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Socioeconomic determinants of the supply and access to kidney replacement therapies in Latin America

Determinantes socioeconómicos sobre la oferta y el acceso a terapias de reemplazo renal en Latinoamérica

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Abstract

Objective: *The increasing global incidence of end-stage chronic kidney disease positions renal replacement therapies (RRT) as critical elements of the financial balance of healthcare systems: their access and distribution are inefficient, with a predominance of less cost-effective techniques, where the supply follows market logic and not public health criteria. Latin America is a region with socioeconomic characteristics where asymmetries and inequalities present a particular panorama. This article analyzes the impact of selected socioeconomic determinants on the supply and access to RRT in Latin America and identifies areas for improvement and research in health policies.* **Materials and methods:** *A correlation analysis was conducted on 28 variables of supply and access to RRT and socioeconomic determinants from relevant databases (2019-2020) from 19 countries.* **Results:** *Access variables (overall prevalence and prevalence by RRT) showed positive correlations with the full range of modalities, early initiation of programs, and the advancement of procurement laws, along with greater urban concentration and economic development indicators (GDP per capita). The supply of professionals and services is uneven, with greater concentration in richer countries, early initiation of Nephrology, greater urban population, and income equality, with a higher prevalence of hemodialysis units compared to peritoneal dialysis and transplantation.* **Conclusions:** *Multiple correlations were found between socioeconomic determinants and RRT access and supply variables, some known and explicit, and others that open the field for research in equitable health policies.*

Keywords: *Renal replacement therapies. Socioeconomic factors. Health care policies.*

Resumen

Objetivo: *La creciente incidencia de la enfermedad renal crónica terminal posiciona a las terapias de reemplazo renal (TRR) como elementos críticos del balance financiero en salud: su acceso y distribución son ineficientes, con predominio de técnicas menos costo-efectivas, donde la oferta sigue lógicas de mercado y no criterios de salud pública. Latinoamérica es una región de características socioeconómicas donde las asimetrías y desigualdades presentan un panorama particular. Evaluar el impacto de determinantes socioeconómicos seleccionados sobre la oferta y acceso a las TRR en Latinoamérica. Identificar áreas de mejora e investigación en políticas sanitarias.* **Material y métodos:** *Análisis de correlación de 28 variables de oferta y acceso a TRR y determinantes socioeconómicos de bases de datos relevantes (2019-2020) para 19 países latinoamericanos.* **Resultados:** *Las*

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variables de acceso (prevalencia global y por TRR) mostraron correlaciones positivas con la oferta completa de modalidades, el inicio precoz de los programas y el avance de leyes de procuración, junto a mayor concentración urbana e indicadores de desarrollo económico (PIB per cápita). La oferta de profesionales y servicios es desigual, con mayor concentración en países más ricos, inicio precoz de la nefrología, mayor población urbana e igualdad de ingresos, y con mayor prevalencia de centros de tratamiento. **Conclusiones:** *Se encontraron múltiples correlaciones entre los determinantes socioeconómicos y las variables de acceso y oferta de TRR, algunas conocidas y explícitas, y otras que abren campo para nuevas investigaciones en políticas sanitarias equitativas.*

Palabras clave: *Terapias de reemplazo renal. Determinantes socioeconómicos. Políticas sanitarias.*

Introduction

The treatment of end-stage chronic kidney disease (ESKD) is carried out through three general modalities of renal replacement therapies (RRT): peritoneal dialysis (PD), hemodialysis (HD), and kidney transplantation (KT). Due to its high cost, coupled with the increasing incidence of ESKD[1], these treatments pose a significant challenge to the financial balance of health systems worldwide[2]. RRTs are crucial for patient survival and cannot be disregarded based on cost-effectiveness criteria alone, requiring universal and equitable access to be guaranteed[3-5]. However, this is particularly difficult in low- or limited-resource countries, where the primary need is the implementation of universal health coverage policies ethically grounded in equity and the rational use of resources[6]. On the other hand, the higher global prevalence of HD compared to other modalities[2,7] suggests a supply defined by market logic rather than public health needs[8-10].

In general terms, macroeconomic and social determinants play a fundamental role in people's health[11], both in relation to variables such as wealth and development, and the level of spending allocated to health as a percentage of the gross domestic product (GDP). Scientific evidence has consistently shown that long-standing inequalities in kidney health have caused socially and economically disadvantaged groups to be at greater risk of poorer health outcomes[12]. The factors determining the supply and demand for health services in general and RRTs in particular are multiple and highly complex to address: some are directly related to technical-medical criteria, but factors related to the economic[13,14], political, and cultural environment of each country or region, such as in Latin America[15,16], also play a role. These include health policies, financing, infrastructure, human resources, access to medical supplies, and socioeconomic inequalities, among others.

The population of Latin America comprises nearly 630 million people (9% of the global population) with a life expectancy four years higher than the global average (76 vs. 72 years). It constitutes the most urbanized region in the world (80% of its population lives in cities) and allocates an average of 6% of GDP to health (lower than the 8.8% in countries of the Organization for Economic Cooperation and Development [OECD])[17,18]. Furthermore, as evidence of inequality, approximately 250 million people in Latin America lack social security (46% of the population), a figure[19] similar to poverty levels (40.2%, with 11.2% in extreme poverty).

In this context, the aim is to analyze the potential impact and relationship of selected socioeconomic determinants on the supply of and access to RRTs in our region: the objective is to identify and objectively characterize possible sources of inequity to develop more specific and tailored health policies to improve the kidney health of the population, distributing resources efficiently, effectively, and accessibly across the different modalities.

Method

Relevant variables were selected to address the issue, and an adaptive methodology was chosen to estimate correlations among them, as described below.

