Original Article

Factors Associated with Mortality from Renal Failure in Brazil: A Descriptive Epidemiological Study

Maria Cecília de Souza Anacleto[1] , Jessica Souza Lopes da Silva[1] , Millena Venâncio Gonçalves[2] , Mateus da Silva Matias Antunes[3*] , Diêgo Correia de Andrade[4]

[1]Undergraduate in Nursing, João Pessoa University Center, João Pessoa, Paraíba, Brazil
[2]Undergraduate in Chemistry, João Pessoa University Center, João Pessoa, Paraíba, Brazil
[3]Mastering Student in Sciences, Faculty of Pharmaceutical Sciences of Ribeirao Preto - University of Sao Paulo, Brazil
[4]MSc in in Anatomy and Associated Pathology, UNIPÊ Nursing Department, João Pessoa University Center, João Pessoa, Paraíba, Brazil

Abstract

Background and aims: The incidence of renal failure (RF) is growing in Brazil, resulting in increased public spending and negatively affecting the public health, which can lead to patient death. Identifying factors associated with mortality from this condition can help to characterize susceptible populations; therefore, institutional and governmental measures can be adopted for prevention and treatment.

Materials and Methods: Descriptive epidemiological study using secondary data from Brazilian database (DATASUS). Deaths from RF between 2009 and 2019 and characteristics such as color/race, gender, education, region, and age group of the individuals were analyzed.

Results: Since 2016, there has been a reduction of approximately 2% per year in the RF case fatality rate. North, Northeast, and Southeast regions had the highest case fatality rate, 13.6%, 13.17%, and 12.84%, respectively, which may be associated with high prevalence of chronic-degenerative diseases. The elderly had the highest case fatality rates, ranging from 9.67% in individuals aged 50-59 years to 27.52% in the elderly over 80 years. Children under 1 year of age had a high case fatality rate of 15.03%. Moreover, the case fatality rate for individuals with education levels above 12 years of schooling was 0.50%, while the case fatality rate for individuals with 1 to 3 years of schooling was 3.52%, which is seven times higher. Case fatality rates of indigenous populations in the South and Southeast regions were 12.0% and 16.5%, approximately 20% higher than other populations.

Conclusion: The presence of chronic-degenerative diseases, age above 50 and below 1 (elderly and preterm newborns), low level of education and being indigenous are factors associated with mortality from RF in Brazil.

Keywords: Kidney failure, Epidemiology, Nephrology, Brazil

Introduction

Renal failure (RF) is a critical but treatable health condition, characterized by the reduction or loss of kidney function that can manifest itself in an acute or chronic form, usually resulting from an injury or kidney disease.[1,2]

In this condition, the treatment of the patient requires special care for a prolonged period of time, given that hemodialysis is the treatment of choice for individuals with chronic RF, being adopted in 92.3% of cases,[3] which has a great impact on the public health.

It is estimated that 2 billion reals are spent annually in Brazil, just for the treatment of patients with kidney diseases, corresponding to about 5% of the budget allocated to the Unified Health System (SUS),[4] however, current data on the expenses caused by RF is lacking.

In addition to the financial costs, RF affects the health and quality of life of those affected and family members, which can cause disability and even the death of the patient.[5] It is estimated that 1.4 million deaths occur annually worldwide due to diseases related to the kidney and urinary tract.[6,7]

After the year 2000, there is a trend in the increase of cases of RF in the world. Between 2003 and 2004, an increase of 6% was observed in the world.[8] In Brazil, the number of patients undergoing treatment for the disease increased by 637% in almost two decades, from 24 000 in 1994 to 153 000 in 2013.[9]

Therefore, studying and describing factors that may be related to RF can assist in understanding the disease and its geographical incidence. It is already known that other comorbidities are associated with the development of RF such as diabetes mellitus and hypertension.[10]

