

## Cohort Profile



# Prevalence of Chronic Kidney Disease and Associated Factors among the Diabetic and Prediabetic Population in the Bandare-Kong Cohort Study; A Population-Based Study

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## Abstract

**Background:** This investigation aims to examine the relationship between diabetes and prediabetes with chronic kidney disease (CKD) while taking into account key risk factors such as gender, age, lifestyle, smoking habits, and blood pressure.

**Methods:** Between November 17, 2016, and November 22, 2018, 4063 subjects aged 35 to 70 years were enrolled in the first phase of the Bandare-Kong Non-Communicable Disease (BKNCD) Cohort Study, which is part of the PERSIAN (Prospective Epidemiological Research Studies in IrAN) cohort and was conducted in a coastal region of the Hormozgan province in southern Iran. CKD was calculated using the Modification of Diet in Renal Disease (MDRD) formula based on glomerular filtration rate (GFR) <60 mL/min per 1.73 m<sup>2</sup>, or albumin/Cr >30 mg/g in random urine, self-reported kidney failure, or dialysis. Urine albumin and creatinine were determined by standard kits (Pars Azmoon, Tehran, Iran) and the BT1500 automatic chemistry analyzer (Biotecnica Instruments, Rome, Italy).

**Results:** The prevalence of CKD was found to be 15.3%, with 29.6% identified in diabetic individuals and 16.5% in prediabetic patients. So, the prevalence of CKD in diabetics was higher than prediabetics and normal people. Increased age, dysglycemia (diabetes or prediabetes), hypertension, and use of angiotensin receptor blockers were markedly associated with an elevated risk of CKD in adults.

**Conclusion:** The study emphasizes the importance of early detection and management of CKD risk factors, particularly among high-risk individuals, to mitigate CKD progression and associated complications. By addressing modifiable risk factors, proactive screening, and enhanced awareness, significant strides can be made in reducing CKD burden and improving patient outcomes.

**Keywords:** Chronic kidney diseases, Diabetes mellitus, Hypertension, Prediabetes

**Cite this article as:** Kheirandish M, Eftekhari E, Azarbad A, Salarpour E, Shahmoradi M, Ghazizadeh S, et al. Prevalence of chronic kidney disease and associated factors among the diabetic and prediabetic population in the Bandare-Kong Cohort Study; a population-based study. Arch Iran Med. 2024;27(9):470-478. doi: 10.34172/aim.31194

**Received:** April 26, 2024, **Accepted:** August 20, 2024, **ePublished:** September 1, 2024

## Introduction

Chronic kidney disease (CKD) is characterized by a persistent reduction in kidney function, the presence of markers indicating kidney damage, or both, lasting for a minimum of three months, regardless of the underlying cause.<sup>1</sup> The rising number of risk factors and other non-communicable diseases contributes to an alarming increase in the population affected by CKD, posing a significant challenge globally.<sup>2</sup> Estimates suggest that CKD prevalence ranges between 11% and 13% worldwide, with the majority in low- to middle-income nations.<sup>3</sup> Approximately 752.7 million individuals globally are affected by CKD, with 5 to 10 million deaths attributed annually to kidney disease.<sup>4,5</sup> Projections indicate a rise in

CKD-related mortality, with an anticipated global rank of 5th in terms of years of life lost (YLL) by 2040, up from 16th in 2016.<sup>6</sup>

There is a strong correlation between CKD and increased risk of death and cardiovascular events.<sup>7</sup> While the exact cause of CKD remains elusive, researchers have found various risk factors to contribute to its development, including male gender, obesity, aging, hypertension, diabetes mellitus, hyperlipidemia, a family history of renal disease, smoking, excessive alcohol drinking, HIV infection, electrolyte disorders, low-income occupations, physical inactivity, urbanization, and population growth.<sup>8-14</sup>

Diabetes and hypertension collectively account for over

60% of end-stage kidney disease (ESKD) cases globally, making them the predominant causes of CKD worldwide.<sup>3</sup> Specifically, diabetes contributes to 30% to 50% of all CKD and ESKD cases worldwide, significantly increasing the risk of cardiovascular complications, mortality, kidney failure, and escalating healthcare expenses.<sup>15,16</sup> Consequently, early screening based on estimated glomerular filtration rate (eGFR) is recommended for diabetic patients to facilitate prompt identification and treatment of CKD.<sup>17</sup>

However, data scarcity persists in the Middle East regarding CKD prevalence among diabetic individuals, and there is considerable variability across other available studies. For example, the prevalence of CKD among diabetic patients is reported to be 38.5% in Palestine,<sup>18</sup> 34.7% in Morocco,<sup>19</sup> 24.6% in South Africa,<sup>20</sup> and 18.2% in Ethiopia.<sup>21</sup> Research indicates that early identification and management of diabetes, hypertension, and other chronic conditions can enhance renal outcomes and may decrease or even prevent the progression of chronic CKD.<sup>22</sup>

Although diabetes is a well-established risk factor for CKD, uncertainty surrounds whether prediabetes also contributes to kidney function impairment and CKD development. Research from the Framingham Heart Study offspring cohort has suggested that cardiovascular risk factors like blood pressure, plasma lipid levels, gender and age may be stronger predictors of CKD than prediabetes itself.<sup>23</sup> In contrast, findings from a cross-sectional study in the Cooperative Health Research in the Augsburg Region (KORA) highlighted the potential negative impact of prediabetes on kidney health.<sup>24</sup> Additionally, studies on the Chinese population have reported conflicting evidence regarding the link between prediabetes and CKD.<sup>25,26</sup> The relationship between prediabetic glycemic indices and CKD remains uncertain, with different studies yielding inconsistent results.<sup>24,27-30</sup>

Given that lifestyle modifications and pharmacological interventions can prevent or mitigate diabetes and its complications in high-risk subjects, understanding the potential association between prediabetes and CKD becomes crucial.<sup>31</sup> Identifying reliable glycemic measurements predictive of increased CKD risk in prediabetic individuals becomes imperative, considering the escalating global prevalence of CKD and its high mortality rate. Such insights could pave the way for novel CKD treatments and more robust preventive measures for individuals with prediabetes and diabetes. The aims of this investigation were to explore the relationship between diabetes, prediabetes, and CKD, considering essential risk factors, including gender, age, lifestyle, smoking habits, and blood pressure.