Database

A preliminary database was developed, consisting of 37 socioeconomic, demographic, and health-related variables, with data from 19 Latin American countries. Subsequently, a selection process was carried out considering the effective and updated access to sources[16,20-23] and their reliability level, resulting in a final list of 28 variables. The countries included were Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, the Dominican Republic, Uruguay, and Venezuela. To complete and update relevant information about the availability of RRT, a specific survey on access to nephrological care was conducted. It

was answered by 98 nephrologists from the selected countries (average 5.2 responses per country).

Various grouping categories were defined for the final variables (Table 1). The analysis focused on the impact of determinants on access to and availability of RRT and was complemented with other supplementary correlations.

Data analysis

Pearson (r) and Spearman (ρ) coefficients were used to assess correlations between all variables. Statistical significance was defined in all cases as a p-value < 0.05. Variables showing statistically significant Pearson correlations with a coefficient greater than 0.60 were modeled using univariate linear regression. Residual normality was evaluated through visual inspection of residual plots against the independent variable. Analyses were performed using JASP and Microsoft Excel.

Results

Tables sequentially present the main correlations regarding access to and availability of services, along with other supplementary correlations. Figures, organized similarly, display linear regressions of the strongest correlations (r ≥ 0.60).

Access to renal replacement therapy services

Table 2 shows statistically significant correlations for access to RRT variables and the rest of the analyzed variables, while figure 1 presents linear regressions of the strongest associations (r ≥ 0.60).

Availability of renal replacement therapy services

Table 3 displays significant correlations for the availability of professionals and RRT services and the rest of the analyzed variables. Figures 2 to 5 show linear regressions for the availability of professionals and HD, PD, and KT services (measured as the number of centers and patients per center) in relation to the explanatory variables with the strongest associations.

The composite variable of patients per HD unit showed a direct correlation with the incidence of RRT, population, and poverty indices; the number of patients per PD unit showed similar positive relationships and a negative correlation with the number of nephrologists per country; finally, the variable of patients per kidney transplant unit showed a positive correlation with the prevalence and incidence of RRT, GDP per capita, and population size (Table 4).

Other relevant correlations

To ensure model consistency and thorough analysis, complementary correlations among explanatory variables were studied, revealing significant results (Table 5).

The population per country showed a negative correlation with the year of the first HD and KT program. Urban population was positively related to wealth indicators; higher urban population and density were associated with greater advancement in KT legislation, earlier initiation of RRT programs, and higher social security coverage. Poverty and extreme poverty were correlated with out-of-pocket health spending, while a negative relationship was observed with the advancement of KT legislation.

Discussion

Although over the past decade the financial burden posed by ESRD and RRT has gained traction in nephrology publications and academic forums, discussions continue to address general terms with limited impact on decisions toward more rational resource allocation[1,2,24,25]. From a non-financial but economic perspective, as with other high-cost health interventions, resource allocation does not follow public health principles but reflects the incentives of the technological market[8,10]. In this context, Nephrology despite the complexity of managing terminal patients, initially expanded through the promotion of HD as a cost-effective method, later developing standardization and quality systems that optimized its benefits, creating large global service provision markets[26]. However, given increasingly scarce healthcare resources, this strategy seems to have encountered limitations in clinical outcomes, restricting access to more cost-effective and less prevalent therapies such as KT (mainly due to donor shortages)[26] and PD (often resigned as a complementary alternative due to minimal incentives)[27,28]. Moreover, in health systems striving for universal coverage, the ethical imperative of rational resource use to improve equity[5,6] and patient-centered strategies[26] conflicts with concepts of technological adoption and financial profitability. It is within this context that the present study sought to

Table 1. Variables by category and information sources

Variables	Source
Access	
Prevalence of RRT (PMP)	SLANH (RLADyT), 2019
Incidence of RRT (PMP/year)	SLANH (RLADyT), 2019
Prevalence of HD (PMP)	SLANH (RLADyT), 2019
Prevalence of DP (PMP)	SLANH (RLADyT), 2019
Prevalence of KT (PMP)	SLANH (RLADyT), 2019
Supply	
Number of nephrologists (PMP)	SLANH (Enc.Acceso), 2024
HD centers (PMP)	SLANH (Enc.Acceso), 2024
PD centers (PMP)	SLANH (Enc.Acceso), 2024
KT centers (PMP)	SLANH (Enc.Acceso), 2024
Patients per HD center	Composite variable
Patients per DP center	Composite variable
Patients per KT center	Composite variable
Year of first HD program	SLANH (Enc.Acceso), 2024
Year of first KT program	SLANH (Enc.Acceso), 2024
Degree of advancement on KT law	SLANH (Enc.Acceso), 2024
Demographics	
Population (inhabitants)	CEPAL, 2019
Urban population (%)	CEPAL, 2019
Population density (inhabitants/km²)	CEPAL, 2019
Economics	
GDP per capita (USD)	OPS-WHO, 2019
GDP per capita adjusted by PPP (USD)	OPS-WHO, 2019
World Bank Classification	World Bank, 2019
Gini Index	OPS-WHO, 2019
Kuznets Ratio	OPS-WHO, 2019
Poverty (%)	OPS-WHO, 2020
Extreme poverty (%)	OPS-WHO, 2020
Health System	
Total health spending (%)	OPS-WHO, 2019
Private health spending (%)	OPS-WHO, 2019
Public health spending (%)	OPS-WHO, 2019
Out-of-pocket health spending (%)	OPS-WHO, 2015
Social security coverage (% of population)	SLANH (Enc.Acceso), 2024
Public health coverage (% of population)	SLANH (Enc.Acceso), 2024

CEPAL: Economic Commission for Latin America and the Caribbean; PD: peritoneal dialysis; Enc.: survey; HD: hemodialysis; OPS-WHO: Pan American Health Organization - World Health Organization; GDP: Gross Domestic Product; PMP: per million people; PPP: purchasing power parity; RLADyT: Latin American Dialysis and Transplant Registry; SLANH: Latin American Society of Nephrology and Hypertension; RRT: renal replacement therapy; KT: kidney transplant.

investigate the characteristics of RRT availability and access from a socioeconomic perspective, highlighting the unequal scenarios in Latin America. The results for each category of selected variables are analyzed sequentially below.

