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Prevalence of chronic kidney disease in a population with type 2 diabetes of a cardiovascular risk program

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Abstract: Introduction: In Colombia, the prevalence of type 2 diabetes mellitus (DM2) is 7-9%, this being the main cause of end-stage renal disease in the world [4] .In the municipality of Armenia, the prevalence of the population suffering from DM2 with chronic kidney disease (CKD) and the risk factors related to its development are unknown. Objective: To determine the prevalence and risk factors of developing chronic kidney disease (CKD) in a population with type 2 diabetes, consultants to a cardiovascular risk program of an IPS of Armenia, Colombia, during the year 2017. Methods: Descriptive cross-sectional study with 232 patients. The variables were described by measures of central tendency and 95% confidence intervals, ANOVA and Chi square tests were performed for the numerical and categorical variables respectively, multiple regression and logistic regression, with a value of P <0.05. Results: The prevalence of diabetes was 34.14% and CKD varies between 22.41-38.79% according to the equation used. 69.83% are in normoalbuminuria, 25% in microalbuminuria and 5.17% in macroalbuminuria. The risk factors identified for CKD were: age (Cockcroft-Gault and CKD-EPI p <0.001; MDRD p = 0.012), abdominal perimeter (Cockcroft-gault p <0.001; MDRD p = 0.028; CKD-EPI p = 0.011), creatinine level (Cockcroft-gault, MDRD, CKD-EPI p <0.001) and sedentary lifestyle (Cockcroft-gault p = 0.046). The most adequate equations for early identification of CKD in this population are CKD-EPI(R2 = 85.74%) and Cockcroft-gault (R2 = 85.43%), with a prognostic value of 95.68% and 93, 96% respectively. Conclusion: The prevalence of CKD varies between 22.41% and 38.79%, depending on the equation used. The risk factors for developing CKD are age, creatinine level, abdominal perimeter and sedentary lifestyle. It is proposed that for this population the Cockcroft-Gault and CKD-EPI equations are the most adequate to identify CKD.

Key words: type 2 diabetes mellitus; chronic kidney disease; prevalence; risk factors; glomerular filtration rate; creatinine (MeSH)

1 Introduction

Type 2 diabetes mellitus (DM2) is a metabolic disorder characterized by chronic hyperglycemia [1]. It constitutes a public health problem and one of the leading causes of early morbidity and mortality worldwide [2]; according to the World Health Organization (WHO), 422 million people worldwide had this disease in 2014 [3]. In Colombia, 7 – 9% of the population has DM2 [4], and in Armenia specifically, this percentage ranges from 12.7% [5] to 22.49% [6].

Diabetes is the leading cause of end-stage kidney disease worldwide, as 8% of patients have proteinuria at the time of type 2 diabetes mellitus (DM2) diagnosis. Of the remaining 92%, 41% are at risk of developing chronic kidney disease (CKD) over the next 20 years; of these, 10% develop end-stage kidney disease [4] .

Risk factors for developing CKD are classified into susceptibility, initiating, progression, and end-stage factors, among which DM2, obesity, and dyslipidemia are particularly noteworthy [7] .

CKD is defined as the presence of kidney abnormalities (structural or functional) lasting more than three months and having health implications [7] . Thus, CKD is considered present when at least one of the following symptoms occurs for three or more months: decreased glomerular filtration rate (<60 mL/min/1.73 m²), presence of markers of kidney damage, or history of kidney transplantation [8].

The glomerular filtration rate can be estimated using various equations, such as MDRD, body surface area-adjusted Cockcroft-Gault (Cockcroft-Gault), and CKD-EPI; the latter is recommended by the KDIGO guidelines [7] and by the Ministry of Health in Colombia [8] .

CKD is a progressive, noncommunicable health problem associated with multiple diseases, primarily cardiovascular diseases and DM2. In Colombia, the incidence, prevalence, and mortality of this condition are unknown; however, it is estimated to have increased due to its association with various risk factors [9] . Given this context, the present study aimed to determine the prevalence and risk factors for developing CKD in patients with DM2 who consulted the cardiovascular risk program at a healthcare provider (IPS) in Armenia, Colombia, during 2017.

