Original Article

Risk Factors Associated to Chronic Kidney Disease in Chalatenango, El Salvador

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Factores de riesgo asociados a la enfermedad renal crónica en Chalatenango, El Salvador

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Abstract

Introduction. In El Salvador, chronic kidney disease affects an important group of economically productive population, being the department of Chalatenango especially vulnerable due to multiple risk factors, such as its prevalence of non-communicable diseases, agricultural activities and occupational exposures. **Objective.** To determine the risk factors associated with chronic kidney disease in the population over 20 years of age in the department of Chalatenango. **Methodology.** It is a matched case-control study, 174 persons participated, 58 cases and 116 controls. People from the department of Chalatenango were included and two controls were matched for each case. **Results.** Of the cases, 63.8 % were men and the mean age was 59.3 years. A significant association was found between the disease and various risk factors, such as harmful alcohol consumption (OR 32.25 CI95 % 1.1-942.19), not exercising (OR 18.30 CI95 % 2.74-49.39), being an agricultural worker (OR 17.03 CI95 % 1.43-204.27), recurrent urinary tract infection (OR 16.07 CI95 % 2-128.99), inadequate consumption of fruits and vegetables (OR 11.65 CI95 % 2.74-49.4), high blood pressure (OR 7.57 CI95 % 1.74-32.88), exposure to pesticides (OR 6.79 CI95 % 1.1-41.88) and diabetes *mellitus* (OR 6.38 CI95 % 1.47-27.71), with a p value < 0.05. **Conclusion.** The study identified multiple traditional risk factors, such as hypertension and diabetes, along with non-traditional factors such as exposure to pesticide, alcohol consumption and lack of exercise.

Keywords
Renal Insufficiency, Risk Factors, Chronic Kidney Diseases of Uncertain Etiology, Case-Control Studies.

Resumen

Introducción. En El Salvador, la enfermedad renal crónica afecta a un grupo importante de población económicamente productiva, el departamento de Chalatenango es especialmente vulnerable debido a múltiples factores, como su prevalencia de enfermedades no transmisibles, actividades agrícolas y exposiciones ocupacionales. **Objetivo.** Determinar los factores de riesgo asociados con la enfermedad renal crónica en la población mayor de 20 años de edad del departamento de Chalatenango. **Metodología.** Estudio de casos y controles, participaron 174 personas, 58 casos y 116 controles. Se incluyeron personas residentes del departamento de Chalatenango y se emparejaron dos controles por cada caso. **Resultados.** El 63,8 % de los casos fueron hombres y la media de edad fue de 59,3 años. Se encontró una asociación significativa entre la enfermedad y diversos factores de riesgo, tales como el consumo nocivo de alcohol (OR 32,25 IC95 % 1,1-942,19), no realizar ejercicio (OR 18,30 IC95 % 2,74-49,39), ser agricultor (OR 17,03 IC95 % 1,43-204,27), infección recurrente de vías urinarias (OR 16,07 IC95 % 2-128,99), consumo inadecuado de frutas y verduras (OR 11,65 IC95 % 2,74-49,4), hipertensión arterial (OR 7,57 IC95 % 1,74-32,88), exposición a plaguicidas (OR 6,79 IC95 % 1,1-41,88) y diabetes *mellitus* (OR 6,38 IC95 % 1,47-27,71), con un valor de p < 0,05. **Conclusión.** El estudio identificó múltiples factores de riesgo tradicionales, como hipertensión y diabetes, junto con factores no tradicionales como exposición de plaguicidas, consumo de alcohol y no realizar ejercicio.

Palabras clave
Enfermedad Renal Crónica, Factores de Riesgo, Enfermedades Renales Crónicas de Etiología Incierta, Estudios de Casos y Controles..

