Prevalence and associated factors of chronic kidney disease among Truká Indigenous adults in Cabrobó, Brazil: a population-based study

Orlando Vieira Gomes,[a,b,*] Carlos Dornels Freire de Souza,[a,b] Jandir Mendonça Nicacio,[a,b] Rodrigo Feliciano do Carmo,[b] Vanessa Cardoso Pereira,[a] Dinani Matoso Fialho de Oliveira Armstrong,[b] Manoel Barral-Netto,[c,d] and Anderson da Costa Armstrong[a,b]

[a]Postgraduate Program in Human Ecology and Socio-Environmental Management, Bahia State University (UNEB), Juazeiro, BA, Brazil
[b]Faculty of Medicine, Federal University of Vale do São Francisco (UNIVASF), Petrolina, PE, Brazil
[c]Oswaldo Cruz Foundation/Fiocruz, Gonçalo Moniz Institute, Salvador, BA, Brazil

The Lancet Regional Health - Americas 2024;38: 100882

Published Online xxx
https://doi.org/10.1016/j.lana.2024.100882

Summary

Background The prevalence of chronic kidney disease (CKD) is increasing worldwide, especially in developing countries, due to factors such as lifestyle changes and the rise of non-communicable diseases. Populations living in socioeconomically disadvantaged areas are subject to a higher burden of CKD. However, the burden of CKD on Brazilian Indigenous people, especially those undergoing an advanced urbanisation process, has not yet been described.

Methods This cross-sectional study included 1715 Truká Indigenous adults from Cabrobó, Brazil. CKD was defined according to the Kidney Disease Improving Global Outcomes guidelines classification as a urinary albumin/creatinine ratio ≥30 mg/g and/or an estimated glomerular filtration rate <60 mL/min/1.73 m^2. Univariate and multiple logistic regression models were used to evaluate factors associated with CKD. Odds ratio (OR) with a 95% confidence interval (CI) was used to measure association.

Findings Out of the 1654 participants analysed (61 excluded due to missing data), the prevalence of CKD was 10% (95% CI, 8.6%–11.5%), with a higher prevalence in women compared to men (12.4% versus 6.9%, $p < 0.001$). The mean age was 40.5 years, with 55.6% being women. In univariate analysis, female sex (OR, 1.9; 95% CI, 1.3–2.7), age ≥60 years (OR, 4.6; 95% CI, 3.2–6.6), cardiovascular disease (OR, 2.1; 95% CI, 1.1–4.1), and dyslipidemia (OR, 1.6; 95% CI, 1.1–2.4) were identified as associated factors with CKD. Multiple logistic regression analysis identified age ≥60 years, female sex, and dyslipidemia as independently associated factors with CKD.

Interpretation The prevalence of CKD among Truká Indigenous adults analysed is high and affects a higher proportion of women. Our study found no association between hypertension, diabetes, obesity, and CKD risk, despite their high prevalence. These findings assist in developing early CKD detection strategies in Brazilian Indigenous communities, supporting disease treatment and prevention.

Funding National Council for Scientific and Technological Development (CNPq)–Ministry of Science, Technology, and Innovation of Brazil, and the Maria Emília Foundation.

Keywords: Indigenous peoples; Chronic kidney disease; Prevalence; Risk factors

Introduction

The global incidence of chronic kidney disease (CKD) is steadily increasing, particularly in low- and middle-income countries, where the most vulnerable populations are disproportionately affected. It is estimated that CKD affects approximately 10% of the world's population, with an even higher prevalence in developing countries due to a lack of access to adequate healthcare and a higher incidence of risk factors such as hypertension and diabetes.[1] CKD is characterised by

*Corresponding author. Faculty of Medicine, Federal University of Vale do São Francisco - UNIVASF, Avenida José de Sá Maniçoba, s/nº, Centro, Petrolina, Pernambuco, 56304-917, Brazil.
E-mail address: orlando.gomes@univasf.edu.br (O.V. Gomes).
[d]Full professor.

Research in context

Evidence before this study

We conducted a search on PubMed, EMBASE and LILACS for population-based studies published in the last 10 years that reported the prevalence of and risk factors for chronic kidney disease (CKD) in indigenous populations. Our search string included 'Renal Insufficiency, Chronic' OR 'Kidney Failure, Chronic' OR 'CKD' AND 'Indigenous Peoples' OR 'Native peoples' OR 'First Nations' OR 'Alaska Natives' OR 'Australian Aboriginal and Torres Strait Islander Peoples' AND ('prevalence' OR 'risk factors' OR 'incidence') in English, Portuguese, and Spanish. CKD affects approximately 10% of the global population, with a higher prevalence in developing nations due to limited access to healthcare and common risk factors such as hypertension and diabetes. The global incidence of CKD is on the rise, particularly in low- and middle-income countries, imposing a significant burden on vulnerable populations. While most studies on CKD in indigenous populations have primarily been conducted in North America and Oceania, in Latin America, including Brazil, where around 826 indigenous groups with a combined population of 45 million reside, there is a noticeable lack of CKD research within these communities. This knowledge gap is concerning because CKD is more prevalent among indigenous populations and arises from a complex interplay of genetic, socioeconomic, and environmental factors. Indigenous communities undergo dietary and lifestyle changes that contribute to higher rates of diabetes and hypertension, which are well-known risk factors for the development of CKD. Despite these challenges, there remains a conspicuous absence of data on the prevalence and risk factors of CKD in indigenous communities, emphasizing the urgent need for research in this area.

Added value of this study

This is the first large-scale study of the prevalence of CKD in the indigenous population of Brazil. Our findings provide valuable insights into the prevalence and associated factors of CKD among Truká Indigenous adults in Cabrobó, Brazil. By identifying age ≥60 years, female sex, and dyslipidemia as independent risk factors for CKD, our study extends the current understanding of CKD risk factors in indigenous populations. Furthermore, it highlights the high burden of CKD in this population, particularly among younger individuals, and underscores the need for targeted interventions for early detection and management of CKD in indigenous communities. Our findings also address the gap in knowledge regarding CKD epidemiology in indigenous communities and provide important information for public health policies aimed at reducing the burden of CKD and its associated complications.

Implications of all the available evidence

Our findings have significant implications for clinical practice, health policy, and future research. We identified independent factors associated with CKD among Truká Indigenous adults, providing a robust basis for targeted prevention and intervention strategies. This includes screening programs and interventions aimed at reducing dyslipidemia and managing comorbidities such as diabetes and hypertension. We emphasize the need for public policies that promote equitable access to healthcare and nephrology services in indigenous communities, including health education initiatives and training for local healthcare professionals. For future research, we recommend longitudinal studies to assess CKD progression and investigations into the social and environmental determinants of the disease. We hope that our study stimulates discussions on inclusive health policies and inspires further research to enhance renal health among indigenous populations in Brazil and worldwide.

severe and irreversible renal impairment, including an estimated glomerular filtration rate (eGFR) < 60 mL/min/1.73 m^2 and/or urinary albumin–creatinine ratio (UACR) ≥ 30 mg/g.[2] Access to healthcare plays a key role in early detection and treatment of CKD.[3]

Disadvantaged communities, particularly those of Indigenous origin, face high rates of undiagnosed and untreated CKD.[3] In New Zealand, a higher prevalence of CKD has been observed in the Indigenous Māori people compared to the non-Indigenous population.[4] In Canada, the Indigenous population exhibits higher rates of diabetes and hypertension, with a CKD prevalence that is two to three times higher than the general population; and these disparities become even more pronounced in rural areas.[5] Indigenous communities face several challenges, including loss of territory and resources, social and cultural marginalisation, and discrimination in the healthcare system.[3,5]

Although Latin America is home to approximately 826 Indigenous groups, with a population of about 45 million people, there is a significant lack of research addressing CKD in Indigenous communities in this region.[6] Similar to many other regions around the world, there is a scarcity of information about CKD within Indigenous populations in Brazil. A previous study that included small samples of Indigenous individuals aged 30–70 years from two ethnic groups in the Northeast Region of Brazil (Truká and Fulni-ô) and exclusively used eGFR <60 mL/min/1.73 m^2 reported a CKD prevalence rate of 4.3%.[7]

These Indigenous communities are currently under various transformations, including demographic,

epidemiological, nutritional, and sociocultural changes. These alterations have a direct impact on dietary habits and lifestyles, consequently increasing the risk of chronic diseases such as diabetes and hypertension.[3,6–8] Within this context, significant challenges persist, such as infectious and parasitic diseases, malnutrition, inadequate sanitary conditions, and a high infant mortality rate.[9] While Indigenous communities strive to preserve their traditions and ensure their fundamental rights, they also face the additional challenge of adapting to a constantly changing world.[7–10]

These changes are a result of the ongoing urbanisation process and have a profound impact on the dynamics of Brazilian Indigenous communities.[8,10] While there is already evidence of the impact of urbanization on population health,[6,8,10] there is uncertainty about the specific impact on the prevalence of CKD and associated risk factors in the Indigenous population of Brazil.[7] A systematic review with meta-analysis, analysing 20,574 adults from 33 Brazilian Indigenous groups, identified higher rates of obesity and hypertension among Indigenous people living in more urbanised regions of Brazil, particularly in the South Region (23% and 30%, respectively), compared to less urbanised areas such as in the North Region (11% and 1%, respectively).[10] This observed trend raises the hypothesis that urbanisation may contribute to an increased risk of CKD in Brazilian Indigenous communities. Therefore, this study aimed to determine the prevalence of CKD in an urbanised Brazilian Indigenous community and investigate possible factors associated with CKD.

