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Evaluation of renal function in the Brazilian adult population, according to laboratory criteria from the National Health Survey

Avaliação da função renal na população adulta brasileira, segundo critérios laboratoriais da Pesquisa Nacional de Saúde

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ABSTRACT: ***Objective:*** To evaluate the renal function of the Brazilian adult population, according to laboratory criteria of the National Health Survey (*Pesquisa Nacional de Saúde* — PNS). ***Methodology:*** A descriptive study was carried out with laboratory data from the PNS, which was collected between the years 2014 and 2015. Population prevalence of the serum creatinine (CR) and estimated glomerular filtration rate (GFR) according to sociodemographic variables, were analyzed from the PNS laboratory data. ***Results:*** The sample consisted of 8,535 individuals aged 18 years old or older for the study of CR and 7,457 for the study of GFR. The GFR prevalence < 60 mL/min/1.73 m² was 6.7% (95%CI 6.0 – 7.4), higher in women (8.2% 95%CI 7.2 – 9.2) than in men (5.0% 95%CI 4.2 – 6.0) p < 0.001, and in elderly > 60 years old it was 21.4%. For the values of CR ≥ 1.3 mg/dL in men were 5.5% (95%CI 4.6 – 6.5), and in women values of CR ≥ 1.1 mg/dL were 4.6% (95%CI 4.0 – 5.4), with no diference between the genders, p = 0.140. ***Conclusion:*** Results from the PNS laboratory identified a higher prevalence of chronic kidney disease in the Brazilian population than that estimated in self-reported studies, with higher GFR < 60 mL/min/1.73 m² in women, and reaching one fifth of the elderly. These tests may be useful for the purpose of identifying the disease early on and thus preventing the progression of renal damage and reduce the risk of cardiovascular events and mortality.

Keywords: Chronic renal insufficiency. Creatinine. Glomerular filtration rate. Risk factors. Health survey. Noncommunicable diseases.

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RESUMO: ***Objetivo:*** O presente estudo avaliou a função renal da população adulta brasileira, segundo critérios laboratoriais da Pesquisa Nacional de Saúde (PNS). ***Metodologia:*** Estudo descritivo realizado com os dados laboratoriais da PNS, coletados entre os anos de 2014 e 2015. Com base nos dados laboratoriais foram analisadas prevalências populacionais de creatinina sérica (CR) e estimativa da taxa de filtração glomerular (TFG), segundo variáveis sociodemográficas. ***Resultados:*** A amostra foi de 8.535 indivíduos com idade de 18 anos ou mais para o estudo da CR e de 7.457 indivíduos para o estudo de TFG. A prevalência TFG < 60 mL/min/1,73 m² foi de 6,7% (IC95% 6,0 – 7,4), foi mais elevada em mulheres (8,2% IC95% 7,2 – 9,2) do que em homens (5,0% IC95% 4,2 – 6,0) p < 0,001 e em idosos ≥ 60 anos foi de 21,4%. Os valores de CR ≥ 1,3 mg/dL em homens foram 5,5% (IC95% 4,6 – 6,5) e em mulheres foram de CR ≥ 1,1 mg/dL, de 4,6% (IC95% 4,0 – 5,4), sem diferença estatística significativa nos valores de CR entre sexo, p = 0,140. ***Conclusão:*** Resultados laboratoriais da PNS identificaram prevalências mais elevadas da doença renal crônica na população brasileira do que o estimado em estudos autorreferidos. A TFG < 60 mL/min/1,73 m² é mais elevada em mulheres e atinge um quinto dos idosos. Esses exames podem ser úteis no propósito de identificar precocemente a doença e, dessa forma, prevenir a progressão da lesão renal e reduzir o risco de eventos cardiovasculares e de mortalidade.

Palavras-chave: Insuficiência renal crônica. Creatinina. Taxa de filtração glomerular. Fatores de risco. Inquéritos epidemiológicos. Doenças não transmissíveis.

INTRODUCTION

Chronic kidney disease (CKD) is the gradual loss of renal structure and function, resulting in progressive loss of physiological function of the kidneys[1]. The decline in renal function is associated with increased mortality, morbidity, limitations in daily life, physical disability and loss of quality of life[2].

