Temporal trend of mortality and hospitalization for chronic kidney disease in adults from Northern Brazil

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Abstract
We aimed to evaluate mortality and hospital admissions for chronic kidney disease in young adults according to sex and state in the northern region of Brazil, between 1996 and 2017. A population-based time series study using official data on mortality and hospital admissions due to chronic kidney disease in individuals aged 20 to 49 years old, residents of the northern region of Brazil, in the periods 1996–2017 and to 2008–2017, respectively. Chronic kidney disease was defined according to the International Classification of Diseases, 10th revision (N18).

The evolution of mortality from chronic kidney disease decreased by 0.881% per year over the period (1996–2017). In the states of Acre and Amapá, there was a reduction of 5.85% and –5.68% per year, respectively, and in Tocantins, an increase of 4.16% per year. The incidence of hospitalization did not vary between 2008 and 2017. However, 2 states showed an increase in hospitalization rates: Acre (6.08% per year) and Pará (2.83% per year), and 2 states showed a reduction: Amazonas (5.09% per year) and Tocantins (6.23% per year).

In general, there was a decrease in mortality rate overtime. However, rate of mortality due to chronic kidney disease increased in the state of Tocantins. The evolution of hospitalization due to chronic kidney disease in a population of young adults remained stationary.

Abbreviations: AHI = hospital admission authorization, APC = annual percent change, CKD = chronic kidney disease, DALY = disability-adjusted life years, DATASUS = information technology department of the national health system, ECKD = end-stage chronic kidney disease, GFR = glomerular filtration rate, IBGE = Brazilian Institute of Geography and Statistics, NCDs = chronic non-communicable diseases, RI = renal failure, RRT = renal replacement therapy, SIH/SUS = Hospital Information System of the Unified Health System, SIM = Mortality Information System, SUS = Unified Health System.

Keywords: chronic kidney disease, hospitalization, mortality, risk factors

1. Introduction
Chronic kidney disease (CKD) currently represents one of the biggest and most relevant public health problems in Brazil and worldwide, with a magnitude that varies from region to region.[1,2] Current international guidelines define CKD as decreased renal function shown by a glomerular filtration rate (GFR) of <60 ml/min per 1.73 m².[3] Decreased kidney function is a predictor of hospitalization, cognitive dysfunction, and poor quality of life[4] and can occur at any stage of the disease, regardless of age, generating a high socioeconomic cost for institutions because of the need for disease management.[5] The frequent adverse clinical effects of the disease are associated with a higher risk of individual mortality.[6]

In the most recent update of the Global Burden of Disease Study, the total disability-adjusted life years (DALY) of the CKD has increased significantly from 29.2 thousand to 35.0 thousand in the last decade, which exceeded many neurological disorders, including dementia and Parkinson disease, as well as chronic liver diseases.[7] The main occurrences of hospitalization often coexist with other chronic diseases, such as diabetes and hypertension, which can further limit the functional capacity of individuals,[8,9] impairing quality of life. Cardiovascular diseases are often associated with CKD, which
is of great importance when considering that these patients are more likely to die from cardiovascular disease than to progress to renal failure.[8]

Allied to these clinical conditions, there are psychosocial repercussions that are stressful for patients, impacting their quality of life. In the United States, in a cross-sectional survey of younger adults (20–64 years), the prevalence of self-reported difficulty in activities of daily living was significantly higher in patients with CKD than in those without CKD, after adjustment for age and sex.[10] Once diagnosed with CKD, patients acquire a pattern of expectations and desires related to the exponential impact of the disease on their personal and professional lives, caused by complex therapeutic regimes and changes in their daily lives, requiring adaptation and coping with the disease and/or treatment dialysis.[11]

In most cases, the development of the disease in young adults can have a favorable prognosis when performed early. However, symptoms may be underestimated, allowing for persistent kidney damage and a potential increase in the chronicity of the disease in adulthood.[12] Renal replacement therapy (RRT) is the only way to sustain life in the advanced stages of the disease. RRT options include hemodialysis, peritoneal dialysis, and kidney transplantation. However, more than two-thirds of patients with the disease die without starting therapy, and of those who start, only one-third survive for more than 5 years.[13] Currently, 2.5 million patients receive kidney transplant therapy, and this is expected to increase to 5.4 million by 2030.[14,15,16]