These data corroborate the results obtained by an exploratory cross-sectional study conducted in Brazil using 105 medical records of patients diagnosed with chronic kidney disease.[11] The association of kidney disease

with age and the prevalence of hypertension, diabetes mellitus, and congestive heart failure was observed.[11]

Arterial hypertension and diabetes mellitus enhance the progression of nephropathy, leading the patient to a terminal state of chronic RF. It is estimated that 34% of the patients affected by RF in Brazil undergoing dialysis are affected by these pathologies.[12]

In addition, it is important to note that Brazil is a country of continental proportions and Brazilians represent one of the most heterogeneous populations in the world.[13] Several genetic, social, ethnic-racial, economic, and geographic factors can influence an individual's health status.[14] Therefore, studying the prevalence of RF under these filters can reveal characteristics of the population that is most affected by this condition and allows quantifying the expense generated.

Based on this information, this study focused on using the morbidity and mortality data available in Brazilian Unified Health System (DATASUS) to trace the prevalence of RF and determine factors associated with this condition in Brazil.[15] Identifying these factors can help in understanding the incidence of the disease and identifying susceptible populations, enabling governments and public or private institutions to develop strategies for the prevention and treatment of RF.

Materials and Methods

This descriptive epidemiological study was carried out using secondary data from DATASUS.[15] DATASUS is an organ of the Strategic and Participatory Management Secretariat of the Brazilian Ministry of Health. Its function is to develop technological solutions and disseminate information about health in Brazil, through the official website of DATASUS (https://datasus.saude.gov.br/). On the website, it is possible to collect information on the health situation in the country through the TABNET application (http://www2.datasus.gov.br/DATASUS/index.php?area=02), a more recently developed network designed specifically for tabular data.

Deaths due to RF between the years 2009 and 2019 and demographic variables such as color, gender, education, age group, and region of individuals were analyzed.

A total of 13 580 773 deaths were recorded in DATASUS, of which 135 161 were from RF according to the International Classification of Diseases, Tenth Revision (ICD-10), between 2009 and 2019. They were of both genders and different social classes, regardless of ethnicity or age group. All these patients were admitted to SUS or a private hospital and were diagnosed with acute RF, chronic RF, or unspecified RF, according to the ICD-10. After hospitalization, regardless of the length of stay in the health care facilities, these patients died due to RF.

The study excluded individuals who died for reasons other than ICD-10 N17, N18, and N19 and individuals whose main cause of death was not RF.

The case fatality rate was obtained by dividing the number of deaths from a specified disease over a defined period of time by the number of hospital admissions during that time and the resulting ratio was multiplied by 100 to yield a percentage.

$$\text{Case fatality rate} = \frac{\text{Number of deaths}}{\text{Number of hospitalizations}} \times 100$$

On the TABNET application, we used the data contained in the epidemiological and morbidity session; SUS Hospital morbidity group; subgroup of general cause, by place of hospitalization from 2008; and in the geographical scope: Brazil by region and federation unit. The filters used were color/race, education, age group, region/federation unit, ICD-10 chapter: all categories, ICD-10 morbidity list: RF, hospitalizations, deaths, and total value.

Descriptive statistics such as mean, standard deviation, and relative frequency (percentage) were used to analyze the data.

Results

According to the data available in DATASUS,[15] in the period between 2009 and 2018, a total of 12 232 541 deaths were recorded in Brazil. Of that number, 121 245 were caused by RF, which is approximately 1% of deaths in the country in almost a decade.

These numbers place RF among the 10 main causes of death in Brazil in the last decade, given that diseases of the genitourinary system occupy the 9th place in the ranking with 323 333 deaths (Figure 1). Mathematically, RF is responsible for 37.49% of deaths from diseases in the genitourinary system.

Analyzing the case fatality rate in Brazil over the years, there is a continuous growth between 2010 and 2016 with an average of 2% per year. After the peak in 2016, there was a reduction in the case fatality rate with an average of 2% per year until 2019 (Figure 2).