Introduction

Chronic kidney disease (CKD) has become a significant public health challenge worldwide. By 2022, the global prevalence was 10%; however, this figure varies considerably among different geographic regions.[i] In Central America, CKD presents specific social, epidemiological, and clinical characteristics that differentiate it from traditional disease behavior. It has a high incidence in young people, a rapid progression, and a history of work in the agricultural sector.[ii,iii] In El Salvador, CKD affects a significant segment of the population of economically productive age. According to 2015 data, the documented prevalence of CKD was 12.6 %, while by 2020, CKD category G5 ranked as the second leading cause of death in adults of both sexes.[iv]

Chalatenango is a department located in the north of El Salvador, sharing a northern border with Honduras and covering an area of 2017 square kilometers. This region is especially vulnerable due to multiple risk factors for CKD, including a high prevalence of noncommunicable diseases, occupational exposures, and risky behaviors, which have favored the development of this disease.[v,vi]

The traditional factors that contribute to the high prevalence of CKD in Chalatenango are mainly comorbidities that are recognized worldwide, such as diabetes *mellitus* and arterial hypertension, whose rates are among the highest in the country, with a prevalence of 12.4 and 33.6 per 100 000 inhabitants, respectively. These risk factors are considered traditional because they are the most common and recognized causes of CKD worldwide, and their negative impact on renal function is well documentedd.[ii,iii]

On the other hand, non-traditional factors include environmental and occupational exposures. These include the use of pesticides, lack of access to quality drinking water, and adverse working conditions. These factors are considered non-traditional because they are specific to certain geographic areas and occupations.[ii,iii] In this regard, Chalatenango has one of the highest rates of pesticide poisoning at the national level, reaching 20.6 %, significantly higher than the national average of 12.6 %.[iv,vii]

According to the Ministry of Health of El Salvador, by 2022, mortality due to CKD in Chalatenango was 102.9 per 100 000 inhabitants, considerably higher than the national rate of 60.1 per 100 000 inhabitants.[vii]

All of the above raises the question of the factors that influence the development of CKD in the Chalatenango population. Therefore, this research aims to identify and analyze these factors to understand the elements that contribute to its high prevalence and delve into the particularities of this region.

Methodology

An analytical case-control study was carried out for a population over 20 years of age in the department of Chalatenango. The Elsevier Fisterra calculator was used to calculate the sample.i A confidence level of 95 % and a power of 80 % were considered. A ratio of two controls for each case was established, a hypothetical exposure proportion of 50 % was assumed, and a minimum detectable odds ratio of 2.5 was considered. The sample size was 174 participants, 58 cases, and 116 controls. Case selection was performed using the CKD database from the department of Chalatenango. This database, generated from the El Salvador Family Records Information System, includes patients diagnosed with CKD in that territory. A case was defined as any person diagnosed with CKD in any of its stages and registered in the database. Since 2010, a digital registry of the population began, and all persons over 20 years of age who were natives and residents of the department and diagnosed between 2010 and 2022 were included.

Persons under medical control in any of the health facilities of the department and who had attended their medical control between January and June 2023 were included. Case selection was done using a simple randomization process of the records in the database of patients with CKD.

A control was defined as any person with a glomerular filtration rate > 60 ml/min/1.73 m^2, proteinuria less than 30 mg/dL in a general urine test, and no history of CKD. The controls were selected from the randomization of persons registered in the Integrated Health System who had been screened by creatinine, glucose, cholesterol, triglycerides, and a general urine test.

Matching was performed according to the municipality of origin of each case, selecting controls without restrictions on comorbidities. The aim was to control for geographic variations that could influence disease prevalence, such as access to medical care, socioeconomic factors, population density, environmental conditions, or cultural practices.

Persons who did not wish to participate, who were clinically incapacitated, or who had died were excluded from the study. Also excluded were those with congenital malformations of the kidney, erroneously registered in the department's CKD database, and those in the evaluation process to confirm CKD.

Recurrent urinary tract infection was defined as more than three infections diagnosed with positive laboratory results and recorded in one year. Nutritional status was assessed by calculating body mass index. For cases, the weight and height recorded in the patient's clinical records at the time of diagnosis of CKD were used since not all cases had a historical weight record. For the controls, weight and height were measured before the interview.