The prevalence of CKD has increased worldwide due to population aging and metabolic risk factors such as hypertension, obesity, diabetes and the use of nephrotoxic agents[3].

Early diagnosis of CKD can be performed through routine laboratory tests such as blood creatinine dosage and glomerular filtration rate[4]. Creatinine is the most commonly used screening test for renal function assessments and is also used to estimate glomerular filtration rates in CKD screenings[5]. It is a residual product of creatine and phosphocreatine metabolism present mainly in skeletal muscles, so people with higher muscle mass tend to have physiologically higher creatinine excretion[6]. This excretion occurs mainly in renal ducts, 85.0% by glomerular filtration and 15.0% by tubular secretion[5]. Due to its availability and low cost, creatinine is the most widespread clinical screening test for renal function assessment.

Glomerular filtration rate (GFR) estimation is commonly used as the standard measure and is an important indicator for the detection, evaluation and prognosis of CKD[7]. The progressive decrease in GFR secondary to irreversible loss of functioning nephrons is manifested at first by a persistent increase in plasma levels of the products that are normally excreted

by the kidneys such as blood urea and creatinine[8]. As the damage progresses, other laboratory alterations and clinical manifestations appear. Progressive deterioration over time produces toxic substance accumulation with a variety of biochemical disorders and multiple symptomatology depending on the stage of CKD[9].

In Brazil, approximately 280 thousand patients registered in dialysis programs in the Unified Health System (Sistema Único de Saúde - SUS) network were identified between 2000 and 2012, which corresponds to 85% of the dialysis performed in the country[10].

CKD was initially monitored in Brazil with self-reported research, such as with the National Household Sample Survey (*Pesquisa Nacional por Amostra de Domicílio* - PNAD) and the National Health Survey (*Pesquisa Nacional de Saúde* - PNS). However, self-reported surveys may cause underreporting of the disease. Thus, the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística* - IBGE) and the Ministry of Health, between 2014 and 2015, added the laboratory component to the PNS, through laboratory creatinine dosage and GFR estimation in the adult population. As such, it is expected to establish population prevalence of CKD, as it is a milestone in the surveillance of the disease in Brazil.

The aim of this study was to analyze the prevalence of chronic kidney disease (CKD) in the Brazilian adult population, according to laboratory criteria from the PNS.

METHODOLOGY

This is a descriptive epidemiological study, using data from PNS laboratory exams from 2014 to 2015. The PNS is a nationwide household-based cross-sectional survey using three-stage probabilistic samples. The primary sampling units (UPAs) were the census tracts or set of sectors, the secondary units, the households, and the tertiary units, the adult residents, aged 18 years or older. Details on the sampling and weighting processes are provided in the publication on the results of PNS[11].

The PNS sample was calculated in 81,254 households, the survey was conducted in 64,348 households, and 60,202 adults were interviewed. The laboratory subsample was defined in 25% of the census tracts, assuming a non-response rate of 20%. The expected number of individuals with laboratory data was 12,000. However, there were several losses in the collection process. Among them, the difficulty of locating the research participants' address and the selected residents' refusal to perform the biological material collection. The laboratory sample consisted of 8,952 people, however due to the loss of biological material and the lack of information such as age, the plasma creatinine values of 8,535 participants and the GFR of 7,457 were obtained.

We considered the sampling process weights, and the post-stratification weights were performed according to gender, age, education and region, in order to correct for possible biases. Thus, the laboratory sample represents the Brazilian adult population. More details of the sampling process can be found in other publications[11,12].

The collection and analysis of the biological material were carried out through a consortium with private laboratories. The laboratories were chosen based on those that met the quality control criteria of the Ministry of Health and those that ensured the compliance with current rules for collection, transport and processing of biological material[12].

Having the data of the household location and the selected individual, the laboratory technician informed the participant about the procedure to be performed. The participant was asked to fill out the Free and Informed Consent Form. After that they were presented with the collection kit and were given guidance on how to receive the report containing the results.

Full details of the laboratory sample collection procedure for testing are available in other publications[12].