## Materials and Methods

This study represents the initial phase of the Bandare-Kong Non-Communicable Disease (BKNCN) Cohort Study, conducted in a coastal region of the Hormozgan province, southern Iran, as part of the larger PERSIAN

(Prospective Epidemiological Research Studies in IrAN) cohort. The methodology has been previously published.<sup>32</sup> Between November 17, 2016, and November 22, 2018, a total of 4063 participants aged 35 to 70 years were enrolled. After excluding incomplete records and pregnant women, the final analysis included 3642 participants. Trained personnel collected sociodemographic data, such as marital status, age, gender, employment status, education level, smoking habits, wealth score index (WSI), and physical activity, through face-to-face interviews. Body weight was determined using a mechanical scale, with participants wearing minimal clothing and no shoes, and accuracy to 0.5 kg. Height was measured with participants standing barefoot, in a natural shoulder position. Waist circumference (WC) was assessed at the midpoint between the iliac crest and the last palpable rib, with each measurement taken twice per participant, and the average value was noted. All measurements were performed using a stretch-resistant tape, with accuracy recorded to the nearest 0.5 cm.

Cigarette smoking status was determined using self-reported data. "Current smokers" were defined as individuals who were actively smoking or had smoked 100 or more cigarettes in their lifetime. "Ex-smokers" were those who had also smoked at least 100 cigarettes but had not smoked within the last six months. Physical activity was assessed by recording 24-hour activity levels, encompassing work, exercise, and leisure activities. These were calculated on a weekly basis and categorized into low, moderate, and vigorous intensity levels. The wealth status index (WSI) was calculated using multiple correspondence analysis, incorporating variables such as ownership of appliances, travel history, and assets. The WSI was then divided into quintiles ranging from "very rich" to "very poor." Quantitative data were expressed as means and standard deviations, while qualitative data were reported as proportions and frequencies.

CKD was calculated using the Modification of Diet in Renal Disease (MDRD) formula based on  $GFR < 60 \text{ mL/min per } 1.73 \text{ m}^2$ , or albumin/Cr  $> 30 \text{ mg/g}$  in random urine, self-reported kidney failure, or dialysis.

Urine albumin and creatinine were measured by standard kits (Pars Azmoon, Tehran, Iran) and the BT1500 automatic chemistry analyzer (Biotechnica Instruments, Rome, Italy).

Normal distribution of the data was checked using Kolmogorov-Smirnov test and Q-Q graph tests. In both cases, the normality of the data distribution was confirmed. For calculation of the descriptive statistics of CKD prevalence, independent *t* test, and Mann-Whitney test were used for normally and non-normally distributed quantitative data, respectively. Chi-square tests, independent *t*-tests, and one-way analysis of variance tests, compared quantitative and qualitative variables between groups; the assumption of independent *t* tests and one-way analysis of variance tests is normality and homogeneity of variance that have been checked.

Logistic regression examined the relationship between chronic renal failure, diabetes, prediabetes, and other risk factors using crude and multivariate models, although the assumption of linearity of the logistic regression model was evaluated for quantitative predictors. Variables with a *P* value of  $\leq 0.2$  in the univariate analysis were included in the multivariate logistic regression model, employing the “Wald” method. A *P* value of  $< 0.05$  was considered as statistically significant. SPSS version 22.0 was used for analysis.

## Results

A total of 3642 individuals participated in this study. Of the total survey subjects, 1610 were men (44.2%), and 2032 were women (55.8%). The average age of people with CKD ( $50.67 \pm 9.84$  year) was higher than that of people without CKD ( $47.67 \pm 9.05$  year). The waist circumference of people with/without CKD was almost equal. The prevalence of CKD in diabetics (29.6%) was higher than prediabetics (16.5%) and normal (10.5%) people (Tables 1, 2).

Table 1 indicates that the prevalence of CKD was higher in men than women among individuals with normal glucose levels and those with prediabetes. However, among diabetic individuals, the prevalence of CKD was higher in women than men. CKD prevalence was higher among cigarette smokers (17.1%) than their counterparts (15.04%). Furthermore, those with an education period of less than 6 years, widowed and divorced people, unemployed people, those with low physical activity, and those belonging to the poorest WSI category were more likely to have CKD than other groups. The risk of developing CKD was greater in individuals with high blood pressure than those without it.

Table 3 shows the crude and adjusted odds ratios for various related risk factors, as determined by multivariable logistic regression. The results showed that age (OR = 1.02; 95% CI: 1.01, 1.03), male sex (OR = 6.64; 95% CI: 5.47, 8.06), dysglycemia (OR<sub>Prediabetes</sub> = 1.26; 95% CI: 1.04, 1.54), (OR<sub>Diabetes</sub> = 1.77; 95% CI: 1.44, 2.18), hypertension (OR = 1.89; 95% CI: 1.48, 2.18), ARB use (OR = 1.48; 95% CI: 1.06, 2.07) and abnormal waist circumference (OR = 1.007; 95% CI: 1.00, 1.01) as independent risk factors lead to an increase in CKD.

## Discussion

The present study was performed on the first phase of the Bandare-Kong Persian cohort. It aimed to assess the epidemiological characteristics of CKD within diabetic, prediabetic, and healthy populations and to identify prognostic factors for CKD utilizing the MDRD GFR equation. The prevalence of CKD was found to be 15.3%, with 29.6% identified in diabetic individuals and 16.5% in prediabetic patients, encompassing a total of 3642 adults in Bandare-Kong. Overall, increased age, dysglycemia (diabetes or prediabetes), hypertension, and the use of ARBs were significantly associated with elevated risk of

CKD in adults. These results align with previous studies offer valuable insight for shaping preventive strategies for CKD.<sup>33</sup>

## Prevalence

The estimate of CKD prevalence in Asia ranges between 7.0% and 34.3%.<sup>34</sup> This aligns closely with the findings of a recent systematic review and meta-analysis involving 100 studies and 6908440 patients, which reported a comparable prevalence of 13.4%.<sup>35</sup> Notably, our CKD prevalence is significantly lower than that reported in a study conducted in Yazd, Iran, where 27.5% of 9781 participants aged 30–73 was found to have CKD.<sup>36</sup>

In 2019, a study conducted in Shiraz, Iran, reported a CKD prevalence of 16.6% based on the estimated glomerular filtration rate (eGFR).<sup>37</sup> In comparison, the Golestan cohort study, which is the largest cohort study in both Iran and the Middle East, estimated CKD prevalence at 23.7% in 2017. This study, led by Sepanlou et al, found a prevalence rate of 26.6% in women and 20.6% in men.<sup>38</sup>

Other studies conducted in Iran show different prevalence rates for CKD. In a cross-sectional study spanning 2002 to 2005, Safarinejad et al identified a CKD prevalence of 12.6% among 17,000 adults aged 14 and older.<sup>39</sup> In contrast, Najafi et al found a lower CKD prevalence of 4.6% among adults in Golestan, based on GFR measurements.<sup>40</sup>

The cumulative data suggest a notable growth in CKD prevalence in Iran over the past few years, indicating a significant health concern.