Regarding the case fatality rate of the decade by region, it is observed that the North, Northeast, and Southeast regions present rates of 13.6%, 13.17%, and 12.84%, respectively, being slightly higher than the national average of 12.44% (Table 1).

Among the states that received the highest amount of federal funds for investment in public health, the Southeast and Northeast regions stand out, which received values above the national average in the last four years analyzed.

Table 1. Number of Hospitalizations, Deaths, and Case Fatality Rate of RF Between 2009 and 2019 by Region

Region	Number of Hospitalizations	Number of Deaths	Case Fatality Rate
1. North	63 024	8572	13.6
2. Southeast	494 132	65 061	13.17
3. Northeast	231 903	29,784	12.84
4. Midwest	79 752	9228	11.57
5. South	217 498	22 516	10.35
Brazil	1 086 309	135 161	12.44

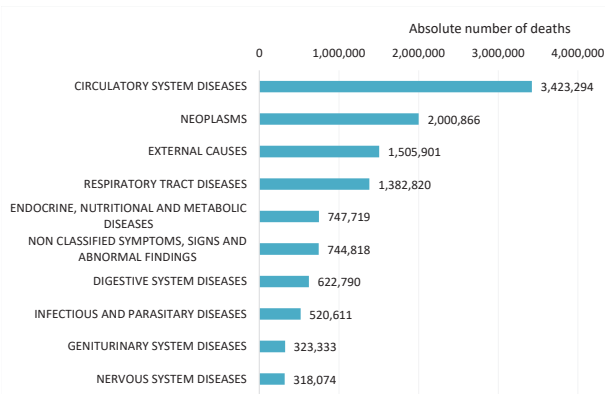Source: Ministry of Health - SUS Hospital Information System (SIH/SUS), 2020.

Figure 1. The Main Causes of Death in Brazil Between 2009 and 2018. Source: Ministry of Health - SUS Hospital Information System (SIH/SUS), 2020.
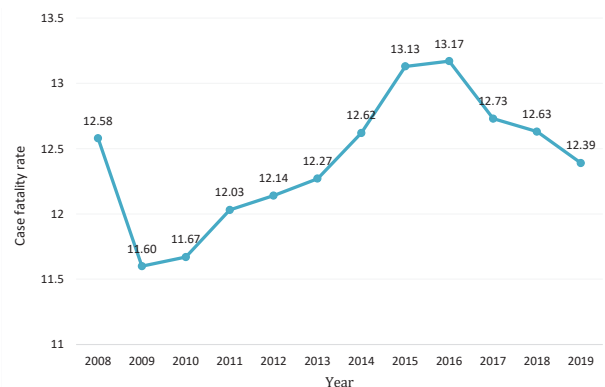

Figure 2. Annual Case Fatality Rate of RF Between 2009 and 2019. Source: Ministry of Health - SUS Hospital Information System (SIH/SUS), 2020

While the national average value in 2019 was 15 billion reais, the North region received approximately 22 billion and the Southeast received 31 billion reais. In contrast, the North region received less financial resources, 5 billion reais (Figure 3).

In addition to receiving more federal funds, the Southeast, Northeast, and South regions were the ones that used the highest amount of resources for the treatment of RF (Figure 4). The southeast region used almost double the resources against RF compared to the national average, while the North and South regions match the national average. These data are consistent with the number of hospitalizations, given that these regions were the ones that admitted the highest number of individuals with RF in the last decade (Table 1).

Analyzing the case fatality rate according to the age group, there is a higher case fatality rate in individuals over 50 years of age with a national rate of 9.67%, which increases by approximately 50% as the age group advances reaching the rate of 27.52% in individuals over 80 years of age (Figure 5). In addition, the high case fatality rate in individuals under the age of 1 year was also observed in the graph with the national average of 15.03, similar to the national average of 13.3 found in individuals between 60 and 69 years old.

Regarding the mortality rate between 2009 and 2019 according to gender, no significant differences were observed, considering that the average was 12.42% for

men and it was 12.44% for women (data not shown).