Worldwide, between 1990 and 2017, CKD health indicators showed a dismal profile: the mortality rate, incidence, and rate of kidney transplantation increased by 2.8%, 29.3%, and 34.4%, respectively.[14] The disease led to 1.2 million deaths in 2017, and, at best, an increase of 2.2 million deaths was projected[17] and will become the fifth largest cause of years of life lost by 2040.[18]

Wide variations between regions and countries were also observed in deaths from CKD; in central Latin America, central Asia, and high-income North America, mortality from CKD increased by approximately 60%. In Central and Andean Latin America, CKD was the second- and fifth-ranked cause of death in 2017, respectively. Overall, these data clearly confirm that low- and middle-income countries increasingly carry the global burden of disease. Middle sociodemographic level,[14,19] In countries with limited resources, there is a need to optimize screening strategies for diseases that often challenge health systems.[20]

In Brazil, it is estimated that more than 10 million people have some degree of renal impairment, aggravating the fact that it is a disease unknown to many people, increasing the possibility of late diagnosis, with consequent abandonment of treatment. Census data from the Brazilian Society of Nephrology indicated that, in 2019, 45,852 individuals were on renal replacement therapy, an increase of 2.2 million deaths was projected[17] and will become the fifth largest cause of years of life lost by 2040.[18]

2. Methods

2.1. Design, study site, and period

This is an ecological time series study using secondary and official data on deaths and hospital admissions due to chronic kidney disease from the Mortality Information System (SIM) and the Hospital Information System of the Unified Health System (SIH/SUS). These indicators were evaluated based on data from the northern region of Brazil, which comprises the states of Acre, Amazonas, Pará, Rondônia, Roraima, and Tocantins. Data on deaths corresponded to the period between 1996 and 2017 and those on hospital admissions to the period between 2008 and 2017. Regarding hospitalizations for CKD, due to database restrictions, it was only possible to compile the data from 2008 onwards. In the latter case, the information referred to the period from January 2008, when the Table of Procedures, Medicines, Orthotics and Prostheses, and Special Materials of the Unified Health System (SUS) was implemented, established by Ordinance GM/MS n. 321, on February 8, 2007. This system provides information available on the website of the SUS IT Department (DATASUS), maintained by the Ministry of Health of Brazil.

2.2. Study population and sample

All deaths and hospitalizations in young adults were considered, defined by individuals with an age cutoff point of 20 to 49 years.[21] Thus, gross and standardized rates of mortality and incidence of hospital admissions due to chronic kidney disease in the North Region, by age group, using the World Health Organization standard population for 2000–2025, were presented.

Data were collected by the place of residence of the deaths. The units of analysis selected for this study were the states of the northern region of Brazil, which have a high degree of urbanization, with an estimated population of 7091,286 million individuals aged 20–49 years.[22]

Population data were extracted from databases made available by the Brazilian Institute of Geography and Statistics (IBGE) and were obtained from the demographic census carried out in 2010 and inter-census estimates for other years.

All deaths that occurred between 1996 and 2017, whose underlying cause was chronic kidney disease, according to the 10th Revision of the International Classification of Diseases (ICD-10) code N18, were included. The age group of the study subjects was 20 to 49 years old, defined as young adults with noncommunicable chronic diseases.[23]

Data on deaths from CKD were collected using for the total population and stratified according to age groups (20–24; 25–29; 30–34; 35–39; 40–44; 45–49 years), states in the North
region, gender (male and female) and calendar years (from 1996 to 2017), available in the DATASUS database.

2.3. Information system

SIM receives, processes, checks the validity, and provides information on deaths, which comprises 96.1% of all deaths registered in Brazil.\textsuperscript{34} Data on deaths are available on the website of the Information Technology Department of the National Health System (DATASUS), the country’s official, free, and public database of health information, where information on deaths from chronic kidney disease used in these data was collected. It is noteworthy that such a system is used to develop public policies in the country.

