Overview of hemodialysis treatment funded by the Brazilian Unified Health System - An economic perspective

INTRODUCTION

Chronic kidney disease (CKD) is currently considered a global public health issue with prevalence estimated to range between 8% and 16%. Although approximately 80% of the cases of CKD are diagnosed in developed nations, incidence has increased in countries of varied economic profiles. In Brazil, an estimated 1.75 million individuals had CKD in 2006, and 405 per million population were estimated to be on chronic dialysis in 2009. In 2012, an estimated 97,586 individuals were on dialysis in Brazil.

The Brazilian Society of Nephrology (SBN) ran the first Brazilian Dialysis Census in 1999. Renal care centers were asked to provide information on areas such as center characteristics, patient prevalence and incidence, and modes of dialysis offered to patients. In 2002, 561 dialysis centers treating a total of 54,523 patients were registered with the SBN. In 2013, the number of registered centers grew to 658. Despite these significant numbers, only 50.8% of the registered renal centers responded the survey of the 2013 Census, thus affecting the accuracy of the published results.

The census reports showed the number of patients on dialysis in Brazil increased in the last decade (84.14%). However, the costs associated with treatment were

ABSTRACT

Introduction: End-stage renal disease (ESRD) is a public health problem and, in Brazil, lacks of data on one of the main treatments, hemodialysis, are still identified. Objective: To determine, through description of resources used in ESRD treatment and its complications, the cost associated to hemodialysis and supplementary medical therapy in patients attended by Brazilian Public Health (SUS). Methods: Methods of cross-sectional and prospective cohort observational analysis were conducted using public data, where information about inpatient and outpatient resource use and patients’ characteristics were collected. From described resource use, costs were calculated. In cross-sectional analysis subjects who underwent hemodialysis between January/2008 and November/2012 were considered and in prospective cohort, started in 2009. Descriptive analyses were performed. Results: 91,475 and 118,847 hemodialysis procedures were performed in 2008 and 2012, respectively, and 24.8% of increase was estimated until 2017. Analysis by federation unit showed that São Paulo, Minas Gerais and Rio de Janeiro states represented almost half of the procedures observed, with mean cost per patient of US$ 7,932.52 in 2008 and US$ 9,112.75 in 2011. In the cohort, composed by 96,600 subjects, the most used drug was alfapoeotin and 8% of the sample used calcitriol 1.0 mcg. The occurrence of complications was observed in 28.2% of patients. Conclusion: After data analysis, different aspects of hemodialysis use were demonstrated, with an increase in amount of procedures and, also, in disease related expenses.

Keywords: calcitriol; costs and cost analysis; kidney failure, chronic; morbidity; renal dialysis.
not covered in the report. According to the DATASUS, approximately R$ 2 billion were spent in hemodialysis procedures in clinics from all over the country in 2012.5-7

Approximately 90% of the individuals with end-stage renal disease (ESRD) are started on dialysis, with significant impact on their survival. The five-year survival of patients with ESRD on dialysis is around 65%.8,9

Despite the relevance of treatment for these patients, hemodialysis implies significant economic and social costs. Brazilian studies have shown that the costs associated with renal disease range from R$ 19,950 to R$ 26,810.30,8,10 In addition to hemodialysis, patients with CKD require other medications such as erythropoietin, calcitriol, iron hydroxide, and sevelamer, which add to the costs incurred in by the health care system.11,12

Besides, the loss of renal function secondary to the development of CKD may also introduce a series of complications such as anemia, metabolic bone disease, and metabolic acidosis.13,14

In order to minimize the occurrence of complications, the Kidney Disease Outcomes Quality Initiative (KDOQI) recommends the prescription of phosphorus chelating agents and vitamin D analogues to help support the mineral metabolism of this group of patients.11 Studies have described an association between higher levels of 25-hydroxyvitamin D and better survival of patients with CKD both on and off dialysis.15

In 2009, Martins et al.16 carried out a study to assess how often these medications were prescribed to dialysis patients treated in the State of Bahia, in the only publication to shed light on this aspect of renal disease in Brazil.

More comprehensive data is still needed on the characteristics and costs of hemodialysis in Brazil. Therefore, this study aimed to calculate the cost of hemodialysis and the adjuvant drug therapies paid by the Brazilian public health care system (SUS) based on a description of the items used in the treatment of CKD and its complications.

**Method**

**Study design**

This study used a combination of the cross-sectional observational method and the prospective cohort method as described by Mussolino et al.17

The cross-sectional observational analysis was carried out with the purpose of providing an overview of the Brazilian public health care system (SUS) and validating the representativeness of the cohort. The prospective cohort portion of the analysis was used to define the hemodialysis patient subgroups followed for 32 months since the first month of treatment started in 2009 and determine the occurrence of cardiac, vascular, bone and parathyroid gland events as described in the International Statistical Classification of Diseases and Related Health Problems - 10th Revision (ICD-10) and recorded in Hospital Admission Authorization (AIH) forms.

**Data sources**

The study included records of the SUS Outpatient Information System (SIA/SUS) and of the SUS Hospital Information System (SIH/SUS) from January 2008 to November 2012.