2 Materials and methods

A descriptive cross-sectional study was conducted with a study population of approximately 2,800 patients diagnosed with type 2 diabetes who visited the cardiovascular risk program at a private healthcare provider in Armenia during 2017. The sample, consisting of 232 subjects, was selected using a formula for finite populations adjusted for a DM2 prevalence of 22.49% based on a previous study conducted in the same population [5], and was randomized in Microsoft Excel® 2016 with systematic replacement of subjects who did not meet the inclusion criteria.

The study included diabetic patients over 18 years of age who had consulted during 2017 and for whom information on the variables required for the study was available.

The data were requested from the IPS databases, following institutional approval, and the data for the study variables were tabulated using Microsoft Excel® 2016. A normality test was performed on the variables, and the data were processed in Statgraphics Centurion® and described using measures of central tendency with 95% confidence intervals (95% CI); an analysis of the variables by sex was also conducted.

The prevalence of CKD, defined as a glomerular filtration rate <60 ml/min/1.73 m², was established using the Cockcroft-Gault, CKD-EPI, and MDRD equations. Classification by stages of albuminuria was performed based on urine albumin levels from a single urine sample. Subsequently, KDIGO progression classification was performed based on stages of glomerular filtration rate and stages of albuminuria.

To identify risk factors for the development of CKD, a one-way analysis of variance for the numerical variables and a chi-square test for the categorical variables in relation to the three equations, followed by multiple regression and logistic regression. A p-value of <0.05 was considered statistically significant.

3 Results

In 2017, 10,500 patients consulted the cardiovascular risk program at the participating IPS, of whom 3,585 were diabetic, indicating a prevalence of 34.14%.

The variables were described by sex, as shown in Table 1. The mean age was 66.73 years (95% CI: 64.44–69.03) for

men and 68.3 years (95% CI: 66.99–69.61) for women; the mean systolic blood pressure was 119.86 mmHg (95% CI: 117.45–122.28) for men and 122.86 mmHg (95% CI: 121.48–124.24) for women, and the average diastolic blood pressure was 74.93 mmHg (95% CI: 73.44–76.42) for men and 74.04 mmHg (95% CI: 73.18–74.89) for women. Regarding anthropometric measurements, the average abdominal circumference was found to be 99.31 cm (95% CI: 97.23–101.39) for men and 94.59 cm (95% CI: 93.40–95.78) for women, and the Body Mass Index (BMI), 26.76 m^2 /kg (95% CI: 25.44 – 28.09) for men and 28.59 m^2 /kg (95% CI: 27.83 – 29.34) for women, indicating a prevalence of overweight and central obesity in both sexes.

Table 1. Description of variables by sex

Variable	Male Mean ± SD	95% CI	Female Mean ± SD	95% CI	p-value
Age (years)	66.73±13.01	64.44–69.03	68.3±12.24	66.99–69.61	0.408
SBP (mmHg)	119.86 ± 14.71	117.45–122.28	122.86 ± 12.53	121.48–124.24	0.135
DBP (mmHg)	74.93 ± 7.91	73.44–76.42	74.04 ± 8.12	73.18–74.89	0.466
Abdominal circumference (cm)	99.31 ± 9.22	97.23–101.39	94.59±11.86	93.40–95.78	0.006
BMI (kg/m²)	26.76 ± 4.33	25.44–28.09	28.59 ± 7.87	27.83–29.34	0.097
HBA1C (%)	7.31 ± 1.99	6.80–7.82	7.95 ± 2.96	7.66–8.24	0.130
Fasting blood glucose (mg/dL)	131.69 ± 60.89	120.49–142.89	140.54 ± 60.64	134.15–146.94	0.340
Total cholesterol (mg/dL)	173.04 ± 52.62	164.52–181.57	187.27 ± 43.91	182.40–192.13	0.446
HDL (mg/dL)	39.77±11.92	37.54–41.99	46.68 ± 12.11	45.41–47.95	<0.001
Non-HDL (mg/dL)	119.01 ± 41.58	111.62–126.41	133.94 ± 39.57	129.73–138.16	0.015
TAG (mg/dL)	221.30 ± 208.26	197.53–245.06	183.21±89.24	169.65–196.78	0.053
Creatinine (mg/dL)	1.07 ± 0.24	1.02–1.13	0.89 ± 0.30	0.85–0.92	<0.001
Occasional albuminuria (mg/g)	53.63 ± 115.80	22.21–85.04	67.48 ± 184.36	49.55–85.41	0.594
eGFR CG (ml/kg/1.73 m²)	68.68 ± 22.00	63.88–73.48	70.80 ± 27.19	68.05–73.54	0.594
eGFR MDRD (ml/kg/1.73 m²)	77.64 ± 20.06	73.20–82.09	74.93±25.22	72.39–77.46	0.459
eGFR CKD-EPI (ml/kg/1.73 m²)	73.89±18.96	70.19–77.58	72.37±20.33	70.27–74.48	0.621