Data on admissions were obtained from the SUS Hospital Information System (SIH/SUS). These are information from public hospitals and SUS network hospitals that send information on admissions by hospital admission authorization (AIH) to municipal and state managers. AIHs are processed by DATASUS, and their data are made available for public consultation on the Internet.

2.4. Study variables and data extraction

The mortality and hospital admission rates were constructed according to the distribution according to sex (male and female), age group (20–24, 25–29, 30–34, 35–39, 40–44, 45–49 years old) year (1996–2017 and 2008–2017, respectively), expressed per 100,000 inhabitants, in crude and standardized form. For the standardization procedure, performed by age, the direct method was used, and the percentage distribution of the world population provided by the World Health Organization between 2000 and 2025 was considered as the standard. All these data were extracted and merged into the TabNet program to create a DBF database.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|}
\hline
Demographic and clinical characteristics & Deaths 1996–2017 & Deaths % 1996–2017 & Annual mortality 1996–2017 \\
\hline
\textbf{TOTAL} & 1259 & 100\% & 0.9 \\

\textbf{Sex} & & & \\
Male & 689 & 54.7 & 1.0 \\
Female & 570 & 45.3 & 0.9 \\

\textbf{Age group (yr)} & & & \\
20–24 & 117 & 9.3 & 0.4 \\
25–29 & 127 & 10.1 & 0.5 \\
30–34 & 163 & 12.9 & 0.7 \\
35–39 & 210 & 16.7 & 1.0 \\
40–44 & 266 & 21.1 & 1.6 \\
45–49 & 376 & 29.9 & 2.8 \\

\textbf{States} & & & \\
Acre (AC) & 42 & 3.3 & 0.8 \\
Amapá (AP) & 53 & 4.2 & 1.1 \\
Amazonas (AM) & 292 & 23.2 & 1.0 \\
Pará (PA) & 580 & 46.1 & 0.9 \\
Rondônia (RO) & 158 & 12.5 & 1.0 \\
Roraima (RR) & 58 & 4.6 & 1.6 \\
Tocantins (TO) & 76 & 6.0 & 0.6 \\

\textbf{Skin color} & & & \\
White & 169 & 13.4 & – \\
Black & 119 & 9.5 & – \\
Yellow & 5 & 0.4 & – \\
Mixed & 752 & 59.7 & – \\
Indigenous & 22 & 1.7 & – \\
Ignored & 192 & 15.3 & – \\

\textbf{Marital status} & & & \\
Single & 44 & 51.1 & – \\
Married & 16 & 29.3 & – \\
Widow/widower & 1 & 1.2 & – \\
Legally separated & 1 & 1.7 & – \\
Other & 8 & 6.4 & – \\
Ignored & 3 & 10.2 & – \\

\textbf{Education} & & & \\
Non & 157 & 12.5 & – \\
1–3 years & 210 & 16.7 & – \\
4–7 years & 260 & 20.7 & – \\
8–11 years & 191 & 15.2 & – \\
12 years or more & 46 & 3.7 & – \\
Ignored & 377 & 29.9 & – \\

\textbf{Place of occurrence} & & & \\
Hospital & 1103 & 87.6 & – \\
Other health establishment & 23 & 1.8 & – \\
Home & 95 & 7.5 & – \\
Public highway & 15 & 1.2 & – \\
Others & 21 & 1.7 & – \\
Ignored & 2 & 0.2 & – \\
\hline
\end{tabular}
\caption{Mortality due to CKD (100,000 inhabitants), in individuals aged 20–49 years, according to demographic and clinical characteristics = North Region, Brazil, 1996–2017.}
\end{table}

Chronic Kidney Disease (CKD).

Source: Sistema de Informações sobre Mortalidade (SIM). Dados do Departamento de Informática do Sistema Unico de Saúde (DATASUS – www.datasus.gov.br), Ministerio da Saúde, Brasil.
2.5. Statistical analysis

Population mortality rates were calculated and stratified by sex, age groups, and states, expressed per 100,000 inhabitants. This procedure ensured sufficient cases and the stability of the analyses.