To collect creatinine (CR), a sample was collected in a gel tube. Thirty minutes passed until clot retraction, and centrifugation was performed at 3,200 revolutions per minute (RPM) for 12 minutes. The analysis was performed using the Jaffé method without deproteinization. For serum creatinine, the following ranges were adopted: for men (CR): <0.6 mg/dL; 0.6 to <1.3 mg/dL, normal values; ≥ 1.3 to <3 mg/dL, slight change; ≥ 3 to <7 mg/dL, moderate change, and ≥ 7mg/dL, high change, and for women: <0.6 mg dL; 0.6 to <1.1 mg/dL, normal values; ≥ 1.1 to <3 mg/dL, slight change; ≥ 3 to <7 mg/dL, moderate change, and ≥ 7 mg/dL, high change. For the dichotomous analysis, the values ≥ 1.3 mg/dL were considered increased for males and ≥ 1.1 mg/dL were considered increased for females. It is worth noting that there are differences between the cutoffs adopted in several studies[13,14], although there is consensus that CR values are higher among men[13-15]. Higher creatinine reference values among men were also confirmed in another PNS laboratory study[15].

The GFR was calculated based on creatinine, by predictive equations using correction factors (age and gender)[13] and by employing regression techniques to model it in a given population[9]. The GFR (in mL/min/1.73 m^2)[16] was calculated by separate equations for men and women and, according to the following formulas, according to gender:

- If female: (175 * ((1 / serum creatinine result) ^{1,154}) * ((1 / patient's age in years) $^{0.203}$) * 0.742);
- If male: 175 * ((1/serum creatinine result) ^{1,154}) * ((1/ patient's age in years) $^{0.203}$).

For GFR, cutoff points were adopted according to the guidelines of the Chronic Kidney Disease[13]group. A diagnosis of renal insufficiency is considered when GFR is less than 60 mL/min /1.73 m^2, and severe renal insufficiency or renal failure is considered when GFR is less than 15 mL/min/1.73 m^2 [13,14].

- Normal (≥ 90 and <120 mL/min/1.73 m^2);
- Slight decrease in GFR (≥ 60 and <90 mL/min/1.73 m^2);
- Moderate decrease in GFR (≥ 30 and <60 mL/min/1.73 m^2);
- Severe decrease in GFR (≥ 15 and <30 mL/min/1.73 m^2).

The same equation was used for the black population, as has been proposed by most methods[13]. Albuminuria parameters were not considered for the diagnosis of CKD, as it was not collected in the PNS.

In the current study, creatinine and GFR prevalence were stratified by gender, age group (18-29, 30-49, 40-59, 60 years or older), skin color, education, and region.

The data analysis were obtained with the aid of the statistical software Stata, version 14.0. A set of commands for the data analysis of surveys with a complex sample (survey) were used.

The PNS was approved by the National Research Ethics Commission (*Comissão Nacional de Ética em Pesquisa* - CONEP) of the National Health Council (*Conselho Nacional de Saúde* - CNS), of the Ministry of Health. Adult participation in the research was voluntary and confidentiality of their information was guaranteed.

RESULTS

The results were calculated by the stratified formulas according to gender. Table 1 shows the distribution of the different ranges of GFR estimates. GFR ≥120 mL/min/1.73 m² and GFR ≥ 90 and <120 mL/min/1.73 m² showed no difference according to gender, and was higher in the groups aged 18 to 29 years old.

The prevalence found for GFR > 30 to <60 mL/min/1.73 m² was 6.4%, ≥ 15 to <30 mL/min/1.73 m² of 0.1% and <15 mL/min/1.73 m² was 0.2%. GFR values ≥ 30 and <60 mL/min/1.73 m² were higher in women (7.8% 95%CI 6.9 - 8.8) than in men (4.8% 95%CI 4.0 - 5.8), with an increase in the age group 60 years or older (20.8% 95%CI 17.9 - 24.1) and among less educated individuals (9.1% CI95 % 7.9 - 10.4) (Table 1).

