salt intake exacerbates hypertension, while high-protein diets may increase the kidneys' filtration burden, accelerating glomerular damage. In contrast, a diet rich in potassium, fiber, and healthy fats can help mitigate kidney dysfunction and promote overall health. Recent studies have emphasized the importance of dietary modifications in managing CKD, particularly in primary care, where dietary counseling can have a significant impact on disease outcomes [32].Smoking is a well-established risk factor for CKD. It accelerates the progression of kidney disease by promoting vascular inflammation, increasing oxidative stress, and impairing renal blood flow. Studies have shown that smokers with CKD experience faster progression to ESRD compared to non-smokers. Smoking cessation is crucial in preventing further kidney damage and improving overall health. Primary care providers should prioritize smoking cessation as a part of the comprehensive management of CKD risk [33]. Physical inactivity is another important lifestyle factor contributing to CKD. Lack of exercise can lead to obesity, hypertension, and insulin resistance, all of which increase the risk for CKD. Regular physical activity has been shown to improve cardiovascular health, reduce blood pressure, and maintain a healthy weight, thereby decreasing the risk of CKD progression. Encouraging physical activity and addressing sedentary behavior in primary care is an essential strategy in CKD prevention [34]. Genetic predisposition plays a significant role in the development of CKD. Family history of kidney disease increases the risk of CKD, particularly in inherited conditions such as polycystic kidney disease (PKD). PKD is a genetic disorder characterized by the development of multiple cysts in the kidneys, which can lead to kidney failure over time. Family members of individuals with PKD or other hereditary kidney diseases should be closely monitored for signs of kidney dysfunction in primary care settings [35]. The use of nephrotoxic medications is another important risk factor for CKD. Drugs such as nonsteroidal anti-inflammatory drugs (NSAIDs), certain antibiotics (e.g., aminoglycosides), and chemotherapeutic agents can cause direct damage to the kidneys. Chronic exposure to these medications, particularly in patients with pre-existing kidney disease, can lead to drug-induced nephropathy. Environmental toxins, including heavy metals like lead and cadmium, also contribute to kidney damage. Primary care providers should be vigilant about the nephrotoxic potential of medications and environmental exposures, ensuring that at-risk patients are monitored and managed appropriately to reduce their risk of kidney injury [36].

Screening and Early Detection in Primary Care. Early detection of Chronic Kidney Disease (CKD) is crucial to slow its progression, reduce complications, and improve patient outcomes. CKD is often asymptomatic in its early stages, with patients remaining unaware of their deteriorating kidney function until the disease has advanced significantly. Detecting CKD early allows healthcare providers to intervene before kidney function is severely compromised, offering the opportunity to modify risk factors such as hypertension, diabetes, and obesity, and to initiate appropriate treatments that can slow disease progression. Studies consistently show that early diagnosis and management of CKD can significantly reduce the risk of progression to end-stage renal disease (ESRD), where dialysis or a kidney transplant becomes necessary. For example, tight control of blood pressure and blood glucose levels in patients with early-stage CKD has been shown to slow the decline of kidney function and reduce the risk of cardiovascular events, which are common in CKD patients [33]. Additionally, the use of medications such as angiotensin-converting enzyme inhibitors (ACE inhibitors) or angiotensin receptor blockers (ARBs) and sodium-glucose cotransporter-2 inhibitors (SGLT2i) can delay disease progression, particularly when started early [34]. Furthermore, early intervention is cost-effective, as it helps to prevent or delay the need for expensive treatments such as dialysis or kidney transplantation, which can place a significant financial burden on both patients and healthcare systems. A study conducted by the Kidney Disease: Improving Global Outcomes (KDIGO) initiative highlighted that early detection and timely intervention could reduce the long-term economic burden associated with CKD, especially in populations at high risk of developing the disease [35].

The role of primary care in the early detection of CKD is increasingly emphasized in various guidelines. Routine screening for CKD involves identifying at-risk populations, performing relevant diagnostic tests, and implementing strategies for prevention and management. The National Kidney Foundation (NKF) and Kidney Disease: Improving Global Outcomes (KDIGO) both recommend screening individuals at high risk for CKD, including those with hypertension, diabetes, obesity, or a family history of kidney disease.