Methods

Study design and recruitment

This is a cross-sectional study conducted from December 2022 to August 2023, analysing data from Truká Indigenous people aged over 18 years in Cabrobó, Pernambuco, Brazil.

In this report, we studied a sample of Indigenous adults aged 18 and over who had volunteered to participate in the study. Written informed consent was obtained from all participants. The sample was calculated based on an estimated population of 2856 Truká Indigenous people residing in Cabrobó, Brazil, of whom approximately 2142 were adults (aged 18 years or older).[11] We used a confidence interval (CI) of 95%, a margin of error of 1%, and an estimated CKD prevalence of 8.9%, based on a previous study of CKD prevalence in non-Indigenous Brazilians that used the same criteria.[12]

We used the online tool at http://sampsize.sourceforge.net/iface/ to calculate the initial sample size, which was 1270 people. However, we invited the entire Truká Indigenous community to participate in the study, resulting in a population of 1715 participants, representing approximately 80% of the estimated adult population. This exceeded the originally calculated sample size, but our goal was to include as many people as possible in this age group, aiming to comprehensively and accurately represent the target population.

The laboratory tests, clinical data, and anthropometric measurements were collected by four Indigenous community health workers, who were previously trained and continuously supervised throughout the field research. They operated at strategic points within the villages, such as health units, schools, and participants' residences. Additionally, to prevent the loss of eligible individuals who might be absent from home, three visits were conducted. These measures were implemented to ensure a more comprehensive representation of the study and to mitigate potential selection biases.

Clinical data encompassed medical and family history, medication use, comorbidities, and smoking status. Anthropometric measurements, including weight and height, were also obtained. Participants who declined to provide blood and/or urine samples or failed to attend all scheduled examinations were excluded from the study, regardless of having provided informed consent and undergone anthropometric measurements. Participants with missing laboratory samples were excluded to maintain data integrity and avoid bias, as missing samples could affect the validity of the results. As a result, 61 participants were excluded from the study due to incomplete required laboratory tests, leading to a final population of 1654 participants.

Population group and setting

The Truká Indigenous people reside in the lower-middle region of the São Francisco River, extending across the Brazilian states of Bahia and Pernambuco.[7] The Brazilian Institute of Geography and Statistics (IBGE) characterises this population based on anthropological, ethnic-linguistic, socio-demographic, geographic, cultural, and self-identification criteria.[11] They primarily inhabit Assunção Island in Cabrobó, covering an area of 6000 m^2 (Fig. 1).[7,8,13] Due to its proximity to the equator, this region experiences high temperatures throughout the year, with maximum temperatures reaching up to 40 °C. Average annual temperatures are consistently above 24 °C, with little monthly and annual variation. In addition, the region receives a large amount of sunlight.[14]

Sociodemographic and anthropometric parameters

Sex was recorded as a binary variable, with the options of male or female. Age was recorded as a continuous variable in years and was grouped into the following five categories: 18–29 years, 30–39 years, 40–49 years, 50–59 years, and 60 years or older. Weight was measured in kilograms using a digital body weight scale (OMRON HN-289). For height verification, a portable stadiometer (Alturexata, with a precision scale of 0.1 cm) was used. Body mass index (BMI) was calculated as body weight

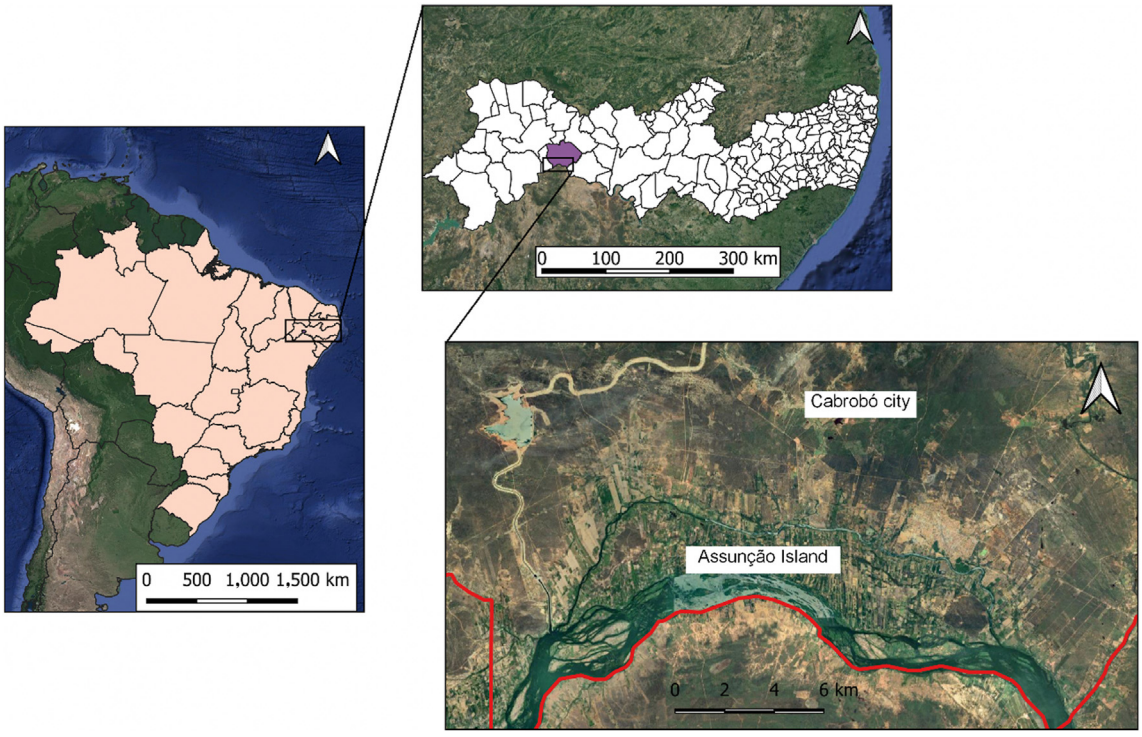

Fig. 1: **Geographic location of the study area. Cabrobó, Pernambuco, Brazil**. Produced by the authors. Map base layers were obtained from Natural Earth <http://www.naturalearthdata.com/about/terms-of-use/> covered by a Creative Commons Attribution 4.0 International (CC BY) License (https://creativecommons.org/licenses/by/4.0/legalcode). Map base layers were modified in QGIS software version 2.18. Pictures from the PAI researchers (no Indigenous person shown).

divided by height squared (kg/m^2). Participants with a BMI ≥30 kg/m^2 were classified as with obesity.[15] To minimize measurement errors, the data collection team received thorough training, and anthropometric measurements were taken up to three times.

Clinical parameters and laboratory testing

The study included questionnaire interviews, blood pressure measurements, and anthropometric assessments. Blood and urine samples were also taken for analysis. During the interviews, participants were questioned about their self-reported hypertension and diabetes, including their medication usage. Specifically, they were asked, "Have you ever received a diagnosis of high blood pressure or diabetes from a healthcare professional?" Participants who answered affirmatively were subsequently asked to provide details about the medications they were presently taking for these conditions. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using an automatic measuring device (OMRON HPB-1120) and cuffs corresponding to the subject's arm circumference. Participants sat comfortably for at least 5 min prior to measurements. Three consecutive blood pressure readings were taken, with intervals of one to 2 min between each reading for both arms. We calculated the average of these readings to obtain the final blood pressure measurement for each participant. Hypertension was defined as SBP ≥140 mmHg, DBP ≥90 mmHg, or if the participant was taking medication for hypertension, according to the recommendations of the Brazilian Guidelines of Hypertension.[16]

Diabetes was defined if the participant had glycated haemoglobin (HbA1c) ≥ 6.5% or was taking diabetes medications.[17] Dyslipidemia was defined if the participant was taking lipid-lowering medication, had high-density lipoprotein cholesterol (HDL-C) level <40 mg/dL for men or < 50 mg/dL for women, had triglycerides >150 mg/dL, had hypercholesterolemia (>240 mg/dL), or had low-density lipoprotein cholesterol (LDL-C) level >160 mg/dL.[18] In the study, the occurrence of cardiovascular disease was defined as cases of coronary revascularization, medical diagnosis of myocardial infarction, stroke, or heart failure. During the interviews, participants were specifically asked: "Have you ever used tobacco?" (Following this inquiry, they were then asked: "On average, how much tobacco do you use per day?"). If they answered affirmatively, they were further questioned about their smoking habits using a standardized questionnaire that recorded the daily

frequency and duration of smoking. The self-reported smoking status was then recorded and classified as active or former based on the answers provided.