## Risk Factors

This study observed an average age of  $50.67 \pm 9.84$  years among individuals with CKD, revealing a higher CKD risk associated with aging. Multivariate analysis indicated a 5% increase in CKD chance for every 10-year increment in age (OR = 1.05; 95% CI: 1.04, 1.06), consistent with prior research emphasizing the age-related rise in CKD odds.<sup>36,38,41,42</sup>

Comparing genders using the MDRD equation did not reveal a significant difference in CKD development (OR = 1.05, 95% CI = 0.88–1.26). However, contrasting results from the Japanese Society for Dialysis Therapy suggested a higher likelihood of CKD in males, differing from UK and Sweden studies.<sup>43,44</sup>

This study demonstrated that diabetic patients were 1.94 times more likely to develop CKD (OR = 1.94, 95% CI = 1.53–2.46), aligning with similar findings in the literature.<sup>45–49</sup>

Diabetes mellitus stands as the primary cause behind CKD and ESRD in both developed and developing nations.<sup>50,51</sup> Data from the United States Renal Data System (USRDS) reveals that diabetic nephropathy is present in half of the newly diagnosed ESRD patients in the United States.<sup>52</sup> In our study, the prevalence of CKD within the diabetic population reached 29.6%, surpassing the rates reported by Kumela Goro et al<sup>53</sup> (26%) and

**Table 1.** Frequency Distribution of Demographic Variables of the Study Subjects with CKD Status

Variables	Normal		Prediabetes		Diabetes	
	CKD		CKD		CKD	
	No	Yes	No	Yes	No	Yes
Age (y) (Mean±SD)	45.78±8.57	52.29±10.25	48.21±8.75	53.51±9.46	52.81±8.70	56.09±8.02
P value	<0.001		<0.001		<0.001	
Waist Circumference (cm)	91.56±11.93	93.99±12.24	95.94±11.40	96.17±11.22	97.41±11.20	97.62±10.43
P value	0.003		0.83		0.82	
GFR (ml/min)	81.07±11.74	63.32±15.46	80.39±12.19	60.63±12.68	78.86±11.50	65.80±18.07
P value	<0.001		<0.001		<0.001	
Urine Alb/Cr ratio (mg/g)	2.33±0.12	44.48±6.19	2.34±0.20	44.69±7.67	4.83±0.34	146.91±17.34
P value	<0.001		<0.001		<0.001	
Gender, N (%)						
Female	1089 (89.9)	123 (10.1)	331 (84.7)	60 (15.3)	294 (68.5)	135 (31.5)
Male	875 (89.0)	108 (11.0)	307 (82.3)	66 (17.7)	187 (73.6)	67 (26.4)
P value	0.53		0.38		0.16	
Hypertension (%)						
No	1561 (92.8)	122 (7.2)	428 (86.8)	65 (13.2)	231 (81.1)	54 (18.9)
Yes	403 (78.7)	109 (21.3)	210 (77.5)	61 (22.5)	250 (62.8)	148 (37.2)
P value	<0.001		0.001		<0.001	
Cigarette smoking (%)						
No	1662 (89.7)	190 (10.3)	556 (84.5)	102 (15.5)	414 (70.4)	174 (29.6)
Yes	302 (88.0)	41 (12.0)	82 (77.4)	24 (22.6)	67 (70.5)	28 (29.5)
P value	0.35		0.06		0.98	
Physical Activity Score (METS/ daily) (%)						
24–36.5	434 (85.6)	73 (14.4)	136 (75.6)	44 (24.4)	159 (64.9)	86 (35.1)
36.6–44.9	1179 (89.9)	133 (10.1)	392 (85.4)	67 (14.6)	271 (73.6)	97 (26.4)
≥45	326 (93.1)	24 (6.9)	97 (88.2)	13 (11.8)	46 (75.4)	15 (24.6)
P value	0.001		0.004		0.04	
Education Year (%)						
<6	1206 (87.3)	176 (12.7)	442 (82.6)	93 (17.4)	362 (66.5)	182 (33.5)
6–12	545 (92.1)	47 (7.9)	144 (86.7)	22 (17.5)	94 (83.9)	18 (16.1)
>12	213 (96.4)	8 (3.6)	52 (82.5)	11 (8.7)	25 (92.6)	2 (17.4)
P value	<0.001		0.45		<0.001	
Occupation (%)						
No	997 (87.3)	145 (12.7)	322 (81.1)	75 (18.9)	305 (67.0)	150 (33.0)
Yes	967 (91.8)	86 (8.2)	316 (86.1)	51 (13.9)	176 (77.2)	52 (22.8)
P value	0.001		0.06		0.006	
Marital status (%)						
Single	54 (94.7)	3 (5.3)	13 (72.2)	5 (27.8)	7 (70.0)	3 (30.0)
Married	1780 (89.8)	203 (10.2)	574 (84.5)	105 (15.5)	422 (70.1)	180 (29.9)
Widowed + Divorce	130 (83.9)	25 (16.1)	51 (76.1)	16 (23.9)	52 (73.2)	19 (26.8)
P value	0.03		0.08		0.86	
Wealth score index (%)						
Poorest	373 (89.7)	43 (10.3)	124 (80.0)	31 (20.0)	94 (63.5)	54 (36.5)
The 2nd poorest	400 (87.1)	59 (12.9)	125 (85.0)	22 (15.0)	106 (67.9)	50 (32.1)
Middle	373 (89.9)	42 (10.1)	128 (85.9)	21 (14.1)	94 (72.3)	36 (27.7)
The 2nd richest	410 (89.7)	47 (10.3)	133 (84.2)	25 (15.8)	101 (71.6)	40 (28.4)
Richest	408 (91.1)	40 (8.9)	128 (82.6)	27 (17.4)	86 (79.6)	22 (20.4)
P value	0.41		0.66		0.07	
ACEI using (%)						
No	1938 (89.7)	223 (10.3)	629 (84.1)	119 (15.9)	452 (71.7)	178 (28.3)
Yes	26 (76.5)	8 (23.5)	9 (56.2)	7 (43.8)	29 (54.7)	24 (45.3)
P value	0.01		0.003		0.009	
ARB using (%)						
No	1909 (90.5)	201 (9.5)	599 (83.9)	115 (16.1)	409 (73.0)	151 (27.0)
Yes	55 (64.7)	30 (35.3)	39 (78.0)	11 (22.0)	72 (58.5)	51 (41.5)
P value	<0.001		0.28		0.001	

CKD, chronic kidney disease; GFR, glomerular filtration rate; MDRD, Modification of Diet in Renal Disease study; METS, metabolic equivalents ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.