Access to renal replacement therapy services

Strong correlations are observed between the greater global prevalence of patients undergoing RRT in countries with more mature and comprehensive treatment modalities, including HD, PD, and KT units, determined by the year programs began and legislative advances in KT. There is also a positive relationship with higher urban concentration and economic development indicators (GDP per capita and World Bank classification). Conversely, there is a negative relationship with extreme poverty levels, pointing to potential inequities in access. These findings support a trend of access to high-cost, complex therapies being concentrated in more economically developed areas[3,7,10,24] Early establishment of the Nephrology as a special field allowed these countries to later provide treatments such as KT[26], which represent an evolution in healthcare and social requirements formalized through procurement legislation[25].

Breaking down by modality, the prevalence of HD patients correlated with the year RRT programs began

Table 2. Correlations for the variables of access to RRT and other analyzed variables

Variables	Global prevalence of RRT		Incidence of RRT		Prevalence of HD		Prevalence of PD		Prevalence of KT	
	r (p)	ρ (p)	r (p)	ρ (p)	r (p)	ρ (p)	r (p)	ρ (p)	r (p)	ρ (p)
Prevalence of global RRT	-	-	0.68 (0.002)	0.50 (0.037)	-	-	-	-	-	-
Prevalence of HD	0.76 (< 0.001)	0.75 (< 0.001)	NS	NS	-	-	NS	NS	NS	NS
Prevalence of DP	0.51 (0.025)	0.47 (0.043)	NS	NS	NS	NS	-	-	-	-
Prevalence of KT	0.82 (< 0.001)	0.74 (< 0.001)	0.81 (< 0.001)	0.52 (0.028)	NS	NS	0.59 (0.008)	0.48 (0.041)	-	-
Number of nephrologists	NS	NS	NS	NS	0.63 (0.006)	NS	NS	NS	NS	NS
HD units	NS	0.50 (0.035)	NS	NS	0.70 (0.001)	0.67 (0.003)	NS	NS	NS	NS
PD units	0.63 (0.005)	0.63 (0.006)	0.55 (0.023)	NS	NS	NS	0.50 (0.035)	0.52 (0.028)	0.77 (< 0.001)	0.84 (< 0.001)
KT units	0.56 (0.016)	0.57 (0.015)	NS	NS	0.56 (0.016)	0.63 (0.006)	NS	NS	0.50 (0.033)	0.54 (0.023)
Year of first HD program	–0.55 (0.017)	–0.52 (0.028)	NS	NS	–0.64 (0.004)	–0.68 (0.002)	NS	NS	NS	NS
Year of first KT program	–0.60 (0.009)	–0.53 (0.024)	NS	NS	–0.52 (0.026)	–0.57 (0.014)	NS	NS	–0.55 (0.017)	NS
Degree of advancement of KT law	0.53 (0.023)	0.59 (0.009)	NS	NS	0.52 (0.028)	0.63 (0.005)	NS	NS	0.50 (0.045)	0.54 (0.020)
Population	NS	NS	0.48 (0.042)	NS	NS	NS	NS	NS	0.53 (0.020)	NS
Urban population	0.47 (0.044)	NS	NS	NS	NS	NS	NS	NS	0.47 (0.044)	0.46 (0.047)
Population density	NS	NS	NS	NS	NS	–0.50 (0.030)	0.50 (0.031)	0.49 (0.032)	NS	NS
GDP per capita	0.58 (0.009)	0.61 (0.007)	NS	NS	0.50 (0.029)	0.46 (0.049)	NS	NS	0.57 (0.012)	0.76 (< 0.001)
GDP per capita adjusted by PPP	0.54 (0.025)	0.62 (0.009)	NS	NS	NS	0.50 (0.045)	NS	NS	0.49 (0.044)	0.76 (< 0.001)
World Bank Classification	0.51 (0.026)	0.51 (0.027)	NS	NS	0.58 (0.010)	0.52 (0.022)	NS	NS	NS	NS
Extreme poverty	NS	–0.50 (0.038)	NS	NS	NS	NS	NS	NS	NS	0.54 (0.023)
Private health spending	NS	NS	NS	0.52 (0.028)	NS	NS	NS	NS	NS	NS

PD: peritoneal dialysis; HD: hemodialysis; NS: not significant; GDP: gross domestic product; PPP: purchasing power parity; RRT: renal replacement therapy; KT: kidney transplant.

Table 3. Correlations for the variables of the supply of professionals and RRT services and other analyzed variables

Variables	Number of Nephrologists		HD units		PD units		KT units	
	r (p)	ρ (p)	r (p)	ρ (p)	r (p)	ρ (p)	r (p)	ρ (p)
HD units	0.70 (0.001)	0.76 (< 0.001)	-	-	NS	NS	0.55 (0.018)	0.53 (0.024)
KT units	0.55 (0.018)	0.55 (0.021)	0.55 (0.018)	0.53 (0.024)	0.64 (0.004)	0.61 (0.008)	-	-
Year of first HD program	NS	–0.56 (0.015)	NS	NS	NS	NS	NS	NS
Degree of advancement of KT law	NS	0.48 (0.044)	NS	NS	0.52 (0.027)	0.52 (0.026)	0.60 (0.009)	0.58 (0.012)
Urban population	0.62 (0.006)	0.70 (0.002)	0.64 (0.004)	0.55 (0.019)	NS	NS	NS	NS
GDP per capita	0.56 (0.016)	0.50 (0.037)	0.60 (0.009)	0.52 (0.028)	0.71 (< 0.001)	0.75 (< 0.001)	0.66 (0.003)	0.61 (0.008)
GDP per capita adjusted by PPP	NS	NS	0.53 (0.030)	0.54 (0.028)	0.77 (< 0.001)	0.82 (< 0.001)	0.58 (0.016)	0.60 (0.013)
World bank classification	0.51 (0.032)	0.48 (0.044)	0.56 (0.016)	0.50 (0.034)	NS	NS	0.48 (0.046)	NS
Gini index	NS	–0.48 (0.046)	–0.48 (0.043)	–0.47 (0.049)	NS	NS	NS	NS
Poverty	–0.60 (0.008)	–0.56 (0.016)	–0.61 (0.007)	–0.62 (0.006)	NS	NS	–0.49 (0.038)	–0.50 (0.034)
Extreme poverty	–0.62 (0.006)	–0.70 (0.002)	–0.70 (0.001)	–0.70 (0.002)	–0.57 (0.013)	–0.63 (0.006)	–0.61 (0.007)	–0.62 (0.007)
Total health spending	NS	NS	NS	0.52 (0.028)	NS	NS	0.50 (0.034)	NS
Public health spending	NS	NS	NS	NS	NS	0.59 (0.011)	0.52 (0.031)	-