Table 2 shows the prevalences of GFR below <60 mL/min/1.73 m². Reduced GFR was higher in women (8.2% 95%CI 7.2 - 9.2) p <0.001, increased with age, was higher in the age group of 60 years or older (21.4% 95%CI 18.4 - 24.7) p <0.001, and had no change according to skin color. The population with a higher level if education had a lower prevalence (4.8% 95%CI 4.0 - 5.7) p <0.001, and was higher among residents of the Northern Region (9.2 95%CI 7.7 - 10.9) p <0.001 (Table 2).

The different creatinine strata are described in Table 3. Creatinine values between 0.6 and <1.3 mg/dL were found in 93.9% of men and between 0.6 and <1.1 mg/dL in 83.9% of women. Altered creatinine in men, CR ≥ 1.3 to <3 mg/dL was 5.3% and in women, CR ≥ 1.1 to <3 mg/dL was 4.4%. Values between CR ≥ 3 to <7 mg/dL and CR ≥ 7 mg/dL were 0.1% in both sexes and strata (Table 3).

Increased creatinine in men (CR ≥ 1.3 mg/dL) was found to be 5.5% 95%CI 4.6 - 6.5, and in women (CR ≥ 1.1 mg/dL), it was found to be 4.6% (95%CI 4 - 5.4). It was higher in the population aged 60 years or older (12.2% 95% CI 10.4 - 14.2), had lower prevalence in the population with an education of 12 years or more (3.8% 95% CI 3.1 - 4.7) and was higher in the Northern Region (8.1% 95%CI 6.8 - 9.7) (Table 4).

Table 1. Glomerular filtration rate according to different cutoff points. Brazil, National Health Survey (PNS), 2014–2015.

		<15 (n = 16)		15 to <30 (n = 11)		30 to <60 (n=567)		60 to <90 (n = 3.725)		90 to <120 (n = 2.564)		≥ 120 (n = 574)		p-value
		%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	
Total		0.2	0.1 (0.4)	0.1	0.0-0.2	6.4	5.7 - 7.1	48.8	47.3 - 50.4	36.8	35.3 - 8.4	7.7	6.9 - 8.5	
Gender	Male	0.1	0.1-0.3	0.0	0.0-0.1	4.8	4.0-5.8	48.0	47.3 - 50.4	40.3	37.9 - 42.7	6.7	5.6-8.0	<0.001
	Female	0.2	0.1-0.5	0.2	0.1-0.4	7.8	6.9 - 8.5	49.6	47.6 – 51.5	33.7	31.9 – 35.6	8.5	7.5 – 9.8	
Age (years)	18 to 29	0.2	0.1 – 0.7	0.1	0.0 – 0.8	1.3	0.8 – 2.1	28.7	25.8 – 31.9	54.5	51.2 – 57.8	15.1	13.0 – 17.5	< 0.001
	30 to 44	0.2	0.1 – 0.6	0.0	0.0 – 0.1	3.1	2.4 – 4.0	50.4	47.8 – 52.9	39.6	37.1 – 42.1	6.7	5.6 – 8.0	
	45 to 59	0.1	0.0 – 0.3	0.1	0.0 – 0.2	9.4	8.0 – 11.0	61.7	59.1 – 64.3	24.9	22.6 – 27.4	3.8	2.8 – 5.0	
	≥ 60	0.2	0.0 – 1.2	0.4	0.2 – 0.9	20.8	17.9 – 24.1	62.6	58.8 – 66.3	14.4	11.9 – 17.4	1.5	0.9 – 2.5	
Education (years)	0 to 8	0.3	0.1 – 0.7	0.1	0.1 – 0.3	9.1	7.9 – 10.4	52.3	50.0 – 54.6	31.0	28.9 – 33.2	7.2	6.0 – 8.5	< 0.001
	9 to 11	0.3	0.1 – 1.1	0.3	0.1 – 1.2	5.2	4.0 – 6.8	42.9	39.1 – 46.8	40.6	36.8 – 44.5	10.8	8.7 – 13.3	
	≥ 12	0.1	0.0 – 0.3	0.0	0.0 – 0.1	4.7	3.9 – 5.6	48.3	45.9 – 50.6	40.0	37.7 – 42.4	7.0	5.8 – 8.2	
Skin color	White	0.1	0.0 – 0.4	0.0	0.0 – 0.1	6.4	5.4 – 7.5	50.2	47.8 – 52.6	36.3	33.9 – 38.8	7.0	5.8 – 8.4	0.1
	Dark-skinned black	0.4	0.1 – 1.5	0.3	0.0 – 2.4	6.7	4.7 – 9.5	53.7	48.6 – 58.7	31.2	26.6 – 36.2	7.7	5.4 – 10.8	
	Light-skinned black	0.3	0.1 – 0.6	0.1	0.1 – 0.3	6.3	5.5 – 7.2	46.3	44.2 – 48.4	38.8	36.7 – 40.9	8.3	7.2 – 9.5	
	Other	0.0	-	0.0	0.0 – 0.0	8.0	2.3 – 24.2	51.7	37.9 – 65.2	31.1	20.7 – 43.8	9.2	4.7 – 17.2	
Region	North	1.1	0.4 – 2.8	0.2	0.1 – 0.6	7.9	6.7 – 9.2	46.5	44.1 – 48.9	34.8	32.5 – 37.2	9.5	8.1 – 11.1	< 0.001
	Northeast	0.1	0.1 – 0.4	0.1	0.0 – 0.3	5.5	4.7 – 6.4	44.1	42.1 – 46.0	39.8	37.8 – 41.8	10.4	9.2 – 11.8	
	Southeast	0.2	0.1 – 0.5	0.1	0.0 – 0.6	5.7	4.6 – 7.1	50.1	47.1 – 53.2	37.2	34.2 – 40.2	6.8	5.3 – 8.5	
	South	0.0	-	0.1	0.0 – 0.5	8.4	6.8 – 10.3	54.7	51.2 – 58.2	32.0	28.6 – 35.5	4.9	3.4 – 7.0	
	Midwest	0.1	0.0-0.4	0.2	0.0-0.7	7.6	6.0-9.5	49.0	45.5-52.6	36.4	33.0-40.0	6.7	5.1-8.9	

