Allocation of Initial Modality for Renal Replacement Therapy in Brazil

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Background and objectives: The use of dialysis modalities for ESRD varies around the world. There is no consensus in literature regarding the most appropriate choice of dialysis method. The aim of this study was to analyze the initial modality for ESRD in Brazil and evaluate the factors determining patients' allocation to either hemodialysis (HD) or peritoneal dialysis (PD).

Design, setting, participants, & measurements: A retrospective cohort study was performed using national administrative registries of all patients financed by the public system who began renal replacement therapy in 2000 in Brazil. Logistic regression analysis was used to investigate factors associated with the probability of receiving HD or PD at the start of treatment. Independent variables tested were age, sex, presence of diabetes, geographic region of residence, and health care supply indicators.

Results: Of 11,563 patients analyzed, 88% started on HD and 12% started on PD. Patients were more likely to be assigned to HD if they were male (odds ratio: 1.44; 95% confidence interval: 1.23 to 1.68) and nondiabetic (odds ratio: 0.71; 95% confidence interval: 0.60 to 0.84). With regard to age, the youngest and the elderly showed lower probability of being in HD. In addition, the state of residence at the start of treatment was very important to explain initial modality allocation.

Conclusions: Our findings suggest that patient allocation in Brazil is not random. The probability of allocation to HD or PD is highly associated with individual attributes and supply variables.

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The use of dialysis methods for ESRD varies around the world. Worldwide, hemodialysis (HD) was used to treat 89% of patients and peritoneal dialysis (PD) used to treat 11% of patients in 2004 (1). There is no consensus in clinical literature regarding the choice of treatment modality (2,3). Several factors may influence the choice of method, including patients' clinical health at the beginning of ESRD therapy, physician and patient preferences, geographic location (2), and individual characteristics. Some studies have also focused on the importance of economic factors, such as the type of reimbursement and the availability of resources (4–6). Although results comparing patient survival in HD and PD are in conflict, the majority of studies found that both therapies have comparable results (7,8).

The number of chronic kidney disease (CKD) patients is growing worldwide, and the treatment of CKD patients presents a significant source of health care expenditure (9–11). From 2004 to 2007 in Brazil, the number of patients receiving renal replacement therapy (RRT) increased by 8.1% (12). Despite these numbers, few studies address RRT in Latin America, particularly in Brazil.

The aim of this study is to analyze factors affecting patient allocation to either HD or PD in Brazil using national administrative registries from all patients financed by the public system who began RRT during the year 2000.

Materials and Methods

We used the National Database for RRT (13,14), which contains patient records for the 2000 to 2004 period. This database was built using Autorizaçao de Procedimentos de Alta Complexidade/Sistema de Informaçoes Ambulatoriais forms, which are administrative records of all complex procedures financed by the public health system in Brazil. The forms are mandatory and filled out by the dialysis providers. The national database includes 95% of all chronic dialysis patients in the country and contains information about the type of dialysis modality, expenditure, cause of CKD, and patient characteristics.

The study population is composed of incident patients that registered

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between January and December 2000. Patients were included only if they had at least three consecutive months of treatment at the beginning of treatment to exclude acute renal failure patients. Besides, there is evidence of high mortality rates at the beginning of treatment caused by previous health status (15,16). Patients who had received a renal transplant between 2000 and December 2004 and patients who had paid for HIV-related procedures were also excluded.

In 2000, there were 18,138 incident patients. The total number of excluded patients was 6575. 3913 patients had less than three consecutive months of treatment at the beginning of treatment; 2601 patients had received a renal transplant during a 4-year follow-up period; and 61 patients had shown symptoms related to HIV. Our final sample included 11,563 patients.

For each patient, there was monthly information about the type of RRT. If the patient record was absent, an imputation of therapy modality was performed according to two criteria: random imputation if a patient had different therapies in the extreme ends of the range, and repetition of treatment modality if a patient presented the same modality in the extreme ends of the range. The initial treatment modality was defined by taking into account the modality that a patient had remained in for at least three consecutive months at the beginning of the treatment, whether or not these three consecutive months occurred in the first three months (which applied to 96.8% of patients in the study).