Regarding the case fatality rate by education, we observed that individuals who attended formal education (1 to 3 years) had the highest number of deaths, with 38343 deaths registered between 2009 and 2019, equivalent to a case fatality rate of 3.52%. On the other hand, individuals with 12 years of schooling or more had the lowest number of deaths due to the disease, with 5501 deaths, equivalent to a case fatality rate of 0.50, this represents a case fatality rate approximately 7 times lower than the group mentioned above (Figure 6).

Regarding the case fatality rate according to race/color of individuals, the South and Southeast regions showed higher case fatality rates in indigenous individuals (12.0 in the South and 16.5 in the Southeast), approximately 20% higher than other populations (Figure 7).

Discussion

Regarding the case fatality rate by region, the data may be related to the high prevalence of other diseases in these regions, such as high blood pressure, diabetes mellitus, and congestive heart failure, which are associated with the development of RF.[11]

The high prevalence of chronic diseases may influence the results found, given that according to data obtained from the last National Health Survey (PNS) of 2013,[16] the Southeast region had the highest percentage of individuals diagnosed with diabetes, high blood pressure and/or heart disease, corroborating the result obtained in DATASUS.

However, the North and Northeast regions, which have the highest case fatality rates of RF, were the regions with
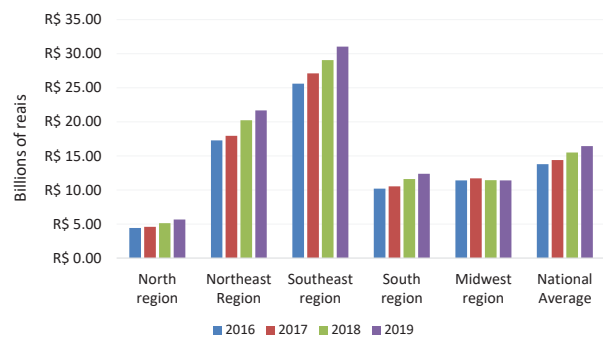

Figure 3. Use of Federal Funds for Health Care Between 2016 and 2019. Source: Brazil, Transparency Portal, 2020.
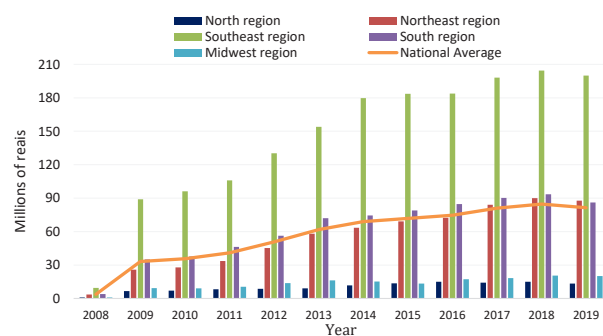

Figure 4. Annual Spending on RF Between 2009 and 2019 by Region. Source: Ministry of Health - SUS Hospital Information System (SIH/SUS), 2020.