**Table 2.** Prevalence of CKD Based on Different Definitions

Variables	Glycemic status			P Value
	Normal	Diabetes	Prediabetes	
CKD, N (%)				<0.001
No	1964 (89.5)	481 (70.4)	638 (83.5)	
Yes	231 (10.5)	202 (29.6)	126 (16.5)	
CKD (GFR < 60 mL/min)				<0.001
No	2048 (93.3)	589 (86.2)	678 (88.7)	
Yes	147 (6.7)	94 (13.8)	86 (11.3)	
CKD (Alb / Cr ≥ 30 mg/g)				<0.001
No	2098 (95.6)	538 (78.8)	718 (94.0)	
Yes	97 (4.4)	145 (21.2)	46 (6.0)	
CKD_Stage2				<0.001
1	431 (19.6)	100 (14.6)	129 (16.9)	
2	1617 (73.6)	489 (71.6)	549 (71.9)	
3	146 (6.7)	91 (13.3)	85 (11.1)	
4	1 (0.1)	2 (0.3)	1 (0.1)	
5	0 (0.0)	1 (0.1)	0 (0.0)	
GFR (MDRD)	79.20 ± 13.34	74.99 ± 15.0	77.13 ± 14.29	<0.001
(Mean ± SD)	6.77 ± 0.71	46.85 ± 5.69	9.32 ± 1.39	<0.001

CKD, Chronic kidney disease; GFR, Glomerular filtration rate; MDRD, Modification of Diet in Renal Disease study.

a study in the United Kingdom (27.5%).<sup>43</sup> Similarly, Spain documented a CKD prevalence of 31.22% among diabetic and hypertensive patients.<sup>54</sup> The United States recorded a CKD prevalence of 38.3% among T2DM patients from 2007 to 2012.<sup>55</sup> Discrepancies in these figures may stem from variations in study populations. Notably, low- and middle-income countries exhibit considerable CKD heterogeneity between urban and rural areas. Furthermore, the etiology of CKD in type 2 diabetic patients in low-income countries is complex, influenced by the burden of both non-communicable and communicable diseases, setting them apart from their counterparts in high-income countries.<sup>56</sup>

Our investigation uncovered a noteworthy correlation between hypertension and CKD (OR=1.75, 95% CI=1.40-2.20). This finding aligns with previous studies,<sup>57-60</sup> affirming hypertension as a pivotal risk factor for CKD development. In our study, 26.93% of the hypertensive population exhibited CKD. The positive impact of blood pressure control and antihypertensive medications on renal function in diabetic patients has been consistently emphasized in recent guidelines.<sup>61</sup> Systemic hypertension exerts pressure on intraglomerular capillaries, contributing to glomerulosclerosis and

**Table 3.** Logistic Regression Analysis of Chronic Kidney Disease and Glycemic Status in Bandare-Kong Cohort Study (n = 3642)

Variable	Crude				Adjusted			
	OR	95% CI		P Value	OR	95% CI		P Value
		Lower	Upper			Lower	Upper	
Age (y)	1.02	1.01	1.03	<0.001	1.02	1.01	1.03	<0.001
Gender								
Female	1	—	—	—	1	—	—	—
Male	5.50	4.73	6.40	<0.001	6.64	5.47	8.06	<0.001
Glycemic status								
Normal	1	—	—	—	1	—	—	—
Prediabetes	1.44	1.21	1.71	<0.001	1.26	1.04	1.54	0.01
Diabetes	1.79	1.50	2.14	<0.001	1.77	1.44	2.18	<0.001
Hypertension								
No	1	—	—	—	1	—	—	—
Yes	1.93	1.67	2.23	<0.001	1.89	1.48	2.18	<0.001
Cigarette Smoking								
No	1	—	—	—	1	—	—	—
Yes	2.94	2.44	3.53	<0.001	0.86	0.69	1.06	0.16
ACEI use								
No	1	—	—	—	1	—	—	—
Yes	1.96	1.34	2.87	0.001	1.39	0.89	2.18	0.14
ARB use								
No	1	—	—	—	1	—	—	—
Yes	1.99	1.56	2.56	<0.001	1.48	1.06	2.07	0.02
Daily energy intake	0.99	0.97	1.00	<0.001	0.99	0.97	1.00	0.39
Waist Circumference	0.11	0.99	1.00	0.11	1.007	1.00	1.01	0.04
Salt (gram/daily)	0.96	0.93	1.00	0.07	0.99	0.95	1.03	0.71

CKD, Chronic kidney disease; ACEI, Angiotensin-converting enzyme inhibitor; ARB, Angiotensin receptor blocker.

subsequent renal function deterioration. Consequently, hypertensive patients face various risks of renal damage, as documented in previous research.<sup>52</sup>

The utilization of ARBs appears to elevate the risk of developing CKD (OR=1.38; 95% CI: 1.01, 1.89). Conversely, there was no statistically significant association found between ACEI use and the presence of CKD. The role of ARBs and ACEI in CKD remains a subject of uncertainty. The KDIGO guideline recommends renin-angiotensin system (RAS) inhibitors for managing CKD in diabetic patients.<sup>62</sup> Additionally, a meta-analysis of 119 randomized trials involving CKD patients, whether or not they had diabetes, showed that both ACEIs and ARBs were effective in reducing the risk of kidney failure, or ESKD, as well as major cardiovascular events.<sup>63</sup> Further, a recent trial found that discontinuing RAS inhibitors did not lead to significant changes in eGFR or a difference in the long-term rate of eGFR decline in patients with advanced and progressive CKD.<sup>64</sup>