In addition to the National Database for RRT, we also used the Medical Sanitary Assistance Survey (2002) (17). We performed our analysis using two datasets. The first dataset contained all patients who began RRT in 2000. The second dataset excluded patients whose causes of CKD were classified as undetermined (3804 patients) and those living in states with fewer than 10 observations in each type of RRT: those from Acre, Amapá, Maranhão, Rondonia, Roraima, Tocantins, Mato Grosso do Sul, Mato Grosso, and Piauí were excluded (673 patients). This dataset contains 7096 patients. The distribution of covariates was quite similar in both databases. Regression results are only reported for the second dataset.

Statistical Analyses

Patients' characteristics were described according to the type of initial therapy. The covariates used were sex, age, state of residence at the start of treatment, and diabetes as the main cause of CKD. We used frequency analysis, measures of central tendency, and variance. The χ^2 test and z-test were also performed.

To analyze the probability of assignment to either modality of treatment, a regression model (logit) was performed. The dependent variable was a dummy variable equal to 1 if the patient's initial modality was HD and equal to 0 if the modality was PD. We used age, sex, state of residence at the beginning of treatment, presence of diabetes, and health care supply indicators as independent variables. Age was included as a cubic polynomial function. The use of polynomial function allows not imposing any specific functional form to the relationship between age and probability of assignment to HD.

We estimated three model specifications. The first model included individual risk variables. In the second specification, we added the state of residence at the beginning of treatment. The state of residence can be interpreted as a proxy for health care supply, because federal states are responsible for managing public policies related to highly complex health care. It also captures differences in socioeconomic conditions. In the third specification, we included other supply variables associated with the local municipality: six dummy variables for the amount of HD machines in the patients' city of residence at the start of treatment, and five dummy variables for the number of hospital beds per capita (17). Although these supply variables are related to differences in the quantity of dialysis machines, they do not distinguish between modalities of RRT.

Table 1. Percentages of incident patients in RRT in selected countries by modality, age, gender and diabetes

Countries	Total			0 to 19 yrs			20 to 44 yrs			45 to 64 yrs			64 to 74 yrs			75+ yrs			Male			Female			Diabetes			Nondiabetes		
	HD	PD	Other	HD	PD	Other	HD	PD	Other	HD	PD	Other	HD	PD	Other	HD	PD	Other	HD	PD	Other	HD	PD	Other	HD	PD	Other	HD	PD	Other
Austria	80	10	10	35	24	41	59	16	25	74	15	11	84	8	8	92	2	6	78	10	12	83	8	9	85	7	8	77	11	12
Denmark	64	32	4	8	42	50	55	34	11	53	41	6	74	25	1	75	25	0	65	31	4	61	33	6	70	27	3	62	33	5
Finland	72	26	2	25	60	15	52	43	5	71	28	1	81	17	2	87	13	0	70	27	3	76	23	1	65	33	2	76	22	2
Greece	87	10	3	50	22	28	81	10	9	84	10	6	87	9	4	90	9	1	86	9	5	87	10	3	85	13	2	87	8	5
Italy	76	14	10	46	40	14	68	20	12	71	19	10	78	13	9	81	10	9	76	14	10	76	15	9	77	14	9	76	14	10
Norway	67	21	12	14	29	57	48	22	30	62	18	20	76	20	4	76	24	0	68	19	13	63	25	12	62	24	14	67	20	13
Sweden	59	36	5	0	47	53	50	38	12	54	38	8	67	32	1	65	35	0	57	38	5	63	31	6	63	35	2	58	36	6
The Netherlands	70	22	8	35	46	19	46	29	25	60	28	12	80	18	2	87	13	0	69	23	8	71	21	8	80	20	0	23	10	67
United Kingdom[a]	70	22	8	-	-	-	54	27	19	64	27	9	78	20	2	86	13	1	71	22	7	69	23	8	73	21	6	70	23	7
United States	92	6	2	52	32	16	86	9	5	90	7	3	93	5	2	96	3	1	92	6	2	92	6	2	94	6	0	90	6	4
Brazil[b]	88	12	-	73	27	-	93	7	-	89	11	-	84	16	-	-	-		89	11	-	86	14	-	86	14	-	88	12	-

Values given as percentages. Percentages are row percentages. "Other" category includes transplant, hemofiltration, hemodiafiltration, and unknown. Sources: European Renal Association–European Dialysis and Transplant Association Registry Annual Report 2007; U.S. Renal Data System 2008 Annual Data Report; National RRT Database 2000. Some of the data reported here have been supplied by the United States Renal Data System. The interpretation and reporting of these data are the responsibility of the author(s) and in no way should be seen as an official policy or interpretation of the U.S. government.