PD: peritoneal dialysis; HD: hemodialysis; NS: not significant; GDP: gross domestic product; PPP: purchasing power parity; RRT: renal replacement therapy; KT: kidney transplant.

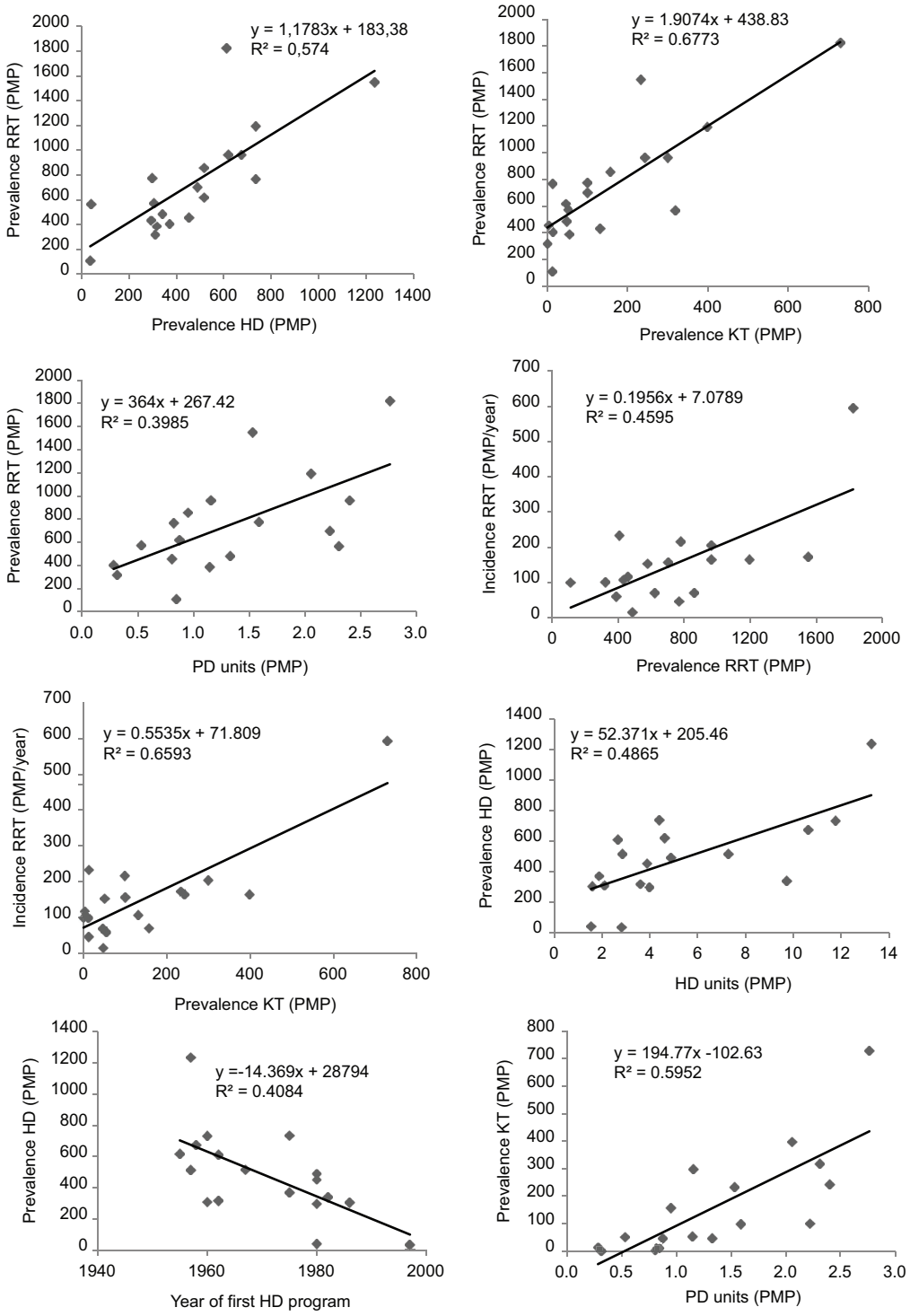

Figure 1. Access to RRT services and relevant correlations. PD: peritoneal dialysis; HD: hemodialysis; PMP: per million people; RRT: renal replacement therapies; KT: kidney transplant.