x: mean; σ: standard deviation; SBP: systolic blood pressure; DBP: diastolic blood pressure; BMI: body mass index; HBA1C: glycated hemoglobin; HDL: high-density lipoproteins; non-HDL: includes LDL (low-density lipoproteins) and VLDL (very low-density lipoproteins); TAG: triglycerides; eGFR CG: glomerular filtration rate calculated using the Cockcroft-Gault equation adjusted for body surface area; eGFR MDRD: glomerular filtration rate calculated using the MDRD equation; eGFR CKD-EPI: glomerular filtration rate calculated using the CKD-EPI equation. Source: own elaboration.

Glycated hemoglobin had a mean of 7.31% (95% CI: 6.80 – 7.82) and 7.95% (95% CI: 7.66 – 8.24) for men and women, respectively, while the average fasting blood glucose level in men was 131.69 mg/dL (95% CI: 120.49 – 142.8) and in women, 140.54 mg/dL (95% CI: 134.15 – 146.94). Regarding the lipid profile, total cholesterol had a mean of 173.04 mg/dL (95% CI: 164.52 – 181.5) for men and 183.40 mg/dL (95% CI: 182.40 – 192.13) for women, while HDL cholesterol was 39.77 mg/dL (95% CI: 37.54 – 41.99) for men and 46.68 mg/dL (95% CI: 45.41 – 47.95) for women; non-HDL was 119.01 mg/dL (95% CI: 111.62 – 126.4) for men and 133.94 mg/dL (95% CI: 129.73 – 138.16) for women;

finally, triglycerides were 221.30 mg/dL (95% CI: 197.53 – 245.06) and 183.21 mg/dL (95% CI: 169.65 – 196.78) for men and women, respectively.

In renal function tests, mean creatinine levels were found to be 1.07 mg/dL (95% CI: 1.02 – 1.13) and 0.89 mg/dL (95% CI: 0.85 – 0.92), and mean albuminuria were 53.63 mg/g (95% CI: 22.21 – 85.04) and 67.48 mg/dL (95% CI: 49.55 – 85.41) for men and women, respectively. Likewise, the mean glomerular filtration rate (GFR) calculated using the Cockcroft-Gault formula was 66.68 mL/kg/1.73 m² (95% CI: 63.88 – 73.48) and 70.80 mL/kg/1.73 m² (95% CI: 68.05 – 73.54), by MDRD it was 77.64 mL/kg/1.73 m² (95% CI: 73.20 – 82.09) and 74.93 mL/kg/ 1.73 m² (95% CI: 72.39 – 77.46), and by CKD-EPI it was 73.89 mL/kg/1.73 m² (95% CI: 70.19 – 77.58) and 72.37 mL/kg/1.73 m² (95% CI: 70.27 – 74.48) for men and women, respectively.

A statistically significant difference was found in the distribution by sex for the variables abdominal circumference ($p=0.006$), creatinine level ($p<0.001$), and HDL cholesterol ($p<0.001$).

The prevalence of CKD varied depending on the equation used to calculate it, with the Cockcroft-Gault equation detecting the highest percentage of disease (38.79%), followed by CKD-EPI (26.1%) and MDRD (22.41%) (Table 2).

According to the KDIGO staging classification (Table 2), the MDRD, CKD-EPI, and Cockcroft-Gault equations identified that 77.59%, 73.89%, and 61.21% of patients, respectively, were in stages 1 and 2. Table 3 shows the stages of albuminuria, indicating that 69.83% of the population was in stage A1 (normoalbuminuria); 25% in stage A2 (microalbuminuria); and 5.17% in stage A3 (macroalbuminuria).

Similarly, a calculation of the risk of CKD progression was performed using the KDIGO classification, which identified that 43.54% of the population was classified as low risk according to the Cockcroft-Gault equation, 56.04% according to MDRD, and 55.67% according to CKD-EPI. A moderate-to-high risk was found in 31.46% of the population using the Cockcroft-Gault equation, 26.29% using MDRD, and 24.14% using CKD-EPI. The population was found to be at high risk in 16.38% of cases using the Cockcroft-Gault equation, in 14.65% using MDRD, and in 14.77% using CKD-EPI. Finally, 8.61% of the population was found to be at very high risk using the Cockcroft-Gault equation, 3.01% using MDRD, and 5.42% using CKD-EPI.