Health habits were investigated and tested using a visual guide and portion meters representing the recommended amount of consumption. Adequate consumption of fruits and vegetables was considered, as the consumption of at least 400 grams daily. To assess harmful alcohol consumption, more than 40 grams per day was considered for men and more than 20 grams per day for women, taking into account the equivalences of different types of alcoholic beverages. Harmful tobacco consumption was defined as the consumption of ten or more cigarettes or two or more cigars daily during a period of five years or more. Excessive salt consumption was defined as exceeding six grams per day or 2.4 grams of sodium.

Adequate water consumption was considered when it exceeded 2.5 liters per day. The practice of physical exercise involved activities in addition to daily or work activities, with thresholds of more than 150 minutes per week for moderate activity and more than 75 minutes for intense activity. Regarding pesticide exposure, reference was made to continuous exposure for more than five years. Regarding chronic use of nonsteroidal analgesics (NSAIDs), it was evaluated whether it exceeded the recommended daily dose for more than five years, with specific limits for each drug.

To collect the information, a structured questionnaire was developed in digital format using KoboToolbox, an open-source platform for creating, collecting, and managing digital forms. For data capture, a visit to the facility was scheduled, and participants were summoned by the local health team. The technique used was the interview, and the sources of information were the clinical record and the Integrated Health System.

The Kolmogórov-Smirnov normality test was performed for continuous variables, obtaining a p-value greater than 0.05, so the mean and standard deviation were used. To analyze the association between variables, the odds ratio (OR), chi-square test, and Fisher's exact test were used, as required. Ninety-five percent confidence intervals (95 %CI) and p-values were calculated with a 0.05 threshold to determine statistical significance. To compare means between cases and controls, the z-test was used, and for differences in proportions of categorical variables, the chi-square test was applied.

To construct the logistic regression model, a correlation matrix with a cut-off point between -0.7 and 0.7 was prepared to select the variables to be included in the model, excluding those with high correlation to avoid multicollinearity. The goodness of fit was assessed using the Likelihood Ratio test and the Wald test, which determined the effectiveness of the model and the significance of the variables, respectively. In addition, the ROC curve and the confusion matrix were used to evaluate the model's discriminative ability. Data processing and analysis were performed using Microsoft Excel 365 and RStudio version 4.3.2.

The effect of confounding or effect-modifying variables was identified by correlating variables and using logistic regression with crude effect estimates and effect estimates adjusted for occupation, urban/rural origin, and pesticide exposure.

This research was conducted using the Helsinki principles for research on human subjects. The participants underwent the informed consent process and were approved by the Research Ethics Committee of the Central Health Region, with act number 05-2023. The database was stored and codified to maintain the confidentiality of the participants.

Results

Descriptive analysis

A total of 174 participants were included, of which 58 (33.3 %) were cases and 116 (66.7 %) controls. Of the total, 52.3 % were from rural areas. The Kolmogorov-Smirnov normality test had a p-value > 0.05. The mean age of the participants was 51.1 years (SD: 15.1). According to the group, the mean age of the cases was 59.3 years (SD: 13.2), while the mean age of the controls was 46.5 years (SD: 13.9). No statistically significant differences were found between their means by z-test (p > 0.05).

The distribution of cases by year of diagnosis revealed that 34.4 % of cases were identified in 2022, followed by 2021 with 13.8 %, and 2015 and 2016, each accounting for 10.3 % of the cases. The disease stage at diagnosis was categorized as follows: 31 % of cases were classified as category G3b, 25.9 % as category G2, and 1.7 % as categories G1 and G5, respectively.

Demographics

Table 1 shows the distribution of the participants according to their variables.

Regarding sex, a higher proportion of women was observed in the control group, 78.4 %, compared to the case group, 36.2 %, p < 0.01; however, there was a higher proportion of male cases, 63.8 %, p < 0.01. Of the participants, 52.3 % were from rural areas, p = 0.68.

Obesity was present in a higher proportion in the control group, 43.1 %, compared to the case group, 24.1 %, and this difference was significant (p = 0.02). The proportion of participants with normal weight was similar between both groups, with 22.4 % of cases and 21.6 % of controls, p = 0.9.