(both HD and KT: the earlier they started, the greater the current availability and prevalence), the number of nephrologists and treatment units, and GDP per capita. These elements are essential for the spread of this therapeutic option. The availability of PD units directly correlates with the prevalence of PD patients and

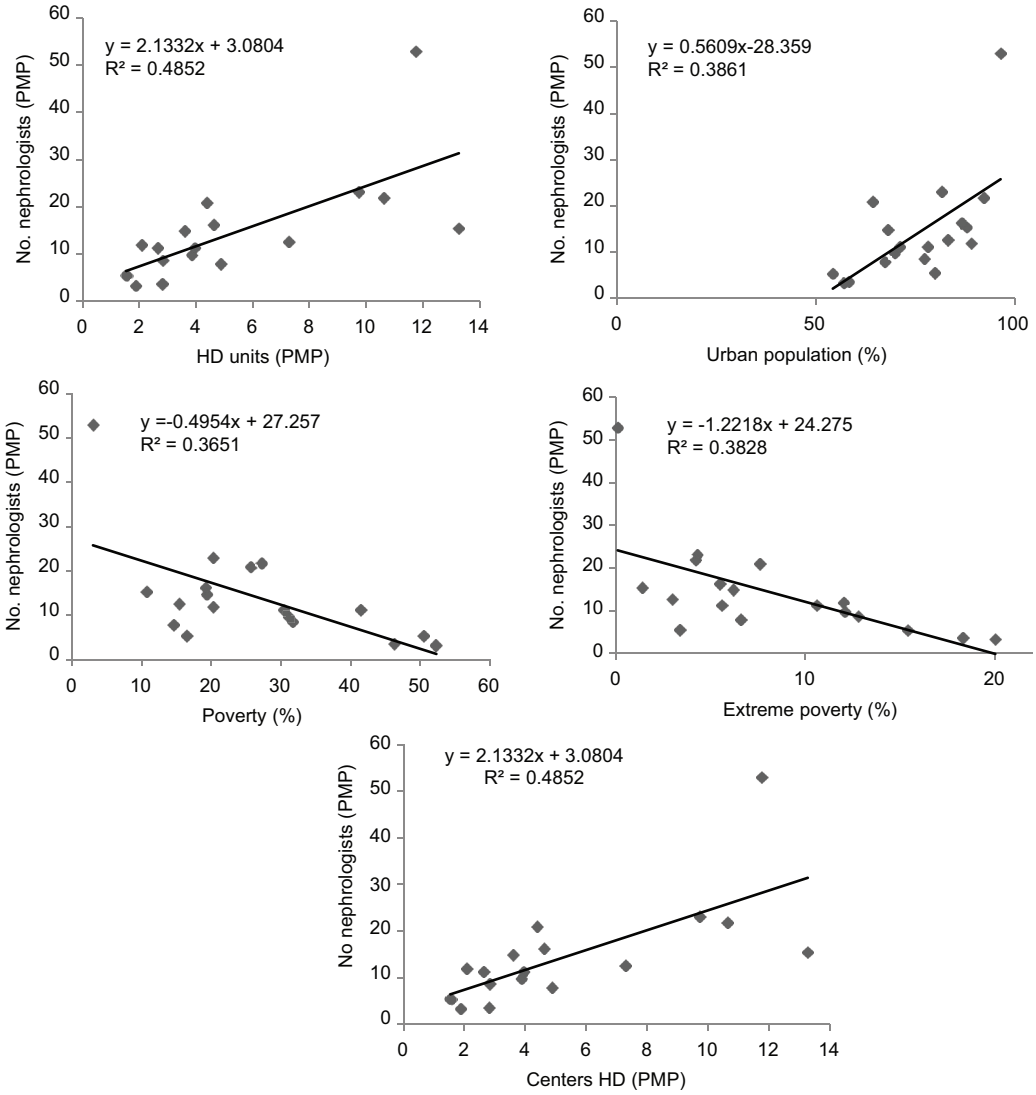

Figure 2. Availability of professionals and relevant correlations. HD: hemodialysis; PMP: per million people.

higher population density. Finally, the prevalence of KT patients is directly related to variables such as urban concentration, total population, national wealth, and the prevalence and incidence of RRT patients[24,25] as well as the availability of treatment centers. This suggests that KT complements overall RRT access but requires a prior foundation of economic development and consolidated training. In this subanalysis of each modality, HD and KT reinforce correlations with variables similar to those observed for global prevalence, while PD is associated with specific availability conditions cited in the literature[2,3,5,15].

Regarding the incidence of RRT patients, correlations align with literature reports, showing a positive association with population size[1,24,25] and private health spending. This could have two explanations: higher incidence may reflect access to differential care (assuming higher quality and access due to direct payment) or indicate that this higher out-of-pocket spending reflects issues in public health systems' capacity to prevent ESRD progression effectively[6,12,24].

Offer of renal replacement therapy services

The unequal distribution of nephrologists highlights a significant current and future issue for the region[1,7,13,16]: their higher concentration is clearly observed in countries with greater wealth (and lower poverty rates)[16],