Key tests recommended for CKD screening include:

- Blood pressure measurement: Regular monitoring of blood pressure is essential, as hypertension is one of the most common risk factors for CKD. Blood pressure control is a cornerstone in managing CKD, and elevated readings should prompt further evaluation of kidney function [36].
- Urine albumin-to-creatinine ratio (ACR): The presence of albumin in the urine (albuminuria) is an early indicator of kidney damage. Measuring urine ACR allows for the detection of subclinical kidney injury, which may not be reflected in traditional kidney function tests such as serum creatinine or estimated glomerular filtration rate (eGFR) [37]. Albuminuria is particularly significant in patients with diabetes and hypertension, as it can predict the progression of CKD and associated cardiovascular risks.
- Estimated glomerular filtration rate (eGFR): eGFR is a measure of kidney function that estimates the rate at which blood is filtered by the kidneys. An eGFR of less than 60 mL/min/1.73 m^2 for three or more months is indicative of CKD. A decline in eGFR over time is a key predictor of CKD progression and can help guide management decisions in primary care [38].

The American Diabetes Association (ADA) recommends annual kidney function screening for all individuals with diabetes starting from the onset of diagnosis, with additional monitoring for those with hypertension or a family history of kidney disease. Similarly, the US Preventive Services Task Force (USPSTF) supports routine screening for CKD in patients with hypertension or diabetes, as these individuals are at a substantially increased risk of developing kidney disease [39]. While universal screening for CKD in the general population is not yet standard practice, certain populations are considered at higher risk and should be screened regularly. These at-risk groups include:

Individuals with diabetes: Diabetes is one of the leading causes of CKD, and individuals with poorly controlled blood glucose levels are at an even higher risk. Screening for albuminuria and eGFR is recommended annually for all diabetic patients.

Individuals with hypertension: Hypertension causes damage to the blood vessels in the kidneys, increasing the risk of CKD. People with sustained high blood pressure should have their kidney function checked regularly, especially if their blood pressure is poorly controlled.

Older adults: Aging increases the likelihood of CKD due to the natural decline in kidney function. Regular monitoring for CKD should be a part of comprehensive care in older patients, particularly those with other comorbid conditions.

Individuals with a family history of kidney disease: Genetic factors play a significant role in CKD, and family members of individuals with conditions such as polycystic kidney disease (PKD) are at increased risk. Early screening in these individuals is vital to identify kidney dysfunction before it becomes symptomatic.

Ethnic minorities: As mentioned previously, certain ethnic groups, particularly African Americans, Hispanics, and Native Americans, have higher rates of CKD. In these populations, regular screening is essential to detect early-stage kidney damage.

Obese individuals: Obesity is a well-established risk factor for CKD, and screening should be part of routine care for patients with a body mass index (BMI) over 30. Weight management, along with kidney function monitoring, can significantly reduce the risk of CKD.

Barriers to Early Detection in Primary Care. Despite the clear benefits of early detection and intervention, several barriers hinder the effective screening and management of CKD in primary care settings. These barriers include:

Many patients with early-stage CKD remain asymptomatic, leading to a lack of awareness about the importance of regular kidney screening. Furthermore, healthcare providers may not always prioritize CKD screening, especially if patients are not presenting with overt symptoms. A study by Lopes et al. found that healthcare providers in primary care often fail to recognize the subtle signs of CKD or to initiate timely screening for high-risk individuals, largely due to insufficient knowledge or a focus on more immediate health concerns [40].

In some healthcare systems, there are financial or systemic barriers that hinder the implementation of routine CKD screening. Limited access to laboratory tests such as urine ACR or eGFR can be an issue, particularly in resource-constrained settings. Additionally, the costs associated with regular monitoring and early interventions may discourage both providers and patients from pursuing CKD detection and management [41].