[a]Patients younger than 20 years.

[b]There are no data available in Brazil related to transplantation as an initial RRT (preemptive). Age groups for Brazilian data are: 0 to 19 years; 20 to 44 years; 45 to 64 years; and older than 64 years.

Results

In Brazil, the majority of patients start RRT in HD, even the youngest patients. This evidence is not observed in developed countries. Although HD is also the most prevalent RRT in developed countries, there is a great contribution of PD, particularly in patients younger than 20 years. (Table 1) (1,18). Table 2 describes patient profiles according to the initial RRT modality. The majority of the patients were male (56.2%), with an average age of 53.4 years. Half of the patients belonged to the Southeast region: 26.3% were in São

Table 2. RRT patients' profiles according to the type of dialysis modality at the start of treatment, Brazil 2000

	HD		PD		Total	
	n	%	*n*	%	*n*	%
Individuals, *N*	10,169	87.9	1394	12.1	11,563	100.0
Gender[a]						
female	4356	42.8	709	50.9	5065	43.8
male	5813	57.2	685	49.1	6498	56.2
Age group[a]						
0 to 19 yrs	273	2.7	100	7.2	373	3.2
20 to 44 yrs	2690	26.5	209	15.0	2899	25.1
45 to 64 yrs	4642	45.7	582	41.8	5224	45.2
older than 65 yrs	2502	24.6	490	35.2	2992	25.9
State of residence						
Acre[a]	1	0.0	16	1.2	17	0.2
Alagoas	243	2.4	31	2.2	274	2.4
Amazonas	118	1.2	10	0.7	128	1.1
Amapá	19	0.2	1	0.1	20	0.2
Bahia	513	5.0	63	4.5	576	5.0
Ceará[a]	348	3.4	11	0.8	359	3.1
Distrito Federal[a]	156	1.5	33	2.4	189	1.6
Espírito Santo[a]	150	1.5	61	4.4	211	1.8
Goiás[a]	185	1.8	43	3.1	228	2.0
Maranhão[a]	214	2.1	6	0.4	220	1.9
Minas Gerais[a]	1153	11.3	131	9.4	1284	11.1
Mato G.Sul	64	0.6	7	0.5	71	0.6
Mato Grosso[a]	105	1.0	7	0.5	112	1.0
Pará[a]	109	1.1	38	2.7	147	1.3
Paraíba	302	3.0	55	4.0	357	3.1
Pernambuco[a]	492	4.8	34	2.4	526	4.6
Piauí[a]	113	1.1	9	0.7	122	1.1
Paraná	564	5.6	75	5.4	639	5.5
Rio Janeiro[a]	1295	12.7	138	9.9	1433	12.4
R. Norte	201	2.0	24	1.7	225	2.0
Rondônia	23	0.2	5	0.4	28	0.2
Roraima	2	0.0	0	0.0	2	0.0
R.G. Sul[a]	845	8.3	52	3.7	897	7.8
S. Catarina[a]	285	2.8	28	2.0	313	2.7
Sergipe[a]	26	0.3	42	3.0	68	0.6
São Paulo[a]	2573	25.3	473	33.9	3046	26.3
Tocantins	70	0.7	1	0.1	71	0.6
CKD cause						
diabetic patients	1954	19.2	309	22.2	2263	19.6
nondiabetic patients	8215	80.8	1085	77.8	9300	80.4
Total	10169	100.0	1394	100.0	11563	100.0

Source: National RRT Database. Patient age is as follows: average age 53.1 yrs, 55.8 yrs, and 53.4 yrs for the HD, PD, and Total groups, respectively; median age 54.2 yrs, 59.4 yrs, and 54.8 yrs for the HD, PD, and Total groups, respectively. Age was significant at 5%.

[a]Significant at 5%.

Paulo, 12.4% in Rio de Janeiro, and 11.1% in Minas Gerais. Almost 20% of patients had diabetes mellitus as the main cause of CKD. For both methods of treatment, the majority of patients were older than 45 years.

A comparison of patient profiles across therapies reveals that patients were quite different. There were a greater proportion of patients younger than 20 years and older than 65 years allocated in PD, whereas patients between 20 and 64 years of age were more likely to be allocated in HD. There were a greater proportion of men on HD and a balanced gender distribution on PD. More patients on PD had diabetes mellitus as the primary CKD diagnosis compared with patients on HD.