The laboratory tests encompassed blood and urine analyses evaluating a range of parameters, including total cholesterol, HDL-C, LDL-C, triglycerides, HbA1c, creatinine, and UACR. Venous blood (fasting) and urine samples were collected by two technicians specialized in sample collection, labelled and kept in a cooler box for transportation to the affiliated laboratory.

Samples were processed using a Biosystems BA400 biochemical analyzer. Total cholesterol, HDL-C, and triglycerides were measured using enzymatic-colorimetric methods. LDL-C was calculated using Friedewald's formula (LDL-C = total cholesterol—HDL-C—triglycerides/5). HbA1c was obtained using the High-Performance Liquid Chromatography (HPLC) method. Creatinine levels were determined utilizing an automated enzymatic method based on the Jaffé reaction, which is standardized to isotope dilution mass spectrometry (IDMS). Additionally, albumin levels were assessed using a highly sensitive immunoturbidimetric method. All laboratory data analysis was centralized in a single accredited facility to ensure uniformity in equipment and procedures.

Study outcomes

The study outcomes were the prevalence and associated factors of CKD among Truká Indigenous adults. The eGFR was calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation for creatinine, specifically the CKD-EPI 2021 version, which is a race-free equation.[19] The UACR was determined by dividing the urine albumin concentration in mg/dl by the urine creatinine concentration in g/dl. CKD was diagnosed based on eGFR and UACR cutoff values according to the Kidney Disease Improving Global Outcomes (KDIGO) CKD risk categories. Specifically, CKD was diagnosed for an eGFR <60 mL/min/1.73 m^2 or an eGFR ≥60 mL/min/1.73 m^2 with coexisting albuminuria (UACR ≥30 mg/g).[2]

Individuals diagnosed with CKD were subsequently classified into CKD stages according to KDIGO guidelines. These stages include stages G1A2-3 and G2A2–3 (eGFR ≥60 with albuminuria), as well as stages G3a (45–59), G3b (30–44), G4 (15–29), and G5 (<15 mL/min/1.73 m^2), regardless of albuminuria.[2]

Statistical analysis

Continuous quantitative variables were described using measures of central tendency (mean ± standard deviation; median and interquartile range [IQR]). Categorical variables were analyzed using the chi-square test. Factors associated with CKD were identified using both univariate and multiple logistic regression analyses. The dependent variable was CKD diagnosis (yes/no), and the independent variables were sex (male/female), age (≥60 years or < 60 years), obesity (yes/no), diabetes (yes/no), hypertension (yes/no), cardiovascular disease (yes/no), dyslipidemia (yes/no), and current smoking (yes/no). Additionally, four conditions were tested according to the CKD diagnostic criteria: condition 1–eGFR <60 mL/min/1.73 m^2; condition 2–UACR ≥30 mg/g; condition 3–eGFR <60 mL/min/1.73 m^2 or UACR ≥30 mg/g; and condition 4–eGFR <60 mL/min/1.73 m^2 and UACR ≥30 mg/g. For all analyses, the 95% confidence interval and significance level of 5% were considered. The analyses were conducted using JASP (version 0.18.0, University of Amsterdam, Amsterdam, The Netherlands).

Ethical approvals

The research conducted in collaboration with Indigenous leaders of participating groups received approval from the Ethics Committee for Human Research of the Federal University of Alagoas under register number 5.818.147 on December 15, 2022. The study adheres to the ethical principles stated in the Declaration of Helsinki (1964) and follows the guidelines outlined in Resolutions 466/2012 and 510/2016 of the Brazilian National Health Council, ensuring full compliance with ethical standards.

Role of the funding source

The funding source had no role in the study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the report for publication.

Results

Population characteristics

Out of the 1715 study participants, 1654 (96%) were eligible for this analysis. 61 participants (4%) were excluded from the study due to incomplete required laboratory tests, specifically missing serum creatinine or urinalysis results. All participants self-identified as Truká Indigenous. The mean age was 40.5 ± 15.9 years (median age was 38 years [IQR, 27.0–52.0]), and 55.6% (920/1654) of participants were females. In the Indigenous people studied, the rate of dyslipidemia was 70.5% (95% CI, 68.3%–72.6%); hypertension was 24.5% (95% CI, 22.5%–26.6%), diabetes was 8.5% (95% CI, 7.2%–9.9%); and obesity was 27.7% (95% CI, 25.5%–29.9%). Additionally, 14.8% (95% CI, 13.1%–16.5%) of participants reported current smoking, while only 3.6% (95% CI, 2.8%–4.6%) reported a cardiovascular disease (Table 1).

Prevalence of CKD and characteristics of CKD patients

The prevalence of CKD in the analysed population, based on the presence of at least one of the adopted criteria, was 10% (165 out of 1654; 95% CI, 8.6%–11.5%) (Table 1). The distribution of CKD stages among participants with CKD, according to the KDIGO guidelines,[2] shows that the majority (63.0%, 104/165) fall into

Variable	CKD				All (95% CI)	OR (95% CI)	P value
	No		Yes				
	N	%	N	%			
All	1489	90.0	165	10.0 (95% CI, 8.6–11.5)	1654		
Sex							<0.001[a]
Female	806	87.6	114	12.4	920	1.9 (1.3–2.7)	
Male	683	93.1	51	6.9	734	Ref (1.0)	
Age group (years)							
<60 years	1321	92.7	104	7.3	1425	Ref (1.0)	<0.001[a]
≥60 years	168	73.4	61	26.6	229 13.8% (12.3–15.6)	4.6 (3.2–6.6)	
Obesity (BMI ≥ 30 kg/m^2)							
No	1085	90.7	111	9.3	1196	Ref (1.0)	0.115[a]
Yes	404	88.2	54	11.8	458 27.7% (25.5–29.9)	1.3 (0.9–1.8)	
Diabetes							
No	1367	90.3	147	9.7	1514	Ref (1.0)	0.235[a]
Yes	122	87.1	18	12.9	140 8.5% (7.2–9.9)	1.4 (0.8–2.3)	
Hypertension							
No	1134	90.8	115	9.2	1249	Ref (1.0)	0.067[a]
Yes	355	87.7	50	12.3	405 24.5% (22.5–26.6)	1.4 (1.0–2.0)	
Cardiovascular disease							
No	1440	90.3	154	9.7	1594	Ref (1.0)	0.044[a]
Yes	49	81.7	11	18.3	60 3.6% (2.8–4.6)	2.1 (1.1–4.1)	
Dyslipidemia							
No	453	92.8	35	7.2	488	Ref (1.0)	0.015[a]
Yes	1036	88.9	130	11.1	1166 70.5% (68.3–72.6)	1.6 (1.1–2.4)	
Current smoking							
No	1274	90.4	136	9.6	1410	Ref (1.0)	0.300[a]
Yes	215	88.1	29	11.9	244 14.8% (13.1–16.5)	1.3 (0.8–1.9)	

Truká Indigenous people. Cabrobó, Pernambuco, Brazil (n = 1654). **Note:** CKD, chronic kidney disease; OR, odds ratio; CI, confidence interval; BMI, body mass index; UACR, urinary albumin–creatinine ratio; eGFR, estimated glomerular filtration rate. [a]X^2 continuity correction.

Table 1: **Characterization of study population by presence of CKD and criteria for CKD: eGFR <60 mL/min/1.73 m^2, UACR ≥30 mg/g, or both.**

stages G1A2–3 and G2A2–3. These stages are characterised by normal eGFR (≥60 mL/min/1.73 m^2) but significant albuminuria (≥30 mg/g). The remaining CKD patients are categorised into stages G3a (30.9%, 51/165), G3b (3.0%, 5/165), G4 (2.4%, 4/165), and G5 (0.6%, 1/165). When presented as a percentage of the Truká adult population analysed, the frequencies of CKD stages are as follows: G1A2–3, 3.5%; G2A2–3, 2.8%; G3a, 3.1%; G3b, 0.4%; G4, 0.3%; and G5, 0.1% (Fig. 2).