Table 2. Classification of eGFR Stages by KDIGO

Stage	eGFR CG	eGFR MDRD	eGFR CKD-EPI
Stage 1	21.12%	18.97%	18.72%
Stage 2	40.09%	58.62%	55.17%
Stage 3A	22.84%	15.52%	15.76%
Stage 3B	14.66%	5.60%	8.37%
Stage 4	1.29%	1.29%	1.97%
Stage 5	0.00%	0.00%	0.00%

eGFR CG: glomerular filtration rate calculated using the Cockcroft-Gault equation adjusted for body surface area; eGFR MDRD: glomerular filtration rate calculated using the MDRD equation; eGFR CKD-EPI: glomerular filtration rate calculated using the CKD-EPI equation. Source: own elaboration.

Table 3. Albuminuria stages

Category	Reference values	Percentage	Terms
A1	< 30 mg/g	69.83%	Normal or moderately increased (Normoalbuminuria)
A2	30–300 mg/g	25%	Moderately increased (Microalbuminuria)
A3	>300 mg/g	5.17%	Severely increased (Macroalbuminuria)

A1: normoalbuminuria, A2: microalbuminuria, A3: macroalbuminuria. Source: own elaboration.

Table 4. Risk factors by glomerular filtration rate

Variable	eGFR CG	eGFR MDRD	eGFR CKD-EPI
Age (years)	p<0.001	p=0.001	p<0.001
DBP (mmHg)	p=0.115	p=0.473	p=0.219
SBP (mmHg)	p=0.086	p=0.400	p=0.114
MAP (mmHg)	p=0.222	p=0.467	p=0.157
BMI (kg/m²)	p=0.614	p=0.717	p=0.760
Abdominal circumference (cm)	p=0.405	p=0.944	p=0.916
Fasting blood glucose (mg/dL)	p=0.572	p=0.002	p=0.356
HBA1C (%)	p=0.051	p=0.037	p=0.117
Creatinine (mg/dL)	p<0.001	p<0.001	p<0.001
Total cholesterol (mg/dL)	p=0.573	p=0.296	p=0.704
HDL (mg/dL)	p=0.067	p=0.277	p=0.157
TAG (mg/dL)	p=0.391	p=0.041	p=0.089
Occasional albuminuria (mg/g)	p=0.057	p=0.113	p=0.290
Sex	p=0.942	p=0.131	p=0.494
Hypertension stage	p<0.001	p<0.001	p=0.547
Physical activity	p=0.059	p=0.939	p=0.474
Smoking	p=0.027	p=0.242	p=0.107

eGFR CG: glomerular filtration rate calculated using the Cockcroft-Gault equation adjusted for body surface area; eGFR MDRD: glomerular filtration rate calculated using the MDRD equation; eGFR CKD-EPI: glomerular filtration rate calculated using the CKD-EPI equation; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; BMI: body mass index; HBA1C: glycated hemoglobin; HDL: high-density lipoproteins; TGL: triglycerides; HTN: hypertension. Source: own elaboration.

Through a univariate analysis (Table 4), all three equations identified age, stage of hypertension and creatinine level as risk factors for developing CKD, with a statistically significant difference. Additionally, the Cockcroft-Gault equation identified smoking, and the MDRD equation identified fasting blood glucose, triglycerides, and glycated hemoglobin.

The multiple regression model (Table 5) identified BMI, LDL cholesterol levels, age, and creatinine levels as risk factors with a statistically significant difference across all three equations. Similarly, fasting blood glucose was also

identified using the Cockcroft-Gault and CKD-EPI equations.