Regarding educational level, most participants in both groups had formal education, with 72.4 % for cases and 84.5 % for controls, p = 0.33. According to educational level, basic education from first to sixth grade was the most frequent in both groups, with 50 % in cases and 38.8 % in controls, p = 0.23. A higher proportion of controls with a high school level was observed at 21.6 % versus cases 6.9 %, p = 0.01.

Regarding occupation, 43.1 % of the cases and 7.8 % of the controls were farmers, p < 0.01. On the other hand, 55.2 % of the controls and 29.3 % of the cases were homemakers, p < 0.01. Concerning the cases, there were no statistically significant differences according to their occupation, p > 0.05.

Tobacco and alcohol consumption

Higher harmful tobacco use was found in cases (15.5 %) compared to controls (1.7 %), p < 0.01. In addition, there was a higher proportion of cases (20.7 %) of alcoholics compared to controls (0.9 %), p < 0.01.

Dietary habits and physical activity

Higher salt consumption was observed among cases (39.7 %) compared to controls (14.7 %), p < 0.01. However, no differences were found in adequate water consumption between the groups, p = 0.26. On the other hand, 19 % of cases reported adequate consumption, compared to 56 % of controls, p < 0.01. According to physical activity, it was reported that 60.3 % of the cases and 67.2 % of the controls reported performing physical exercise, p = 0.54.

Medical history

Concerning medical history, cardiovascular risk factors such as diabetes presented a proportion of 50 % in cases versus 15.5 % of controls, p < 0.01. Dyslipidemia was present in 62.1 % of cases versus 39.7 % of controls, p = 0.03, and arterial hypertension was present in 65.5 % of cases versus 31.9 % of controls, p<0.01. About cases, differences were found between being hypertensive p < 0.05, but not in being diabetic, p > 0.05. Recurrent urinary tract infection was more frequent in cases 17.2 % than in controls 6 %, p< 0.05.

No statistically significant differences were found between the groups in renal lithiasis and family history of cardiovas-

Tabla 1. Distribution of cases and controls according to demographic variables, lifestyle, medical, and family history of disease.

Variable		Casos	%	Controles	%	Total	%	Valor p
Demográficas								
Sex	Female	21	36.2	91	78.4	112	64.4	< 0.01
	Male	37	63.8	25	21.6	62	35.6	< 0.01
Nutritional statusl	Underweight	2	3.4	0	0	2	1.1	0.07
	Normal	13	22.4	25	21.6	38	21.8	0.9
	Obesity	14	24.1	50	43.1	64	36.8	0.02
	Overweight	29	50	41	35.3	70	40.2	0.11
Area	Rural	32	55.2	59	50.9	91	52.3	0.68
	Urban	26	44.8	57	49.1	83	47.7	0.66
Educación formal	Yes	42	72.4	98	84.5	140	80.5	0.33
	No	16	27.6	18	15.5	34	19.5	0.07
Educational level	1st - 6th grade	29	50	45	38.8	74	42.5	0.23
	7th- 9th grade	7	12.1	21	18.1	28	16.1	0.27
	10th- 12th grade	4	6.9	25	21.6	29	16.7	0.01
	Higher technical educationr	0	0	2	1.7	2	1.1	0.19
	University	2	3.4	5	4.3	7	4	0.75
	None	16	27.6	18	15.5	34	19.5	0.07