Table 2. Glomerular filtration rate < 60 mL/min/1.73 m^2, according to gender. Brazil, National Health Survey (PNS), 2014–2015.

TFG < 60 mL/min/1,73 m^2		Total (n = 7,457)			Male (n = 3,114)			Female (n = 4,343)		
		%	95%CI	p-value	%	95%CI	p-value	%	95%CI	p-value
Total		6.7	6.0 – 7.4		5.0	4.2 – 6.0		8.2	7.2 – 9.2	< 0.001
Age (years)	18 to 29	1.6	1.0 – 2.6	< 0.001	0.7	0.3 – 1.7	< 0.001	2.6	1.5 – 4.3	< 0.001
	30 to 44	3.4	2.7 – 4.3		2.7	1.8 – 4.1		4.0	3.0 – 5.2	
	45 to 59	9.6	8.2 – 11.2		7.9	6.0 – 10.3		11.1	9.1 – 13.5	
	≥ 60	21.4	18.4 – 24.7		16.7	12.7 – 21.7		25.0	20.9 – 29.6	
Education (years)	0 to 8	9.6	8.4 – 10.9	< 0.001	7.0	5.5 – 8.8	< 0.001	12.1	10.3 – 14.1	< 0.001
	9 to 11	5.8	4.4 – 7.5		4.2	2.7 – 6.7		7.4	5.4 – 10.1	
	≥ 12	4.8	4.0 – 5.7		3.7	2.7 – 5.1		5.7	4.5 – 7.1	
Skin color	White	6.5	5.5 – 7.6	0.9	5.0	3.7 – 6.6	0.6	7.8	6.4 – 9.5	0.6
	Dark-skinned black	7.4	5.3 – 10.3		4.8	2.8 – 8.3		9.8	6.5 – 14.6	
	Light-skinned black	6.7	5.8 – 7.6		5.2	4.1 – 6.6		8.1	6.9 – 9.5	
	Other	8.0	2.3 – 24.2		0.2	0.0 – 1.4		13.0	3.8 – 36.4	
Region	North	9.2	7.7 – 10.9	< 0.001	6.1	4.6 – 8.0	0.3	12.0	9.7 – 14.8	< 0.001
	Northeast	5.8	4.9 – 6.7		4.5	3.4 – 6.0		6.8	5.7 – 8.2	
	Southeast	5.9	4.8 – 7.3		4.5	3.2 – 6.4		7.2	5.5 – 9.4	
	South	8.4	6.8 – 10.4		6.7	4.6 – 9.7		10.1	7.9 – 12.8	
	Midwest	7.8	6.2 – 9.8		4.8	3.0 – 7.5		10.6	8.2 – 13.6	

Table 3. Plasma creatinine values, according to sociodemographic variables. Brazil, National Health Survey (PNS), 2014–2015.