The current study found no evidence linking CKD with either cigarette smoking or hookah use, which contrasts with previous research.<sup>36,65</sup> Earlier, a systematic review and meta-analysis of 15 cohort studies had identified cigarette smoking as an independent risk factor for developing CKD.<sup>65</sup> Additionally, the research by Dehghani et al also recognized smoking as a risk factor for CKD.<sup>36</sup>

Furthermore, this study did not find a statistically significant correlation between CKD and physical activity. This is in contrast to Shi et al who indicated an inverse relationship between overall physical activity and the risk of CKD.<sup>66</sup>

### Limitations

Although our investigation contains valuable insight regarding the prevalence and risk factors of CKD among subjects with different glycemic statuses, it has some limitations. Firstly, our subjects were collected from a coastal area in southern Iran. So, it may not completely represent the entire country, which could limit the generalizability of the study findings. Secondly, single urine creatinine and albumin assay was used for CKD classification with no follow-up test conducted after three months. This could decrease the accuracy of our CKD classification. A more precise monitoring protocol would increase accuracy. Thirdly, although our data was adjusted for different known confounders, some unmeasured variables such as physical activity, environmental exposures, dietary habits, and genetic predispositions might affect the association between glycemic status and CKD. Future studies should consider a broader range of potential confounders for a more comprehensive understanding.

### Conclusion

The findings underscore that the primary risk factors for CKD are potentially modifiable. By effectively managing blood pressure and blood sugar, particularly in individuals

with diabetes and hypertension, there exists the potential to mitigate the occurrence of CKD. Given the age-related increase in CKD prevalence, it is advisable to incorporate CKD screening into the primary healthcare system, particularly targeting individuals aged 50 and above.

This proactive screening approach facilitates the early detection of CKD, enabling interventions to prevent its progression to advanced stages requiring kidney replacement therapy. Therefore, strategic decisions should be implemented to improve both healthcare professionals' and the general population's knowledge and awareness of the importance of early diagnosis and prevention of CKD.

This concerted effort aims not only to improve CKD prognosis but also to alleviate mortality rates and reduce the financial strain caused by kidney failure.

### Acknowledgments

BKNCD is a part of the PERSIAN national cohort. We would like to express our gratitude to Professor Reza Malekzadeh, a Director of the PERSIAN cohort, as well as to Dr. Hossein Poustchi, Executive Director of the PERSIAN cohort. The funding of the PERSIAN Cohort was provided by the Iranian Ministry of Health and Medical Education through grant number 700/534.

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### Competing Interests

The authors declare that they have no competing interests.

### Data Availability Statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

### Ethics Approval

The cohort study was given ethical approval by the Ethics Committee of Hormozgan University of Medical Sciences. IR.HUMS.REC.1399.305

### Funding

The Iranian Ministry of Health and Medical Education has provided funding for the PERSIAN Cohort under grant number 700/534.


### References

1. Levey AS, Eckardt KU, Tsukamoto Y, Levin A, Coresh J, Rossert J, et al. Definition and classification of chronic kidney disease: a position statement from Kidney Disease: Improving Global Outcomes (KDIGO). *Kidney Int.* 2005;67(6):2089-100. doi: 10.1111/j.1523-1755.2005.00365.x.
2. Nugent RA, Fathima SF, Feigl AB, Chyung D. The burden of chronic kidney disease on developing nations: a 21st century challenge in global health. *Nephron Clin Pract.*