Variable		Casos	%	Controles	%	Total	%	Valor p
Demographics								
Marital statusl	Married	31	53.4	48	41.4	79	45.4	0.22
	Living with couple	12	20.7	30	25.9	42	24.1	0.45
	Single	5	8.6	23	19.8	28	16.1	0.04
	Widowed	6	10.3	10	8.6	16	9.2	0.7
	Separated/Divorced	4	6.9	5	4.3	9	5.2	0.44
Occupation	Housewife	17	29.3	64	55.2	81	46.6	< 0.01
	Farmer	25	43.1	9	7.8	34	19.5	< 0.01
	Employee	5	8.6	19	16.4	24	13.8	0.12
	Merchant	5	8.6	10	8.6	15	8.6	1
	Other	5	8.6	7	6	12	6.9	0.5
	Unemployed	1	1.7	5	4.3	6	3.4	0.29
	Student	0	0	2	1.7	2	1.1	0.19
Habits								
Tobacco	Yes	9	15.5	2	1.7	11	6.3	< 0.01
	No	49	84.5	114	98.3	163	93.7	0.31
Alcohol consumption	Yes	12	20.7	1	0.9	13	7.5	< 0.00
	No	46	79.3	115	99.1	161	92.5	0.14
Salt consumption	Sí	23	39.7	17	14.7	40	23	< 0.01
	No	35	60.3	99	85.3	134	77	0.04
Adequate water consumption	Yes	25	43.1	63	54.3	88	50.6	0.26
	No	33	56.9	53	45.7	86	49.4	0.27
Adequate consumption of fruits and vegetables	Yes	11	19	65	56	76	43.7	< 0.01
	No	47	81	51	44	98	56.3	< 0.01
Exercise	Yes	35	60.3	78	67.2	113	64.9	0.54
	No	23	39.7	38	32.8	61	35.1	0.42
Medical history								
Diabetes	Yes	29	50	18	15.5	47	27	< 0.00
	No	29	50	98	84.5	127	73	0
Dyslipidemia	Yes	36	62.1	46	39.7	82	47.1	0.03
	No	22	37.9	70	60.3	92	52.9	0.02
Hypertension	Yes	38	65.5	37	31.9	75	43.1	< 0.01
	No	20	34.5	79	68.1	99	56.9	< 0.01
Obesity	Yes	13	22.4	46	39.7	59	33.9	0.03
	No	45	77.6	70	60.3	115	66.1	0.14
Recurrent UTI	Yes	10	17.2	7	6	17	9.8	0.02
	No	48	82.8	109	94	157	90.2	0.4
Renal lithiasis	Yes	7	12.1	7	6	14	8	0.15
	No	51	87.9	109	94	160	92	0.65
Occupational exposure and NSAID use								
High temperature activity	Sí	32	55.2	18	15.5	50	28.7	< 0.01
	No	26	44.8	98	84.5	124	71.3	< 0.01
Chronic exposure to pesticides	Sí	31	53.4	11	9.5	42	24.1	< 0.01
	No	27	46.6	105	90.5	132	75.9	< 0.01
Chronic consumption of NSAIDs	Sí	2	3.4	1	0.9	3	1.7	0.23
	No	56	96.6	115	99.1	171	98.3	0.86
Total		58	100	116	100	174	100	

NSAIDs = Nonsteroidal analgesics., UTI= Urinary tract infection, CKD= Chronic kidney disease, CVA= Cerebrovascular accident, AMI= Acute myocardial infarction.

cular or renal disease. The family history of various conditions also showed no significant differences between the two groups (all p values > 0.05).

Occupational, pesticide, and NSAID exposure

Occupational exposure to high temperatures was more frequent in the case group, 55.2 % versus 15.5 % of the controls, $p < 0.01$. About exposure to pesticides, 53.4 % exposure was found in the case group and 9.5 % in the control group, $p < 0.01$. NSAID consumption was low in both groups with no significant differences, $p = 0.23$.

In the bivariate analysis (Table 2), harmful alcohol consumption (OR 30), exposure to pesticides (OR 10.96), harmful tobacco use (OR 10.47), being a farmer (OR 9.01), working in high temperatures (OR 6.7), male sex (OR 6, 41), inadequate consumption of fruits and vegetables (OR 5.45), diabetes (OR 5.44), hypertension (OR 4.06), recurrent urinary tract infection (OR 3.24) and dyslipidemia (OR 2.49) showed a significant association with increased risk of CKD. Other variables, such as area of residence, formal education, salt intake, physical exercise, renal lithiasis, and NSAID use, showed no association.

To evaluate the association between the variables, a logistic regression model was constructed that included the variables identified in the correlation matrix, and a specific model was developed for occupation and pesticide exposure. The results showed that pesticide exposure was a main and independent factor in the development of CKD, even when considering the occupation variable ($p > 0.05$). Both correlation test and occupation-specific logistic regression analysis by occupation and pesticide exposure confirmed that pesticide exposure was associated with the development of CKD and was independent of occupation ($p < 0.05$).