The SIH/SUS contained information related to the hospital procedures described in the Hospital Admission Authorization (AIH) forms, namely: demographic data (age and gender); municipality of residence; disease code (N18) as per the ICD-10; place of treatment (institution, municipality, and state); procedures performed; length of hospitalization; admission to an intensive care unit (ICU); and death during hospitalization.

The SIA/SUS database had the following information on outpatient procedures: patient profile (age and gender), municipality of residence, disease code as per the ICD-10 (N18), procedures performed, and place of treatment (institution, municipality, state). The information present in the documents used to record Outpatient Procedure Authorizations (APAC) and in the documents used to report medium and high complexity outpatient procedures, including
chronic patient treatment schedules (for patients on dialysis, for example) and oncologic care, were collected.

The occurrence of complications was established based on the codes entered in the SIH/SUS and SIA/SUS databases for the endpoints of interest (cardiac, bone, and vascular events, and parathyroid gland removal). Table 1 describes the procedures performed for each type of complication.

The information collected range from January of 2008, when the Chart of Procedures, Medications, Prosthetics, Orthotics, and Special Materials for the Brazilian Public Health Care System (SUS) was originally published, to November of 2012. Reimbursement fees were estimated from the price list updated on December 17, 2012 by the São Paulo State Secretary of Health considering yearly weighted averages. The resulting values were converted into American Dollars (USD) considering the mean exchange rate from 2008 to 2011.

IDENTIFICATION OF INDIVIDUALS IN THE DATABASES

A deterministic approach was used to identify the patients in the SIA/SUS database, with equal records for a unique key being considered a match. However, as there was no such unique key in the SIH/SUS, patients were identified via probabilistic relationships.

The data points related to one same patient in the databases were identified through record linkage. Once the patient identification procedures of the outpatient and hospital settings were different, patients were identified based on probabilistic relationships.

STUDY POPULATION

The cross-sectional observational portion of the study included individuals on hemodialysis entered into the SIA/SUS database from January 2008 to November 2012 assigned an N18 ICD-10 code for chronic kidney disease in their AIH forms. A second analysis was then carried out to include the following subgroups: “Hemodialysis I (no more than three sessions a week)” (SIGTAP: 03.05.01.006-9) and “Hemodialysis II (no more than three sessions a week)” (SIGTAP: 03.05.01.010-7). The subgroups were defined based on the availability of the data in the database; the difference lies basically on the degree of specialization of the center at which the procedures were performed.

The prospective cohort portion of the study included the 96,303 individuals on hemodialysis (I and II, no more than three sessions a week) in 2009. Patients on 1.0 mcg calcitriol (n = 7,728) were analyzed separately due to the described association between prescription of vitamin D analogues and reduced mortality of patients on dialysis.

DATA ANALYSIS

The study population was described through measures of central tendency (mean values and standard deviation) for continuous variables and measures of frequency for categorical variables. The data sets were analyzed on Microsoft Excel.

The Forecast function on Microsoft Excel was used to estimate a linear trend line for the data.

RESULTS

PRESCRIPTION OF HEMODIALYSIS IN BRAZIL, 2008-2017

A total of 91,475 and 118,847 individuals were on hemodialysis in 2008 and 2012, respectively. The estimated linear trend indicated that the number of patients on hemodialysis would grow by 24.8% from 2012 to 2017, reaching a total of 148,315 patients in the latter year.

When the patients on three hemodialysis sessions per week were analyzed separately from the individuals who underwent one additional weekly hemodialysis session, the total number of patients in 2008 added up to 91,431 and 38,911 respectively, while in 2012 the numbers came to 118,793 and 46,858 respectively. The number of patients on one additional hemodialysis session associated to three weekly sessions was estimated to grow by 20.4% by 2017, while the ranks of individuals on three hemodialysis sessions per week was estimated to grow by 24.8% by the same time.
**Table 1**