Creatinina		< 0.6 (n = 528)		0.6 a < 1.3 men | 0.6 to < 1.1 women (n = 7,511)		1.3 to < 3 men | 1.1 to < 3 women (n = 474)		3 a < 7 (n = 12)		≥ 7 (n = 10)		p-value
		%	95%CI	%	95%CI	%	95%CI	%	95%CI	%	95%CI	
Gender	Male	0.6	0.4 – 0.9	93.9	92.9 – 94.8	5.3	4.5 – 6.3	0.1	0.0 – 0.3	0.1	0.0 – 0.3	< 0.001
	Female	10.2	9.1 – 11.4	85.2	83.9 – 86.5	4.4	3.7 – 5.1	0.2	0.1 – 0.5	0.1	0.0 – 0.2	
Age (years)	18 to 29	7.1	5.7 – 8.7	89.8	87.8 – 91.4	3.0	2.0 – 4.4	0.1	0.0 – 0.7	0.1	0.0 – 0.4	< 0.001
	30 to 44	6.5	5.4 – 7.8	90.8	89.3 – 92.0	2.5	1.9 – 3.3	0.2	0.1 – 0.6	0.1	0.0 – 0.2	
	45 to 59	5.1	4.1 – 6.4	90.3	88.8 – 91.7	4.4	3.5 – 5.5	0.1	0.0 – 0.4	0.0	0.0 – 0.2	
	≥ 60	3.0	2.1 – 4.1	84.8	82.6 – 86.8	11.9	10.1 – 13.9	0.2	0.1 – 0.6	0.1	0.0 – 0.7	
Education	0 to 8	5.6	4.7 – 6.5	87.9	86.6 – 89.1	6.2	5.3 – 7.2	0.3	0.1 – 0.6	0.1	0.0 – 0.3	< 0.001
	9 to 11	7.3	5.5 – 9.5	87.9	85.3 – 90.1	4.6	3.3 – 6.3	0.2	0.0 – 1.1	0.1	0.0 – 0.3	
	≥ 12	5.2	4.3 – 6.2	91.0	89.7 – 92.1	3.7	3.0 – 4.6	0.0	0.0 – 0.1	0.1	0.0 – 0.2	
Skin color	White	5.4	4.4 – 6.5	89.9	88.6 – 91.1	4.6	3.9 – 5.5	0.1	0.0 – 0.4	0.0	0.0 – 0.1	0.6345
	Dark-skinned black	5.2	3.7 – 7.2	89.1	86.1 – 91.5	5.2	3.5 – 7.6	0.4	0.1 – 1.6	0.1	0.0 – 0.8	
	Light-skinned black	6.1	5.3 – 7.0	88.7	87.5 – 89.9	4.9	4.1 – 5.8	0.2	0.1 – 0.5	0.1	0.1 – 0.3	
	Other	7.5	2.5 – 20.5	85.0	69.6 – 93.3	7.5	2.1 – 23.6	0.0	0.0 – 0.0	0.0	0.0 – 0.0	
Region	North	6.2	5.3 – 7.4	85.6	83.8 – 87.3	7.1	6.0 – 8.3	0.5	0.1 – 2.1	0.6	0.2 – 1.6	< 0.001
	Northeast	7.0	6.1 – 8	88.3	87.1 – 89.5	4.5	3.8 – 5.3	0.1	0.0 – 0.3	0.1	0.0 – 0.3	
	Southeast	5.7	4.6 – 7.1	89.9	88.2 – 91.4	4.2	3.2 – 5.3	0.2	0.1 – 0.5	0.0	0.0 – 0.3	
	South	2.9	2.0 – 4.1	90.7	88.8 – 92.4	6.3	5.0 – 8.1	0.0	0.0 – 0.0	0.0	0.0 – 0.0	
	Midwest	5.4	4.1 – 7.1	89.8	87.7 – 91.6	4.6	3.4 – 6.2	0.2	0.0 – 0.7	0.1	0.0 – 0.4	

Table 4. Frequency of creatinine values ≥ 1.3 mg/dl for males and ≥ 1.1 mg/dl for females, Brazil, National Health Survey (PNS), 2014-2015.