In the time series, which is a set of observations made in sequence over time, where the analyzed times were placed in order, which was fundamental for the final analysis, thus following the methodological indications presented by [35] were used. The time series was constructed using the Prais-Winsten regression model, which allows for first-order autocorrelation correction in the analysis of a series of values organized in time. Thus, the angular coefficient ($\beta$) and probability (p) were estimated, considering a significance level of 95%.

The modeling process included transforming the rates into a logarithmic function of the base 10. In addition, the Durbin-Watson test was used, and the annual growth or decline rates were calculated according to the values of the annual percent change specific by sex and states in the northern region of Brazil. This procedure made it possible to classify the temporal trends as increasing, decreasing, or stationary, in addition to quantifying the annual increment. In addition, we used the technique of central moving averages of order 3 to facilitate the visualization of mortality trends and reduce white noise in the graphs of the historical series. All analyses were performed using the Stata 15.1 statistical program (CollegeStation, TX).

2.6. Ethical and legal aspects of research

This study involved only the description and analysis of secondary population data (general population census) and deaths collected in the Information System on Mortality and hospital admissions of the SIH/SUS. All these sources of information are in the public domain. No additional information, which was not freely accessible, was collected. Individual identification information was not obtained in this study. This study did not require approval from the Research Ethics Committee (CEP) of Brazil.

3. Results

Regarding deaths (Table 1), 1259 deaths due to chronic kidney disease were reported in individuals aged 20—9 years (young adults) living in the northern region of Brazil during the study period (1996–2017). Most deaths occurred among men (54.7%), but the mortality rate was very similar between men and women. The proportion of deaths and mortality rates increased with age. The oldest age group (40–49 years old) in the study had a higher relative frequency of deaths (29.9%) and a higher mortality rate (2.8 deaths per 100,000 inhabitants per year). The states with the highest number of deaths were Pará and Amazonas (46.1% and 23.2%, respectively). The highest mortality rate in the period occurred in Roraima and the lowest in Tocantins, with 1.6 and 0.6 deaths per 100,000 inhabitants per year.

According to the demographic characteristics (Table 1), the predominance of deaths was identified in brown-skinned people (59.7%), single (51.1%), without education or with up to 7 years of study (49.9%). More deaths occurred in hospitals (87.7%).

The temporal evolution of the annual mortality rate due to general CKD, stratified by sex, is shown in Figure 1. Considering both sexes, in the period 1996 to 2017, there was a reduction of 0.88% per year in mortality among young adults in the northern region of Brazil.

Regarding the specific curves for each sex (Fig. 1), it was noted that in the first 2 years mortality among women was higher than that among men. From 1998 onwards, this relationship was inverted, and the mortality rate for men increased and remained the same until the end of the time series. Mortality in the female population decreased over time, reaching its lowest value in the last year of the series. Mortality in the male population mortality in the period oscillated in increasing and decreasing intervals, closing in the last year at a higher value than at the beginning of the series. The decrease in the female mortality rate occurred at a rate of −1.86% per year during the study period. In men, there were no statistically significant variations.

When analyzing the annual percentage change in mortality from CKD for young adults in the states of the North Region of Brazil, a stationary trend of the rate was noted in Amazonas, Rondônia, Roraima, and Pará. In Acre and Amapá, there was a reduction in mortality (~5.86% and ~5.68% per year). In the state of Tocantins, there was an increase in mortality of 4.16% per year (Table 2).

The states of Acre, Amapá, and Tocantins stood out for their high mortality rates due to kidney disease. However, over the years, Acre and Amapá have declined. In contrast, the state of Tocantins showed an increasing trend over the years, surpassing Acre and Amapá in terms of mortality (Fig. 2).
From 2008 to 2017 (Table 3), there were 16,749 hospitalizations of young adults in the northern region of Brazil, corresponding to an average annual incidence of 22.9 hospitalizations per 100,000 inhabitants. The proportion and incidence of hospitalizations were similar for men and women and increased with age. Hospitalization in the last age group (from 40 to 49 years old) was the most frequent (24.7%) and the most incident (53.1 admissions per 100,000 inhabitants per year). The states with the highest proportion of hospitalizations were Pará and Amazonas (43.5% and 18.5%, respectively). The highest incidences of hospitalization occurred in Acre, Tocantins, and Roraima (44.0, 33.1, and 28.2 admissions per 100,000 inhabitants per year). The other states had an incidence of hospitalization close to 20 admissions per 100,000 inhabitants per year.