Based on the KDIGO risk categories,[2] the majority of the population was categorised as low risk, including individuals with low to mildly increased urine excretion of albumin (UACR <30 mg/g), accounting for 90.0% of the sample (1489 out of 1654 individuals). The prevalence of moderately increased risk, high risk, and very high risk was 8.58%, 0.91%, and 0.48%, respectively. Among all the participants with CKD, 99.1% (164/165) had a UACR of less than 300 mg/g (Fig. 2). Additionally, the proportion of individuals with altered albuminuria was also 1.8 times higher than the proportion of individuals with altered eGFR (6.8% and 3.7%, respectively) (Fig. 3).

The prevalence of CKD was significantly higher in women, being 1.8 times higher than in men (12.4% versus 6.9%, p < 0.001) (Table 1). Out of the 165 cases diagnosed with CKD, a significant proportion, 110 (66.7%), did not have hypertension or diabetes. Among diabetic patients, 18 (10.9%) had CKD; among hypertensive patients, 50 (12.3%) had CKD; and among obese

Prognosis of CKD by eGFR and albuminuria categories: KDIGO 2024		Persistent albuminuria categories Description and range						All	
		A1 Normal to mildly increased < 30 mg/g		A2 Moderately increased 30 to 300 mg/g		A3 Severely increased > 300 mg/g			
		n	%	*n*	%	*n*	%	*n*	%
eGFR categories (ml/min/1.73m²) Description and range	G1	826	49.9	53	3.2	5	0.3	884	53.4
	G2	663	40.0	41	2.5	5	0.3	709	42.9
	G3a	48	2.9	2	0.1	1	0.1	51	3.1
	G3b	3	0.2	1	0.1	1	0.1	5	0.3
	G4	1	0.1	1	0.1	2	0.1	4	0.2
	G5	0	0	1	0.1	0	0	1	0.1
	All	1541	93.1	99	6.1	14	0.9	1654	100

***Fig. 2*: Estimated percentage of Truká Indigenous adults at risk of CKD outcomes, categorized by eGFR (estimated by CKD-EPI formula without correction for race) and albuminuria category, according to KDIGO 2024. Note:** Green: low risk (if no other markers of kidney disease, no CKD); Yellow: moderately increased risk; Orange: high risk; Red, very high risk. **Legend:** CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate. KDIGO, Kidney Disease Improving Global Outcomes. G1- Normal or high (≥90); G2–Mildly decreased (60–89); G3a–Mildly to moderately decreased (45–59); G3b–Moderately to severely decreased (30–44); G4–Severely decreased (15–29); G5–Kidney failure (<15).

patients, 53 (11.6%) had CKD. Notably, among Truká Indigenous adults diagnosed with CKD, the prevalence of diabetes and obesity was higher in women compared to men (12.3% versus 7.8% and 35.1% versus 27.5%, respectively) (Fig. 4).

Of those diagnosed with CKD, 52 (3.1%) had impaired renal function without albuminuria. In addition, 104 (6.3%) had renal dysfunction manifested solely by albuminuria. Only 9 (0.5%) individuals had both reduced eGFR and albuminuria. The prevalence

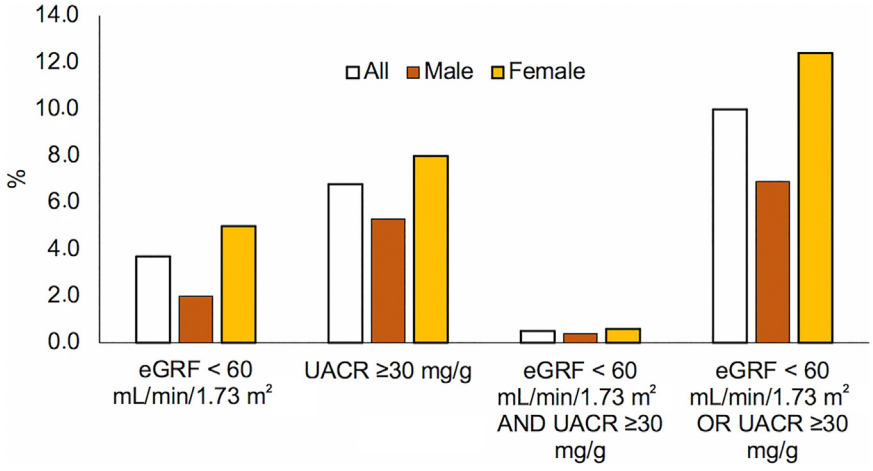

***Fig. 3*: Prevalence of CKD according to the criteria adopted. Truká Indigenous people from Cabrobó, Pernambuco, Brazil (n = 1654).** **Legend**: UACR, urinary albumin–creatinine ratio (mg/g); eGFR, estimated glomerular filtration rate.

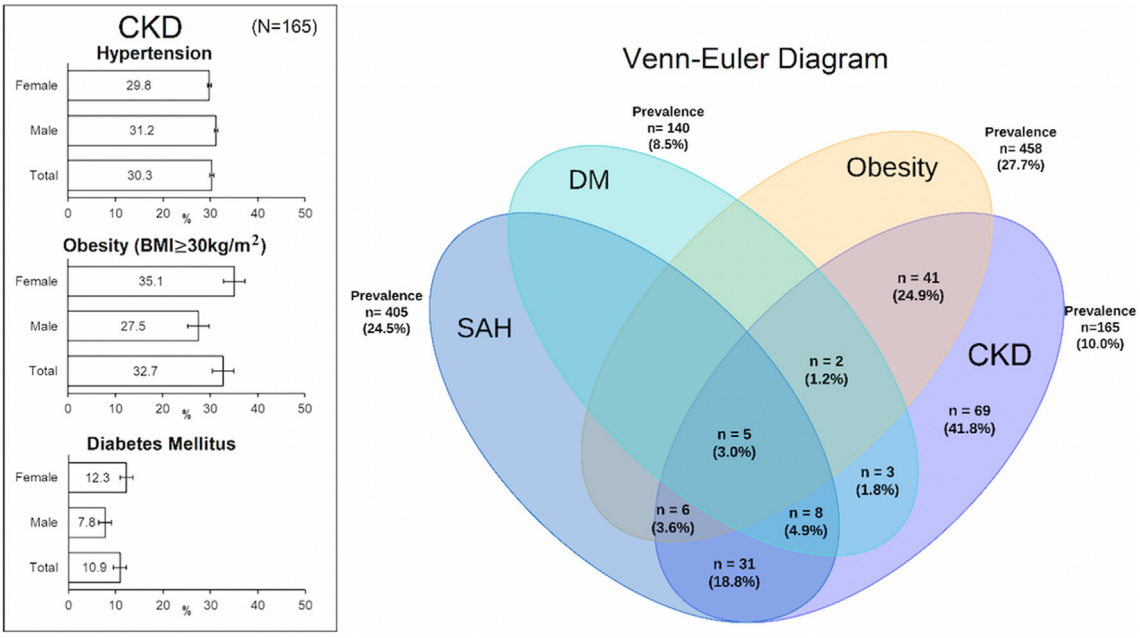

Fig. 4: **Venn–Euler diagram: Prevalence of hypertension, obesity, and diabetes in patients with CKD. Truká Indigenous people from Cabrobó, Pernambuco, Brazil (n = 1654). Legend:** CKD, chronic kidney disease; BMI, body mass index; DM, diabetes mellitus; SAH, systemic arterial hypertension.

increased with age, reaching 26.6% in those aged 60 years and older compared to 5.4% in those aged 18–29 years. Among women aged 60 years and older, the prevalence of CKD was even higher, reaching 35.7% (Table 2).

Factors associated with CKD

Univariate logistic regression analysis revealed differences in variables associated with CKD, including female sex (OR = 1.9; 95% CI, 1.3–2.7), age over 60 years (OR = 4.6; 95% CI 3.2–6.6), cardiovascular disease (OR = 2.1; 95% CI, 1.1–4.1) and dyslipidemia (OR = 1.6; 95% CI, 1.1–2.4). However, no significant association was found between the prevalence of CKD and known risk factors in the general population, such as obesity, hypertension, diabetes, and current smoking, as shown by the univariate logistic regression model. The prevalence of these factors was similar in participants with and without CKD (Table 1).