	Total (n = 8532)			Male (n = 3,550)			Female (n = 4,982)		
	%	95%CI	p-value	%	95%CI	p-value	%	95%CI	p-value
Total	5.0	4.5 – 5.6		5.5	4.6 – 6.5		4.6	4 – 5.4	0.140
Age range									
18 to 29	3.2	2.2 – 4.6	< 0.001	3.4	1.9 – 5.9	< 0.001	3.0	1.9 – 4.8	< 0.001
30 to 44	2.8	2.1 – 3.6		3.1	2.1 – 4.4		2.5	1.7 – 3.5	
45 to 59	4.6	3.7 – 5.7		5.2	3.8 – 7.0		4.0	2.9 – 5.4	
≥ 60	12.2	10.4 – 14.2		13.8	10.9 – 17.3		11.0	8.8 – 13.5	
Education (years)									
0 to 8	6.5	5.6 – 7.6	< 0.001	7.1	5.7 – 8.8	< 0.001	6.0	4.9 – 7.4	0.004
9 a 11	4.8	3.5 – 6.6		4.7	2.8 – 7.7		5.0	3.4 – 7.3	
≥ 12	3.8	3.1 – 4.7		4.4	3.2 – 5.9		3.4	2.6 – 4.5	
Skin color									
White	4.7	3.9 – 5.6	0.657	5.1	3.9 – 6.6	0.6	4.4	3.5 – 5.6	0.4853
Dark-skinned black	5.7	4 – 8.2		5.1	3.0 – 8.5		6.3	3.8 – 10.3	
Light-skinned black	5.2	4.4 – 6.1		5.9	4.7 – 7.5		4.5	3.7 – 5.6	
Other	7.5	2.1 – 23.6		12.2	1.9 – 49.8		4.5	1.5 – 12.6	
Region									
North	8.1	6.8 – 9.7	0.002	8.4	6.6 – 10.5	< 0.001	7.9	6 – 10.4	0.0277
Northeast	4.7	3.9 – 5.5		4.8	3.7 – 6.1		4.6	3.7 – 5.7	
Southeast	4.4	3.4 – 5.6		5.0	3.5 – 7.0		3.8	2.7 – 5.3	
South	6.3	5 – 8.1		7.6	5.4 – 10.6		5.2	3.7 – 7.3	
Midwest	4.8	3.6 – 6.4		4.1	2.6 – 6.5		5.5	3.8 – 7.8	

DISCUSSION

This is the first national study to present a renal function assessment using laboratory criteria for the Brazilian adult population. The estimates given here were up to four times higher compared to the self-reported studies, suggesting the under-diagnosis of CKD in the country. The prevalence of GFR <60 was 6.7%, and was higher in women, the elderly and individuals with lower levels of education. Increased creatinine values were found in 5.0%

of the population and were higher in the elderly, in people with low levels of education, and people living in the Northern Region. The study is innovative in that it uses equations that do not increase GFR among black people, so there was no difference in the prevalence of CKD between white and black people.

Age is an important factor in increased CKD. US survey data from the National Health and Nutrition Examination Surveys (NHANES)[17] show a gradual increase, rising from 6.6% in the 20 to 39 age group, to 10.6% in individuals aged 40 to 59, and increasing of 32.6% in those 60 and older, increasing Medicare health spending[18]. Reduction in GFR is expected with increasing age as a function of physiological aging, in which renal blood flow decreases and glomerular membrane permeability increases[19,20]. Among the main causes for reduced renal function in the elderly are systemic arterial hypertension, smoking exposure, dyslipidemia, obesity, and polypharmacy[21]. Possible overestimation of the prevalence of CKD in the elderly has been discussed in the literature, and some studies suggest that a lower cutoff point should be adopted for the classification of CKD in this population.