The geographic distribution of patients across states revealed that the health care supply of RRT was not uniformly distributed in Brazil. About 50% of patients who received RRT were concentrated in São Paulo, Rio de Janeiro, and Minas Gerais. In addition, there were states in which the supply of RRT was quite low. In terms of RRT prevalence, São Paulo presents the greatest prevalence: 453 patients per 1 million in population compared with 354 per 1 million in the whole country (13,14). Regarding the differences in distribution between both modalities, this difference in distribution was statistically significant in a majority of states. The distribution of patients on PD was much more concentrated than those on HD. São Paulo was the state with the greatest number of patients on PD, containing 34% of all PD patients in the country (Table 2). Concerning supply variables, individuals on PD lived in municipalities containing a greater amount of HD machines but a lower number of hospital beds per capita (Table 3).

Table 4 shows the odds ratios for the three models estimated. The results were very stable. The coefficients did not vary significantly when new variables were added. Results showed that patients were not randomly allocated between HD and PD. Women, patients with diabetes, and the oldest and youngest patients had a higher probability of being allocated to PD treatment.

Figure 1 shows the average estimated probability to be allocated to HD by age, adjusted for all covariates. The probability of allocation to HD increases with age until 45 years, remains stable until about 60 years, and then decreases. The slope of the curve is greater for individuals up to 20 years old. The results indicate an increased probability of allocation to PD in the youngest and in the elderly patients.

Besides individual characteristics, modality allocation was strongly correlated with the state of residence. Pseudo R^2 comparison between models 1 and 2 demonstrated the importance of geographic factors. Model 3, which included local supply variables, showed that patients living in cities with a greater number of hospital beds per capita had a higher probability of being in HD modality.

Discussion

This paper describes the patients' profiles at the start of RRT by analyzing the factors that were more associated with their allocation to HD or PD at the start of treatment in Brazil.

We took advantage of existing data from the National Database of RRT, which included a cohort of patients who began RRT in 2000. Despite its advantages, the National Database of RRT still has some limitations. First, patient characteristics are

Table 3. Health care services supply at the municipality of residence according to initial modality of RRT, Brazil 2000

	HD		PD		Total	
	n	%	*n*	%	*n*	%
Individuals (*N*)	10169	87.9	1394	12,1	11563	100.0
Number of HD machines						
no machines[a]	3497	34.4	432	31.0	3929	34.0
1 to 20	1040	10.2	164	11.8	1204	10.4
20 to 50	1495	14.7	185	13.3	1680	14.5
50 to 70	282	2.8	40	2.9	322	2.8
70 to 100	924	9.1	141	10.1	1065	9.2
>100	2931	28.8	432	31.0	3363	29.1
Hospital beds per capita						
no beds[a]	650	6.4	112	8.0	762	6.6
0 to 1[a]	465	4.6	40	2.9	505	4.4
1 to 3	4690	46.1	611	43.8	5301	45.8
3 to 5[a]	3457	34.0	536	38.5	3993	34.5
>5[a]	907	8.9	95	6.8	1002	8.7
Total	10169	100.0	1394	100.0	11563	100.0

Source: National RRT Database, Brazilian Institute of Geography and Statistics, and the Medical Sanitary Assistance Survey 2002.

[a]Significant at 5%.

Table 4. Probability of being allocated to HD at the start of treatment, Brazil 2000