Many primary care providers may lack the specific training needed to identify and manage CKD effectively. In particular, there is often insufficient emphasis on kidney health during medical education and residency training programs. A study by Miller et al. found that while general practitioners frequently assess blood pressure and diabetes, they are less likely to implement routine screening for kidney disease, and many lack awareness of the latest guidelines for CKD management [42]. Addressing these barriers requires comprehensive education and training for primary care providers, improving access to screening tools, and raising awareness among patients about the importance of kidney health. Ultimately, a concerted effort is needed to integrate CKD screening into routine care and to promote early detection as a key strategy in managing the growing burden of CKD.

Managing and Preventing CKD in Primary Care. Lifestyle modifications are central to the prevention and management of Chronic Kidney Disease (CKD). Given that many risk factors for CKD, such as obesity, hypertension, and diabetes, are closely tied to lifestyle choices, encouraging healthier behaviors is an essential component of primary care management.

3. Diet and Nutrition Recommendations

Dietary interventions play a significant role in slowing CKD progression and maintaining kidney health. Key dietary recommendations include:

Reducing sodium intake: High sodium intake is known to contribute to hypertension and fluid retention, both of which can worsen CKD. Primary care practitioners should encourage patients to limit their sodium intake to less than 2,300 mg per day, as recommended by the American Heart Association (AHA) [43]. This involves reducing the consumption of processed foods, salty snacks, and fast foods, while focusing on fresh fruits and vegetables, lean proteins, and whole grains.

Controlling protein intake: Excessive protein intake can increase kidney workload by generating more nitrogenous waste products, which the kidneys must filter. However, the evidence regarding the optimal amount of protein in CKD patients is still evolving. Most guidelines recommend moderate protein restriction for patients in the early stages of CKD, especially those with diabetic nephropathy [44]. Protein sources should prioritize plant-based options such as legumes and tofu, while animal protein intake should be reduced.

Increasing potassium intake: A diet rich in potassium can help balance sodium levels and mitigate the harmful effects of high blood pressure. However, in advanced CKD, potassium intake should be carefully monitored to avoid hyperkalemia, a dangerous condition where potassium levels become too high.

3.1. Exercise Plans and Weight Management Strategies

Regular physical activity is vital for CKD management, particularly in controlling hypertension, managing diabetes, and reducing cardiovascular risk. Primary care providers should encourage patients to engage in at least 150 minutes of moderate-intensity aerobic activity per week, as outlined by the American College of Cardiology (ACC) [45]. Additionally, incorporating strength training exercises two or more days per week can help improve muscle mass, which is often lost during chronic illness.

In patients who are overweight or obese, weight management becomes even more crucial. Obesity exacerbates both hypertension and diabetes, two leading risk factors for CKD. A combination of dietary changes and increased physical activity can help achieve a healthy weight. For those with significant obesity, referral to a specialized weight management program or bariatric surgery may be considered in advanced cases, as it can lead to improved kidney outcomes [46].

3.2. Smoking Cessation Programs

Smoking accelerates the progression of CKD by promoting inflammation, oxidative stress, and damage to the blood vessels, which impairs kidney function. Smoking also exacerbates comorbid conditions like hypertension and diabetes. Primary care providers should regularly assess smoking status and offer tailored smoking cessation programs. These may include counseling, behavioral therapy, and pharmacotherapy with nicotine replacement therapy or other medications like varenicline and bupropion [47]. Encouraging patients to quit smoking early in CKD is crucial, as it can reduce the risk of complications and slow kidney decline.

Medical Interventions. Managing the underlying conditions that contribute to CKD is key to slowing its progression. Primary care providers play a critical role in the medical management of these comorbidities.

3.3. Managing Underlying Conditions: Hypertension and Diabetes:

3.3.1. Hypertension

High blood pressure is both a cause and consequence of CKD. Effective blood pressure management can reduce kidney damage and delay progression to end-stage renal disease (ESRD). The Kidney Disease: Improving Global Outcomes (KDIGO) guidelines recommend maintaining a target blood pressure of less than 130/80 mmHg in CKD patients, particularly those with proteinuria [48]. Lifestyle changes (e.g., salt restriction, weight loss, exercise) and pharmacological interventions are essential to achieve this goal. Angiotensin-converting enzyme inhibitors (ACE inhibitors) and angiotensin receptor blockers (ARBs) are commonly used due to their protective effects on kidney function by reducing intraglomerular pressure.