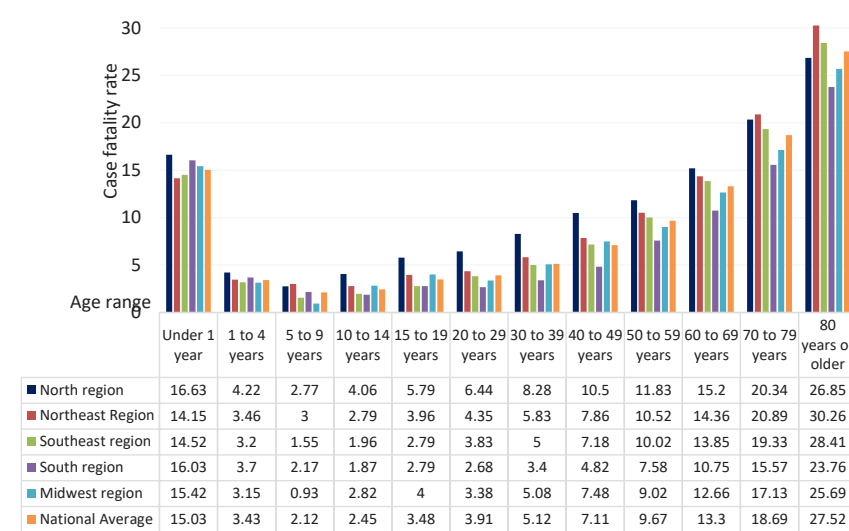| Age range	Under 1 year	1 to 4 years	5 to 9 years	10 to 14 years	15 to 19 years	20 to 29 years	30 to 39 years	40 to 49 years	50 to 59 years	60 to 69 years	70 to 79 years	80 years or older
North region	16.63	4.22	2.77	4.06	5.79	6.44	8.28	10.5	11.83	15.2	20.34	26.85
Northeast Region	14.15	3.46	3	2.79	3.96	4.35	5.83	7.86	10.52	14.36	20.89	30.26
Southeast region	14.52	3.2	1.55	1.96	2.79	3.83	5	7.18	10.02	13.85	19.33	28.41
South region	16.03	3.7	2.17	1.87	2.79	2.68	3.4	4.82	7.58	10.75	15.57	23.76
Midwest region	15.42	3.15	0.93	2.82	4	3.38	5.08	7.48	9.02	12.66	17.13	25.69
National Average	15.03	3.43	2.12	2.45	3.48	3.91	5.12	7.11	9.67	13.3	18.69	27.52

Figure 5. Case Fatality Rate of RF by Age Group Between 2009 and 2019. Source: Ministry of Health - SUS Hospital Information System (SIH/SUS), 2020
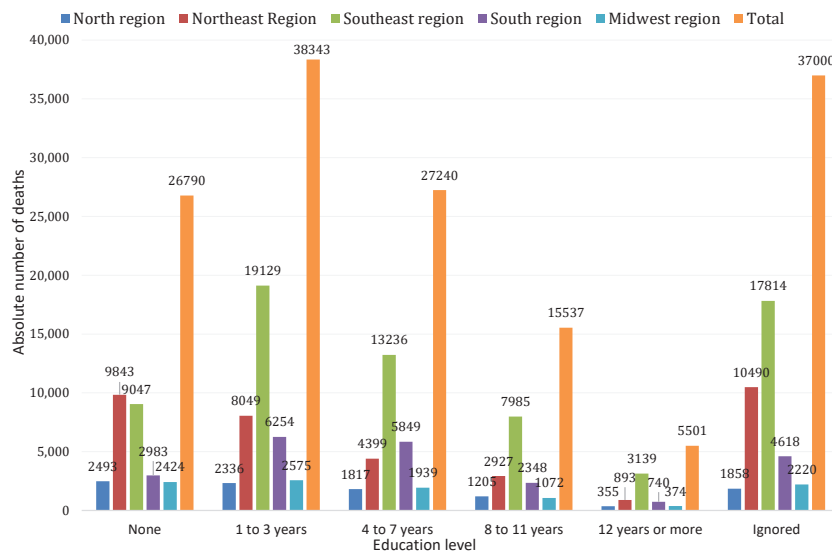

Figure 6. Case Fatality Rate of RF by Education Level Between 2009 and 2019. Source: Ministry of Health - SUS Hospital Information System (SIH/SUS), 2020
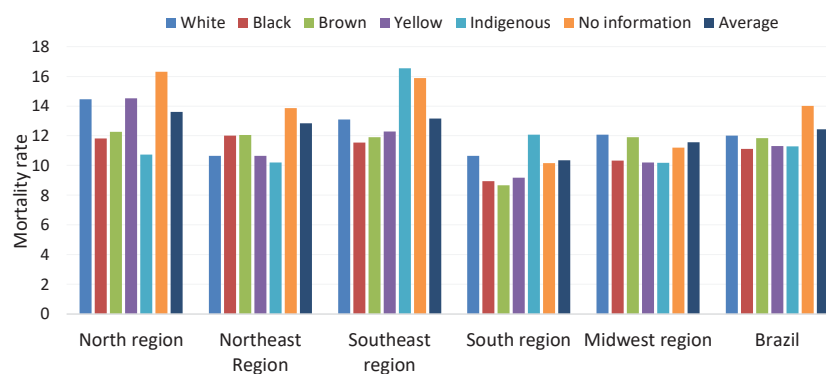