Table 5. Factors explaining the variation in eGFR equations

Variable	eGFR CG	eGFR MDRD	eGFR CKD-EPI
R^2	85.43%	66.87%	85.74%
Absolute Error	6.13	8.93	6.07
Age (Years)	<0.001	<0.001	<0.001
DBP (mmHg)	0.923	0.954	0.123
SBP (mmHg)	0.831	0.997	0.112
MAP (mmHg)	0.914	0.946	0.099
BMI (kg/m²)	<0.001	0.016	0.021
Abdominal circumference (cm)	0.381	0.822	0.910
Fasting blood glucose (mg/dL)	0.047	0.112	0.003
Creatinine (mg/dL)	<0.001	<0.001	<0.001
Total cholesterol (mg/dL)	0.319	0.262	0.494
HDL (mg/dL)	0.515	0.204	0.115
LDL (mg/dL)	0.057	0.030	0.048
HBA1C (%)	0.345	0.354	0.929
Occasional Albuminuria (mg/g)	0.696	0.591	0.342

eGFR CG: glomerular filtration rate calculated using the Cockcroft- Gault equation adjusted for body surface area; eGFR MDRD: glomerular filtration rate calculated using the MDRD equation; eGFR CKD-EPI: glomerular filtration rate calculated using the CKD-EPI equation; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; BMI: body mass index; HbA1C: glycated hemoglobin; HDL: high-density lipoprotein; LDL: low-density lipoprotein.

A logistic regression model was performed to identify which variables were most likely to trigger CKD. It found that the the risk factors with the greatest impact on this population are age (Cockcroft-Gault and CKD- EPI $p<0.001$; MDRD $p=0.012$), abdominal circumference (Cockcroft-Gault $p<0.001$; MDRD $p=0.028$; CKD-EPI $p=0.011$), creatinine level (Cockcroft-Gault, MDRD, CKD-EPI $p<0.001$), and lack of physical activity (Cockcroft-Gault $p=0.046$, MDRD $p=0.569$, and CKD-EPI $p=0.393$).

Multiple regression was used to identify the explained variance (R^2) of the glomerular filtration rate in relation to the study variables, as shown in Table 5: the CKD-EPI equation yielded the highest explained variance in the model (R^2= 85.74%) and the smallest error (6.07), followed by Cockcroft-Gault (R^2= 85.43% and E = 6.13) and MDRD (R^2= 66.87% and E = 8.93). This was similar to what was observed in the logistic regression model, in which the equation found to have the highest probability explained by the model was Cockcroft- Gault at 68.84% (predictive value 94.82%), followed by CKD-EPI with 62.29% (predictive value 95.68%) and MDRD with 54.28% (predictive value 93.96%).

4 Discussion

The prevalence of DM2 found in the study population was 34.14%. In a study conducted in 2016 [6] with a population from the same cardiovascular risk program, a prevalence of 22.49% was determined, indicating a significant increase of 11.65% in the number of cases of the disease. However, it is possible that more patients were included in the

present study, and therefore the figure is higher.

Similarly, a study conducted in 2014 found that the proportion of people with diabetes was 25.5% [10] , suggesting that there may have been a significant increase in this figure in recent years.

According to McCulloch [11], the global prevalence of type 2 diabetes was 6.4% in the general population in 2017; in Colombia, this figure was estimated to be between 7% and 9% of the total population in 2016 [4]. Specifically, the National Demographic and Health Survey [5] found that in the department of Quindío, this disease affects 12.7% of older adults.

This indicates that the proportion of people with type 2 diabetes in this cardiovascular risk program in Armenia is well above both the national and global averages, which was to be expected given that the sample was drawn from a population enrolled in a cardiovascular risk program that included both hypertensive and diabetic patients.

According to the Pan American Health Organization (PAHO), the WHO, and the Latin American Society of Nephrology, the prevalence of CKD in the general population was estimated at 10% for the year 2015 [12] . In a study conducted in New Zealand [13] covering 93.5% of the country's total population, a prevalence of kidney disease of 12.8% was found in the general population; of this percentage, 82.5% had CKD according to the CKD- EPI equation. In the present study, with a population at high cardiovascular risk due to DM, a prevalence of CKD higher than these estimates is evident.

When compared with other studies with demographic characteristics different from those of the present study, a prevalence of CKD of 48.8% was found in New Zealand [13] , while in Spain, in a population of older adults with diabetes, the prevalence was 37.2% [14] ; both proportions were measured using the CKD-EPI equation. In 2013, in a diabetic population with nephropathy in Korea, a prevalence of 54% was found according to the MDRD scale and 51.6% according to CKD-EPI [15] .

It is clear that, compared to the general population, there is a significant increase in the prevalence of CKD among various populations at risk for cardiovascular disease; however, there is also a difference in the prevalence of CKD patients among the aforementioned populations, which may be due to the specific demographic characteristics of each.