| Complications | SIGTAP Code |
|---------------|-------------|
| **Cardiac complications** | |
| Diagnosis and/or emergency consultation with general practitioner | 03.01.06.008-8 |
| Coronary angioplasty | 04.06.03.001-4 |
| Coronary angioplasty, two stents implanted | 04.06.03.002-2 |
| Coronary angioplasty with stenting | 04.06.03.003-0 |
| Primary coronary angioplasty (includes catheterization) | 04.06.03.004-9 |
| Therapeutic electrophysiological study I (atrial flutter ablation) | 04.06.05.002-3 |
| Therapeutic electrophysiological study II (atrial fibrillation ablation) | 04.06.05.007-4 |
| Transvenous placement of multi-site pacing devices | 04.06.01.063-3 |
| Implantation of prosthetic heart valves | 04.06.01.069-2 |
| Valvuloplasty | 04.06.01.080-3 |
| Valvuloplasty with myocardial revascularization | 04.06.01.081-1 |
| Valvuloplasty and/or multiple valve change | 04.06.01.082-0 |
| Treatment with multiple surgical procedures | 04.15.01.001-2 |
| Treatment of arrhythmia | 03.03.06.002-6 |
| Treatment of acute pulmonary edema | 03.03.06.013-1 |
| Treatment of acute myocardial infarction | 03.03.06.019-0 |
| Treatment of heart failure | 03.03.06.021-2 |
| Treatment of acute coronary syndrome | 03.03.06.028-0 |
| Valve change with myocardial revascularization | 04.06.01.120-6 |
| Percutaneous aortic valve replacement | 04.06.03.011-1 |
| Percutaneous mitral valve repair | 04.06.03.012-0 |
| Percutaneous pulmonary valve replacement | 04.06.03.013-8 |
| Parathyroid complications | |
| Parathyroid gland removal | 04.02.01.002-7 |
| **Vascular complications** | |
| Amputation/disarticulation of finger | 04.08.06.004-2 |
| Amputation/disarticulation of lower limbs | 04.08.05.001-2 |
| Amputation/disarticulation of feet and tarsum | 04.08.05.002-0 |
| Intraluminal angioplasty of vessels in the extremities (uncoated stent) | 04.06.04.006-0 |
| Intraluminal angioplasty of vessels in the extremities (without stenting) | 04.06.04.005-2 |
| Intraluminal angioplasty of visceral vessels with coated stent | 04.06.04.011-7 |
| Intraluminal angioplasty of supra-aortic vessels in the neck/trunk (coated stent) | 04.06.04.013-3 |
| Diagnosis and/or emergency consultation with surgeon | 03.01.06.007-0 |
| Arterial embolectomy | 04.06.02.012-4 |
| Detachable balloon embolization of carotid-cavernous fistula | 04.03.07.009-0 |
| Embolization of arteriovenous vascular malformation (includes angiogram) | 04.06.04.020-6 |
| Other procedures with sequential surgical procedures | 04.15.02.003-4 |
| Myocardial revascularization with extracorporeal circulation | 04.06.01.092-7 |
| Myocardial revascularization with extracorporeal circulation (two or more grafts) | 04.06.01.093-5 |
| Myocardial revascularization without extracorporeal circulation (two or more grafts) | 04.06.01.095-1 |
| CABG/thromboendarterectomy of other distal arteries | 04.06.02.043-4 |
| CABG/proximal femoropopliteal thromboendarterectomy | 04.06.02.045-0 |
| Treatment with multiple surgical procedures | 04.15.01.001-2 |
### Table 1

| Description                                                                 | Code |
|-----------------------------------------------------------------------------|------|
| Treatment of stroke (ischemic or acute hemorrhagic)                         | 03.03.04.014-9 |
| Treatment of arterial insufficiency with critical ischemia                  | 03.03.06.020-4 |
| Endovascular treatment of arteriovenous fistula                             | 04.06.04.032-0 |
| Bone complications                                                          |      |
| Diagnosis and/or emergency consultation with surgeon                        | 03.01.06.007-0 |
| Two-level anterior neck fusion                                              | 04.08.03.007-0 |
| Three-level anterior neck fusion                                             | 04.08.03.006-2 |
| One-level anterior neck fusion                                               | 04.08.03.011-9 |
| Posterior two-level thoracolumbar and sacral fusions, including instrumentation | 04.08.03.029-1 |
| Posterior six-level thoracolumbar and sacral fusions, including instrumentation | 04.08.03.031-3 |
| Partial hip replacement                                                     | 04.08.04.005-0 |
| Primary cemented total hip replacement                                       | 04.08.04.008-4 |
| Primary non-cemented/hybrid total hip replacement                            | 04.08.04.009-2 |
| Diagnosis and/or emergency consultation with general practitioner            | 03.01.06.008-8 |
| Closed reduction of shaft fracture/physeal injury in the proximal femur     | 04.08.05.023-3 |
| Closed reduction of knee fracture or physeal injury                         | 04.08.05.025-0 |
| Closed reduction of dislocated/fractured-dislocated knee                    | 04.08.05.026-8 |
| Closed reduction of dislocated/dislocated/fractured/fractured-dislocated pelvic ring | 04.08.04.020-3 |
| Removal of foreign body from the cervical spine via anterior approach       | 04.08.03.057-7 |
| Removal of plate and/or pins                                                 | 04.08.06.037-9 |
| Treatment with multiple surgical procedures                                  | 04.15.01.001-2 |
| Surgery for avulsion of tuberosities/spines and iliac crest without injury to the pelvic ring | 04.08.04.024-6 |
| Surgery for combined fractured/dislocated/fractured-dislocated/dislocated pelvic ring | 04.08.04.025-4 |
| Surgery for proximal (neck) femur (synthesis) physeal fracture/injury       | 04.08.05.048-9 |
| Surgery for fractured/dislocated/fractured-dislocated/disjointed anteroposterior pelvic ring | 04.08.04.026-2 |
| Surgery for coxofemoral fracture/dislocation with fractured femoral shaft   | 04.08.04.028-9 |
| Surgery for femur shaft fractures                                            | 04.08.05.051-9 |
| Surgery for acetabular fractures                                             | 04.08.04.029-7 |
| Surgery for intercondylar distal femur fractures                             | 04.08.05.058-6 |
| Surgery for physeal injury/fracture at the level of the knee                | 04.08.05.059-4 |
| Surgery for subtrochanteric fractures                                        | 04.08.05.061-6 |
| Surgery for femur supracondylar fractures (distal metaphysis)              | 04.08.05.062-4 |
| Surgery for transtrochanteric fractures                                      | 04.08.05.063-2 |
| Surgery for dislocation/fracture-dislocation at the level of the knee       | 04.08.05.068-3 |
| Multiple trauma patient surgery                                              | 04.15.03.001-3 |
| Conservative treatment for fracture/ligament injury/bone avulsion at the level of the pelvis | 03.03.09.013-8 |
| Conservative treatment of fractured pelvic rings                             | 03.03.09.019-7 |
| Conservative treatment of fractured lower limbs with immobilization         | 03.03.09.020-0 |
| Conservative treatment of thoracolumbar and sacral spine with orthotics     | 03.03.09.023-5 |
| Conservative treatment of spinal cord injury                                | 03.03.04.011-4 |
| Treatment of fractured spine with spinal cord injury                         | 03.03.04.023-8 |