According to demographic characteristics (Table 3), there was a predominance of hospitalizations in people with mixed skin color (60.3%). Most patients were on an emergency basis (78.2%). The average hospital stay was 11.8 days for men and 12.9 days for women. In 8.5% (1433) of admissions, death occurred in the hospital. Despite the stability of hospitalization incidences for the Northern Region over the period studied, there was a temporal variation of this parameter in some states when analyzed separately (Fig. 3). There was no increase or reduction in hospitalization rates in only 2 states (Amapá and Rondônia). Two others showed an increase in hospitalization rates during the study period: Acre (6.08% per year) and Pará (2.83% per year). Two states showed a reduction in hospitalization rates between 2008 and 2017: Amazonas (5.09% per year) and Tocantins (6.23% per year). The temporal trends of hospitalizations in the 5 mentioned, with an increase or decrease over the period, are shown in Figure 3. In the graph, it is highlighted that in all states, the variations occurred with greater intensity from 2010 onwards.

In Figure 3, during the period 2008–2017, the states of Acre and Pará showed an increasing incidence of hospitalization, unlike the states of Amazonas and Tocantins, which showed a reduction as of 2009.

### Table 2
Prais-Winsten regression estimates for mortality rates in individuals aged 20–49, Northern Brazil, 1996–2017.

| Estado      | Standardized mortality | B   | P   | \(R^2\) | APC (%) | APC (95% CI) |
|-------------|------------------------|-----|-----|---------|---------|--------------|
| Rondonia    | 0.012                  | 0.162 | 0.054 | 2.81 | (−1.21: 6.98) |
| Acre        | −0.026                 | 0.029 | 0.213 | −5.86 | (−10.76: 0.68) |
| Amazonas    | −0.003                 | 0.404 | −0.012 | −0.63 | (−2.16: 0.92) |
| Roraima     | −0.005                 | 0.638 | −0.046 | −1.25 | (−6.52: 4.32) |
| Para        | −0.006                 | 0.214 | 0.005 | −1.41 | (−3.67: 0.90) |
| Amapa       | −0.025                 | 0.030 | 0.204 | −5.68 | (−10.46: −0.65) |
| Tocantins   | 0.017                  | 0.035 | 0.172 | 4.16  | (0.33: 8.14) |
| Men         | −0.004                 | 0.011 | −0.044 | −0.10 | (−0.91: 0.73) |
| Women       | −0.008                 | 0.002 | 0.383 | −1.86 | (−2.90: −0.80) |
| Total (North Region) | −0.004 | 0.013 | 0.238 | −0.88 | (−1.56: −0.21) |

The values in bold are because they had a significance of 0.05%.

APC = annual percent change, 95% CI = 95% confidence interval.

**4. Discussion**

In the northern region of Brazil, from 2008 to 2017, the incidence of hospitalization among young adults was higher in the 40–49 age group. It must be considered that, in the same country and within its regions, marked socioeconomic differences can influence the incidence of the disease. Pará was the state with the highest number of hospitalizations (7299). The same state has a higher population concentration, which may be related to the high number of hospitalizations or lack of adequate outpatient and/or specialized treatment, with an increased risk of complications and hospitalization. Therefore, social disadvantage factors, such as geographic distance to healthcare, are strongly associated with disease worsening rates.[35] In turn, the states of Amazonas and Tocantins had a reduction in these rates, suggesting that the health system has beneficial effects on the population, whether through promotion, prevention, and/or rehabilitation, as postulated by.[24]

In general, a study revealed that the worst rates of use of outpatient and specialized health services for CKD are concentrated in the North region, with low availability of doctors (1/1000 inhabitants), 7 times lower than in the capitals of the South of Brazil (7.1/1000).[36]
Table 3
Incidence of hospitalization for kidney disease (100,000 inhabitants) in individuals aged 20–49 years, according to demographic and clinical characteristics, North Region, Brazil, 2008–2017.