For each analysed condition, according to the CKD diagnostic criterion, multiple logistic regression was utilized. Regarding CKD with eGFR <60 mL/min/1.73 m^2, out of the seven variables assessed, the following three were significantly associated with CKD: female sex ($p < 0.001$), age ≥60 years ($p < 0.001$), and dyslipidemia ($p = 0.039$). In instances of CKD with UACR ≥30 mg/g, only female sex ($p = 0.025$) and age ≥60 years ($p = 0.001$) showed statistical significance. When both criteria were considered together, only age ≥60 years ($p < 0.001$) was associated with CKD. Therefore, age ≥60 years is significantly associated with CKD, regardless of the criterion used, while female sex and dyslipidemia were strongly associated with CKD under specific conditions. Although an association between cardiovascular disease and the CKD scenario represented by UACR >30 mg/g was observed, this finding failed to achieve statistical significance ($p = 0.317$) (Table 3), contrasting with its significance in the univariate analysis (Table 1).

Discussion

This study aimed to determine the prevalence of CKD in an Indigenous population undergoing an advanced urbanisation process embedded in a context of dietary and cultural transition.[7,8,10] The results showed a high prevalence of CKD in the studied population, composed of relatively young people, not associated with traditional risk factors for the disease, such as hypertension and diabetes. Our study revealed a prevalence of CKD in line with global estimates,[1] but notably higher than the finding of 8.9% in a study conducted on the general Brazilian population, which employed the same CKD screening parameters.[12] This identified disparity was also previously observed in a study focusing on the older adult population of the same Indigenous community. The median age of patients with CKD was 71 years (IQR, 66.0–78.0), and the prevalence of CKD was significantly higher compared to the non-Indigenous Brazilian older adult population (26.1% versus

	Age group–% (n)					All
	18–29 years	30–39 years	40–49 years	50–59 years	60 years and above	
Female (n = 920)						
Non- CKD						
eGFR ≥60 and UACR <30 (normal and normal)	93.3% (n = 277)	94.9% (n = 204)	88.7% (n = 141)	82.1% (n = 110)	64.3% (n = 74)	87.6% (n = 806)
CKD	**6.7%**	**5.1%**	**11.3%**	**17.9%**	**35.7%**	**12.4%**
eGFR <60 and UACR <30 (altered and normal)	0.3% (n = 1)	0.9% (n = 2)	1.3% (n = 2)	9.0% (n = 12)	20.0% (n = 23)	4.3% (n = 40)
eGFR ≥60 and UACR ≥30 (normal and altered)	6.4% (n = 8)	3.7% (n = 8)	8.8% (n = 14)	9.0% (n = 12)	13.0% (n = 15)	7.4% (n = 68)
eGFR <60 and UACR ≥30 (altered and altered)	<0.1% (n = 1)	0.5% (n = 1)	1.3% (n = 2)	0.0% (n = 0)	2.6% (n = 3)	0.7% (n = 6)
Male (n = 734)						
Non-CKD						
eGFR ≥60 and UACR <30 (normal and normal)	96.5% (n = 194)	94.7% (n = 162)	97.1% (n = 133)	90.1% (n = 100)	82.5% (n = 94)	93.1% (n = 683)
CKD	**3.5%**	**5.3%**	**2.9%**	**9.9%**	**17.5%**	**6.9%**
eGFR <60 and UACR <30 (altered e normal)	0.0% (n = 0)	0.0% (n = 0)	0.0% (n = 0)	1.8% (n = 2)	8.8% (n = 10)	1.6% (n = 12)
eGFR ≥60 and UACR ≥30 (normal e altered)	3.5% (n = 7)	4.7% (n = 8)	2.9% (n = 4)	8.1% (n = 9)	7.0% (n = 8)	4.9% (n = 36)
eGFR <60 and UACR ≥30 (altered e altered)	0.0% (n = 0)	0.6% (n = 1)	0.0% (n = 0)	0.0% (n = 0)	1.8% (n = 2)	0.4% (n = 3)
All (n = 1654)						
Non-CKD						
eGFR ≥60 and UACR <30 (normal and normal)	94.6% (n = 471)	94.8% (n = 366)	92.6% (n = 274)	85.7% (n = 210)	73.4% (n = 168)	90.0% (n = 1489)
CKD	**5.4%**	**5.2%**	**7.4%**	**14.3%**	**26.6%**	**10.0%**
eGFR <60 and UACR <30 (altered and normal)	0.2% (n = 1)	0.5% (n = 2)	0.7% (n = 2)	5.7% (n = 14)	14.4% (n = 33)	3.1% (n = 52)
eGFR ≥60 and UACR ≥30 (normal and altered)	5.2% (n = 26)	4.1% (n = 16)	6.1% (n = 18)	8.6% (n = 21)	10.0% (n = 23)	6.3% (n = 104)
eGFR <60 and UACR ≥30 (altered and altered)	0.0% (n = 0)	0.5% (n = 2)	0.7% (n = 2)	0.0% (n = 0)	2.2% (n = 5)	0.5% (n = 9)

Legend: CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate; UACR, urinary albumin–creatinine ratio (mg/g).

***Table 2*: Distribution of the Truká Indigenous people according to CKD definition criteria (eGFR and UACR), categorized by sex and age structure (n = 1654).**

21.4%).[20] In our study, the median age of the entire population was 38 years (IQR, 27.0–52.0).

The current study was focused on the Truká Indigenous community, which has occupied Assunção Island, the largest island in the São Francisco River, for centuries, with records dating back to the 18th century.[8] Throughout this period, they have faced considerable challenges, including the gradual loss of their ancestral territories, cultural heritage, and traditional connection with nature.[8,21] Despite decades of territorial conflicts, the group managed to resettle on their lands in 2002, which represented an opportunity to reaffirm their Indigenous traditions and territory sovereignty.[8,22] Traditionally, the Truká relied on subsistence agriculture, fishing, and gathering, utilising the natural resources of the São Francisco River region.[21] However, the construction of dams and other infrastructure projects has significantly altered these activities, leading to profound changes in their economic, social, cultural, and health dynamics due to increasing urbanisation.[8,21,22] These transformations challenge the Truká community to adapt to a constantly evolving environment and, at the same time, seek to preserve their identity and ancestral traditions.[8,22]

In addition to presenting a higher rate of CKD compared to the non-Indigenous Brazilian population, it is acknowledged that the Truká Indigenous community faces significant challenges in accessing healthcare services, exacerbated by the concurrent state of poverty.[8,20,22] The socioeconomic challenges faced by the Truká Indigenous people and other Indigenous communities in Brazil have a significant impact on their health and well-being. Limited access to basic services, environmental pressures, poverty, and threats to cultural preservation are pressing issues.[8–10] These factors contribute to health inequalities, including high rates of chronic disease.[3,5,8] It is critical to develop policies and programs that address these specific needs while respecting the cultural and territorial rights of communities. Ongoing research is essential to develop effective and culturally sensitive interventions that improve the health and well-being of the Truká Indigenous and other Indigenous communities in Brazil.

This scenario is also mirrored in other Indigenous communities worldwide. Likewise, in Canada, the Indigenous population faces unfavourable clinical outcomes, particularly in rural regions, where elevated rates of diabetes mellitus, hypertension, and CKD are prominent.[5] The difficulty in accessing fundamental and specialised medical care exacerbates the challenges, mainly due to the scarcity of family physicians and specialists across the nation.[5] A similar pattern is observed in New Zealand, where the Indigenous Māori population has an end-stage renal disease (ESRD) prevalence rate of 255 per million population (pmp), significantly higher than the 64 pmp rate for New