The results showed that being a farmer presented an independent association (OR 17.1) and harmful alcohol consumption (OR 32.3). Other factors such as history of diabetes *mellitus* (OR 6.38), arterial hypertension (OR 7.57), recurrent urinary tract infections (OR 16.07), exposure to pesticides (OR 6.79), inadequate consumption of fruits and vegetables (OR 11.65), and lack of regular physical exercise (OR 18.30), all had significant associations, $p < 0.05$, (Table 3).

Discussion

The study provides evidence of the multiple risk factors associated with CKD in Chalatenango. The results highlight the multifactorial nature of this pathology and describe medical and behavioral determinants, as well as sociodemographic and occupational factors.[viii]

Among the most relevant findings of this study, a strong independent association was found between CKD and cardiovascular comorbidities such as diabetes and arterial hypertension.[ix-xi] These results are consistent with the available evidence, which describes these pathologies as important risk factors for the development of CKD, independently of the presence of other sociodemographic, regional, or economic variables.[xii] In the bivariate and multivariate models, being diabetic was significantly associated with the development of CKD, which is consistent with what has been reported in other studies. For example, in the United States, it is estimated that approximately 1 % of people with diabetes *mellitus* have CKD category G5 and that increases to 40 % have some category of CKD;[xii] furthermore, in some developing countries, diabetes *mellitus* was directly related to the burden of renal patients in health systems.[xiv]

Arterial hypertension was also statistically associated with CKD, as reported by a systematic review with meta-analysis that included six countries and 12 studies. The review associated arterial hypertension as an important cause of chronic kidney damage and as the leading cause of the prevalence of CKD14; nevertheless, the pathophysiological mechanisms for CKD are multiple, which together converge to initiate and continue kidney damage.[viii]

Arterial hypertension was also statistically associated with CKD, as reported by a systematic review with meta-analysis that included six countries and 12 studies. The review associated arterial hypertension as an important cause of chronic kidney damage and as the leading cause of the prevalence of CKD14; nevertheless, the pathophysiological mechanisms for CKD are multiple, which together converge to initiate and continue kidney damage.[viii]

Agricultural occupation was an independent risk factor for CKD, even after adjusting for covariates. This finding is consistent with a study involving 261 major cities in China and a cross-sectional study involving 47 204 people who reported an increased risk of CKD due to occupational exposure, heat stress, inadequate hydration, and exposure to pesticides with nephrotoxic potential.[xvi,xvii] Furthermore, in various agricultural communities in Central America, excess mortality due to renal causes has been observed, reinforcing these factors' importance in the region.[xviii,xix]

Table 2. Bivariate analysis of factors associated with chronic kidney disease

Variable	Cases (N 58)	% Cases	Controls (N 116)	% Controls	OR	CI95 %		p-value
Alcohol consumption	12	20.7	1	0.9	30	3.79	237.38	< 0.01
Exposure to pesticides	31	53.4	11	9.48	10.96	4.89	24.57	< 0.01
Tobacco consumption	9	15.5	2	1.7	10.47	2.18	50.24	< 0.01
Farmer	25	43.1	9	7.8	9.01	3.83	21.2	< 0.01
Work in high temperatures	32	55.2	18	15.52	6.7	3.26	13.79	< 0.01
Male sex	37	63.8	25	21.5	6.41	3.2	12.85	< 0.01
Inadequate consumption of fruits and vegetables	47	81	51	43.9	5.45	2.57	11.55	< 0.01
Diabetes	29	50	18	15.5	5.44	2.65	11.18	< 0.01
NSAID consumption	2	3.4	1	0.8	4.11	0.36	46.26	0.258
Hypertension	38	65.5	37	31.9	4.06	2.08	7.91	< 0.01
Recurrent UTI	10	17.2	7	6	3.24	1.17	9.03	0.019
Dyslipidemia	36	62.1	46	39.7	2.49	1.3	4.76	< 0.01
Renal lithiasisl	7	12.1	7	6	2.14	0.71	6.42	0.278
No formal education	42	72.4	98	84.5	2.07	0.97	4.45	0.058
Inadequate consumption of water	33	56.9	53	45.9	1.57	0.83	2.96	0.163
Sedentary lifestyle	23	39.6	38	32.7	1.35	0.7	2.59	0.369
Rural area	32	55.2	59	50.9	1.19	0.63	2.24	0.592
Obesity	14	24.1	50	43.1	0.42	0.21	0.85	0.014