### Prescription and Cost of Hemodialysis per State in Brazil, 2008-2011

Table 2 shows the analysis of hemodialysis prescriptions per Brazilian State based only on the records referring to Hemodialysis I and II procedures - three sessions a week. In 2008 and 2011, a total of 9,868,978 and 11,382,988 hemodialysis sessions were carried out in Brazil, respectively.
### Table 2: Number of Hemodialysis Sessions and Reimbursements Paid per State, 2008-2011

| State                  | 2008       | 2009       | 2010       | 2011       |
|------------------------|------------|------------|------------|------------|
| São Paulo              |            |            |            |            |
| Number of sessions     | 2,395,134  | 2,468,270  | 2,534,919  | 2,645,313  |
| Reimbursement paid (USD) | 175,896,850.06 | 195,851,803.38 | 204,989,964.80 | 225,667,374.36 |
| Minas Gerais           |            |            |            |            |
| Number of sessions     | 1,300,663  | 1,365,671  | 1,430,601  | 1,490,897  |
| Reimbursement paid (USD) | 95,351,782.33 | 108,359,564.38 | 115,718,184.58 | 127,186,012.18 |
| Rio de Janeiro         |            |            |            |            |
| Number of sessions     | 1,126,630  | 1,157,190  | 1,187,748  | 1,204,781  |
| Reimbursement paid (USD) | 82,558,528.29 | 91,757,527.29 | 96,026,758.76 | 102,777,861.65 |
| Rio Grande do Sul      |            |            |            |            |
| Number of sessions     | 733,779    | 752,295    | 762,411    | 761,428    |
| Reimbursement paid (USD) | 58,890,091.43 | 60,085,587.97 | 61,652,630.87 | 64,948,375.49 |
| Bahia                  |            |            |            |            |
| Number of sessions     | 576,071    | 621,916    | 670,203    | 712,044    |
| Reimbursement paid (USD) | 42,304,307.11 | 49,347,668.81 | 54,228,055.18 | 60,743,322.21 |
| Paraná                 |            |            |            |            |
| Number of sessions     | 538,469    | 554,140    | 576,015    | 594,772    |
| Reimbursement paid (USD) | 39,492,461.35 | 43,917,034.02 | 46,558,350.52 | 50,690,799.77 |
| Pernambuco             |            |            |            |            |
| Number of sessions     | 482,471    | 523,236    | 557,491    | 577,016    |
| Reimbursement paid (USD) | 35,435,135.22 | 41,517,627.33 | 45,099,815.49 | 49,224,301.88 |
| Ceará                  |            |            |            |            |
| Number of sessions     | 387,915    | 409,182    | 434,503    | 460,860    |
| Reimbursement paid (USD) | 28,492,383.47 | 32,467,693.03 | 35,148,228.82 | 39,315,221.35 |
| Goiás                  |            |            |            |            |
| Number of sessions     | 322,193    | 360,897    | 391,898    | 412,992    |
| Reimbursement paid (USD) | 23,674,492.93 | 28,636,384.03 | 31,693,829.31 | 35,231,679.68 |
| Santa Catarina         |            |            |            |            |
| Number of sessions     | 268,821    | 280,305    | 285,728    | 296,499    |
| Reimbursement paid (USD) | 19,820,552.44 | 22,240,999.48 | 23,106,165.18 | 25,293,593.75 |
| Espírito Santo         |            |            |            |            |
| Number of sessions     | 204,634    | 217,342    | 225,946    | 250,282    |
| Reimbursement paid (USD) | 15,031,338.72 | 17,245,610.26 | 18,268,828.73 | 21,361,152.70 |
| Maranhão               |            |            |            |            |
| Number of sessions     | 174,322    | 190,446    | 210,458    | 226,070    |
| Reimbursement paid (USD) | 12,800,659.35 | 15,111,471.91 | 17,021,769.87 | 19,285,666.13 |
| Rio Grande do Norte    |            |            |            |            |
| Number of sessions     | 162,025    | 178,636    | 197,010    | 203,276    |
| Reimbursement paid (USD) | 11,898,214.99 | 14,174,238.79 | 54,462,553.61 | 17,341,146.85 |
| Pará                   |            |            |            |            |
| Number of sessions     | 112,703    | 135,356    | 181,573    | 201,117    |
| Reimbursement paid (USD) | 8,278,760.83 | 10,740,201.58 | 14,698,050.43 | 17,156,966.05 |
| Piauí                  |            |            |            |            |
| Number of sessions     | 145,387    | 160,560    | 173,356    | 192,356    |
| Reimbursement paid (USD) | 10,684,191.39 | 12,740,083.24 | 14,043,984.45 | 16,409,579.31 |
**Continued Table 2**