Figure 7. National Case Fatality Rate of RF by Race/Color Between 2009 and 2019. Source: Ministry of Health - SUS Hospital Information System (SIH/SUS), 2020.

the lowest percentages of individuals diagnosed with these comorbidities, suggesting the possibility of underreporting cases of diabetes, high blood pressure and heart disease or precarious health system in these regions, contributing to the increase in the case fatality rate.

About the use of federal funds, it is possible that the high case fatality rate in the Southeast and Northeast regions is associated with the poor management of state governments that lead the system to scrap and inefficiency,[17] given that these regions were the ones that received the largest amount of resources for health in the last four years.[18]

In all, R$ 3 442 161 103.00 was spent on the treatment of RF between the years 2009 and 2019, the annual expenditure of R$ 344 216 110.30 in that period. Data

from DATASUS show that in the last three years, R\$ 404 884 245.70 was allocated in 2017, R\$ 423 358 723.10 in 2018, and R\$ 407 364 268.60 in 2019 only for the treatment of RF, suggesting that this amount should remain constant in the coming years due to the Constitutional Amendment Proposal (PEC, 241/16) which freezes public spending until 2036.[19]

About the case fatality rate by age group, a high case fatality rate in the elderly is expected because aging makes the individual more vulnerable to pathological processes and several diseases such as high blood pressure, diabetes, and heart failure that predispose the elderly to kidney disease.[20] In addition, anatomical and physiological changes in the kidneys, resulting from the senescence process, constitute an aggravating factor since such changes render the renal system unable to perform its normal functions.[21,22]

Although the elderly are more prone to kidney disease, interestingly, the mortality rate for individuals under 1 year of age was high. This data reflects the high mortality rate of neonates with severe renal dysplasia[23] and preterm newborns who are born with a weight of less than 1000 g and incomplete development of the nephrons, making these individuals more susceptible to acute kidney injury and consequently to death.[24-26]

Regarding the case fatality rate according to gender, although the global incidence of chronic kidney diseases is higher in women,[8] our results suggest that the individual's gender does not influence the risk of death from RF in Brazil.

About the level of education, the data suggest that people without formal education are more susceptible to death from RF. This result highlights the socioeconomic disparity in Brazil that allows people with higher education to have better financial conditions that allow access to medical resources and health information more easily than individuals without formal education.[27] In addition, people with little education tend to be unaware of habits and choices that can prevent the development of kidney disease and consequently the RF.[28]

Furthermore, the results still reveal a high number of deaths without recording the individual's educational level, constituting 37 000 individuals. The absence of this data makes it difficult to estimate the impact of education on mortality due to RF.

About the high case fatality rate by race/color observed in indigenous individuals from Southeastern and Southern regions, this data reflects socio-geographical issues such as the difficulty of access to health services for isolated indigenous populations as well as cultural factors that can influence their thoughts, decisions-, and actions, especially actions regarding care.[29,30]

In addition, as study limitations, it is worth mentioning the lack of records on the color/race of individuals who died of RF. The case fatality rate of individuals with ignored color/race information exceeds the rates of individuals affected by RF in Brazil. Once again, the lack of records

becomes a difficulty and limitation for the production of scientific knowledge and for the identification of populations most vulnerable to RF.

Conclusion

RF is responsible for 1.1% of deaths in Brazil in the last decade and R\$ 3 442 161 103.00 was spent on it. In addition, among the factors associated with mortality from RF, the presence of chronic-degenerative disease, age above 50 years or below 1 year in the case of preterm newborns or individuals with severe dysplasia, low level of education, and being indigenous to the South and Southeast regions were identified.