UTI = Urinary tract infection. NSAIDs = Non-steroidal analgesics

Table 3. Multivariate analysis of factors associated with chronic kidney disease

Variable	OR	Coefficient	IC95 %	IC95 %	Standard Error	z-value	p-value
Intercept	0.03	-10.21	0	1.06	2.443	-4.18	0.054
Harmful alcohol consumption	32.25	3.474	1.1	942.19	1.722	2.017	0.044
No exercise	18.3	2.907	2.74	49.39	0.970	2.995	<0.001
Farmer	17.09	2.838	1.43	204.27	1.266	2.242	0.025
Recurrent UTI	16.07	2.777	2	128.99	1.063	2.614	0.009
Inadequate fruit and vegetable consumption	11.65	2.456	2.74	49.4	0.736	3.333	<0.001
Hypertension	7.57	2.025	1.74	32.88	0.749	2.703	0.007
Pesticide exposure	6.79	1.916	1.1	41.88	0.928	2.064	0.039
Diabetes	6.38	1.853	1.47	27.71	0.749	2.474	0.013
Male sex	4.52	1.508	0.3	67.55	1.38	1.092	0.275
Inadequate water consumption	3.59	1.278	0.87	14.81	0.723	1.768	0.077
Excessive salt consumption	3.23	1.172	0.77	13.48	0.729	1.607	0.108
Harmful tobacco consumption	2.48	0.909	0.18	34.9	1.348	0.675	0.5
Rural area	1.35	0.301	0.36	5.1	0.677	0.445	0.657
Chronic NSAID use	1.14	0.135	0.02	82.01	2.179	0.062	0.951
Age	1.04	0.038	0.98	1.1	0.027	1.383	0.167
Formal education	1	0.000	0.17	5.94	0.909	0	1
Working in high temperatures	0.59	-0.528	0.03	12.71	1.566	-0.337	0.736
Obesity	0.56	-0.581	0.12	2.55	0.774	-0.751	0.452

UTI = Urinary tract infection. NSAIDs = Non-steroidal analgesics. Likelihood ratio < 0.01. Wald test < 0.01

This study also identified that adequate fruit and vegetable consumption and physical activity are independent protective factors against CKD.[xvi] These findings are consistent with extensive scientific evidence, including a systematic review with meta-analysis combining 18 cohort studies and 630 108 adults, concluding that a healthy dietary pattern can prevent CKD and albuminuria. In addition, it has been shown that a diet low in potassium can cause fibrosis and kidney damage, accelerate the progression of CKD, and is common in patients with endemic nephropathy in Mesoamerica.[xx,xxi]

A recent systematic review with meta-analysis that included 12 cohorts with 1 281 727 participants and evaluated the benefits of physical activity as a protective factor for CKD determined that more active people had a lower prevalence of CKD.[xxii] It is believed that physical exercise would reduce markers of endothelial dysfunction and oxidative stress and decrease the risk of developing other diseases directly related to CKD, such as arterial hypertension, diabetes *mellitus*, dyslipidemia and obesity.[xxiii,xxiv]

This investigation identified that harmful alcohol and tobacco consumption are risk factors for CKD, even after adjusting for possible confounding variables. These findings are consistent with existing evidence linking smoking and alcoholism with CKD by inducing alterations in lipid metabolism, blood pressure, insulin sensitivity, and prothrombotic and proinflammatory markers.[xxv,xxvi] In addition, a systematic review with meta-analysis that included 17 articles and 149 958 participants found a significant association between excessive alcohol consumption and an increased risk of developing CKD.[xxi]