Covariates	Model 1			Model 2			Model 3		
	Odds Ratio	95% Confidence Interval		Odds Ratio	95% Confidence Interval		Odds Ratio	95% Confidence Interval	
Age	1.19	1.13	1.25[a]	1.18	1.12	1.24[a]	1.18	1.12	1.24[a]
Age square	0.99	0.99	0.99[a]	0.99	0.99	0.99[a]	0.99	0.99	0.99[a]
Age cubic	1.00	1.00	1.00[a]	1.00	1.00	1.00[a]	1.00	1.00	1.00[a]
Sex	1.40	1.21	1.63[a]	1.44	1.24	1.69[a]	1.44	1.23	1.68[a]
Diabetes mellitus	0.74	0.63	0.87[a]	0.72	0.61	0.85[a]	0.71	0.60	0.84[a]
State									
Alagoas				1.59	0.98	2.59[b]	2.04	1.21	3.47[a]
Amazonas				2.05	1.02	4.11[c]	1.95	0.89	4.27[b]
Bahia				1.79	1.15	2.79[c]	2.15	1.37	3.38[a]
Ceara				6.69	3.11	14.37[a]	7.94	3.67	17.17[a]
Distrito Federal				0.36	0.18	0.72[a]	0.34	0.16	0.75[a]
Espírito Santo				0.38	0.22	0.64[a]	0.38	0.22	0.66[a]
Goiás				0.66	0.43	1.03[b]	0.89	0.56	1.41
Minas Gerais				1.69	1.28	2.23[a]	1.94	1.45	2.60[a]
Para				0.58	0.33	1.01[b]	0.77	0.43	1.38
Paraíba				1.38	0.87	2.20	1.71	1.03	2.84[c]
Pernambuco				2.30	1.56	3.40[a]	2.36	1.57	3.56[a]
Piauí									
Paraná				1.38	1.00	1.92[b]	1.63	1.16	2.29[a]
Rio de Janeiro				1.78	1.41	2.27[a]	2.20	1.70	2.85[a]
Rio G. Norte				1.85	1.03	3.34[c]	2.30	1.26	4.19[a]
R. G. Sul				4.76	2.91	7.78[a]	5.27	3.20	8.67[a]
Santa Catarina				2.24	1.30	3.88[a]	2.53	1.45	4.40[a]
Sergipe				0.10	0.06	0.16[a]	0.13	0.07	0.22[a]
Hospital beds per capita									
0 to 1							1.48	0.88	2.49
1 to 3							1.44	1.00	2.08[c]
3 to 5							0.88	0.61	1.27
> 5							1.12	0.71	1.76
Number of HD machines									
1 to 20							0.87	0.65	1.15
20 to 50							1.07	0.82	1.41
50 to 70							1.14	0.69	1.90
70 to 100							0.94	0.63	1.39
>100							1.02	0.82	1.28
Pseudo R^2	0.03			0.09			0.09		
Number of observations[d]	7046			7046			7046		

Reference categories: female gender, state of São Paulo, non-diabetes mellitus, no beds per capita, and no HD machines. Source: National RRT Database, Brazilian Institute of Geography and Statistics, and the Medical Sanitary Assistance Survey 2002.

[a] $P < 0.01$.

[b] $P < 0.10$.

[c] $P < 0.05$.

[d] 50 individuals did not present age information and were excluded from the regression estimations.

related only to age, sex, and place of residence, and there is no information about socioeconomic conditions, individual preferences, individuals' health status at the start of treatment, or comorbidities and laboratorial data. Second, although it contains some provider information, these variables still present several missing data.

The issue of preferred choice of RRT modality is controversial in literature. The major lines of evidence come from devel-

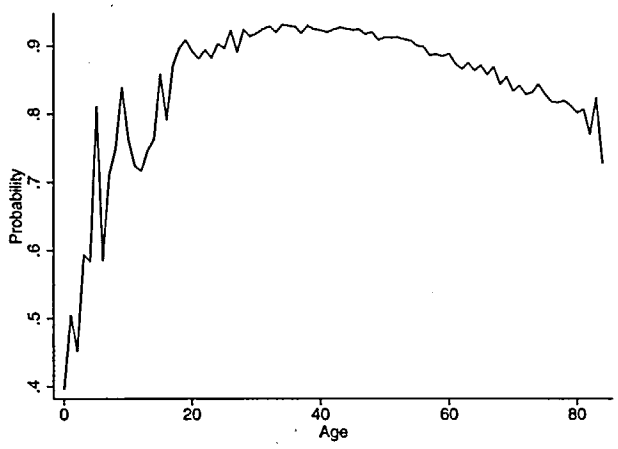

Figure 1. Probability of assignment to HD by age, Brazil, 2000. Note: The graph is built considering the average estimated probability of assignment to HD by age adjusted for age, sex, state of residence at the beginning of RRT, presence of diabetes, and supply of health care services.

oped countries. Although some clinical conditions should be considered when allocating patients to either HD or PD (19), studies worldwide have shown that there are other factors that are quite important. These include patients' preferences, education, and training of physicians and nurses, as well as nonclinical factors such as financing, reimbursement, resource availability, and sociocultural habits. All of these factors interact in complex ways to determine patient outcomes and treatment costs (4,20). Worldwide, the majority of patients receive HD treatment. This is also true in developing countries, with the exception of Mexico (6,21). In addition to the wide international variability in the selection of a treatment modality, geographic variability also exists within the same country. Some authors have pointed out that this variability may be associated with various factors, such as an aging population, geographic location, distance from an HD dialysis facility, or even physician bias (2,20,22).