| State             | Number of sessions | Reimbursement paid (USD) |
|-------------------|--------------------|--------------------------|
| Alagoas           | 142,656            | 10,486,201.09            |
| Mato Grosso       | 104,734            | 8,427,480.31             |
| Distrito Federal  | 134,201            | 9,856,494.79             |
| Mato Grosso do Sul| 121,190            | 8,906,533.66             |
| Paraíba           | 125,227            | 9,196,100.03             |
| Sergipe           | 65,167             | 4,791,770.22             |
| Amazonas          | 75,450             | 5,537,394.10             |
| Rondônia          | 63,923             | 4,692,376.04             |
| Tocantins         | 45,705             | 3,357,331.22             |
| Acre              | 19,043             | 1,081,306.32             |
| Amapá             | 16,044             | 911,015.93               |
| Roraima           | 13,421             | 987,934.92               |
| Total             | 9,868,978          | 723,841,688.56           |

The number of sessions grew by 15.3% within the studied time period. Similar increases were observed in each Brazilian State. Although the states of São Paulo, Minas Gerais, and Rio de Janeiro accounted for almost half of the procedures prescribed at a national level, their numbers decreased slightly in the studied time period, from 48.8% to 46.9%, showing the growing importance of other states.

The fees paid to dialysis centers for hemodialysis sessions were raised by 34.1%
from 2008 to 2011, an increase equivalent to roughly twice the growth of the number of procedures. In 2011, the mean cost of a patient on dialysis was USD 9,112.75 (± 650.05) versus USD 7,932.52 (± 514.55) in 2008.

Prospective cohort analysis: costs, complications, and prescribed medications

Study population profile

The prospective cohort analysis included 96,600 patients, most of which (57.6%) were males. The majority of the patients on dialysis were aged between 40 and 69 years (62.9%). A significant portion of them (24.2%) resided in the state of São Paulo.

The patients in the cohort were followed up for 32 months since they were first observed in 2009. Twelve months into follow-up, 71.3% of the patients were still on dialysis. After 24 and 32 months, 55.1% and 42.7% remained on dialysis, respectively.

Prescription of calcitriol

Eight percent of the patients were on 1.0 mcg calcitriol. Figure 1 shows the calcitriol prescription distribution between different regions in Brazil; more prescriptions were observed among patients seen in the Southeast and Northeast regions of the country.

Figure 1. Calcitriol prescriptions per region in Brazil.

The occurrence of prescriptions of 1.0 mcg calcitriol decreased from 8.0% to 6.1% after 32 months of follow-up. Calcitriol was introduced a mean of 8.1 (± 9.7) months after the start of dialysis.

Prescription of other medications

Table 3 shows the prescription of medications other than calcitriol. Epoetin alfa was the most commonly prescribed medication (65.1%), but sevelamer, although less frequently used (26.0%), had a higher cost impact when compared to other drugs. Ferric saccharate was frequently prescribed (50.6%) and had the lowest cost impact per patient per year - USD 56.14. The total cost incurred in with medications other than calcitriol was USD 35,964,856.25 - a mean of USD 598.81 per patient per year.

Incidence of complications

Over a quarter (28.2%) of the patients suffered with complications. Cardiac events were recorded in 17.1% of the patients, vascular events in 4.3%, bone-related events in 6.8%, and parathyroid gland complications in 0.2%. Patients on 1.0 mcg calcitriol had fewer complications in general, with the exception of parathyroid-related events (Table 4).

Table 4 shows the incidence and costs related to the complications observed in the study group. Patients on 1.0 mcg calcitriol had fewer complications but higher overall treatment costs when compared to individuals on dialysis in all complication categories. The largest share of the costs incurred in the treatment of patients not given calcitriol was associated with parathyroid gland removal procedures (mean cost per patient per year: USD 2,016.03); for patients on calcitriol, the largest share of the expenditure was devoted to heart complications (mean cost per patient per year: US$ 2,100.24). Bone complications accounted for the smallest share of the costs observed in both groups (mean cost per patient per year: USD 695.68 and USD 791.44).
Table 3  Frequency of use and cost of other drugs prescribed to the studied population

| Drug                  | N (%)   | Total cost (USD) | Mean/Patient/Year (USD) |
|-----------------------|---------|------------------|-------------------------|
| Epoetin alfa          | 59,475  (61.8) | 15,148,812.77 | 254.82                  |
| Ferric saccharate     | 48,711  (50.6) | 2,725,644.11  | 56.14                   |
| Sevelamer             | 25,008  (26.0) | 17,841,220.19 | 713.29                  |
| Alfacalcidol          | 1,621   (1.7)  | 125,113.82     | 77.05                   |
| Desferroxamine        | 396     (0.4)   | 124,035.09     | 313.16                  |
| Total                 | 60,082  (62.4) | 35,964,856.25 | 598.81                  |