Regarding sex, a higher proportion of CKD was observed in men, a finding that coincides with the majority of reports suggesting a greater susceptibility in this sex.[viii] This result is in agreement with other epidemiological reports at a global level, which document a greater susceptibility and risk in the male sex.[xxvii] Similar findings have been reported in the United States, Europe, and most Asian and Latin American countries.[xxviii,xxix]

Likewise, a meta-analysis that included data from six cohorts, with 2 382 712 individuals and 6856 incident CKD events, found that the occurrence of CKD or CKD category G5 was 23 % lower in women compared to men.[xxx] Another study estimates that 60 % of patients with CKD are men.[xvi] Although the exact mechanism is unknown, it has been related to hormonal differences associated with estrogens, greater muscle mass and metabolism, a more atherogenic lipid profile, and differential blood pressure regulation in men.[viii]

In this study, the area of rural or urban residence did not show a significant association, unlike other studies that indicate a greater risk of CKD in rural areas due to limited access to drinking water, greater occupational exposure in agricultural workers, and insufficient sanitary infrastructure.[xxxi,xxxii] However, a systematic review that included countries in Africa, America, Asia, and Europe reported a higher prevalence of CKD in urban areas, mainly associated with diseases such as diabetes, hypertension, and obesity. The differences in exposures in the different regions explain this discrepancy.[xxxiii]

Recurrent urinary tract infections were identified as an independent risk factor for CKD, coinciding with other studies that report an accelerated decrease in glomerular filtration rate and a higher incidence of CKD in patients with recurrent pyelonephritis.[xxxiv] It has been proposed that these repeated episodes cause renal scarring, tubular atrophy, and chronic nephropathy, in addition to the risk of nephrotoxicity due to the use of antibiotics to treat these infections.[xxxiv,xxxv]

Excessive salt consumption was not statistically significant, contrasting with what has been reported in the literature and other meta-analyses that indicate detrimental health effects, including the development of arterial hypertension and CKD due to high sodium consumption.[xxxvi] This discrepancy could be explained by the low proportion of people who confirmed high salt consumption, even though the 2015 National Survey of Chronic Noncommunicable Diseases (ENECA) indicated that Chalatenango has the highest prevalence of salt consumption in El Salvador.[iv]

The presence of renal lithiasis and chronic use of NSAIDs did not show a significant association with CKD. The results contrast with other studies that have reported an accelerated decrease in glomerular filtration rate and an increased risk of CKD category G5 in patients with a history of renal lithiasis or prolonged use of NSAIDs.[xxxvii,xxxviii] Mechanisms such as obstruction and recurrent infections have been suggested in lithiasis, while NSAIDs could directly affect renal perfusion and cause tubular damage.

As for weight, overweight was not significantly associated with a greater risk of CKD. Even in the bivariate analysis, obesity behaved as a protective factor, contrasting with other studies that link a higher body mass index with the development of CKD.[xxxix] This finding could be explained by limitations in the sample size or by differences in the population studied in comparison with other studies and should, therefore, be interpreted with caution, given that the evidence suggests that obesity is a risk factor for CKD.[xvi,xxxix,xl] However, in the multivariate analysis, obesity did not show a statistically significant association, which could indicate that other confounding variables influenced this variable during the initial analysis.

Finally, in the study of variables such as formal education level, family history of CFD or cardiovascular disease, and dietary factors such as water intake, in contrast to some previous studies, CKD is not represented as a risk factor.[ix,xii,xli]

Conclusion

Multiple risk factors were identified, both traditional, such as arterial hypertension and diabetes mellitus, and non-traditional, such as chronic pesticide use, excessive alcohol consumption, lack of physical activity, agricultural occupation, recurrent urinary tract infections, and insufficient fruit and vegetable consumption. All these factors showed a significant association with the development of CKD in the population analyzed.

Despite the study's limitations, the findings highlight chronic kidney disease's complex and multifactorial nature, evidencing the need for future research with a more robust design and tighter control of bias to confirm and extend these results.

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