- 2011;118(3):c269-77. doi: [10.1159/000321382](https://doi.org/10.1159/000321382).
3. Hill NR, Fatoba ST, Oke JL, Hirst JA, O'Callaghan CA, Lasserson DS, et al. Global prevalence of chronic kidney disease - a systematic review and meta-analysis. *PLoS One*. 2016;11(7):e0158765. doi: [10.1371/journal.pone.0158765](https://doi.org/10.1371/journal.pone.0158765).
  4. Bikbov B, Perico N, Remuzzi G. Disparities in chronic kidney disease prevalence among males and females in 195 countries: analysis of the Global Burden of Disease 2016 Study. *Nephron*. 2018;139(4):313-8. doi: [10.1159/000489897](https://doi.org/10.1159/000489897).
  5. Luyckx VA, Tonelli M, Stanifer JW. The global burden of kidney disease and the sustainable development goals. *Bull World Health Organ*. 2018;96(6):414-22d. doi: [10.2471/blt.17.206441](https://doi.org/10.2471/blt.17.206441).
  6. Foreman KJ, Marquez N, Dolgert A, Fukutaki K, Fullman N, McGaughey M, et al. Forecasting life expectancy, years of life lost, and all-cause and cause-specific mortality for 250 causes of death: reference and alternative scenarios for 2016-40 for 195 countries and territories. *Lancet*. 2018;392(10159):2052-90. doi: [10.1016/s0140-6736\(18\)31694-5](https://doi.org/10.1016/s0140-6736(18)31694-5).
  7. GBD 2013 Mortality and Causes of Death Collaborators. Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2015;385(9963):117-71. doi: [10.1016/s0140-6736\(14\)61682-2](https://doi.org/10.1016/s0140-6736(14)61682-2).
  8. Adugna T, Merga H, Gudina EK. Impaired glomerular filtration rate, high grade albuminuria and associated factors among adult patients admitted to tertiary hospital in Ethiopia. *BMC Nephrol*. 2018;19(1):345. doi: [10.1186/s12882-018-1153-5](https://doi.org/10.1186/s12882-018-1153-5).
  9. Senevirathna L, Abeysekera T, Nanayakkara S, Chandrajith R, Ratnatunga N, Harada KH, et al. Risk factors associated with disease progression and mortality in chronic kidney disease of uncertain etiology: a cohort study in Medawachchiya, Sri Lanka. *Environ Health Prev Med*. 2012;17(3):191-8. doi: [10.1007/s12199-011-0237-7](https://doi.org/10.1007/s12199-011-0237-7).
  10. Chen W, Chen W, Wang H, Dong X, Liu Q, Mao H, et al. Prevalence and risk factors associated with chronic kidney disease in an adult population from southern China. *Nephrol Dial Transplant*. 2009;24(4):1205-12. doi: [10.1093/ndt/gfn604](https://doi.org/10.1093/ndt/gfn604).
  11. Chukwuonye, II, Ogah OS, Anyabolu EN, Ohagwu KA, Nwabuko OC, Onwuchekwa U, et al. Prevalence of chronic kidney disease in Nigeria: systematic review of population-based studies. *Int J Nephrol Renovasc Dis*. 2018;11:165-72. doi: [10.2147/ijnd.s162230](https://doi.org/10.2147/ijnd.s162230).
  12. Ephraim RK, Biekpe S, Sakyi SA, Adoba P, Agbodjakey H, Antoh EO. Prevalence of chronic kidney disease among the high-risk population in South-Western Ghana; a cross-sectional study. *Can J Kidney Health Dis*. 2015;2:40. doi: [10.1186/s40697-015-0076-3](https://doi.org/10.1186/s40697-015-0076-3).
  13. Levey AS, Coresh J, Balk E, Kausz AT, Levin A, Steffes MW, et al. National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Ann Intern Med*. 2003;139(2):137-47. doi: [10.7326/0003-4819-139-2-200307150-00013](https://doi.org/10.7326/0003-4819-139-2-200307150-00013).
  14. Moosa MR, Van der Walt I, Naicker S, Meyers AM. Important causes of chronic kidney disease in South Africa. *S Afr Med J*. 2015;105(4):2681. doi: [10.7196/samj.9535](https://doi.org/10.7196/samj.9535).
  15. Hamada S, Gulliford MC. Multiple risk factor control, mortality and cardiovascular events in type 2 diabetes and chronic kidney disease: a population-based cohort study. *BMJ Open*. 2018;8(5):e019950. doi: [10.1136/bmjopen-2017-019950](https://doi.org/10.1136/bmjopen-2017-019950).
  16. Harjutsalo V, Groop PH. Epidemiology and risk factors for diabetic kidney disease. *Adv Chronic Kidney Dis*. 2014;21(3):260-6. doi: [10.1053/j.ackd.2014.03.009](https://doi.org/10.1053/j.ackd.2014.03.009).
  17. Persson F, Rossing P. Diagnosis of diabetic kidney disease: state of the art and future perspective. *Kidney Int Suppl* (2011). 2018;8(1):2-7. doi: [10.1016/j.kisu.2017.10.003](https://doi.org/10.1016/j.kisu.2017.10.003).
  18. Shahwan MJ, Gacem SA, Zaidi SK. Prevalence of diabetic nephropathy and associated risk factors among type 2 diabetes mellitus patients in Ramallah, Palestine. *Diabetes Metab Syndr*. 2019;13(2):1491-6. doi: [10.1016/j.dsx.2019.02.017](https://doi.org/10.1016/j.dsx.2019.02.017).
  19. Bentata Y, Haddiya I, Latrech H, Serraj K, Abouqal R. Progression of diabetic nephropathy, risk of end-stage renal disease and mortality in patients with type-1 diabetes. *Saudi J Kidney Dis Transpl*. 2013;24(2):392-402. doi: [10.4103/1319-2442.109617](https://doi.org/10.4103/1319-2442.109617).
  20. Motala AA, Pirie FJ, Gouws E, Amod A, Omar MA. Microvascular complications in South African patients with long-duration diabetes mellitus. *S Afr Med J*. 2001;91(11):987-92.
  21. Fiseha T, Kassim M, Yemane T. Chronic kidney disease and underdiagnosis of renal insufficiency among diabetic patients attending a hospital in Southern Ethiopia. *BMC Nephrol*. 2014;15:198. doi: [10.1186/1471-2369-15-198](https://doi.org/10.1186/1471-2369-15-198).
  22. Shiferaw WS, Akalu TY, Aynalem YA. Chronic kidney disease among diabetes patients in Ethiopia: a systematic review and meta-analysis. *Int J Nephrol*. 2020;2020:8890331. doi: [10.1155/2020/8890331](https://doi.org/10.1155/2020/8890331).
  23. Fox CS, Larson MG, Leip EP, Meigs JB, Wilson PW, Levy D. Glycemic status and development of kidney disease: the Framingham Heart Study. *Diabetes Care*. 2005;28(10):2436-40. doi: [10.2337/diacare.28.10.2436](https://doi.org/10.2337/diacare.28.10.2436).
  24. Markus MR, Ittermann T, Baumeister SE, Huth C, Thorand B, Herder C, et al. Prediabetes is associated with microalbuminuria, reduced kidney function and chronic kidney disease in the general population: the KORA (Cooperative Health Research in the Augsburg Region) F4-Study. *Nutr Metab Cardiovasc Dis*. 2018;28(3):234-42. doi: [10.1016/j.numecd.2017.12.005](https://doi.org/10.1016/j.numecd.2017.12.005).
  25. Zhou Y, Echouffo-Tcheugui JB, Gu JJ, Ruan XN, Zhao GM, Xu WH, et al. Prevalence of chronic kidney disease across levels of glycemia among adults in Pudong New Area, Shanghai, China. *BMC Nephrol*. 2013;14:253. doi: [10.1186/1471-2369-14-253](https://doi.org/10.1186/1471-2369-14-253).
  26. Lin L, Lu J, Chen L, Mu Y, Ye Z, Liu C, et al. Glycemic status and chronic kidney disease in Chinese adults: findings from the REACTION study. *J Diabetes*. 2017;9(9):837-45. doi: [10.1111/1753-0407.12490](https://doi.org/10.1111/1753-0407.12490).
  27. Wang C, Song J, Sun Y, Hou X, Chen L. Blood glucose is associated with chronic kidney disease in subjects with impaired glucose tolerance, but not in those with impaired fasting glucose. *J Diabetes*. 2014;6(6):574-6. doi: [10.1111/1753-0407.12174](https://doi.org/10.1111/1753-0407.12174).
  28. Koshi T, Sagesaka H, Sato Y, Hirabayashi K, Koike H, Yamauchi K, et al. Elevated haemoglobin A1c but not fasting plasma glucose conveys risk of chronic kidney disease in non-diabetic individuals. *Diabetes Res Clin Pract*. 2018;146:233-9. doi: [10.1016/j.diabres.2018.10.026](https://doi.org/10.1016/j.diabres.2018.10.026).
  29. Kim GS, Oh HH, Kim SH, Kim BO, Byun YS. Association between prediabetes (defined by HbA1(C), fasting plasma glucose, and impaired glucose tolerance) and the development of chronic kidney disease: a 9-year prospective cohort study. *BMC Nephrol*. 2019;20(1):130. doi: [10.1186/s12882-019-1307-0](https://doi.org/10.1186/s12882-019-1307-0).
  30. Bigotte Vieira M, Neves JS, Leitão L, Baptista RB, Magriço R, Viegas Dias C, et al. Impaired fasting glucose and chronic kidney disease, albuminuria, or worsening kidney function: a secondary analysis of SPRINT. *J Clin Endocrinol Metab*. 2019;104(9):4024-32. doi: [10.1210/je.2019-00073](https://doi.org/10.1210/je.2019-00073).
  31. Florez H, Pan Q, Ackermann RT, Marrero DG, Barrett-Connor E, Delahanty L, et al. Impact of lifestyle intervention and metformin on health-related quality of life: the diabetes prevention program randomized trial. *J Gen Intern Med*. 2012;27(12):1594-601. doi: [10.1007/s11606-012-2122-5](https://doi.org/10.1007/s11606-012-2122-5).
  32. Nejatizadeh A, Eftekhari E, Shekari M, Farshidi H, Davoodi SH,