Table 4  Frequency of occurrence and cost of complications observed in included patients (n = 96,303) and patients on calcitriol (n = 7,056)

| Complication                  | N (%)       | Mean Cost/Patient/Year (USD) | Patients on calcitriol presenting complications | Mean Cost/Patient on calcitriol (USD) |
|-------------------------------|-------------|-----------------------------|-----------------------------------------------|----------------------------------------|
| Cardiac                       | 16,490 (17.1) | 1,894.40                    | 347 (5.9)                                    | 2,100.24                               |
| Vascular                      | 4,189 (4.3)  | 1,061.68                    | 78 (1.1)                                     | 985.17                                 |
| Bone                          | 6,570 (6.8)  | 695.68                      | 10 (0.1)                                     | 791.44                                 |
| Parathyroid gland removal     | 174 (0.2)   | 2,016.03                    | 165 (2.3)                                    | 1,983.01                               |
| Total                         | 27,118 (28.2) | 1,812.94                    | 593 (8.4)                                    | 1,923.57                               |

Discussion

This study aimed to provide a comprehensive understanding of the costs and characteristics of the hemodialysis procedures and the drug therapies offered to patients with chronic kidney disease treated through the Brazilian Public Health Care system (SUS). The used hemodialysis procedures were described, along with the characteristics of the patients prescribed hemodialysis in terms of their geographic distribution, genders, ages, prescribed drugs, and incidence of complications. Secondary data analysis allowed the assessment of large patient cohorts from every Brazilian state, which helped achieve the goals set for the study. However, a limitation of the study was the impossibility of defining treatment start dates. Additionally, patients prescribed hemodialysis for acute kidney injury may have been included in the study population. The method used in the study also posed other constraints as a consequence of the secondary nature of the analyzed databases, which limited the scope of the conclusions presented herein. The limitations included the way patients and costs were identified, resource utilization was assessed, and hospitalizations due to complications were defined; moreover, although infection is a common adverse event among hemodialysis patients, cases of infection were not considered in the study.

The number of hemodialysis procedures offered through the SUS grew by 29.9% between 2008 and 2012. Estimates indicate this number will grow by 24.8% between 2012 and 2017. The 2012 Dialysis Census, however, reported an increase of 12.1% in the number of patients on hemodialysis from 2008 to 2012.4 The census survey, organized by the Brazilian Society of Nephrology (SBN), included dialysis centers from the entire country reimbursed by the SUS and other parties. The disagreement between the census and this study may stem from the low response rate seen in the census. In 2008, only 47.8% of the 684 dialysis centers registered with the SBN responded the survey. In 2012, 651 (39.1%) centers registered with the SBN responded the survey.4 Nonetheless, the trend of an increase in the prevalence and incidence of hemodialysis in the SUS was previously reported to have reached 3.6% and 1.8% a year, respectively, from 2000 to 2012.19
In addition to presenting the totals concerning patients on dialysis in Brazil, the Dialysis Census also offered the breakdown for each Brazilian State. Most of the individuals included in this study were on hemodialysis in southeastern states, as also described in the census for the same time period (2008-2011) and by other authors. However, the dialysis census surveys suggest that this finding may have been biased by the availability of dialysis centers in the southeast region, which accounted for 49.2% to 52.1% of the responding centers in the 2009-2011 time period. The higher prevalence of kidney disease reported in this region of the country - 453 patients per million population in the state of São Paulo versus a national prevalence of 354 patients per million population - may have been biased by easier access to treatment in the country’s southeast region. Underreporting and incomplete patient records may have also led to underestimated incidence and prevalence rates in other regions of the country.

Moura et al. looked into the number of patients on hemodialysis in each Brazilian state and also found greater numbers of patients in the southeastern states and percent rates similar to the ones reported in this study.

The reimbursements paid by the SUS in 2008 and 2011 for hemodialysis procedures added to USD 723,841,688.56 and USD 970,354,599.98, respectively, or an estimated mean annual cost per patient of USD 7,932.52 in 2008 and USD 9,112.75 in 2011. Three studies have been carried out in Brazil on the costs of CKD, with reported mean annual costs per patient ranging widely between USD 7,980 and USD 28,570. The values reported in this study were closer to the figures described by Sesso et al., in a study using primary data and cost descriptions from the standpoint of the Ministry of Health, which corroborated our findings. The greatest discrepancy was observed in relation to the study published by Abreu et al., in which the mean cost of hemodialysis per patient per year of USD 28,570 included indirect costs not considered in this study.

In addition to the pattern of hemodialysis prescription in Brazil, this study also described the use of costly medication to treat patients with CKD in general terms and of calcitriol in particular.

Vitamin D analogues are recommended by the KDOQI, and 8.0% of the studied patients were on calcitriol on any dosage. Martins et al. assessed the cost of these drugs for 747 patients on hemodialysis in Salvador, Brazil, and found that 31.9% of them were on calcitriol on any dosage. Despite the disagreement, these are the only studies in which the use of calcitriol by individuals on hemodialysis in Brazil has been described.

The study also revealed that 62.4% of the patients were on other medications, such as epoetin alfa, ferric saccharate, sevelamer, alfacalcidol, or desferoxamine. Epoetin alfa was the most commonly prescribed drug with 61.8% of the patients, as described in the 2008-2011 dialysis census surveys. 