3.3.2. Diabetes

Diabetes is the leading cause of CKD, and strict glucose control is paramount in slowing its progression. Primary care providers should aim for an HbA1c level of less than 7%, as this has been shown to reduce the risk of diabetic nephropathy. Additionally, SGLT2 inhibitors such as empagliflozin and dapagliflozin have emerged as pivotal treatments for CKD patients with diabetes, as they not only improve glycemic control but also offer nephroprotective benefits [49].

3.4. Pharmacological Treatments

- ACE Inhibitors and ARBs: ACE inhibitors and ARBs are considered the cornerstone of treatment for CKD, particularly for patients with hypertension and proteinuria. These medications reduce blood pressure, decrease proteinuria, and have direct renoprotective effects. They are particularly effective in conditions like diabetic nephropathy and hypertensive nephrosclerosis [50].
- Sodium-Glucose Cotransporter-2 Inhibitors (SGLT2i): SGLT2 inhibitors are a relatively new class of drugs that have shown significant promise in slowing CKD progression, especially in diabetic patients. These drugs help reduce blood glucose levels, lower blood pressure, and provide additional kidney protection through mechanisms such as reducing hyperfiltration and decreasing albuminuria [51].
- Other pharmacological interventions: For patients with hyperlipidemia, statins may be prescribed to reduce cardiovascular risk, which is heightened in CKD patients. Additionally, phosphate binders and vitamin D supplementation are recommended in advanced CKD to manage mineral and bone disorders [52].

3.5. Patient Education and Empowerment

An essential part of managing CKD in primary care is patient education. Empowering patients to take an active role in managing their health is critical for long-term outcomes. Education should focus on:

- Understanding CKD and its progression: Patients need to comprehend how kidney disease develops and how their lifestyle choices can impact the course of their disease.
- Self-monitoring: Encouraging patients to regularly monitor their blood pressure, blood glucose, and weight can help them become more engaged in their health. This is particularly important for those with comorbid conditions such as hypertension and diabetes, which directly affect kidney function.
- Regular check-ups: Patients should be educated about the importance of regular follow-ups with their primary care providers to monitor kidney function through tests like eGFR and urine albumin. Early intervention based on regular monitoring can prevent complications and slow CKD progression.

3.6. Referral to Specialist Care

Despite the best efforts of primary care providers, some patients may require referral to nephrologists or kidney specialists for more advanced management. Referral is indicated in cases such as:

- Rapid progression of CKD: If there is a significant decline in kidney function (e.g., a drop in eGFR > 30% within a few months), referral to a nephrologist is necessary to investigate underlying causes and consider more intensive therapies.
- Complicated cases: Patients with multiple comorbidities, difficult-to-control blood pressure, or diabetes, or those experiencing complications such as nephrotic syndrome, may benefit from specialized care.
- Dialysis or transplantation consideration: As CKD progresses to stages 4 or 5, nephrologists will guide decisions related to dialysis initiation or kidney transplantation, as these treatments require specialized expertise [53].
- Managing CKD in primary care requires a multifaceted approach that includes lifestyle modifications, medical interventions, patient education, and timely referrals to specialist care. By adopting a proactive and comprehensive strategy, primary care providers can significantly reduce the burden of CKD and improve patient outcomes.

4. Conclusion

Chronic Kidney Disease (CKD) poses a significant public health burden worldwide, with its prevalence steadily increasing due to aging populations, rising rates of diabetes, hypertension, and other comorbid conditions. The management of CKD, particularly in primary care settings, is critical to slowing disease progression and improving patient outcomes. This comprehensive review has highlighted the key risk factors for CKD in primary care, emphasizing the importance of early detection, timely interventions, and proactive management strategies.

The proactive management of CKD in primary care settings is a vital step towards improving patient outcomes, reducing healthcare costs, and enhancing public health. It is essential that primary care providers are equipped with the necessary tools, knowledge, and support to identify at-risk individuals, screen for CKD, and implement early interventions. As research advances and healthcare systems adapt to the increasing burden of CKD, a concerted effort to prioritize CKD management in primary care will be key to mitigating the impact of this chronic condition.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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