In the study by Zaman [16], which compared the three equations for calculating glomerular filtration rate in a diabetic population, the prevalence of CKD was 21.4% for MDRD, 21.9% for CKD-EPI, and 31.4% for Cockcroft-Gault; these results are consistent with those found in the present study. This could support the idea that the Cockcroft-Gault equation detects CKD at the earliest stage.

In the present study, 78–81% of the population was classified as stages 2 and 3 using the different equations (Table 2), which was consistent with other studies conducted in various diabetic populations worldwide [13–15] . In the national context, the department of Quindío reported a higher number of patients in stages 2 and 3 in 2016 compared to the rest of the country [17] .

According to the KDIGO staging classification (Table 2), the MDRD equation identified that 77.59% of the population was in stages 1 and 2; the percentages for these stages identified by CKD-EPI and Cockcroft-Gault were 73.89% and 61.21%, respectively. Similarly, the Cockcroft-Gault equation detected the highest percentage of patients with CKD (38.79%). These results are similar to those of the study by Schwandt et al. [18] , conducted among two cohorts (one German and one Austrian) of patients with type 1 diabetes mellitus and type 2 diabetes mellitus, which analyzed the performance of the CKD-EPI, MDRD, Cockcroft-Gault, and body surface area-adjusted Cockcroft-Gault equations by comparing the estimated glomerular filtration rate with the measured glomerular filtration rate using 24- hour creatinine clearance; that study found that the CKD-EPI and MDRD equations identified the highest proportion of stages 1 and 2,

while the MDRD equation identified a higher proportion of stages 3 to 5.

This study found that 69.83% of the participants had normoalbuminuria, similar to two studies conducted in Spain [14] and Korea [15] among diabetic populations, in which 79.4% and 51%, respectively, had normoalbuminuria; 17.8% and 39%, respectively, had microalbuminuria, and 2.8% and 10%, respectively, had macroalbuminuria; that is, it was found that the majority of patients in these populations, despite having a high-impact risk factor for developing CKD, have adequate renal function.

Based on the KDIGO classification of CKD progression risk, the majority of patients in this study were at low risk (Cockcroft-Gault: 43.54%, MDRD: 56.04%, and CKD-EPI 55.67%). This classification also allowed us to establish that the CKD-EPI and MDRD equations are the ones that detect disease progression earliest, whereas for moderate, high, and very high risk, the most appropriate is Cockcroft-Gault.

In the study by Ji & Kim [19],the estimated glomerular filtration rate (eGFR) was determined using the CKD-EPI equation, and upon classification according to KDIGO, it was found that 92% of the general population was at low risk.

The KDIGO guidelines for the assessment and management of chronic kidney disease [7] state that risk factors for developing the disease in the general population are classified as susceptibility, initiator, progression, and end-stage factors. In the present study, the population exhibited susceptibility, initiator, and progression factors, such as diabetes; furthermore, it was demonstrated that abdominal circumference, BMI, and the stage of hypertension are risk factors that increase susceptibility to developing CKD, and that levels of triglycerides, LDL cholesterol, and glycated hemoglobin are also risk factors for CKD progression. In other words, although the majority of the study population does not have CKD, they do have the aforementioned risk factors, which makes this population highly susceptible to developing the disease.

According to KDIGO [7], age is a risk factor for developing CKD due to the decline in the number of nephrons and the glomerular filtration rate that occurs over time [20]. In the present study, it was found that as age increases, so does the risk of CKD (Figure 1); however, it is important to clarify that some study participants, in addition to having diabetes, also had hypertension, and that the average age for this population was 68 years. Therefore, it is likely that the development of CKD is also influenced by the presence of these factors.

It is important to note that in this study, 62.06% of the population was over 65 years of age, which means that, in the calculation itself, using any of the equations, the results fall mainly into stage 2; however, upon verifying microalbuminuria and macroalbuminuria—which provide greater information on renal damage at the pathophysiological level—these accounted for 30.17%.