| Demographic and clinical characteristics | Hospitalizations 2008–2017 | Proportion of admissions 2008–2017 | Annual incidence 2008–2017 |
|-----------------------------------------|----------------------------|-----------------------------------|---------------------------|
| TOTAL                                   | 16,779                     | 100%                              | 22.9                      |
| Sex                                     |                            |                                   |                           |
| Male                                    | 8526                       | 50.8                              | 23.1                      |
| Female                                  | 8253                       | 49.2                              | 22.6                      |
| Age group (years)                       |                            |                                   |                           |
| 20–24                                   | 1819                       | 10.8                              | 11.3                      |
| 25–29                                   | 2362                       | 14.1                              | 15.4                      |
| 30–34                                   | 2486                       | 14.8                              | 18.6                      |
| 35–39                                   | 2869                       | 17.1                              | 25.7                      |
| 40–44                                   | 3103                       | 18.5                              | 32.8                      |
| 45–49                                   | 4140                       | 24.7                              | 53.1                      |
| States                                  |                            |                                   |                           |
| Acre (AC)                               | 1452                       | 8.7                               | 44.0                      |
| Amapa (AP)                              | 679                        | 4.0                               | 21.8                      |
| Amazonas (AM)                           | 3124                       | 18.6                              | 19.8                      |
| Pará (PA)                               | 7299                       | 43.5                              | 20.7                      |
| Rondônia (RO)                           | 1541                       | 9.2                               | 20.4                      |
| Roraima (RR)                            | 596                        | 3.6                               | 28.2                      |
| Tocantins (TO)                          | 2088                       | 12.4                              | 33.1                      |
| Skin color                              |                            |                                   |                           |
| White                                   | 773                        | 4.6                               | –                         |
| Black                                   | 443                        | 2.6                               | –                         |
| Yellow                                  | 10,125                     | 60.3                              | –                         |
| Mixed                                   | 88                         | 0.5                               | –                         |
| Indigenous                              | 76                         | 0.5                               | –                         |
| Ignored                                 | 5274                       | 31.4                              | –                         |
| Service                                 |                            |                                   |                           |
| Elective                                | 3666                       | 21.8                              | –                         |
| Urgency                                 | 13,113                     | 78.2                              | –                         |
| Total cost (Brazilian = reais)           |                            |                                   |                           |
| Men                                     | 21,539,592.73              | 54.6                              | –                         |
| Women                                   | 17,861,205.09              | 45.4                              | –                         |
| Average hospital stay (d)               |                            |                                   |                           |
| Men                                     | 11.8                       | –                                 | –                         |
| Women                                   | 12.9                       | –                                 | –                         |
| Hospital lethality                      |                            |                                   |                           |
| Men                                     | 688                        | 8.1                               | –                         |
| Women                                   | 745                        | 9.0                               | –                         |
| Total                                   | 1433                       | 8.5                               | –                         |

Chronic Kidney Disease (CKD), Renal failure (N17-N19).
Source: Sistema de Informacoes Hospitalares do SUS-SIS-SUS.

Figure 3. Incidence of hospitalization for Chronic Kidney Disease in the North Region and in the States of Acre (AC), Amazonas (AM), Pará (PA), Roraima (RR) and Tocantins (TO) for individuals aged between 20 and 49 years during the period from 1996 to 2017.
Another aspect of the study was that the proportion and incidence of hospitalizations were similar for both men and women. With regard to sex, it can be speculated that this result is due to the health care provided by both. Where access to health services and actions is scarce or nonexistent, the search for early intervention is a powerful tool that can minimize the progression of CKD.[29] A study carried out in Brazil, analyzing hospitalizations for CKD from 1996 to 2017, observed that the most affected population was male, with a tendency towards an increase in the number of hospitalizations during that period. A lower incidence of hospitalization was also noted in women. This can be explained by women’s greater access to and adherence to treatment, which is more influenced by health promotion and prevention.[24]