- Shahmoradi M, et al. Cohort profile: Bandar Kong prospective study of chronic non-communicable diseases. *PLoS One*. 2022;17(5):e0265388. doi: [10.1371/journal.pone.0265388](https://doi.org/10.1371/journal.pone.0265388).
33. Duan J, Wang C, Liu D, Qiao Y, Pan S, Jiang D, et al. Prevalence and risk factors of chronic kidney disease and diabetic kidney disease in Chinese rural residents: a cross-sectional survey. *Sci Rep*. 2019;9(1):10408. doi: [10.1038/s41598-019-46857-7](https://doi.org/10.1038/s41598-019-46857-7).
  34. Liyanage T, Toyama T, Hockham C, Ninomiya T, Perkovic V, Woodward M, et al. Prevalence of chronic kidney disease in Asia: a systematic review and analysis. *BMJ Glob Health*. 2022;7(1):e007525. doi: [10.1136/bmjgh-2021-007525](https://doi.org/10.1136/bmjgh-2021-007525).
  35. Kovesdy CP. Epidemiology of chronic kidney disease: an update 2022. *Kidney Int Suppl* (2011). 2022;12(1):7-11. doi: [10.1016/j.kisu.2021.11.003](https://doi.org/10.1016/j.kisu.2021.11.003).
  36. Dehghani A, Alishavandi S, Nourimajalan N, Fallahzadeh H, Rahmanian V. Prevalence of chronic kidney diseases and its determinants among Iranian adults: results of the first phase of Shahedieh cohort study. *BMC Nephrol*. 2022;23(1):203. doi: [10.1186/s12882-022-02832-5](https://doi.org/10.1186/s12882-022-02832-5).
  37. Bakhshayeshkaram M, Roozbeh J, Heydari ST, Honarvar B, Dabbaghmanesh MH, Ghoreyshi M, et al. A population-based study on the prevalence and risk factors of chronic kidney disease in the adult population of Shiraz, Southern Iran. *Galen Med J*. 2019;8:e935. doi: [10.31661/gmj.v0i0.935](https://doi.org/10.31661/gmj.v0i0.935).
  38. Sepanlou SG, Barahimi H, Najafi I, Kamangar F, Poustchi H, Shakeri R, et al. Prevalence and determinants of chronic kidney disease in northeast of Iran: results of the Golestan cohort study. *PLoS One*. 2017;12(5):e0176540. doi: [10.1371/journal.pone.0176540](https://doi.org/10.1371/journal.pone.0176540).
  39. Safarinejad MR. The epidemiology of adult chronic kidney disease in a population-based study in Iran: prevalence and associated risk factors. *J Nephrol*. 2009;22(1):99-108.
  40. Najafi I, Attari F, Islami F, Shakeri R, Malekzadeh F, Salehi R, et al. Renal function and risk factors of moderate to severe chronic kidney disease in Golestan province, northeast of Iran. *PLoS One*. 2010;5(12):e14216. doi: [10.1371/journal.pone.0014216](https://doi.org/10.1371/journal.pone.0014216).
  41. Ene-Iordache B, Perico N, Bikbov B, Carminati S, Remuzzi A, Perna A, et al. Chronic kidney disease and cardiovascular risk in six regions of the world (ISN-KDDC): a cross-sectional study. *Lancet Glob Health*. 2016;4(5):e307-19. doi: [10.1016/s2214-109x\(16\)00071-1](https://doi.org/10.1016/s2214-109x(16)00071-1).
  42. Goncalves GMR, da Silva EN. Cost of chronic kidney disease attributable to diabetes from the perspective of the Brazilian Unified Health System. *PLoS One*. 2018;13(10):e0203992. doi: [10.1371/journal.pone.0203992](https://doi.org/10.1371/journal.pone.0203992).
  43. Middleton RJ, Foley RN, Hegarty J, Cheung CM, McElduff P, Gibson JM, et al. The unrecognized prevalence of chronic kidney disease in diabetes. *Nephrol Dial Transplant*. 2006;21(1):88-92. doi: [10.1093/ndt/gfi163](https://doi.org/10.1093/ndt/gfi163).
  44. Afghahi H, Cederholm J, Eliasson B, Zethelius B, Gudbjörnsdóttir S, Hadimeri H, et al. Risk factors for the development of albuminuria and renal impairment in type 2 diabetes--the Swedish National Diabetes Register (NDR). *Nephrol Dial Transplant*. 2011;26(4):1236-43. doi: [10.1093/ndt/gfq535](https://doi.org/10.1093/ndt/gfq535).
  45. Yacoub R, Habib H, Lahdo A, Al Ali R, Varjabedian L, Atalla G, et al. Association between smoking and chronic kidney disease: a case control study. *BMC Public Health*. 2010;10:731. doi: [10.1186/1471-2458-10-731](https://doi.org/10.1186/1471-2458-10-731).
  46. Saucier NA, Sinha MK, Liang KV, Krambeck AE, Weaver AL, Bergstralh EJ, et al. Risk factors for CKD in persons with kidney stones: a case-control study in Olmsted county, Minnesota. *Am J Kidney Dis*. 2010;55(1):61-8. doi: [10.1053/j.ajkd.2009.08.008](https://doi.org/10.1053/j.ajkd.2009.08.008).
  47. Ghelichi-Ghojogh M, Fararouei M, Seif M, Pakfetrat M. Chronic kidney disease and its health-related factors: a case-control study. *BMC Nephrol*. 2022;23(1):24. doi: [10.1186/s12882-021-02655-w](https://doi.org/10.1186/s12882-021-02655-w).
  48. Khajehdehi P, Malekmakan L, Pakfetrat M, Roozbeh J, Sayadi M. Prevalence of chronic kidney disease and its contributing risk factors in southern Iran: a cross-sectional adult population-based study. *Iran J Kidney Dis*. 2014;8(2):109-15.
  49. Li H, Lu W, Wang A, Jiang H, Lyu J. Changing epidemiology of chronic kidney disease as a result of type 2 diabetes mellitus from 1990 to 2017: estimates from Global Burden of Disease 2017. *J Diabetes Investig*. 2021;12(3):346-56. doi: [10.1111/jdi.13355](https://doi.org/10.1111/jdi.13355).
  50. Kazancioglu R. Risk factors for chronic kidney disease: an update. *Kidney Int Suppl* (2011). 2013;3(4):368-71. doi: [10.1038/kisup.2013.79](https://doi.org/10.1038/kisup.2013.79).
  51. McClellan WM, Flanders WD. Risk factors for progressive chronic kidney disease. *J Am Soc Nephrol*. 2003;14(7 Suppl 2):S65-70. doi: [10.1097/01.asn.0000070147.10399.9e](https://doi.org/10.1097/01.asn.0000070147.10399.9e).
  52. Lea JP, Nicholas SB. Diabetes mellitus and hypertension: key risk factors for kidney disease. *J Natl Med Assoc*. 2002;94(8 Suppl):7S-15S.
  53. Kumela Goro K, Desalegn Wolide A, Kerga Dibaba F, Gashe Fufa F, Wakjira Garedow A, Edilu Tufa B, et al. Patient awareness, prevalence, and risk factors of chronic kidney disease among diabetes mellitus and hypertensive patients at Jimma University Medical Center, Ethiopia. *Biomed Res Int*. 2019;2019:2383508. doi: [10.1155/2019/2383508](https://doi.org/10.1155/2019/2383508).
  54. Alemán-Vega G, Gómez Cabañas I, Reques Sastre L, Rosado Martín J, Polentinos-Castro E, Rodríguez Barrientos R. Prevalence and risk of progression of chronic kidney disease in diabetics and hypertensive patients followed in primary care in Madrid. *Nefrología*. 2017;37(3):343-5. doi: [10.1016/j.nefro.2016.10.019](https://doi.org/10.1016/j.nefro.2016.10.019).
  55. Wu B, Bell K, Stanford A, Kern DM, Tunceli O, Vupputuri S, et al. Understanding CKD among patients with T2DM: prevalence, temporal trends, and treatment patterns-NHANES 2007-2012. *BMJ Open Diabetes Res Care*. 2016;4(1):e000154. doi: [10.1136/bmjdr-2015-000154](https://doi.org/10.1136/bmjdr-2015-000154).
  56. Jitraknatee J, Ruengorn C, Nochaiwong S. Prevalence and risk factors of chronic kidney disease among type 2 diabetes patients: a cross-sectional study in primary care practice. *Sci Rep*. 2020;10(1):6205. doi: [10.1038/s41598-020-63443-4](https://doi.org/10.1038/s41598-020-63443-4).
  57. Jee SH, Boulware LE, Guallar E, Suh I, Appel LJ, Miller ER 3rd. Direct, progressive association of cardiovascular risk factors with incident proteinuria: results from the Korea Medical Insurance Corporation (KMIC) study. *Arch Intern Med*. 2005;165(19):2299-304. doi: [10.1001/archinte.165.19.2299](https://doi.org/10.1001/archinte.165.19.2299).
  58. Kanno A, Kikuya M, Ohkubo T, Hashimoto T, Satoh M, Hirose T, et al. Pre-hypertension as a significant predictor of chronic kidney disease in a general population: the Ohasama Study. *Nephrol Dial Transplant*. 2012;27(8):3218-23. doi: [10.1093/ndt/gfs054](https://doi.org/10.1093/ndt/gfs054).
  59. Tohidi M, Hashemina M, Mohebi R, Khalili D, Hosseinpahan F, Yazdani B, et al. Incidence of chronic kidney disease and its risk factors, results of over 10 year follow up in an Iranian cohort. *PLoS One*. 2012;7(9):e45304. doi: [10.1371/journal.pone.0045304](https://doi.org/10.1371/journal.pone.0045304).
  60. Komura H, Nomura I, Kitamura K, Kuwasako K, Kato J. Gender difference in relationship between body mass index and development of chronic kidney disease. *BMC Res Notes*. 2013;6:463. doi: [10.1186/1756-0500-6-463](https://doi.org/10.1186/1756-0500-6-463).
  61. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Am J Kidney Dis*. 2002;39(2 Suppl 1):S1-266.
  62. Kidney Disease: Improving Global Outcomes (KDIGO) Diabetes Work Group. KDIGO 2020 clinical practice guideline for diabetes management in chronic kidney disease. *Kidney Int*. 2020;98(4s):S1-115. doi: [10.1016/j.kint.2020.06.019](https://doi.org/10.1016/j.kint.2020.06.019).
  63. Xie X, Liu Y, Perkovic V, Li X, Ninomiya T, Hou W, et al. Renin-