Conflict of Interest Disclosures
The authors declare that there is no conflict of interests.

References
1. Pinto PS, Carminatti M, Lacet T, Rodrigues DF, Nogueira LO, Bastos MG, et al. Nephrotoxic acute renal failure: prevalence, clinical course and outcome. Braz J Nephrol. 2009;31(3):183-9. doi: 10.1590/s0101-28002009000300003.
2. Morsch C, Veronese FJ. Doença renal crônica: definição e complicações. Clin Biomed Res. 2011;31(1):114-5.
3. de Menezes Neves, de Castro Cintra Sesso R, Thomé FS, Lugon JR, Nasicmento MM. Brazilian dialysis census: analysis of data from the 2009-2018 decade. J Bras Nefrol. 2020;42(2):191-200. doi: 10.1590/2175-8239-jbn-2019-0234.
4. Alcalde PR, Kirsztajn GM. Expenses of the Brazilian public healthcare system with chronic kidney disease. J Bras Nefrol. 2018;40(2):122-9. doi: 10.1590/2175-8239-jbn-3918.
5. Weykamp JM, Nunes MH, Cecagno D, de Siqueira HC. Quality of life and chronic renal failure. Rev Fund Care Online. 2017;9(4):1113-20. doi: 10.9789/2175-5361.2017. v9i4.1113-1120.
6. Kassebaum NJ, Arora M, Barber RM, Bhutta ZA, Brown J, Carter A, et al. Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. Lancet. 2016;388(10053):1603-58. doi: 10.1016/s0140-6736(16)31460-x.
7. Bikbov B, Perico N, Remuzzi G. Disparities in Chronic Kidney Disease Prevalence among Males and Females in 195 Countries: Analysis of the Global Burden of Disease 2016 Study. Nephron. 2018;139(4):313-8. doi: 10.1159/000489897.
8. Grassmann A, Gioberge S, Moeller S, Brown G. ESRD patients in 2004: global overview of patient numbers, treatment modalities and associated trends. Nephrol Dial Transplant. 2005;20(12):2587-93. doi: 10.1093/ndt/gfi159.
9. Brasil, IBGE - Instituto Brasileiro de Geografia e Estatística. Pesquisa Nacional por Amostra de Domicílios Contínua. 2018 [cited 2020 Oct 11]. Available from: https://www.ibge.gov.br/estatisticas/sociais/educacao/9173-pesquisa-nacional-por-amostra-de-domicilios-continua-trimestral.html?=&t=o-que-e.
10. Bakris GL, Weir MR, Shanifar S, Zhang Z, Douglas J, van Dijk DJ, et al. Effects of blood pressure level on progression of diabetic nephropathy: results from the RENAAL study. Arch Intern Med. 2003;163(13):1555-65. doi: 10.1001/

archinte.163.13.1555.

11. de Pinho NA, da Silva GV, Pierin AM. Prevalence and factors associated with chronic kidney disease among hospitalized patients in a university hospital in the city of São Paulo, SP, Brazil. J Bras Nefrol. 2015;37(1):91-7. doi: 10.5935/0101-2800.20150013.

12. de Castro Cintra Sesso R, Lopes AA, Thomé FS, Lugon JR, Watanabe Y, dos Santos DR. [Report of the Brazilian chronic dialysis census 2012]. J Bras Nefrol. 2014;36(1):48-53. doi: 10.5935/0101-2800.20140009.

13. Suarez-Kurtz G. Pharmacogenomics and the genetic diversity of the Brazilian population. Cad Saude Publica. 2009;25(8):1650-1. doi: 10.1590/s0102-311x2009000800001.

14. George F. Sobre Determinantes da Saúde. Lisboa: Direção-Geral da Saúde; 2011. Available from: http://bit.ly/2vZqVke.

15. Brasil, Ministério da Saúde. DATASUS Tecnologia da Informação a Serviço do SUS [Internet]. 2020 [cited 2020 Oct 01]. Avaliable from: http://www2.datasus.gov.br/DATASUS/index.php?area=02.