Complications were observed in 28.2% of the patients and 8.4% of the individuals on calcitriol on any dosage. The incidence of complications among patients on regular hemodialysis has not been clearly defined, as only aspects concerning each type of complication have been described.

Cardiac adverse events were the most common complication described in this study. Other authors have ranked it as the number one cause of death of individuals with CKD and a factor associated with higher hospitalization costs when compared to individuals not manifesting this type of complication.

Conclusion

The analysis of the data collected from the DATASUS database allowed the description of different aspects of the treatment of chronic kidney disease and hemodialysis, and the presentation of a comprehensive overview of renal disease in Brazil.

The number of individuals in need of dialysis grew from 91,475 in 2008 to 118,847 in 2012. By 2017, the number of patients on dialysis has been estimated to grow to 148,315.
Similarly, the costs associated with treating chronic kidney disease have increased. The reimbursements paid by the SUS for hemodialysis procedures grew by 34.1% from 2008 to 2011, elevating the mean cost per patient per year from USD 7,932.52 in 2008 to USD 9,112.75 in 2011.

Cohort analysis of the patients on dialysis included in the DATASUS database shed light on the use of vitamin D analogues and the incidence of various types of complications. Complications were reported for 28.2% of the patients, with cardiac adverse events topping the list. Eight percent of the patients were started on 1 mcg calcitriol a mean of 8.1 months after the start of dialysis. More than 50% of the patients were on other medications such as epoetin alfa and ferric saccharate. The mean cost per patient per year with complications was USD 1,923.57 and USD 1,812.94 for patients on and off 1 mcg calcitriol, respectively.

Despite the insights brought by this study into the reality of chronic kidney disease in Brazil, the limitations posed by the chosen method call for the organization of further studies on the subject.

Acknowledgements

The authors would like to thank the medical writing experts at ANOVA for their support in the preparation of this manuscript.