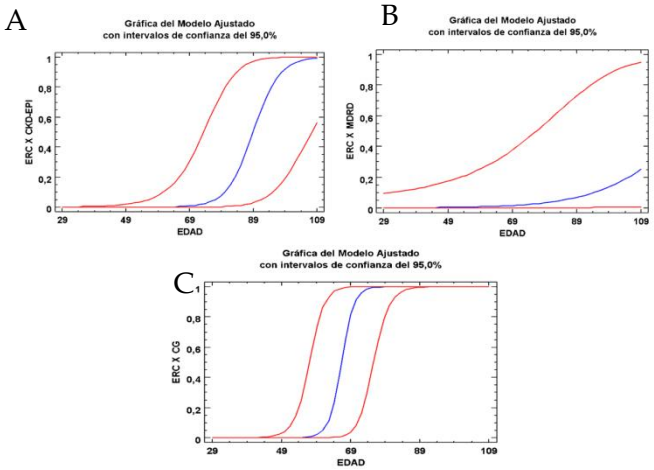

Figure 1. Risk of developing chronic kidney disease by age according to the different equations

A) CKD-EPI; B) MDRD; C) CG. Source: own elaboration

Various studies show that obesity and metabolic syndrome have been linked as risk factors for CKD [21,22] , as evidenced in the present study, in which 41.81% of diabetics were overweight and 27.98% were obese.

BMI and abdominal circumference were the anthropometric risk factors associated with the development of CKD identified in this study, with the latter having the greatest impact. In this regard, a study conducted between 2012 and 2013, which included 870 patients with non-insulin-dependent type 2 diabetes to determine the association between the anthropometric variables BMI, waist-to-hip ratio, and abdominal circumference and the risk of developing CKD [23], it was found, through logistic regression, that abdominal circumference was associated with a higher probability of this disease (p=0.030). Similarly, in the present study it was found that the risk of CKD is more significant for middle-aged patients with visceral obesity than for those under 45 or over 80 years of age with visceral obesity.

The study sample also found that a sedentary lifestyle was a major risk factor for the development of CKD. This is consistent with other studies that have shown that individuals who eat a healthy diet and are physically active have a low risk of this disease, and that physical exercise acts as a protective factor with a more pronounced effect than smoking cessation; Furthermore, engaging in daily physical exercise could reduce the risk of developing CKD by 5% and overall mortality at 5.5 years by 12% [24] .

Although univariate analysis (Table 4) showed that the MDRD equation identified the most risk factors, multiple regression (Table 5) and logistic regression showed that this model had the lowest explained variance, the highest error, and the lowest predictive value, unlike the Cockcroft-Gault and CKD-EPI equations, which in this case would be the most appropriate for earlier identification of CKD. These results differ from those found by Schwandt et al.[18] in a multicenter study that showed that the MDRD equation was the most accurate for estimating glomerular filtration rate in patients with normal, mildly reduced, or impaired renal function.

Furthermore, a cross-sectional study conducted in 2015, which examined 4,042 patients with type 2 diabetes, found that the CKD-EPI equation was the most appropriate for estimating glomerular filtration rate and identifying CKD in diabetic patients [16]. Another study conducted in Armenia in a university community with no identified diseases established that the most appropriate equation for determining glomerular filtration rate in this population was the Cockcroft-Gault equation [25]. Likewise, the Colombian Clinical Practice Guidelines for the Diagnosis and Treatment of Chronic Kidney Disease [8] and the KDIGO [7] recommend using the CKD-EPI equation.

In summary, based on the results of this study, it can be concluded that the most appropriate equations for the early identification of CKD in patients with type 2 diabetes are the Cockcroft-Gault and CKD-EPI equations. Similarly, we were able to estimate the risk of CKD by identifying the factors with the greatest explained variance, the lowest error, and the highest predictive value.

Although the identification of risk factors allows for the prediction of the onset of certain chronic conditions [26], given the characteristics of this study, it was not possible to determine the risk of developing CKD in the diabetic population, as risk must be measured on an individual basis because renal function is complex and is affected by multiple factors that differ from person to person.

5 Conclusions

The prevalence of CKD in the study population ranged from 22.41 % to 38.79 %, depending on the equation used. The Cockcroft-Gault equation enabled the earliest identification of the disease.

The risk factors for developing CKD with the highest explained variation and lowest error were age, creatinine level, abdominal circumference, and physical inactivity.

The most appropriate equations for the early identification of CKD are CKD-EPI (R^2= 85.74%) and Cockcroft-Gault

(R^2= 85.43%), with a predictive value of 95.68% and 93.96%, respectively.

Ethical responsibilities

Protection of humans and animals: The authors declare that no experiments were conducted on humans or animals for this research.

Data confidentiality: The authors declare that no patient data appear in this article.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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