16. Brasil, Instituto Brasileiro de Geografia e Estatística (IBGE). Pesquisa Nacional de Saúde 2013 [Internet]. 2014 [cited 2020 Oct 09]. Avaliable from: https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html?=&t=o-que-e.

17. Sales OP, Vieira AF, Martins AM, Garcia LG, Ferreira RK. O Sistema Único de Saúde: desafios, avanços e debates em 30 anos de história. Humanidades & Inovação. 2019;6(17):54-65.

18. Brasil; CGU - Controladoria-geral da União. Portal da Transparência do Governo Federal, Despesas e Receitas, Painel por Área de Atuação, Saúde: banco de dados [Internet]. 2020 [cited 2020 Oct 12]. Available from: http://www.portaltransparencia.gov.br/url/3c9fb300.

19. Vieira FS, Benevides RP. Os Impactos do novo regime fiscal para o financiamento do Sistema Único de Saúde e para a efetivação do direito à saúde no Brasil. Brasília: Instituto de Pesquisa Econômica Aplicada; 2016. Avaliable from: http://repositorio.ipea.gov.br/handle/11058/7270.

20. World Health Organization (WHO). Global Health and Aging (NIH Publication No. 11-7737). Geneva: WHO; 2011.

Avaliable from: https://www.who.int/ageing/publications/global_health/en.

21. Lessa I. O adulto brasileiro e as doenças da modernidade: epidemiologia das doenças crônicas não-transmissíveis. 1st ed. São Paulo: Hucitec; 1998.

22. Smeltzer SC, Bare BG. Tratado de enfermagem médico-cirúrgica. In: Hinkle JL, Cheever KH, eds. Brunner & Suddarth: Tratado de Enfermagem Médico-Cirúrgica. Rio de Janeiro: Guanabara Koogan; 2005. p. 1133.

23. Müller AL, Vettori DV, Duque JA, de Azevedo Magalhães JA. Taxa de mortalidade neonatal associada às malformações fetais congênitas no Hospital de Clínicas de Porto Alegre. Clin Biomed Res. 2018;38(1):231.

24. Gubhaju L, Sutherland MR, Horne RS, Medhurst A, Kent AL, Ramsden A, et al. Assessment of renal functional maturation and injury in preterm neonates during the first month of life. Am J Physiol Renal Physiol. 2014;307(2):F149-58. doi: 10.1152/ajprenal.00439.2013.

25. Brophy P. Maternal determinants of renal mass and function in the fetus and neonate. Semin Fetal Neonatal Med. 2017;22(2):67-70. doi: 10.1016/j.siny.2017.01.004.

26. Rosenblum S, Pal A, Reidy K. Renal development in the fetus and premature infant. Semin Fetal Neonatal Med. 2017;22(2):58-66. doi: 10.1016/j.siny.2017.01.001.

27. Neri M, Soares W. [Social inequality and health in Brazil]. Cad Saude Publica. 2002;18 Suppl:77-87. doi: 10.1590/s0102-311x2002000700009.

28. Sanchez RM, Ciconelli RM. [The concepts of health access]. Rev Panam Salud Publica. 2012;31(3):260-8. doi: 10.1590/s1020-49892012000300012.

29. Borghi AC, Alvarez AM, Marcon SS, Carreira L. [Cultural singularities: indigenous elderly access to Public Health Service]. Rev Esc Enferm USP. 2015;49(4):589-95. doi: 10.1590/s0080-623420150000400008.

30. Brasil, IBGE - Instituto Brasileiro de Geografia e Estatística. Censo 2010 - Atlas censo demografico [Internet]. 2013 [cited 2020 Oct 02]. Available from: https://www.ibge.gov.br/geociencias/atlas/tematicos/16361-atlas-do-censo-demografico.html?=&t=o-que-e.