References

1. Jha V, Garcia-Garcia G, Iseki K, Li Z, Naicker S, Plattner B, et al. Chronic kidney disease: global dimension and perspectives. Lancet 2013;382:260-72. PMID: 23727169 DOI: http://dx.doi.org/10.1016/S0140-6736(13)60687-X
2. Oliveira MB, Romão JE Jr. Zatz R. End-stage renal disease in Brazil: epidemiology, prevention, and treatment. Kidney Int Suppl 2005;S82-6. PMID: 16014106 DOI: http://dx.doi.org/10.1111/j.1523-1755.2005.09714.x
3. Bastos MG, Kirsztajn GM. Doença renal crônica: importância do diagnóstico precoces, encaminhamento imediato e abordagem interdisciplinar estruturada para melhora do desfecho em pacientes ainda não submetidos à diálise. J Bras Nefrol 2011;33:93-108. DOI: http://dx.doi.org/10.1590/S0101-28002011000100013
4. Sociedade Brasileira de Nefrologia. Censo de Diálise - SBN 2012 [Internet]. 2012 [cited 2015 Jun 20]. Available from: http://www.sbn.org.br/pdf/publico2012.pdf
5. Romão Júnior JE, Pinto SWL, Canziani ME, Praxedes JN, Santello JL, Moreira JCM. Censo SBN 2002: informações epidemiológicas das unidades de diálise do Brasil. J Bras Nefrol 2003;23:188-99.
6. Sociedade Brasileira de Nefrologia. Censo de Diálise - SBN 2013 [Internet]. 2013 [cited 2014 May 26]. Available from: http://sbn.org.br/pdf/censo_2013_publico_leigo.pdf
7. Brasil. DATASUS. TABNET. TabNet Win32 3.0: Produção Ambulatorial do SUS - Brasil - por local de atendimento [Internet]. [cited 2014 May 27]. Available from: http://tabnet.datasus.gov.br/cgi/tabcgi.exe/sia/conv/qsusf.def
8. Sesso R, da Silva CB, Kowsalski SC, Mandrioli SR, Canziani ME, Draibe SA, et al. Dialysis care, cardiovascular disease, and costs in end-stage renal disease in Brazil. Int J Technol Assess Health Care 2007;23:126-30. DOI: http://dx.doi.org/10.1017/S0266464607051665
9. Silva LA, Mezzomo NF, Pansard HM, Arantes LC, Rempel W, Argenta LC, et al. Sobrevivida em hemodiálise crônica: estudo de uma coorte de 1.009 pacientes em 25 anos. J Bras Nefrol 2009;31:190-7. DOI: http://dx.doi.org/10.1590/S0101-28002009003000004
10. Cherchiglia ML, Gomes IC, Alves J, Guerra Júnior A, Arcúcio FA, Andrade EI, et al. Determinantes dos gastos com diálise no Sistema único de saúde, Brasil, 2000 a 2004. Cad Saúde Pública 2010;26:1627-41. DOI: http://dx.doi.org/10.1590/S0102-311X2010000800016
11. National Kidney Foundation. K/DOQI clinical practice guidelines for bone metabolism and disease in chronic kidney disease. Am J Kidney Dis 2003;42:S1-202.
12. Brasil. Ministério da Saúde. Diretrizes Clínicas para o Cuidado ao Paciente com Doença Renal Crônica - DRC no Sistema Único de Saúde; 2014.
13. Bastos MG, Carmona WB, Abrira RR, Almeida EC, Mafra D, Costa DMM, et al. Doença renal crônica: problemas e soluções. J Bras Nefrol 2004;26:202-15.
14. Kidney Disease: Improving Global Outcomes (KDIGO) CKD Work Group. KDIGO 2012. Clinical Practice Guideline for the Evaluation and Management of Chronic Kidney Disease. Kidney Int Suppl 2013;3:1-150.
15. Pilz S, Iodice S, Zittermann A, Grant WB, Gandini S. Vitamin D status and mortality risk in CKD: a meta-analysis of prospective studies. Am J Kidney Dis 2011;58:374-82. DOI: http://dx.doi.org/10.1053/j.ajkd.2011.03.020
16. Martins MTS, Silva LF, Martins MTS, Matos CM, Melo NAD, Azevedo MFC, et al. Prescrição de quelantes de fósforo e calcitriol para pacientes em hemodiálise crônica. Rev Assoc Med Bras 2009;55:750-74. DOI: http://dx.doi.org/10.1590/S0104-42302009001000019
17. Mussolini ME, Vaz P. Dados do mundo real: uma ferramenta para tomada de decisões em saúde. J Bras Econ Saúde 2013;5:2-9.
18. Sesso R, Lopes AA, Thomé FS, Bevilacqua JL. Relatório do Censo Brasileiro de Diálise, 2008. J Bras Nefrol 2008;30:233-8.
19. de Moura L, Prestes IV, Duncan BB, Thomé FS, Schmidt MI. Dialysis for end stage renal disease financed through the Brazilian National Health System, 2000 to 2012. BMC Nephrol 2014;15:111. DOI: http://dx.doi.org/10.1186/1471-2369-15-111
20. Sesso RCC, Lopes AA, Thomé FS, Lugon JR, Burdmann EA. Censo Brasileiro de Diálise, 2009. J Bras Nefrol 2010;32:380-4. DOI: http://dx.doi.org/10.1590/S0101-28002010000400007
21. Sesso RCC, Lopes AA, Thomé FS, Lugon JR, Santos DR. Relatório do Censo Brasileiro de Diálise de 2010. J Bras Nefrol 2011;33:442-7. DOI: http://dx.doi.org/10.1590/S0101-28002011000400009
22. Sesso RCC, Lopes AA, Thomé FS, Lugon JR, Watanabe Y, Santos DR dos. Diálise Crônica no Brasil - Relatório do Censo Brasileiro de Diálise, 2011. J Bras Nefrol 2012;34:272-7. DOI: http://dx.doi.org/10.9353/jneph/0101-280020120002000441
23. Andrade MV, Junoy JP, Andrade EI, Arcúcio Fde A, Sesso R, Queiroz OV, et al. Allocation of initial modality for renal replacement therapy in Brazil. Clin J Am Soc Nephrol 2010;5:637-44. DOI: http://dx.doi.org/10.2215/CJN.04840709
24. de Abreu MM, Walker DR, Sesso RC, Ferraz MB. A cost evaluation of peritoneal dialysis and hemodialysis in the treatment of end-stage renal disease in Sao Paulo, Brazil. Perit Dial Int 2013;33:304-15. DOI: http://dx.doi.org/10.3747/pdi.2011.00138
25. Peres LAB, Biela R, Herrmann M, Matsuo T, Ann HK, Camargo MTA, et al. Estudo epidemiológico da doença renal crônica terminal no oeste do Paraná. Uma experiência de 878 casos atendidos em 25 anos. J Bras Nefrol 2010;32:51-6. DOI: http://dx.doi.org/10.1590/S0101-28002010000100010

26. Barberato SH, Bucharles SGE, Sousa AM, Costantini CO, Costantini CRF, Pecoits Filho R. Prevalência e impacto prognóstico da disfunção diastólica na doença renal crônica em hemodiálise. Arq Bras Cardiol 2010;94:457-62. DOI: http://dx.doi.org/10.1590/S0066-782X20100005000016

27. Bregman R, Lemos C, Pecoits Filho R, Abensur H, Draibe S, Bastos MG, et al. Hipertrofia ventricular esquerda em pacientes com doença renal crônica em tratamento conservador. J Bras Nefrol 2010;32:85-90. DOI: http://dx.doi.org/10.1590/S0101-28002010000100014

28. Breitsameter G, Thomé EG da R, Silveira DT. Complicações que levam o doente renal crônico a um serviço de emergência. Rev Gaúch Enferm 2008;29:543-50.

29. Gomes CP, Silva MI, Duarte ME, Dorigo D, Lemos CC, Bregman R. Bone disease in patients with chronic kidney disease under conservative management. São Paulo Med J 2005;123:83-7. PMID: 15947836 DOI: http://dx.doi.org/10.1590/S1590-8151-2005000200010

30. Silva LS, Oliveira RA, Silva GB, Lima JW, Silva RP, Liborio AB, et al. Cardiovascular disease in patients with end-stage renal disease on hemodialysis in a developing country. Saudi J Kidney Dis Transpl 2012;23:262-6.