- angiotensin system inhibitors and kidney and cardiovascular outcomes in patients with CKD: a Bayesian network meta-analysis of randomized clinical trials. *Am J Kidney Dis.* 2016;67(5):728-41. doi: [10.1053/j.ajkd.2015.10.011](https://doi.org/10.1053/j.ajkd.2015.10.011).
64. Bhandari S, Mehta S, Khwaja A, Cleland JGF, Ives N, Brettell E, et al. Renin-angiotensin system inhibition in advanced chronic kidney disease. *N Engl J Med.* 2022;387(22):2021-32. doi: [10.1056/NEJMoa2210639](https://doi.org/10.1056/NEJMoa2210639).
65. Xia J, Wang L, Ma Z, Zhong L, Wang Y, Gao Y, et al. Cigarette smoking and chronic kidney disease in the general population: a systematic review and meta-analysis of prospective cohort studies. *Nephrol Dial Transplant.* 2017;32(3):475-87. doi: [10.1093/ndt/gfw452](https://doi.org/10.1093/ndt/gfw452).
66. Shi K, Zhu Y, Lv J, Sun D, Pei P, Du H, et al. Association of physical activity with risk of chronic kidney disease in China: a population-based cohort study. *J Sport Health Sci.* 2024;13(2):204-11. doi: [10.1016/j.jshs.2023.07.004](https://doi.org/10.1016/j.jshs.2023.07.004).

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