The literature also indicates that male sex are more associated with loss of renal function, with lower GFR[21,24,25], differing from the current study, which identified a higher prevalence in women.

Creatine metabolism, creatinine metabolite, originates mainly from skeletal muscle, and because men have higher muscle mass, they tend to have higher physiological CR values[6]. This origin explains why creatinine reference values within the normal range are higher in men (0.8 - 1.3 mg/dL) than in women (0.6 - 1.0 mg/dL)[6]. Thus, cutoff points and GFR estimation equations were different considering gender and age differences[13].

Studies from the NHANES found a higher prevalence of CKD in African Americans (16.9%) than in white Americans (15.2%)[17,18]. However, these results differ from the current study, which did not identify differences according to skin color. The Brazilian Longitudinal Study of Adult Health (Elsa Brazil) used similar equations for whites and blacks, which is more adequate for the reality of the country and, after these adjustments, found no differences due to skin color[14]. A cross-sectional study in Rio de Janeiro also did not apply the 20% correction in GFR, and similarly there were no differences between blacks and whites in CKD prevalence[8]. In light of these results, we strongly suggest revising these equations to estimate GFR, regarding the correction factor according to skin color.

The GFR increased in individuals with lower levels of education, proxy of socioeconomic status, due to greater difficulty in accessing health systems and diagnoses and due to inadequate control of the disease[26]. A study that analyzed the socioeconomic profile of patients with CKD found that patients on hemodialysis had significantly lower levels of education[26]. Another study found that 3.2% of CKD patients were not literate and 34.9% had not completed elementary school[27]. In addition, low levels of education can interfere in the adherence and access to proper treatment, as well as quality of life, since it compromises access to health information and represents difficulties in understanding guidelines provided by health professionals[28]. In the Elsa Brazil study, the prevalence of

CKD also increased in those with primary and secondary education when compared with those with higher levels of education[14].

The literature indicates that creatinine has been the most widespread screening test in clinical practice, due to its availability and low cost[5,29]. The authors suggest that serum creatinine dosage enables the calculation of endogenous glomerular filtration and/or renal clearance. However, its use may be a late parameter in detecting impaired renal function, since the change occurs after the patient loses about 50 to 60% of GFR. Therefore, CKD may be under-diagnosed when using only creatinine as a parameter for the disease. There are other markers such as cystatin, inulin among others, which would be more specific, though more expensive and not used in clinical practice[30].

Limitations of the study include the use of serum creatinine to estimate GFR and the fact that other tests, such as albuminuria, which is included in the laboratory classification criteria for CKD, were not considered, which may have underestimated the prevalence found in this study. There are different equations for GFR, and there may be large variations in estimates depending on the method employed, which may change the sensitivity and specificity of the test.

CONCLUSION

The present study evaluated renal function in the Brazilian population through serum creatinine and GFR, analyzing laboratory data from the PNS. The biochemical data analyzed here indicate higher population prevalence when compared to surveys using self-reported questions from previous medical diagnoses. The GFR <60 was higher in the elderly, in women, and in less educated populations. The study points out that there was no difference according to skin color and suggests a review of the equations that estimate GFR according to this parameter, confirming that the 20% increase in GFR calculation among black people should not be included to the formula. The equation in the form as it has been used may underestimate the diagnosis of CKD among black people, delaying the diagnosis of declining renal function among them.

The PNS was a landmark in surveillance by including laboratory tests and estimating underreporting of CKD in the Brazilian population. CKD is considered a public health problem, with an important impact on morbidity and mortality and loss of quality of life. CKD surveillance, including monitoring of population and patient epidemiological data, can improve care planning as well as treatment effectiveness, and thus, can support coping with this problem. The higher prevalence of CKD in the elderly demonstrates the need for an early diagnosis, especially in at-risk groups. The use of measures of creatinine and GFR may be useful in the early identification of the disease, which can thus prevent the progression of renal damage and reduce the risk of cardiovascular events and mortality.

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