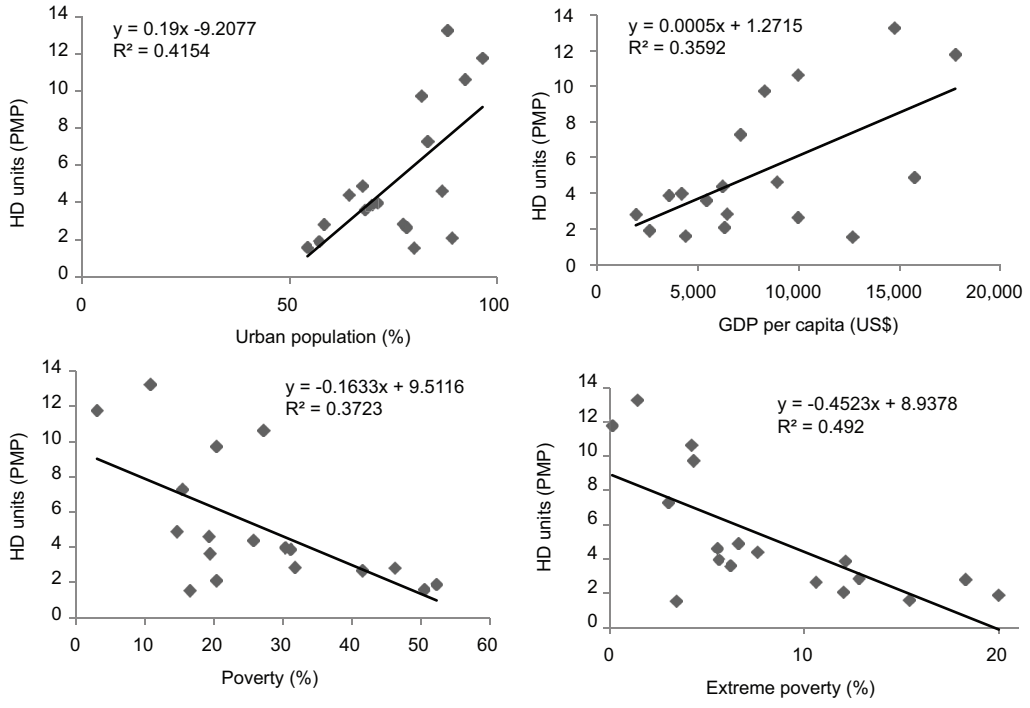

Figure 3. Availability of HD and relevant correlations. HD: hemodialysis; PMP: per million people.

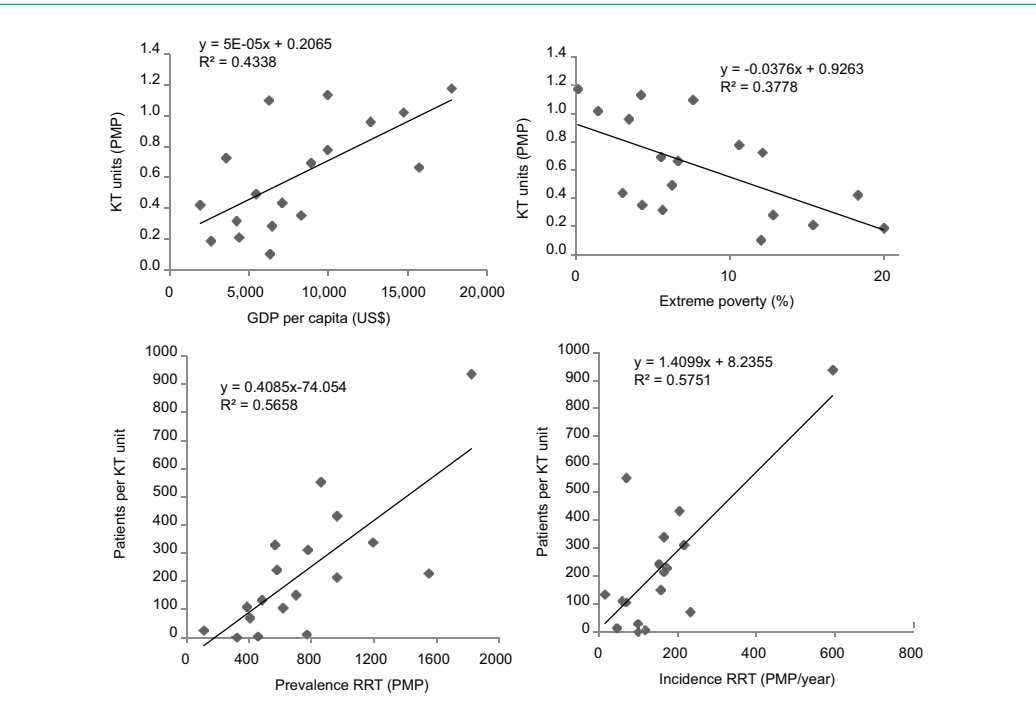

Figure 4. Availability of DP and relevant correlations. PD: peritoneal dialysis; GDP: gross domestic product; PPP: purchasing power parity; PMP: per million people; KT: kidney transplant.