This study is the first to describe the relationship between RRT factors and allocation of patients to either HD or PD in a developing country. Our findings suggest that patient allocation in Brazil has not been random. Diabetic, youngest, and oldest patients had a greater probability of being allocated to PD. In the United States, PD allocation is more closely associated with younger individuals, whereas in France it is a common treatment option for the elderly (2,19,23,24).

Besides individual risk variables, the allocation between methods was highly associated with supply variables. Around 50% of the multivariate regression model variance was explained by supply variables. Resource availability also influenced the selection of the dialysis modality (4). Historically, the Brazilian Health System has consolidated into a mixed system, with a huge presence from the private sector. With regard to HD services, private industries monopolize RRT equipment and medicine sectors (25). Moreover, the type of reimbursement can also be an incentive to an intensive use of HD because in Brazil HD is paid in a fee-for-service structure; for PD, equipment suppliers are paid directly, and physicians are reimbursed only through visits and training services. Another possible explanation that deserves more investigation includes the utilization capacity. According to Just *et al.* (6), when the HD capacity is higher, there is a perceived and actual incentive to use the higher capacity rather than place patients on alternative methods, such as PD.

Our findings show that the choice of a modality in Brazil is strongly related to the state of residence at the start of treatment. As mentioned, the responsibility of managing a public and highly complex health care system in Brazil belongs to the state governments rather than the local governments. Our assumption is that patients living in the same state have similar access to RRT services once the providers' contracts and RRT supply are managed by state governments. We recognize that our supply variables were limited because we did not have information about all RRT methods that were available when the patient was assigned to the initial modality of treatment. Further research should include more variables about HD suppliers, primarily with regard to treatment options.

The importance of the state of residence may also be associated with inequality in health care access among different Brazilian regions. This unequal distribution may be related to the distribution of nephrologists. In Brazil, 63.5% of the nephrologists are located in only four federal states (26). A key factor influencing the allocation of treatment modality is the timing of referral to a nephrologist. When patients are referred late to a nephrologist's care or urgently need to initiate dialysis without planned access, they are nearly always started on HD. Similarly, frequent visits to a nephrologist were associated with greater likelihood of placement on PD over HD (2,6,20,27). According to Sesso and Belasco (28), 58% of patients admitted to a maintenance dialysis program in Brazil had a late diagnosis. In this study, 32% of patients were diagnosed with renal failure less than 60 days before starting on dialysis, and only 5% of these patients had access to a nephrologist before reaching ESRD. In addition, it has been suggested that ESRD is underdiagnosed in Brazil (29). On the other hand, late diagnosis can partly explain why high-risk patients are more commonly assigned to PD.

In Brazil, other important nonmedical factors that might affect the choice of modality are related to social and economic conditions. In 2003, only 68% of households lived in adequate sanitary conditions. Furthermore, individuals older than 10 years had an average of 6.4 years of schooling, and the illiteracy rate of the population in the last 15 years was around 15%. These numbers seem to be even worse for the CKD population. A study done in Rio Grande do Sul showed that patients who underwent HD treatment had less schooling and lower family income per capita (30). Socioeconomic conditions can limit the ability of patients to manage home dialysis (20). Moreover, household sanitary conditions can often counteract the effects of dialysis done at home.

It should be noted that limited access to ESRD treatment due to poverty and social deprivation occurs mainly in undeveloped and developing countries. In developed countries, barri-

ers to accessing renal care are also observed, including factors such as race, ethnicity, age, sex, and distance to the closest major center for renal care. The reasons for these associations are complex and are influenced by patient and provider preferences, socioeconomic conditions of patients, and the health care delivery system (31–34).

Finally, the number of studies on RRT in Brazil and other developing countries is scarce. We hope that this study improves this gap of knowledge. We recognize that choice modality is a complex process, and this paper contributes to clarifying some aspects in Brazil. Brazil has an increasing prevalence rate of dialysis patients, and thus more investigation about RRT is warranted to promote adequate selection and optimization of each treatment modality (11). It also underscores the importance of patient autonomy as well as equal access to health care and primary and pre-ESRD care in improving patients' clinical outcomes from CKD. This will allow the Brazilian government to improve the outcomes and to offer ESRD patients higher survival rates, less morbidity, and a better quality of life.

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Disclosures

None.

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