	Estimated parameters	Standard errors	z	p
A) CKD–eGFR <60 mL/min/1.73 m^2				
(Intercept)	1.376	0.600	2.294	0.022[a]
Sex	1.056	0.319	3.307	<0.001[a]
Age ≥60 years	2.691	0.304	8.854	<0.001[a]
Obesity (BMI ≥30 kg/m^2)	0.391	0.298	1.312	0.189
Hypertension	−0.269	0.315	−0.857	0.392
Dyslipidemia	0.869	0.420	2.067	0.039[a]
Diabetes	−0.431	0.519	−0.830	0.406
Current smoking	−0.112	0.374	−0.299	0.765
B) CKD—UACR ≥ 30 mg/g				
(Intercept)	1.129	0.524	2.156	0.031[a]
Sex	0.469	0.209	2.242	0.025[a]
Age ≥60 years	0.796	0.245	3.252	0.001[a]
Obesity (BMI ≥30 kg/m^2)	0.063	0.218	0.289	0.773
Hypertension	−0.100	0.240	−0.417	0.677
Dyslipidemia	0.004	0.223	0.020	0.984
Diabetes	0.300	0.329	0.911	0.362
Cardiovascular disease	0.425	0.425	1	0.317
C) CKD–eGFR < 60 mL/min/1.73 m^2 OR UACR ≥ 30 mg/g				
(Intercept)	0.549	0.232	2.370	0.018[a]
Sex	0.700	0.185	3.786	<0.001[a]
Age ≥60 years	1.609	0.194	8.290	<0.001[a]
Obesity (BMI ≥30 kg/m^2)	0.189	0.184	1.025	0.305
Hypertension	−0.096	0.197	−0.490	0.624
Dyslipidemia	0.285	0.206	1.387	0.165
D) CKD–eGFR < 60 mL/min/1.73 m^2 AND UACR ≥ 30 mg/g				
(Intercept)	−4.301	0.985	−4.365	<0.001[a]
Sex	−0.740	0.735	−1.007	0.314
Age ≥60 years	−2.357	0.708	−3.328	<0.001[a]
Obesity (BMI ≥30 kg/m^2)	0.319	0.816	0.390	0.696
Hypertension	0.774	0.837	0.925	0.355
Dyslipidemia	0.447	0.735	0.609	0.543

Legend: UACR, urinary albumin–creatinine ratio (mg/g); BMI, body mass index; CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate. **Note:** Variables compromising the statistical quality of the model were excluded. [a]Variables with significant association.

Table 3: **Multiple logistic regression analysis of four conditions, based on CKD diagnostic criteria.**

Zealand Europeans. Furthermore, 70% of ESRD cases among Māori are attributed to diabetic kidney disease.[4] Comorbidities and socioeconomic factors contribute to these disparities in disease incidence and treatment requirement. The increased incidence of kidney disease is driven by higher rates of poverty, diabetes mellitus, hypertension, and cardiovascular diseases.[3,5]

In our research, CKD was diagnosed in 6.3% of patients based solely on albuminuria criteria. Albuminuria serves as a sensitive indicator of early CKD, enabling timely interventions to slow disease progression and reduce the risk of severe renal complications.[2] Besides the risk of kidney failure, albuminuria is also associated with an increased risk of cardiovascular events and mortality.[2,23] Thus, identifying albuminuria and promptly addressing its modifiable risk factors could potentially delay the progression to advanced stages of CKD, including ESRD.[2] Implementing this approach presents an appealing strategy to alleviate the burden of morbidity and mortality associated with advanced CKD. These findings underscore the significance of our study within the population, potentially leading to improved clinical outcomes and enhanced quality of life for those affected.

The study found a correlation between CKD and age and female sex. This higher prevalence of CKD in women is also supported by another study conducted in Belize, where the prevalence in women was 14.8% compared to 12.5% in men.[24] Additionally, among individuals affected by CKD, conditions such as diabetes and obesity were more prevalent in the female study population compared to males, which could perhaps explain the increased prevalence of CKD among women, although such comorbidities were not

associated with CKD in the general study population. In terms of age, CKD is known to be more prevalent in older people.[1,2] Likewise, the prevalence of CKD was higher in older adults (7.3% for <60 years and 26.6% for ≥60 years), exceeding the result of a previous study of non-Indigenous Brazilian older people.[25] Compounding the issue, Indigenous peoples present with CKD at a younger age compared to non-Indigenous populations.[3,7] A previous study found that the Brazilian population, with a median age of 51 years, had a CKD prevalence of 8.9%.[12] Notably, the Indigenous population in our study, with a median age of 38 years, exhibited an even higher CKD prevalence compared to the aforementioned Brazilian population. However, conclusions about the age-incidence of CKD in the general and Indigenous populations should be further evaluated in a larger, properly designed comparative study.

A high prevalence of hypertension was identified in our study population, closely resembling the 24.1% rate of hypertension observed in the general Brazilian population.[26] This pattern has also been observed in other Indigenous populations in Brazil, such as the Krenak Indigenous people from Minas Gerais, where the prevalence was even higher, reaching 31.2%.[27] Regarding diabetes, the rate in our study population was slightly lower than the prevalence of 9.2% in the Brazilian population.[28] Among Indigenous populations, diabetes prevalence varies considerably. A recent integrative review, comprising of 14 studies focused on adult Brazilian Indigenous groups, revealed a diabetes prevalence ranging from 3.0% to 24.9%.[29] These findings suggest potential variations in the health status among different Indigenous communities in the country. Despite the high prevalence, we found no association between diabetes or hypertension and the prevalence of CKD in our population, although these conditions are recognised as traditional risk factors.[1,2]

The transition to urban living among Indigenous communities is associated with an increase in adverse cardiometabolic health outcomes, as traditional lifestyles undergo significant societal changes.[8,10] In this context, a previous study involving the Truká population indicated a high prevalence of hypertension (33.9%) among individuals aged 30–70 years, along with a greater cardiovascular risk, compared to a less urbanised population.[8] Furthermore, it is possible that the forced-urbanised Indigenous populations face worse healthcare in urban centers because once expelled from their land, they move into deprived areas on peri-urban suburbs with low access to healthcare. This intersection of poverty, marginalisation, and forced urbanisation places these communities in areas with lower healthcare access compared to rural Indigenous communities, which usually benefit from specific programs aimed at Indigenous health.[30] Consequently, limited access to adequate healthcare services in urban areas may result in delayed diagnosis and inadequate treatment of conditions, potentially exacerbating complications such as CKD.[7,20]

We observed a high prevalence of obesity and dyslipidemia in our population, consistent with findings in other Brazilian Indigenous people.[10,31] Studies indicate that approximately 45% of Brazilian Indigenous adults are affected by overweight and obesity.[31] A study conducted in Parintins, Amazonas, with the urbanised Indigenous population of the Sateré-Mawé ethnic group revealed a concerning overweight rate affecting 42% of the sample.[32] Additionally, results from the First National Survey of Indigenous People's Health and Nutrition in Brazil unveiled elevated rates of overweight and obesity, particularly among Indigenous women aged 14 to 49.[33] In our study, obesity rates exceeded those in the non-Indigenous Brazilian population, as reported in a study showing a prevalence of 16.8% in men and 24.4% in women.[34] These findings underscore the challenges faced by Indigenous communities migrating to urban areas, where they encounter different lifestyles and have limited access to their traditional diets and physical activity. Dietary shifts, loss of territories, and rapid urbanisation are factors linked to the observed nutritional transition and together with changes in lifestyles may exacerbate the prevalence of overweight and obesity among Indigenous peoples.[8,10,31]

While obesity is often linked to an increased risk of CKD,[1,12] our study did not establish a significant association, a result similarly found in a study conducted within a rural population in Thailand.[35] These findings underscore the complex and multifaceted nature of the relationship between obesity and CKD, where outcomes may differ among diverse populations and settings. Nevertheless, it is worth noting that our study revealed a notable and substantial association between dyslipidemia and CKD. In our population, cardiovascular disease and active smoking were prevalent. However, in a more comprehensive analysis of the data (multiple logistic regression), we found no statistically significant evidence of an association between cardiovascular disease, active smoking, and CKD, although previous studies suggested this possible association.[12,35]

The absence of an association between classical risk factors and CKD in this population creates uncertainty about the disease's origins. Although occupation was not examined in this study, it is important to emphasise that a majority of Truká Indigenous people work in agriculture.[13,21] Environmental and occupational factors are considered potential contributors to CKD development.[24,36] Given their agricultural background and the region's arid climate,[13,14] it is plausible that factors such as dehydration and recurrent hypovolemia might contribute to CKD.[36] Another factor could be poisoning by pesticides, which are widely used in the this population's plantations[21] and may be associated with renal dysfunction.[36] Thus, the potential existence of a distinctive form of CKD of unknown cause, also known

as Mesoamerican nephropathy or chronic interstitial nephritis in agricultural communities (CINAC), cannot be ruled out. This nephropathy, whose aetiologia is not yet fully understood, mainly affects rural populations in Latin American regions.[24,36] Population-based surveys in Nicaragua, El Salvador, and other Central American countries have noted a significant increase in ESRD and kidney-related deaths, particularly among agricultural workers.[36–38] In Nicaragua, the prevalence can reach up to 13% among agricultural workers,[37] and in El Salvador, up to 18%.[38] In Belize, a high prevalence of CKD (15.2%) is observed among the Mestizo/Hispanic population, a significant portion of whom work in agriculture.[24] Chronic exposure to pesticides, recurrent dehydration due to adverse climatic conditions, and limited access to healthcare are believed to contribute to the development of CKD in these populations.[24,36]

Additionally, the Truká Indigenous community faces socioeconomic challenges,[21] reflecting a common scenario among populations affected by CINAC.[36] Limited access to basic healthcare services, combined with environmental pressures, poverty, and discrimination, are recognized factors that significantly contribute to health disparities.[10] Communities subjected to discrimination with inadequate access to primary healthcare are more likely to face a heavier burden of chronic diseases, including CKD.[3,5] These environmental, occupational, and socioeconomic factors could partially explain the higher prevalence of CKD in our population, as well as the lack of association between CKD and diabetes and hypertension. Furthermore, it is crucial to conduct further research with this population to better understand these connections, including investigations into previous exposure to pesticides and other chemicals, hydration practices, routine use of non-steroidal anti-inflammatory drugs, and any diseases or hospitalisations related to occupational activity. Moreover, there is a pressing need for targeted investigations into the socioeconomic factors that impact health outcomes within Indigenous communities.