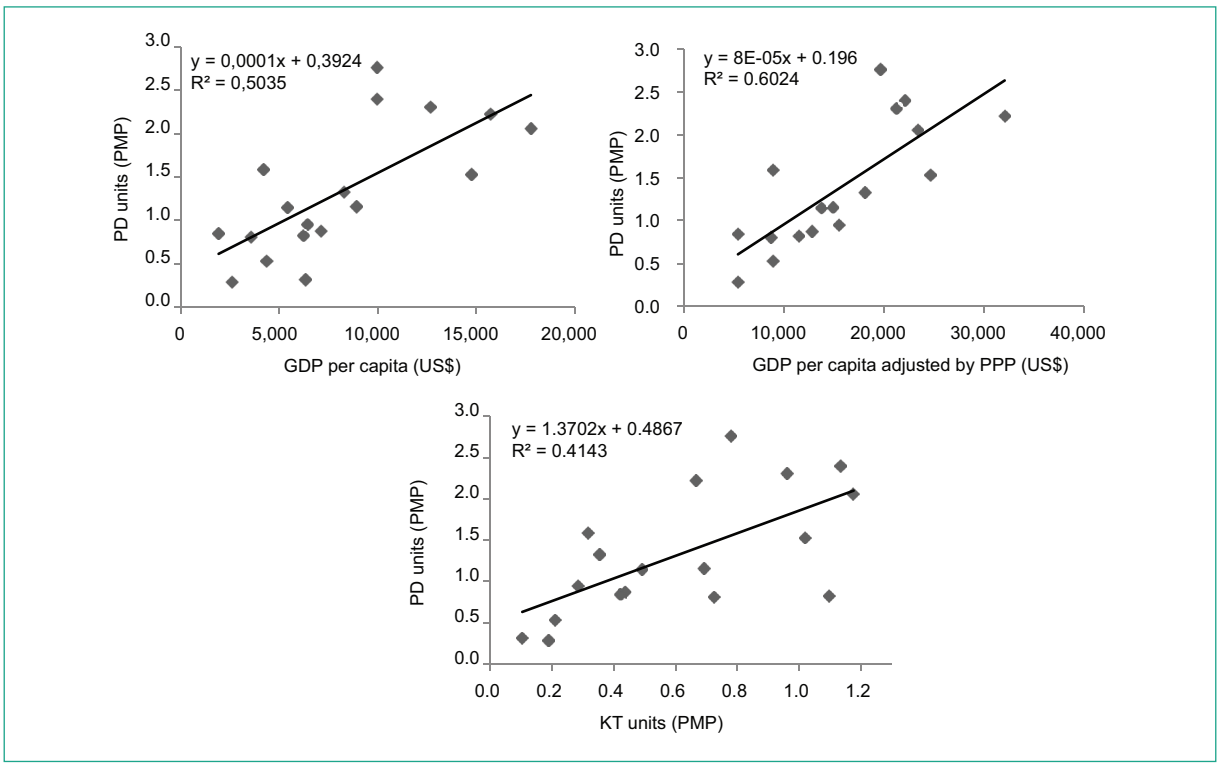

Figure 5. Availability of KT and relevant correlations. GDP: gross domestic product; PMP: per million people; RRT: renal replacement therapies; KT: kidney transplant.

Table 4. Correlations for the composite variables of RRT service supply and other analyzed variables

Variables	Patients per HD unit		Patients per PD unit		Patients per KT unit	
	ρ (p)	r (p)	ρ (p)	r (p)	ρ (p)	r (p)
Prevalence of global RRT	NS	NS	NS	NS	0.75 (< 0.001)	0.74 (< 0.001)
Incidence of RRT	0.50 (0.042)	NS	NS	NS	0.76 (< 0.001)	0.50 (0.045)
Number of nephrologists	NS	NS	NS	–0.56 (0.018)	NS	NS
Population	NS	0.48 (0.045)	NS	NS	0.59 (0.011)	NS
Population density	NS	NS	0.57 (0.013)	0.77 (<0.001)	NS	NS
GDP per capita	NS	NS	NS	NS	NS	0.53 (0.030)
GDP per capita adjusted by PPP	NS	NS	NS	NS	NS	0.52 (0.035)
Kuznets ratio	0.58 (0.036)	0.59 (0.036)	NS	NS	NS	NS
Poverty	0.48 (0.044)	NS	0.55 (0.019)	NS	NS	NS
Extreme poverty	0.49 (0.041)	0.57 (0.015)	NS	NS	NS	NS

PD: peritoneal dialysis; HD: hemodialysis; NS: not significant; GDP: gross domestic product; PPP: purchasing power parity; RRT: renal replacement therapy; KT: kidney transplant.

larger urban populations, and greater income equality. Furthermore, a greater number of nephrologists is also associated with a longer history of the specialty, using the establishment of the first HD program as a proxy. This, in turn, suggests a greater initial availability of HD in terms of prevalence and centers[2,26]. A similar

Table 5. Correlations for complementary variables and other analyzed variables

Variables	Population		Urban population		Population density	
	ρ (p)	r (p)	ρ (p)	r (p)	ρ (p)	r (p)
First HD program year	–0.48 (0.043)	–0.54 (0.022)	–0.74 (< 0.001)	–0.71 (0.001)	0.52 (0.028)	0.61 (0.007)
First KT program year	–0.49 (0.041)	–0.63 (0.006)	–0.75 (< 0.001)	–0.74 (< 0.001)	NS	NS
GDP per capita	NS	NS	0.64 (0.003)	0.66 (0.003)	NS	NS
GDP per capita adjusted by PPP	NS	NS	0.61 (0.009)	0.67 (0.004)	NS	NS
World bank classification	NS	NS	0.52 (0.022)	0.48 (0.037)	NS	NS
Gini index	0.47 (0.048)	NS	NS	NS	NS	NS
Kuznets ratio	0.64 (0.018)	NS	NS	NS	NS	NS
Poverty	NS	NS	–0.73 (< 0.001)	0.62 (0.006)	NS	NS
Extreme poverty	NS	NS	–0.72 (< 0.001)	–0.75 (< 0.001)	NS	NS
Out-of-pocket health spending	NS	NS	–0.66 (0.003)	–0.69 (0.006)	NS	0.54 (0.020)
Social security coverage	NS	NS	0.54 (0.021)	0.55 (0.018)	NS	NS

Variables	Poverty		Extreme poverty	
	ρ (p)	r (p)	ρ (p)	r (p)
First HD program year	0.52 (0.029)	0.49 (0.038)	0.51 (0.032)	0.52 (0.028)
Kuznets ratio	–0.73 (< 0.001)	–0.56 (0.016)	–0.65 (0.003)	NS
GDP per capita	–0.74 (< 0.001)	–0.75 (< 0.001)	–0.73 (< 0.001)	–0.75 (< 0.001)
GDP per capita adjusted by PPP	–0.69 (0.002)	–0.72 (0.002)	–0.67 (0.004)	–0.68 (0.003)
World bank classification	–0.70 (0.001)	–0.74 (< 0.001)	–0.63 (0.005)	–0.60 (0.009)
Out-of-pocket health spending	0.59 (0.011)	NS	0.48 (0.042)	NS
Social security coverage	–0.50 (0.034)	–0.54 (0.022)	NS	–0.49 (0.041)

Variables	Total health spending (r)		Private health spending		Public health spending		Out-of-pocket health spending	
	ρ (p)	r (p)	ρ (p)	r (p)	ρ (p)	r (p)	ρ (p)	r (p)
Progress of KT law	NS	NS	NS	NS	NS	NS	–0.60 (0.009)	–0.54 (0.021)
Social security coverage	NS	NS	–0.47 (0.049)	NS	NS	NS	NS	NS

Variables	Population with social security coverage		Population with public health coverage (ρ)	
	ρ (p)	r (p)	ρ (p)	r (p)
Progress of KT law	0.55 (0.017)	0.62 (0.006)	NS	NS
GDP per capita	0.62 (0.006)	0.68 (0.002)	NS	NS
GDP per capita adjusted by PPP	0.73 (< 0.001)	0.79 (< 0.001)	NS	NS
World bank classification	0.54 (0.020)	0.59 (0.010)	NS	NS

PD: peritoneal dialysis; HD: hemodialysis; NS: not significant; GDP: gross domestic product; PPA: purchasing power parity (PPP); TRR: renal replacement therapy; KT: kidney transplant.

interpretation can be made regarding the direct correlation between a higher number of nephrologists and the existence of more KT units. These findings reinforce access correlations: the early introduction of nephrology in higher-income countries and the early initiation of programs fostered the initial expansion of HD[10,26], likely influenced by the dissemination of technologies in emerging and economically solvent markets[24,25].