In Brazil, when estimating the cost of CKD and ECKD attributable to diabetes, a study found that, with 51% of the population being women, the cost was higher than for men. This finding was explained by 3 factors: a higher prevalence of diabetes, a higher relative risk of CKD and ECKD, and physiological issues in the female sex.[37] Diabetes accounts for 30%–50% of all CKD cases, affecting 285 million (6.4%) adults worldwide, although this number is expected to increase by 69% in high-income countries and 20% in low-income countries. Average income by 2030.[38] As for skin color, brown predominated, with 10,125 hospitalizations for skin color, brown predominated, with 10,125 hospitalizations compared to 1996, is explained by the lower use of health services, social determinants interact in both men and women to determine the occurrence, progression, and outcomes of the disease.[17,37,44]

It is possible that the closure at a higher value in 2017, compared to 1996, is explained by the lower use of health services, lower adherence to treatments, and psychological variables that influence their health habits. It can also be speculated that, in relation to the state of Tocantins, the increase may be determined by the underdiagnosis related to this and/or other chronic diseases and by the limitations in the availability, access, and quality of health care. More distant areas, where the increase in patients with CKD is found, may harbor the smallest concentrations of health resources (clinics, doctors, nurses, medical equipment), resulting in late diagnosis and suboptimal treatment. These hypotheses should be addressed, researched, and corroborated in future studies.

Using a similar methodology and the same observation period,[24] analyzed mortality and the incidence of hospital admissions for CKD in the state of Espírito Santo, southeastern Brazil. The results showed that the mortality was stationary. When stratified by sex, the phenomenon remained when evaluated over the 20-year period, although there was an increase between 2011 and 2014. However, when evaluating the mortality trend for years above 2003, an increase of 7.87% was observed per year for women.

This study has limitations related to the use of the SIH/SUS database. Data coverage depends on the degree of use and access of the population to hospital services contracted and associated with the SUS. There is no identification of readmissions and transfers from other hospitals, which eventually leads to double or triple counting of the same patient who goes through these situations.

It is hoped that the data found in this study can be considered a valuable resource for guiding the epidemiological monitoring of CKD and prioritizing the most appropriate health interventions for each context.

Knowledge of the disease is necessary, especially in high-risk populations, in addition to strengthening diagnosis and control in its early stages and strengthening institutional capacity through the training of health personnel, especially in primary care, to prevent the incidence of hospitalizations and deaths.

5. Conclusions

In general, there was decrease in mortality rate overtime. However, rate of mortality due to CKD increased in the state of Tocantins. The number of deaths was higher in males, with a higher number of cases in year 2016. The evolution of hospitalization due to CKD in a population of young adults remained stationary. The number of cases in year 2016. The evolution of hospitalization due to CKD in the state of Tocantins, the increase may be determined by the underdiagnosis related to this and/or other chronic diseases and by the limitations in the availability, access, and quality of health care. More distant areas, where the increase in patients with CKD is found, may harbor the smallest concentrations of health resources (clinics, doctors, nurses, medical equipment), resulting in late diagnosis and suboptimal treatment. These hypotheses should be addressed, researched, and corroborated in future studies.

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Acknowledgments

The authors thank Acre State Secretariat of Health (SESACRE), Acre, Brazil, the Federal University of Acre (UFAC), Acre, Brazil, and the Santo ABC University Center (FMABC) Santo André, São Paulo, Brazil, for the opportunity to develop masters, doctors, and researchers training in health, through Agreement 007/2015 (SESACRE/UFAC/FMABC). All researchers, undergraduate,
master’s, and doctorate students of the Laboratory of Study Design and Scientific Writing of the ABC University Center (FMABC) made it possible to develop research and science in the western Amazon, Brazil.

Author contributions
Alliny Sales Rodrigues: Collected the data, carried out the experiments, and wrote the manuscript.
Edit Felipe de Sousa Santos: Wrote the manuscript and followed the guidelines of the journal.
Mauro José de Deus Morais: Wrote the manuscript, followed the journal guidelines, and reviewed the statistical analyses.
Francisco Naioldo Cardoso Leitao: Wrote the manuscript, followed the journal guidelines, and reviewed the statistical analyses.
Gardenia Lima Gurgel do Amaral: Wrote the manuscript, followed the journal guidelines, and reviewed the statistical analyses.
Luiz Carlos de Abreu: Collected data, conducted the experiments, and wrote the manuscript.
Ricardo Peres do Souto: Collected data, conducted the experiments, and wrote the manuscript.

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