Conversely, we found a higher prevalence of CKD in women, which contrasts with the epidemiology of CINAC, which generally affects more men.[36] However, Truká Indigenous women have a significant role in agricultural activities, focusing on providing subsistence for their families. Their participation in agriculture, medicinal plant cultivation, natural resource management, and fishing is considered essential to ensuring food security and sustainability in Indigenous communities.[21] Finally, it is important to consider the possibility of overlap between CINAC and comorbidities such as diabetes and obesity. It was observed that, among individuals affected by CKD, these health conditions were more prevalent in the female study population.

Our research has several strengths. Our study is the first to describe the prevalence of CKD in a large sample of Brazilian Indigenous people and achieved a high participation rate of the adult population studied. Importantly, the data collection was conducted in close collaboration with Indigenous leaders and four Indigenous community health workers, ensuring cultural sensitivity and community engagement throughout the research process. Indigenous people diagnosed with serious abnormalities were referred to and received specialised treatment. Additionally, we used standardised CKD definitions that allowed us to make international comparisons of disease prevalence. Furthermore, we hypothesize that CINAC may be a contributing factor to the development of CKD in these specific groups, which opens a new perspective on this topic. To the best of our knowledge, there are no reports of CINAC in Brazil. These findings have important public health implications and contribute to the development of prevention and treatment strategies and programs for these populations.

However, the study also had limitations. One limitation arises from its cross-sectional nature, as confirmation of CKD requires the presence of abnormalities in eGFR or albuminuria over a period of at least three months.[2] However, this method is widely used in large-scale population surveys.[12,24,35] In low- and middle-income countries, a single measurement of eGFR and albuminuria can be used to determine the prevalence of CKD in an affordable, efficient and feasible way, where resources are limited.[39] Moreover, the efficacy of the CKD-EPI formulas in Indigenous people remains unexplored, representing an additional limitation in our research. Furthermore, our study did not explore the social determinants of health, which are crucial in influencing health outcomes, including the prevalence and management of CKD in Indigenous people.[3,5] Further understanding of these factors could offer valuable insights. Additionally, it is essential to recognise the significant ethnic and cultural diversity among Brazilian Indigenous people. This diversity complicates the extrapolation of our findings to other Indigenous communities in Brazil, posing challenges for reaching conclusive analyses on CKD prevalence within these populations outside of the Truká community.

In conclusion, our study revealed a significant prevalence of CKD in a relatively young Brazilian Indigenous community, surpassing the prevalence observed in the non-Indigenous Brazilian population. CKD was found to be most prevalent among women, older adults, and individuals with dyslipidemia within our study group. Despite well-established associations in the literature between CKD and factors such as hypertension, diabetes, and obesity, our results showed no significant correlations with these elements in this specific population. These findings underscore the urgent need for further research to comprehensively understand the causes and prevalence of CKD in Indigenous communities to design effective and targeted solutions. Genetic investigations and histopathological studies, conducted

through renal biopsies, hold promise for providing critical insights, improving diagnostic accuracy, and enabling the development of more personalised and effective treatment strategies in certain situations. Longitudinal studies to assess CKD progression and investigations into social determinants of health are crucial for advancing our understanding and addressing the burden of CKD in Indigenous communities.

Contributors

The study was conceptualized by OVG, CDFS, and ACA. Data curation was carried out by CDFS and VCP, while OVG and CDFS developed the methodology. Formal analysis and investigation were performed by OVG, CDFS, JMN, RFC, VCP, DMFOA, MBN, and ACA. The original draft of the writing was prepared by OVG and CDFS and later reviewed and edited by OVG, CDFS, and ACA. Supervision of the study was provided by OVG, CDFS, MBN, and ACA. All authors critically revised the manuscript and approved the final version of the manuscript.

Data sharing statement

Data on Brazilian Indigenous peoples are restricted by various regulations. Therefore, we are not allowed to freely distribute our dataset. Any researcher interested in our dataset must obtain permission from the official regulatory agency, Fundação Nacional do Índio (FUNAI) at https://www.gov.br/funai/pt-br.

Editor's note

The Lancet Group takes a neutral position with respect to territorial claims in published maps and institutional affiliations.

Declaration of interests

All the authors declared no competing interests.

Acknowledgements

The authors thank the Truká Indigenous community for their generously participated in this study. Our sincere thanks also go to the dedicated students and health team for their involvement in the meticulous data collection process. This study was supported by the National Council for Scientific and Technological Development (CNPq)–Ministry of Science, Technology, and Innovation of Brazil, the Maria Emília Foundation, and JBS S.A. through the Oswaldo Cruz Foundation (Fiocruz). ACA has a scientific productivity scholarship grant from CNPq and Fundação de Amparo a Ciência e Tecnologia do Estado de Pernambuco (FACEPE). MBN and CDFS have a scientific productivity scholarship grant from CNPq. RFC has a scientific productivity scholarship grant from FACEPE.

Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2024.100882.