Similarly, the explicit availability of HD centers correlates directly with wealthier countries, urban concentration, income equality (and lower poverty), and the aforementioned prevalence of RRT and HD, alongside the coexistence of more KT units (possibly as a result of the established primary dialysis options)[26]. Adjusting the number of centers by prevalence reveals a previously unexplored relationship in the literature: countries with centers serving more concentrated patient populations also exhibit greater inequalities and poverty. This finding is notable, potentially linking larger facility sizes to countries with fewer specialists available to provide care.

A similar pattern is observed with PD centers: although their number per country correlates with higher economic development, lower poverty, and greater RRT prevalence, when adjusted for patient concentration (more patients per unit), a positive correlation emerges with higher poverty levels. Finally, in terms of KT units per million inhabitants, their presence is consolidated in wealthier countries with higher healthcare spending, where RRT prevalence is greater, service offerings are more developed[26], and legislative advancements on KT are more defined[29]. However, the association with financing mechanisms is also remarkable, predominating in countries with a higher public healthcare share, indicating equitable policies for access to high-complexity interventions. Additionally, when considering the proportion of patients per unit, higher volumes are observed in countries with larger populations and earlier transplant program initiation, suggesting greater expertise and centralized management of larger patient cohorts under follow-up.

Other relevant correlations

Further exploration of correlations to confirm the logical behavior of selected variables in the model revealed expected results. Larger country populations inversely correlated with the timing of the first RRT programs (the larger the population, the earlier the dialysis and KT programs began) or directly with income equality (though this correlation may have more complex explanations)[30]. Beyond the previously mentioned relationships with treatment prevalence and units availability, greater urban density directly correlated with wealthier countries, lower poverty, and broader social security coverage[30,31]. Inverse correlations were observed with the timing of RRT program initiation (more urban populations saw earlier therapy supply, consolidating the idea of greater service availability stemming from urban centers) and out-of-pocket healthcare spending (greater population concentration correlates with lower out-of-pocket costs, perhaps reflecting stronger economic development and formal employment in urban areas)[30,32]. Supporting this, indicators of healthcare spending and coverage showed that a greater proportion of people covered by social security directly correlated with wealth indices and inversely with out-of-pocket spending. Complementarily, a direct relationship was found between out-of-pocket spending and poverty-related economic indicators (healthcare access depends on the individual economies of patients and their families) but was clearly inverse with the proportion of people covered by public systems. This suggests a necessary compensatory effect from public health to ensure equity in healthcare access[30,31]. To mitigate the direct impact of limited accessibility, addressing this imbalance in coverage capabilities could become an area of development for alternative insurance models for catastrophic illnesses.

Limitations

The sources of information correspond to records that, in some cases, have been validated and published, originating from official statistics and supplemented with preliminary data from ad hoc records and surveys currently being updated and published. Even in this context, data closest to the period prior to the COVID-19 pandemic were adjusted for proper comparison. The pandemic disrupted socioeconomic indicators in these countries as well as the availability of RRT services[33].

While there is significant effort by scientific societies to consolidate RRT registries, these efforts should be strengthened by considering the socioeconomic and historical context in which they are implemented. Including determinants like those analyzed here could improve the perspective and accuracy of such registries. These results are general and indicative, and they do not fully explain specific exceptional situations, such as the noteworthy case of Costa Rica's predominance of KT prevalence[4], which represents a unique case study with unique dynamics.

Finally, the limited number of countries in the region poses a sampling limitation, preventing more comprehensive statistical analyses through multivariate methodologies. Although correlations indicating trends in the behavior of the selected variables were established, they do not imply causality or direct association, nor do they determine the relative weight of the most sensitive variables compared to the accessory ones beyond the scope of evaluation. Nonetheless, the approximate values derived from combining methods could indicate associations for future lines of research on this topic.

Conclusions

In general, it is observed that access variables (incidence, overall prevalence, and RRT-specific prevalence) correlate with the complete availability of modalities, early program initiation, advancements in procurement legislation, greater urban concentration, and economic development indicators. On the other hand, the availability of professionals and services is unequal, with higher concentrations in wealthier countries, earlier Nephrology program initiation, greater urban population concentration, and income equality, leading to a higher prevalence of HD units compared to PD and KT. Healthcare coverage in the region is characterized by out-of-pocket expenses and their complementarity with public health as predominant in countries with higher poverty rates, while social security coverage in those with larger populations, greater urban concentration, and higher wealth. In this financing framework, efforts should focus on promoting cost-effective RRT options to improve equitable access[6].

Understanding this process of RRT implementation through an economic and historical lens could provide a realistic foundation for future discussions on improving equity in resource distribution and its impact on health policies in Latin America. The findings from this analysis are unprecedented for the region, as there are few bibliographic references on the subject. This underscores the importance of this work, not for establishing definitive explanations of direct associations but to understand the distribution logic of patient care, the sources of inequity, and to open new pathways for research on decision-making and resource allocation in healthcare.

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Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical considerations

Protection of human subjects and animals. The authors declare that no experiments on humans or animals were performed for this research.

Confidentiality, informed consent, and ethical approval. The authors have obtained approval from the Ethics Committee for the analysis of routinely collected and anonymized clinical data; therefore, individual informed consent was not required. Relevant ethical recommendations have been followed.

Declaration on the use of artificial intelligence (AI). The authors declare that no generative artificial intelligence was used in the writing or creation of the content of this manuscript.

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