References

1 Kalantar-Zadeh K, Jafar TH, Nitsch D, Neuen BL, Perkovic V. Chronic kidney disease. *Lancet*. 2021;398(10302):786–802. https://doi.org/10.1016/S0140-6736(21)00519-5.
2 KDIGO 2024 clinical practice guideline for the evaluation and management of chronic kidney disease. *Kidney Int*. 2024;105(4S):S117–S314. https://doi.org/10.1016/j.kint.2023.10.018.
3 Huria T, Pitama SG, Beckert L, et al. Reported sources of health inequities in Indigenous Peoples with chronic kidney disease: a systematic review of quantitative studies. *BMC Publ Health*. 2021;21(1):1447. https://doi.org/10.1186/s12889-021-11180-2.
4 Walker RJ, Tafunai M, Krishnan A. Chronic kidney disease in New Zealand Māori and pacific people. *Semin Nephrol*. 2019;39(3):297–299. https://doi.org/10.1016/j.semnephrol.2019.03.001.
5 Harasemiw O, Komenda P, Tangri N. Addressing inequities in kidney care for indigenous people in Canada. *J Am Soc Nephrol*. 2022;33(8):1474–1476. https://doi.org/10.1681/ASN.2022020215.
6 Sabath E. Kidney disease in Latin America: indigenous and immigrants, the forgotten population. *Kidney Int*. 2019;96(4):1038. https://doi.org/10.1016/j.kint.2018.11.049.
7 Gomes OV, Guimarães MP, Nicacio JM, et al. Urbanization and kidney dysfunction in Brazilian indigenous people: a burden for the youth. *Rev Assoc Med Bras*. 2023;69(2):240–245. https://doi.org/10.1590/1806-9282.20220934.
8 Armstrong ADC, de Souza CDF, Santos JMD, et al. Urbanization and cardiovascular health among Indigenous groups in Brazil. *Commun Med*. 2023;3(1):17. https://doi.org/10.1038/s43856-023-00239-3.
9 Lima JFB, Silva RAR, D'Eça Júnior A, Batista RFL, Rolim ILTP. Analysis of the mortality trend in the indigenous population of Brazil, 2000–2016. *Publ Health*. 2020;186:87–94. https://doi.org/10.1016/j.puhe.2020.06.008.
10 Kramer CK, Leitão CB, Viana LV. The impact of urbanisation on the cardiometabolic health of indigenous Brazilian peoples: a systematic review and meta-analysis, and data from the Brazilian health registry. *Lancet*. 2022;400:2074–2083. https://doi.org/10.1016/S0140-6736(22)00625-0.
11 Instituto Brasileiro de Geografia e Estatística (IBGE). *Censo demográfico 2022: indígenas: primeiros resultados do universo*. Rio de Janeiro: IBGE; 2023. Available from: https://biblioteca.ibge.gov.br/visualizacao/livros/liv102018.pdf. Accessed March 2024.
12 Barreto SM, Ladeira RM, Duncan BB, et al. Chronic kidney disease among adult participants of the ELSA-Brasil cohort: association with race and socioeconomic position. *J Epidemiol Community Health*. 2016;70(4):380–389. https://doi.org/10.1136/jech-2015-205834.
13 Nicacio JM, Khouri R, da Silva AML, et al. Anti-chikungunya virus seroprevalence in indigenous groups in the São Francisco valley, Brazil. *PLoS Negl Trop Dis*. 2021;15(6):e0009468. https://doi.org/10.1371/journal.pntd.0009468.
14 Araújo SMS. A região semiárida do nordeste do Brasil: questões ambientais e possibilidades de uso sustentável dos recursos. *Rios Eletrônica-Revista Científica da FASETE*. 2011;5(5):89–98. Available from: https://www.unirios.edu.br/revistarios/media/revistas/2011/5/a_regiao_semiarida_do_nordeste_do_brasil.pdf. Accessed October 2023.
15 World Health Organization (WHO). World health organization: body mass index- BMI. https://www.euro.who.int/en/health-topics/disease-prevention/%0Anutrition/a-healthy-lifestyle/body-mass-index-bmi; 2021. Accessed March 2024.
16 Barroso WKS, Rodrigues CIS, Bortolotto LA, et al. Diretrizes Brasileiras de Hipertensão Arterial–2020. *Arq Bras Cardiol*. 2021;116(3):516–658. https://doi.org/10.36660/abc.20201238.
17 Chaila MZ, Viniegra M, Gagliardino JJ, et al. Glycated hemoglobin measurement: comparison of three methods versus high performance Liquid Chromatography. *J Diabetes Sci Technol*. 2022;16(3):724–731. https://doi.org/10.1177/1932296821997179.
18 Faludi AA, Izar MCO, Saraiva JFK, et al. Atualização da Diretriz Brasileira de Dislipidemias e Prevenção da Aterosclerose—2017. *Arq Bras Cardiol*. 2017;109(2 Supl 1):1–76. https://doi.org/10.5935/abc.20170121.
19 Inker LA, Eneanya ND, Coresh J, et al. New creatinine- and cystatin C-based equations to estimate GFR without race. *N Engl J Med*. 2021;385:1737–1749. http://doi:10.1056/NEJMoa2102953.
20 Gomes OV, de Souza CDF, Nicacio JM, et al. Epidemiology of chronic kidney disease in older indigenous peoples of Brazil: findings from a cross-sectional survey. *Aging Clin Exp Res*. 2023;35(10):2201–2209. https://doi.org/10.1007/s40520-023-02510-y.
21 Monteiro EB, Schröder PW. *Eu já vi água ir embora (...) com natureza não se mexe, (...) eu já vi água ir embora os truká (PE), grandes projetos e o sentido da territorialidade no exercício da cidadania indígena contemporânea. Dissertation (Master's). Postgraduate program in anthropology, federal University of Pernambuco*. Recife; 2008. Available from: https://repositorio.ufpe.br/handle/123456789/496. Accessed October 2023.
22 Gomes OV, Nicacio JM, Guimaraes PM, Morena L, Souza CDF, Armstrong AC. Challenges and opportunities to health promotion education in indigenous communities: an experience report. *Rev Baiana Saúde Pública*. 2023;47:249–260. https://doi.org/10.22278/2318-2660.2023.v47.n3.a3938.
23 Shlipak MG, Tummalapalli SL, Boulware LE, et al. The case for early identification and intervention of chronic kidney disease: conclusions from a Kidney Disease: improving Global Outcomes (KDIGO) Controversies Conference. *Kidney Int*. 2021;99(1):34–47. https://doi.org/10.1016/j.kint.2020.10.012.

24 Lin JJ, Morey F, Wu HY, et al. Prevalence and risk factors for chronic kidney disease in Belize: a population-based survey. *Lancet Reg Health Am*. 2021;1:100013. https://doi.org/10.1016/j.lana.2021.100013.

25 Amaral TLM, Amaral C de A, Vasconcellos MTL de, Monteiro GTR. Prevalence and factors associated to chronic kidney disease in older adults. *Rev Saude Publica*. 2019;53:44. https://doi.org/10.11606/S1518-8787.2019053000727.

26 Malta DC, Bernal RTI, Andrade SSC, Silva MMA da, Velasquez-Melendez G. Prevalence of and factors associated with self-reported high blood pressure in Brazilian adults. *Rev Saude Publica*. 2017;51:11s. https://doi.org/10.1590/S1518-8787.2017051000006.

27 Chagas CA, Castro TG de, Leite MS, et al. Prevalência estimada e fatores associados à hipertensão arterial em indígenas adultos Krenak do Estado de Minas Gerais, Brasil. [Estimated prevalence of hypertension and associated factors in Krenak indigenous adults in the state of Minas Gerais, Brazil]. *Cad Saúde Pública*. 2020;36(1):e00206818. https://doi.org/10.1590/0102-311X00206818.

28 Muzy J, Campos MR, Emmerick I, et al. Prevalence of diabetes mellitus and its complications and characterization of healthcare gaps based on triangulation of studies. *Cad Saúde Pública*. 2021;37(5):e00076120. https://doi.org/10.1590/0102-311X00076120.

29 Benedito JC de S, Medeiros AA, Sá JS de, Teston EF. Diabetes na população indígena adulta brasileira: uma revisão integrativa. [Diabetes in the Brazilian adult indigenous population: an integrative review]. *Multitemas*. 2023;28(69):47–66. https://doi.org/10.20435/multi.v28i69.3917.

30 Brasil. Fundação Nacional de Saúde. *Política Nacional de Atenção à Saúde dos Povos Indígenas*. 2ª ed. Brasília: Ministério da Saúde, Fundação Nacional de Saúde; 2002. Available from: https://bvsms.saude.gov.br/bvs/publicacoes/politica_saude_indigena.pdf. Accessed July 2024.

31 Baldoni NR, Aquino JA, Alves GCS, et al. Prevalence of overweight and obesity in the adult indigenous population in Brazil: a systematic review with meta-analysis. *Diabetes Metab Syndr*. 2019;13(3):1705–1715. https://doi.org/10.1016/j.dsx.2019.03.024.

32 Radicchi MR. Overweight in Sateré-Mawé indigenous residents of an urban area in Parintins, Amazonas. *Rev Nutr*. 2023;36:e220109. https://doi.org/10.1590/1678-9865202336e220109.

33 Coimbra CEA Jr, Tavares FG, Ferreira AA, et al. Socioeconomic determinants of excess weight and obesity among indigenous women: findings from the first national survey of indigenous people's health and nutrition in Brazil. *Public Health Nutr*. 2020;24:1941–1951. https://doi.org/10.1017/S1368980020000610.

34 Ferreira APS, Szwarcwald CL, Damacena GN. Prevalence of obesity and associated factors in the Brazilian population: a study of data from the 2013 National Health Survey. *Rev Bras Epidemiol*. 2019;22:e190024. https://doi.org/10.1590/1980-549720190024.

35 Cha'on U, Tippayawat P, Sae-ung N, et al. High prevalence of chronic kidney disease and its related risk factors in rural areas of Northeast Thailand. *Sci Rep*. 2022;12:18188. https://doi.org/10.1038/s41598-022-22538-w.

36 Holliday MW Jr, Majeti RN, Sheikh-Hamad D. Chronic interstitial nephritis in agricultural communities: observational and mechanistic evidence supporting the role of nephrotoxic agrochemicals. *Clin J Am Soc Nephrol*. 2023;19:538. https://doi.org/10.2215/CJN.0000000000000312.

37 O'Donnell JK, Tobey M, Weiner DE, et al. Prevalence of and risk factors for chronic kidney disease in rural Nicaragua. *Nephrol Dial Transplant*. 2011;26:2798. https://doi.org/10.1093/ndt/gfq385.

38 Orantes CM, Herrera R, Almaguer M, et al. Epidemiology of chronic kidney disease in adults of Salvador an agricultural communities. *MEDICC Rev*. 2014;16(5):23–30. https://doi.org/10.37757/MR2014.V16.N2.

39 Caplin B, Jakobsson K, Glaser J, et al. International collaboration for the epidemiology of eGFR in low- and middle-income populations–rationale and core protocol for the disadvantaged populations eGFR epidemiology study (DEGREE). *BMC Nephrol*. 2017;18(1):1. https://doi.org/10.1186/s12882-016-0417-1.